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RESEARCH ARTICLE

The relationship between the intensity levels and speech production fluency in the delayed auditory feedback test in normally hearing listeners

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Abstract

Background and Aim: Sometimes people with functional hearing loss are referred to audiology clinics. The delayed auditory feedback (DAF) is a test which assesses functional hearing loss qualitatively. This study aimed to quantify DAF and accordingly use it in more precise way.

Methods: Fifteen normally hearing students participated in this experiment. Each person's voice was presented to his or her ear once without and another time with fixed time delay when he or she was reading simple texts. The delayed voices were presented in different intensity levels. Stuttering, unusual lengthy, and non-fluent utterances indicated the perception and hearing of the delayed voices.

Results: The length of the utterances increased and the fluency of the utterances decreased significantly for delayed compared to non-delay condition and for different intensity levels.

Conclusion: These results showed that the levels of intensity of the delayed voices might influence the perception of the delay.

Keywords: Delayed auditory feedback; non-organic hearing loss; speech fluency

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Introduction

Among the variety of patients with auditory disorders, some patients present with non-organic or functional hearing loss. In this type of hearing loss, auditory system has no obvious organic disorder but patients' behavioral or functional manifestations defies their audiometric results [1,2]. The probable reasons for this type of hearing loss include malingering, exaggeration of hearing loss, psychogenic disorders, or inaccurate test results due to lack of patient cooperation [3]. Even if the patient does not cooperate, it is the audiologist's duty to determine his or her actual hearing threshold and organic hearing [4].

When suspecting a non-organic hearing disorder, audiologist can use several tests for distinguishing organic from non-organic hearing loss. Some of these methods aim at confusing the examinee. Others help to determine the actual hearing threshold. Some methods can be learned easily by the patient and audiologist may experience difficulty in using them. Others are resistant to learning and experience [5]. Although we can use electrophysiologic tests for patients suspected of non-organic hearing loss or patients with poor behavioral cooperation, the high cost of these tests and their limited accessibility in audiologic centers decrease their feasibility. Many centers make use of other tests with low cost and simple procedures to estimate the hearing level of these patients [6].

Delayed auditory feedback (DAF) evaluates non-organic hearing loss in a qualitative way. In DAF, the patient hears his or her voice through a device that is able to make a given amount of delay. This delay makes his speech non-fluent [7-9]. Therefore, if patient's speech fluency is affected by DAF while the presentation level is below the pretended threshold, it is indicative of non-organic hearing loss. It means that he/she could hear speech at that given presentation level [10,11]. DAF can have a potential application in quantitative hearing threshold estimation. The present study aimed to assess DAF results in subjects with normal hearing.

Methods

This study was conducted on 15 volunteer students (8 males and 7 females) from Iran University of Medical Sciences. Their age range was from 21 to 42 years (Mean±SD age: 26.8±6.2 years). All volunteers had normal hearing within 250-8000 Hz frequency range with type A tympanogram and normal auditory reflex threshold. The auditory threshold was traced with one dB steps. Word recognition score of all subjects was excellent (≥96%). For speech DAF, four written texts were given to each subject and they read them into the microphone of the DAF device in an acoustic room. Sentences and words in the texts were arranged in a way that all texts needed equal average time for reading in a normal situation. For ensuring equal average duration of reading, 15 normal subjects (other than study cases) were asked to read texts in a natural way and the reading duration was measured. Then, the average time for reading was compared. The reason for using four texts was preventing learning effect because experience can affect the speed of reading.

In the text 1, the participants listened to their voice without any delay (0 ms) at 50 dBHL that was their most comfortable level (MCL). For remaining texts there was 200 ms delay [12] and the level of presentation were 30, 50, and 70 dBHL, respectively. Any change in reading speed and duration, voice level on the VU meter, stuttering, syllable prolongation, and influent speech were considered positive result [12-14].

For statistical analysis, SPSS 16 was used. Based on K-S test, data distribution was normal, therefore repeated measurement and independent sample t-test were used for comparing reading duration and the threshold of two ears, respectively.

Results

In this study, 15 subjects aged 21 to 42 years (Mean±SD age of 26.8±6.2 years old) were participated. The pure tone average (PTA) of 500, 1000, and 2000 Hz were from 0 to 6.7 dBHL (Mean±SD: 2.66±1.86 dB) and from 1.7 to 5 dBHL (Mean±SD: 3.44±1.33 dB) for the right and the left ear, respectively. Both sexes had a better hearing threshold in the left ear but there was not any significant difference between two ears (p>0.05). Table 1 shows age, sex, and reading duration (seconds) for four texts. Fig. 1 shows mean reading duration of four texts in both sexes. According to repeated measurement with Wilks lambda index, there was a significant difference between two sexes (p=0.029) with regard to reading duration. Based on Mauchly's test, the equality of variances of differences was rejected (p≤0.001). As Mauchly's test or sphericity hypothesis was not true, Tukey post hoc was used for determining which situation had a significant difference. Significant level was set at 0.05. Table 2 shows mean reading duration of texts (seconds) and their p values. Intra-group effects for both sexes were not significant (p=0.17). As Mauchly's test of sphericity was not true, the Greenhouse-Geisser method was a better choice (p≤0.000, F=15.956, df=1.390). Levene's test was used for testing equality of variances. Based on this method, results were not significant in any situation.

Discussion

The present study was conducted to assess the relationship between the effects of intensity

Table 1. Participants' age, sex, and duration of reading four text with 0 and 200 ms delayed auditory feedback and different presentation levels

Participant	Age	Sex	Reading duration (s)			
			Text 1 (delay: 0 ms; PL: 50 dBHL)	Text 2 (delay: 200 ms; PL: 30 dBHL)	Text 3 (delay: 200 ms; PL: 50 dBHL)	Text 4 (delay: 200 ms; PL: 70 dBHL)
1	40	F	24	27	27	28
2	24	M	18	23	24	26
3	21	M	22	27	33	33
4	22	M	22	44	37	50
5	25	M	22	28	26	30
6	28	M	23	26	29	27
7	26	M	26	31	29	30
8	22	F	20	19	19	22
9	24	M	22	24	25	24
10	30	F	21	22	22	22
11	42	F.	24	25	30	31
12	25	M	23	37	37	42
13	24	F	20	25	27	32
14	25	F	23	28	32	35
15	24	F	19	21	21	21

PL; presentation level, F; female, M; male

levels and speech production fluency in the DAF test administered to normal-hearing listeners. Previous studies on speech DAF had studied non-organic hearing loss and alteration of speech fluency qualitatively and to the best of our knowledge, there has not been any study on the relationship between DAF presentation level and speech fluency.

In this study, mean PTA of females were better than males but as PTA of all cases were within normal limits and there was not any significant difference between two ears. The sex difference could not confound results and test procedure. Based on Table 1, mean duration for reading texts 1 to 4 were 21.93, 27.13, 27.87 and 30.2 seconds, respectively. As it is shown, there was no significant reading duration change in the transition from text 2 to 3. Repeated measurement showed a significant difference in the reading duration of texts. It shows that delayed feedback and increasing presentation level of delayed feedback can increase reading duration and decrease speech fluency. Results of the multifactorial Wilk's lambda (by adding sex factor) was also significant.

In Table 2, the reading duration of four texts was compared two by two among the participants. In all paired comparisons, there was a significant difference except for paired comparison between text 2 and 3. In other words, the difference of speech fluency in baseline situation (text 1) from all delayed situations were significant. The only exception was the difference between text 2 and 3 (with presentation level of 30 and 50 dBHL, respectively). It seems that presentation level of DAF in the text 4 is

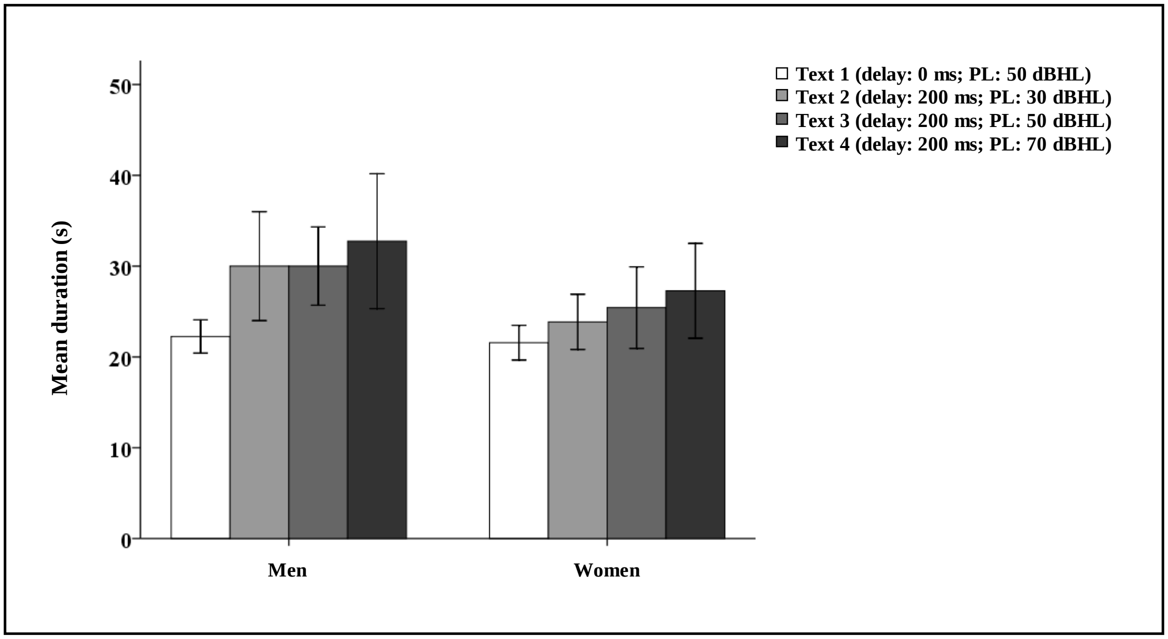

Fig. 1. Mean (standard deviation) duration of reading the texts 1 to 4 in men and women.

high enough to overcome the non-delayed natural speech that participants hear through their bone conduction and that is the reason for the significant speech alteration in the fourth situation. It is worth to mention that speech articulation and fluency are the results of feedback and feedforward interactions. In text 4, the presentation level of DAF through air conduction has overcome the intensity level of undelayed auditory feedback which is heard through bone conduction and has a role in feedforward adjustment, and has led to influent speech [15]. It was not possible to determine the exact intensity level of DAF that could overcome bone conduction feedback because speech production level of participants was variable.

Table 2. Comparison of the mean (standard deviation) duration of reading four texts in seconds

Text	Mean (SD) duration of reading (s)	p
1	21.93 (2.09)	vs text 2 0.004
		vs text 3 <0.001
		vs text 4 0.001
2	27.13 (6.36)	vs text 3 0.386
		vs text 4 0.001
3	27.87 (5.38)	vs text 4 0.026
4	30.20 (7.82)	

Table 1 indicates that in some participants applying delay and increasing presentation level of the delayed speech from text 1 to 4 had less effects on reading duration and speech fluency than others. This was mostly true in females. Naturally, people mainly use feedforward for adjusting 75%-80% of their speech fluency and articulation speed and use feedback for the rest 20%-25% [16]. As delayed feedback had less destructive effect on speech fluency of females, it seems that females rely more on feedforward than males. Similar studies showed the same results. In addition, studies have shown that if delayed speech results in altered speech fluency in females, the alteration is less significant than males [17].

Finally in Fig. 1, the mean reading duration in four texts in females was less than males which is indicative of faster reading speed in females than males [17].

Conclusion

The present study showed that with delayed speech and increasing the presentation level of this delayed speech, reading duration of texts increases and speech fluency decreases. In the other words, with an increment of delayed speech presentation level, speech fluency will be influenced more. Thus DAF might be able for quantifying hearing level and help to diagnose malingering.

Since to the best of our knowledge, this study was the first study to assess the relationship between DAF presentation level and speech fluency and only three presentation levels (30, 50 and 70 dBHL) were used, the exact level of speech that caused influent speech could not be determined (e.g. based on dBSL re*:* SRT) and DAF could not be quantified. Speech production level variety in participants was a confounding factor. Clinical audiologists are recommended to do more research on quantifying speech DAF and methods for eliminating speech production level variability.

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Conflict of interest

The authors declare that they have no conflict of interest.

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