RESEARCH ARTICLE

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

Sayyed Hossein Hosseini, Ali Akbar Tahaei, Nariman Rahbar*

Department of Audiology, School of Rehabilitation Sciences, Iran University of Medical Sciences, Tehran, Iran

Received: 25 Nov 2017, Revised: 19 Feb 2018, Accepted: 27 Feb 2018, Published: 15 Jul 2018

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

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 accessi-
bility in audiologic centers decrease their feasibil-
ity. 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 applica-
tion in quantitative hearing threshold esti-
mation. The present study aimed to assess DAF
results in subjects with normal hearing.

Methods
This study was conducted on 15 volunteer stu-
dents (8 males and 7 females) from Iran Univer-
sity 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 tym-
panogram 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 ave-
rage 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 experi-
ence 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 spe-
ed and duration, voice level on the VU meter,
stuttering, syllable prolongation, and influ-
tent 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 indepen-
dent sample t-test were used for comparing rea-
ding 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 signifi-
cant difference between two sexes (p=0.029)
with regard to reading duration. Based on
Mauchly’s test, the equality of variances of dif-
fferences was rejected (p≤0.001). As Mauchly’s
test or sphericity hypothesis was not true, Tukey
post hoc was used for determining which situ-
ation 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
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

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

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

PL: presentation level, F: female, M: male
The effect of the DAF intensity on speech fluency


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

<table>
<thead>
<tr>
<th>Text</th>
<th>Mean (SD) duration of reading (s)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>21.93 (2.09)</td>
<td>vs text 2 0.004 vs text 3 &lt;0.001 vs text 4 0.001</td>
</tr>
<tr>
<td>2</td>
<td>27.13 (6.36)</td>
<td>vs text 3 0.386 vs text 4 0.001</td>
</tr>
<tr>
<td>3</td>
<td>27.87 (5.38)</td>
<td>vs text 4 0.026</td>
</tr>
<tr>
<td>4</td>
<td>30.20 (7.82)</td>
<td></td>
</tr>
</tbody>
</table>

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

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 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.

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.
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 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 influence 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.

Acknowledgements
The authors would like to thank Dr. Mohammad Ma'arefvand for his assistance in writing the article and also to all participants in this study.

Conflict of interest
The authors declare that they have no conflict of interest.

REFERENCES

http://avr.tums.ac.ir