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Immediate speech fluency improvement after application of the Digital Speech Aid in stuttering patients

Authors' Contribution:

- A** Study Design
- B** Data Collection
- C** Statistical Analysis
- D** Data Interpretation
- E** Manuscript Preparation
- F** Literature Search
- G** Funds Collection

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Summary

Background:

The Digital Speech Aid (DSA) is a pocket-sized device used for speech correction in stutterers. The device modifies the patient's auditory feedback with the use of Delayed Auditory Feedback (DAF) and Frequency-shifted Auditory Feedback (FAF). Both methods are well-known to improve speech fluency in stuttering persons. The aim of this study was to assess immediate disfluency reduction after application of the DSA.

Material/Methods:

The study included 335 patients aged 6–64 years with speech disfluency. DSA fitting was performed during 3-day hospitalization. Speech disfluency was assessed during reading, in dialogue and in monologue before fitting and after selection of optimal DAF and FAF parameters. Fluency improvement was assessed statistically with Student's t test for logarithms of the odds of disfluency presence without the DSA and with the DSA.

Results:

For all speaking situations, statistically significant improvement was achieved, with $p < 0.005$. Immediate fluency improvement was observed in 82.1% of patients during reading, in 84.5% during dialogue, and in 81.2% during monologue. Values different from placebo (reliable improvement) were obtained in 66.9% of patients during reading, in 66.6% during dialogue, and in 63.9% during monologue.

Conclusions:

The results show that the DSA is an effective tool for immediate disfluency reduction in stutterers.

key words:

stuttering • auditory feedback • Digital Speech Aid

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BACKGROUND

Stuttering, although it is a common problem, remains a challenge for speech pathologists and the search for effective therapies for this speech disorder continues. Altered auditory feedback (AAF) is a well-known method, producing immediate speech fluency improvement [1]. The most common method of altering auditory feedback is delayed auditory feedback (DAF) [2,3]. In this method, the delayed patient's voice is provided by auditory loop via headphones when speaking. This method has been proven to successfully reduce speech disfluency in stutterers. More recently, frequency-shifted auditory feedback (FAF) has been introduced [4]. In FAF, the voice pitch is shifted either downwards or upwards and provided by headphones during speech, thus interfering with normal speech control. The Digital Speech Aid is a novel pocket-sized device that includes both DAF and FAF. It has been developed in cooperation between the Gdańsk Technical University and the Dalhousie University in Halifax [5,6]. The aim of the present study was to assess the immediate speech fluency improvement after application of the Digital Speech Aid in a large group of stutterers.

MATERIAL AND METHODS

Material

The studied group consisted of 335 stutterers aged 6–64 years, who were admitted to the Phoniatic Clinic of the Institute of Physiology and Pathology of Hearing in Warsaw during the period 2003–2006. Average age in the group was 17.9 years (standard deviation 9.0 years). The group included 268 males (80%) and 67 females (20%). The patients had had speech therapy and/or other stuttering therapies, but found them to be ineffective or insufficiently effective.

Equipment

The Digital Speech Aid (DSA) (Figure 1) is a portable device sized 8×6 cm, weighing 150 g. It is battery-operated and has connections for microphone and headphones. The device includes delayed auditory feedback (DAF), frequency transposition of the voice (FAF), and can combine DAF and FAF of different values. The delay ranges from 45 ms to 355 ms, and frequency transposition ranges from –89% octave to +69% octave with the tolerance $\pm 0.5\%$. Delaying the voice is regulated smoothly with the potentiometer, with the tolerance ± 5 ms for delay 45 ms, $\pm 10\%$ for value from 90 ms to 310 ms and ± 35 ms for value 355 ms. Voice loudness can be also regulated.

Method

Digital Speech Aid fitting was carried out during a 3-day hospitalization in the Phoniatic Clinic of the Institute of Physiology and Pathology of Hearing in Warsaw. All patients were examined by the phoniatician and had pure tone audiometry and impedance audiometry performed. The level of speech disfluency was assessed with the Kurkowski Syllabic test [7], which shows the number of disfluent syllables in 100 pronounced syllables during reading (or of naming pictures, in the case of children), in dialogue and during monologue (telling a picture story). The Syllabic test was performed by an experienced speech therapist before fitting of the DSA

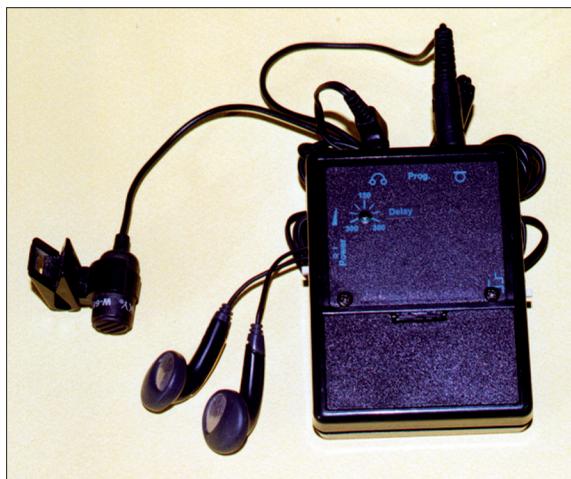


Figure 1. Digital speech aid.

and after choosing the optimal DAF/FAF combination. The DSA was fitted by the physician. After each fitting, the improvement of speech fluency was judged subjectively by the patient and the physician during reading and dialogue. The Syllabic test was not used with every change of the DSA setting due to the risk of habituation to the test. Every patient tested at least 6 different settings of the DSA. Patients used each setting for at least 2 hours. They were instructed to read aloud and talk to accompanying persons using the DSA. After finishing the hospitalization they were instructed to borrow the DSA and to use it in everyday situations.

Statistical analysis

Data were entered into the database and subjected to statistical analysis with the use of the statistical package Statistica, version 7.1 (StatSoft, Inc. 2005). The level of disfluency was represented by odds value. The odds ratio represents the relationship between the odds of disfluency without the DSA and the odds of disfluency with the DSA on. For computational purposes, the logarithms of odds and odds ratios are used. A value of the logarithm of odds ratio equal to 0 means no change in speech fluency, a value greater than 0 means improvement, and a value less than 0 represents speech deterioration after application of the DSA. For the assessment of speech fluency improvement, the t test was applied, where the data were logarithms of odds of disfluency presence without the DSA and with the DSA on.

RESULTS

The highest values of disfluency, both without the DSA and with the DSA, were observed during the dialogue. The lowest values of disfluency, both without the DSA and with the DSA, were noted during reading (Table 1).

In all 3 tests, being elements of the Syllabic test, statistically significant values were achieved, with $p < 0.005$. During reading, the odds of stuttering without the DSA was 0.17, with the DSA it was 0.05, and the odds ratio of the disfluency chances without the DSA and with the DSA was 3.39. In the dialogue the odds of disfluency without the DSA were equal 0.58, with the DSA on the odds were 0.18 and the odds ratio was 3.19. In monologue, the odds of disfluency without

Table 1. Results obtained in the Syllabic test without the DSA and with the DSA. SD – standard deviation, DSA – digital speech aid.

Element of the Syllabic test	Average [% stuttering]	Minimum [% stuttering]	Maximum [% stuttering]	SD [%]
Reading without the DSA	19.7	0	93	18.0
Dialogue without the DSA	39.2	0	97	21.6
Monologue without the DSA	32.1	0	94	19.3
Reading with the DSA	7.7	0	57	10.2
Dialogue with the DSA	20.1	0	80	16.2
Monologue with the DSA	17.1	0	83	14.2

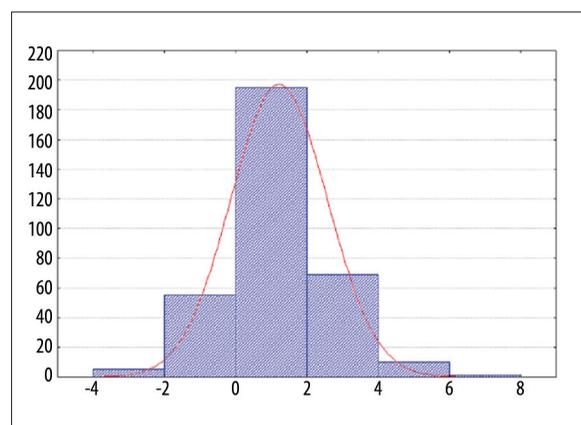


Figure 2. Fluency change after application of the DSA during reading. "X" axis represent the logarithm of odds ratios, "Y" axis – number of cases. The value of the logarithm of odds ratio equal to 0 means no change in speech fluency, the value greater than 0 means improvement and the value less than 0 represents speech deterioration after application of the DSA.

the DSA were equal to 0.40, with the DSA on were equal to 0.15, and the odds ratio was 2.69.

Distribution fluency change after application of the DSA showed that in all 3 elements of the Syllabic test an improvement was most often of moderate or average rank, with the logarithm of the odds ratio ranging from 0 to 4. In reading, the improvements of the mentioned value constituted 78.8% of the examined group (264 persons). Very considerable improvement with the logarithm of the odds ratio above 4 was observed in 3.3% (11 persons). Cases of the lack of change in fluency were also found (logarithm of the odds ratio 0) or deteriorations (logarithm of the odds ratio less than 0). This phenomenon was observed during reading in 17.9% of the examined group (60 persons) (Figure 2).

In the dialogue, moderate and average improvement with the logarithm of the odds ratio from 0 to 4 was observed in 81.8% (274 persons), and very considerable improvement was observed in 2.7% (9 persons). Deterioration or lack of improvement was observed in 15.5% (52 persons) (Figure 3).

In monologue, moderate and average improvement were found in 78.8% (264 persons), and very considerable

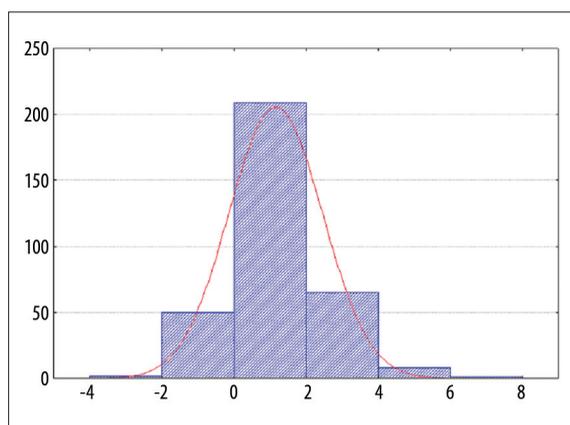


Figure 3. Fluency change after application of the digital speech aid in dialogue. "X" axis represent the logarithm of odds ratios, "Y" axis – number of cases.

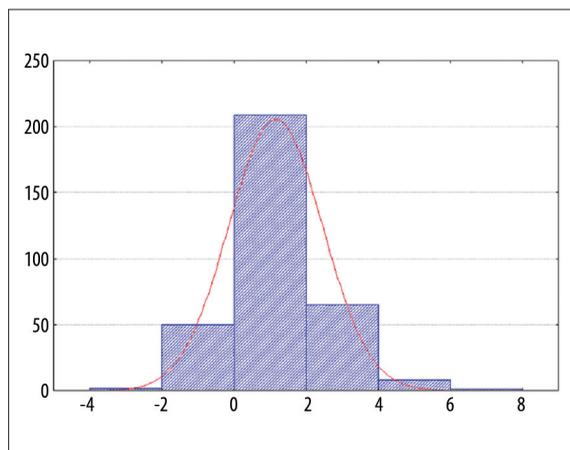


Figure 4. Fluency change after application of the digital speech aid during monologue. "X" axis represent the logarithm of odds ratios, "Y" axis – number of cases.

improvement was found in 2.4% (8 persons). Deterioration or lack of improvement in fluency was found in 18.8% (63 persons) (Figure 4).

Generally, improvement of speech fluency was observed in 82.1% of patients during reading, in 84.5% during dialogue,

and in 82.2% during monologue. In order to find the border value for the measure of the improvement which will not have an incidental character, we established that distribution for placebo is the same as the distribution observed in the study only deprived of the average (effect of the DSA is missing). Additionally, we assumed that distributions are symmetrical, which fits with observation of distributions of logarithms of odds ratios. If the improvement is greater than half of the average value in the examined group, it is more probable that the case belongs to the examined group. Otherwise, it is more probable that the case belongs to the placebo group. The borderline value is half of the average value of the improvement (in this study, half of the average logarithm of the odds ratio). Applying such assumptions, it was determined that the borderline value of the odds ratio during reading was 1.84. While reading, reliable improvement in fluency was obtained in 224 persons, which is 66.9% of the examined group. In dialogue, the borderline value of the odds ratio was 1.78. Reliable improvement was obtained in 223 persons, which is 66.6% of the examined group. While telling a picture story, the borderline value of the odds ratio was 1.64. Reliable improvement was obtained in 214 persons, which is 63.9% of the examined group.

DISCUSSION

Statistical analysis showed that after application of the DSA in all 3 speaking situations, statistically significant improvement was obtained. In the majority of cases, moderate or average improvement was observed. These results seem to be slightly worse than those obtained by other authors [8–11], which may result from the fact that optimal fitting of the DSA in the study was a compromise between speech improvement and patient comfort. Patients, knowing that afterwards they would use the DSA in everyday conditions, chose the settings that did not cause major changes in speech naturalness (i.e., of great DAF value); however, this was often at the cost of the smaller improvement in fluency. Recent studies show that obtaining natural speech may be even more important to the patient than achieving fluent speech at any cost (i.e., unnaturally slowed by DAF of high values) [1,12]. In 15% to 19% of patients no positive effect was observed or the speech fluency deteriorated. This observation is in accordance with those of other authors [1]. Some authors suggest that training with the DSA should be backed-up with other strategies that may increase the

effectiveness of the speech aid, for example, prolongation of vowels during speaking. According to Kalinowski and Saltuklaroglu, prolonging vowels causes additional activation of brain mirror neuronal systems, which in their opinion is responsible for speech fluency improvement under altered auditory feedback [1]. Thus, prolongation of vowels contributes to the effect of AAF.

CONCLUSIONS

The majority of patients had immediate speech fluency improvement after application of the DSA. The obtained results show that the Digital Speech Aid is an effective method for immediate stuttering reduction. Further research on the long-term effect of the DSA is necessary.

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