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Impact of SpeakFluent Device on Speech of Persons with Stuttering

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Abstract

Since decades, fluency has always been a major area of research in the field of speech and hearing. Till date, numerous causes have been put forward to explain the various types of dysfluencies which leads to stuttering. Also, based on these causes various techniques and devices have come into picture to enhance the fluency in the person with stuttering (PWS). On a similar research line, based on the cause of disturbance in auditory-motor processing, DAF (Delayed Auditory Feedback) device has been proposed which works on the principle where auditory feedback is being provided to PWS and that would determine whether the planned (and expected) speech output matches the actual product and generate corrective motor commands if a mismatch is detected (Max, Guenther, Gracco, Ghosh, & Wallace, 2004). The present study has been conducted with the main aim to see the effectiveness of SpeakFluent device having delayed auditory feedback and live visual feedback on PWS. Further, it also aimed to see the speech naturalness and comfort level of the individuals using the device. A total of twenty PWS participated in the study and were categorized into two groups. These two groups were subjected to two different conditions of fluency shaping therapy i.e., using SpeakFluent device and without using the device. The number of dysfluencies and rate of speech obtained were subjected to statistical analyses. The overall results revealed that Speakfluent device has a major impact on PWS in reducing the disfluencies and enhancing the correct rate of speech.

Key words: SpeakFluent Device, Stuttering, Delayed Auditory Feedback, Speech Naturalness, Disfluency, Rate of specch

Introduction

Disfluency has been defined as a part-word, whole word, or phase repetition; a part-word prolongation; an inaudible postural fixation; a starter; or a filler (e.g., "um," "uh," "you know," “like”). According to Guitar (2005), a starter or a filler can be counted as disfluency only if it is determined that the participant used it habitually to postpone the next word or as a means to say the desired word fluently. Also, a syllable could be counted as stuttered only once. For instance, “um, um, um, I want to g-, to g-, to go” would be counted as two disfluencies.

The effect of promoting fluency from choral speech is based on its role in providing an external auditory stimulus that facilitates the activation of the auditory cortex. This second speech signal can be interpreted as additional signal information that promotes fluent speech. Thus, the additional auditory feedback provided by the chorus functions as an exogenous speech motor control, i.e., fluent production takes place through motor recovery, made possible by increased activation of the cortex. With the chorus, the speaker adopts motor control strategies that maximize feedback, which makes monitoring more efficient, resulting in an improvement in fluency.

The increase in Speech like disfluencies for most normally fluent speakers is most likely accounted for by a disturbance in auditory-motor processing. It has been suggested that the primary role of auditory feedback in normally fluent adults is to update and adjust stored speech motor commands in natural speaking conditions. In this view, auditory feedback is incorporated into internal models of speech production that determine whether planned (and expected) speech output matches the actual product and generate corrective motor commands if a mismatch is detected (Max, Guenther, Gracco, Ghosh, & Wallace, 2004). The DAF-induced temporal asynchrony induces a mismatch between expected auditory feedback and the actual feedback. The disfluencies may be unsuccessful attempts to correct for the mismatch or errors induced by the mismatch. The SEs may also result from the same mismatch. There are important theoretical implications in that the DAF-induced disfluencies and errors that impacted segmental production (i.e., SLDs and SEs) were accompanied by altered suprasegmental production (i.e., AR). Unperturbed auditory feedback may therefore be important for implementing accurate segmental motor commands.

Altered auditory feedback (AAF) devices are derived from the choral speech phenomenon and arose as an attempt to simulate the chorus effect. The term AAF refers to all conditions that alter the way in which the speaker hears his/her own speech (auditory return or feedback). This alteration may be called delayed auditory feedback (DAF) when auditory feedback is delayed or frequency altered feedback (FAF) when the speaker hears his/her voice with an altered frequency – (i.e., deeper or sharper).

Alternated auditory feedback is any electronic altering in the speech signal so as the speech signal is perceived different from the normal. It is also known as second speech signal (Guntupalli, Kalinowski, Saltuklaroglu, & Nanjundeswaran, 2005). Speech alterations can be done in form of masking auditory feedback, delayed auditory feedback and frequency altered feedback.

Delayed auditory feedback occurs when the voice signal is delayed typically by 50-100 milliseconds at the ear of the speaker's air conduction. Delayed auditory feedback is the best known form of AAF. It usually arises from the "temporal asynchrony between speech production and its feedback to the auditory system" (Hashimoto & Sakai, 2003). Many studies have been conducted to understand the effect of DAF on stuttering. And it has been proved that DAF is the most powerful method to reduce stuttering (Sparks, Grant, Millay, Walker-Baston, & Hynan, 2002; Van Borsel, Reunes, & Van den Bergh, 2003). There is individual variations also seen (Van Borsel, Reunes, & Van den Bergh, 2003).

The studies on Delayed Auditory feedback done in early 90s employed long delay times, mostly 250 milliseconds which induced slow prolonged speech. Recent research employ shorter delay times i.e. 50 milliseconds which is barely perceived by the listner. Sparks, Grant, Millay, Walker-Baston, & Hynan, 2002 found that speakers can maintain fast rate of speech under these short auditory delay. Kalinowski et al. (1996) found that a delay of 50 ms is the "minimum delay necessary for maximum fluency enhancement".

Many studies have compared the different delays (25ms, 50ms and 75ms). The results reveal that people produce less stuttering moments at the delay of 75ms than 50ms and 25ms. But other studies do suggest that the delay of 50ms is the one at which maximum people get advantage.

Another study (Van Borsel, et al., 2003) compared the effect of Delayed Auditory Feedback as the treatment of stuttering before and after three months of daily use. This was done in clinical environment during prescribed speech tasks. The researchers used CasaFutura School DAF for

131-408 minute per week and with delays of 13- 187ms. The speech was assessed during a range of tasks including oral reading, picture description and conversation. The result showed immediate stuttering reduction using Delayed Auditory Feedback and this reduction in stuttering was maintained after 3 months of continuous use of the device. The authors noticed that the stuttering reduced more in oral reading and picture description than on conversation task on both the occasions.

Stuart, et al. (2004) investigated the impact of the SpeechEasy device on the speech of four adults and four youths who stuttered at initial fitting and at a 4-month follow-up visit. The SpeechEasy® device delivers DAF and FAF simultaneously and was set at a delay of 60 ms and a frequency shift upwards of 500 Hz. Participants were advised to listen to the device and to make "minor alterations to their speech production pattern" such as prolonging vowels and using starters to assist with initiation and continuation of the second speech signal when necessary. Stuart et al. (2004) also investigated the perceived speech naturalness of the eight participants when speaking with and without the device.

Judges rated speech as more natural during device use except for youths during the monologue task, when speech was judged as more natural without the device.

Pollard, et al., 2009 investigated quantitative and qualitative effects of the SpeechEasy device when used under challenging, extraclinical conditions over an extended period of time. The purposes were to help establish Phase I level information about the therapeutic viability of AAF as delivered by the SpeechEasy and to compare these results with previous findings obtained in laboratory and clinical settings. Individual responses were documented and described in order to mark the changes in the overt disfluencies or emotional aspects of stuttering. The authors also introduced the questions addressing areas like overall effectiveness of the device, differential effects across speech tasks, variability in response profiles, and congruity between subjective impressions of the device and objective speech performance. Group analyses indicated that the device was most beneficial while participants read a passage aloud (58% less stuttering), was less so during conversation (15% less stuttering), and performed poorest during the often challenging task of asking a question to a stranger (2% less stuttering). It is important to note, however, that no statistically significant treatment effect was found for any of the three speech tasks used in this study.

In recent years, AAF devices have been increasingly used as a treatment for stuttering. The literature contains a large number of studies on the effects of AAF on the speech of people who stutter. Thus far, major methodological differences between studies preclude a definitive conclusion about the efficacy of such treatments, although most studies agree that AAF devices can decrease the number of stuttering events.

In addition to investigating treatment efficacy in terms of reducing the frequency of speech disfluencies when using AAF devices, it is also necessary to investigate the effect of these devices on speech naturalness. By altering the way sounds are perceived by speakers, device users can modify the structural aspects of speech (such as intensity and fundamental frequency) in an attempt to compensate for this effect, which may generate unnatural speech. There are few studies in the literature that have investigated speech naturalness with the use of different types of AAF devices. Furthermore, these studies have produced contradictory results. It is necessary to take into account that speech naturalness is a difficult characteristic to measure. There are studies using perceptual scales to assess speech naturalness, defining the term "naturalness" as something that is achieved in a habitual and effortless way that is free of artificiality. However, perceptual evaluations often have constraints, particularly regarding data reliability and reproducibility.

Stuart, Kalinowski and Rastatter (1997) compared stuttering reductions during DAF, FAF and NAF when the feedback was delivered monaurally or binaurally. During both DAF and FAF, stuttering was reduced by 60% during monaural presentation and 75% during binaural presentation. No significant differences in stuttering levels were found between monaural presentation of DAF or FAF to the left or right ear. These results suggest that AAF may be more effective in reducing stuttering when delivered binaurally.

The objective of this study was to see the effectiveness in rate of speech for the person with stuttering using the SpeakFluent device and comparing it to the control group with no device. The

SpeakFluent provides auditory feedback with the delay from 0.1s to 1.2s which is accompanied by live visual feedback of rate of speech.

Method

A comparative study was conducted to check the efficacy of the delayed auditory feedback with combination of live visual feedback of speech in PWS. SpeakFluent device (patent details) was used for the therapy.

Participants

Age range of population included was 18-35 years of age (mean age 23.45). The population of males and females, residing in near area, were included in the study. The therapy was planned for 1 month.

The inclusion criterion for the sample:

- The individual has stuttering for more than 6 months.
- There is no family history of stuttering.
- Participants have not attended any fluency shaping or enhancing therapy in past.
- Participants are educated.

Tools

- SpeakFluent device with chargeable batteries.
- Philips headphone (SHM1900)
- Sony CyberShot DSCVX220 for video recording

Within this duration of the study points considered before and after the usage of device were -

- Maintenance of fluency
- Speech naturalness
- Comfort of the person with stuttering using device

All individuals were subjected to speech and hearing assessment, pre- and post-therapy. The speech and hearing assessment consisted of speech and hearing screening and specific assessment of stuttering. Family history, hearing complaints and general health information was collected in the interview. The informal speech and language assessment was carried out to check for the language of the subject. The monologue, conversation and reading sample was recorded in camera (Sony CyberShot DSCVX220) and transcribed for assessment. The same sample was used to estimate the severity of stuttering using the SSI-4 (Riley, 2009). We also assessed the speech rate (syllables per minute) in spontaneous speech recordings. It was used as normality criteria for adult individual values between 219-257 syllable/min in speech rate according to the criterion described in the literature. Participants were divided into two groups (S1 and S2).

Procedure

STEP 1

Individuals in S1 were given fluency shaping therapy, using electronic device SpeakFluent, which gave them delayed auditory feedback and live speech stimulation. The two fluency shaping techniques used were breathing exercise and vocal relaxation exercise.

STEP 2

The Person with stuttering was called for 4 sessions of 30 minutes each. During the session the participant was made to sit comfortably on a chair at 1 meter distance facing the instructor. The device was kept on the table and the participant was asked to wear headphone so as the headband should fully cover the ears. The individual was instructed to read a word and wait for the feedback. After he/she hears the feedback they have to read the next word. If he/she speaks at fast rate of speech the LCD screen of the device would start blinking and the individual needs to stop reading and start again (visual feedback). Delayed auditory feedback introduced in this step was 1.2 seconds using the device. These sessions were divided in 20 minutes reading task and 10 minutes monologue. In reading, individuals were given stories to read in their native language. The last 10 minutes of the session the individuals were asked to talk about the topic of their interest.

The population was asked to attend 4 therapy sessions of 30 minutes each in which the delay was reduced to 0.8 seconds. The therapy was divided into 15 minutes reading task and next 15 minutes monologue.

In this week the individuals' auditory feedback was maintained the same (0.8 seconds) with 15 minutes monologue and 15 minutes conversation task clinically.
As the individual attained 80% fluency the auditory feedback delay was reduced to 0.3 seconds and conversation task was carried out in next 4 sessions.

Other group S2 underwent the same fluency shaping therapy but without the SpeakFluent device. They were also called for same number of sessions and given the same hierarchy of treatment.

The comfort level of the subject was calculated through a five point rating scale, where zero was explained as not at all comfortable and four was explained as very comfortable.

Statistics

For quantitative analysis the mean, median, minimum and maximum values and standard deviation was calculated using SPSS Software version 16.0 for comparing the level of stuttering individuals by grouping them with and without device as pre- and post-therapy. The analysis of variance (ANOVA) with repeated measures ANOVA (parametric test) was used for comparison of groups with and without the device, in the early stages, according atypical dysfluency (%), and information production rate (word/min).

Result & Discussion

The objective of the study was to see the effectiveness of SpeakFluent device having delayed auditory feedback and live visual feedback on the persons with stuttering. It also aimed to see the speech naturalness and comfort level of the individuals using the device.

Table l. depicts the mean percentage of stuttering, standard deviation in percentage of stuttering, mean change in words per minute and its standard deviation obtained before and after therapy. The results of the S1 group (with device) analysis regarding the rate of speech (words per minute) and stuttering percentage revealed a mean increase in 23 words per minute and mean decrease in 9.15% of stuttering. Group S2 results show the mean increase in 10.75 words per minute and mean decrease in 5.75% of stuttering. Thus, there is significant reduction in the level of stuttering in the final assessment when compared to the initial in S1 group, i.e. the group with SpeakFluent device.

Treatment	Level of Stuttering	S1 (%)	S2 (%)	Total (%)
Pre	Mild	2 (10.0)	4 (20.0)	6 (15.0)
	Moderate	8 (40.0)	8 (40.0)	16 (40.0)
	Severe	10 (50.0)	8 (40.0)	18 (45.5)
	Total	20 (100)	20 (100)	40 (100)
Post	Very mild	14 (70.0)	4 (200)	11 (27.5)
	Mild	4 (20.0)	8 (40.0)	14 (35.0)
	Moderate	2 (10.0)	8 (40.0)	10 (25.0)
	Severe	0 (00.0)	0 (00.0)	0 (00.0)
	Total	20 (100)	20 (100)	40(100)

Significant at ($p<0.001$); S1 = stutterers undergoing therapy using SpeakFluent device; S2 = stutterers submitted to the therapy, without the use of SpeakFluent device

Table 1. Level of stuttering and atypical disfluencies, pre- and post-treatment

Treatment	n	Mean	Median	SD
Pre	20	13.45	13	4.46
Post	20	4.30	4	2.83
Pre	20	12.97	11	4.77
Post	20	5.52	6	2.9

($p < 0.001$*)

Table 2. Rates of articulatory speed and the production information, pre- and post- treatment

TPI (word/min)	Groups	n	Mean	Median	SD
Initial	S1	20	106.0	107.5	33.28
	S2	20	117.2	142.0	43.06
	Total	40	111.6	131.5	38.7
Final	S1	20	129	133	19.24
	S2	20	106.45	123	29.73
	Total	40	117.72	126	27.37

*Significant values ($p<0.01$); TVA = rates of articulatory speed; syl/min = syllables per minute; TPI = production information; word/min = words per minute; S1 = stutterers undergoing therapy using SpeakFluent device;

S2 = stutterers submitted to the therapy, without the use of SpeakFluent device

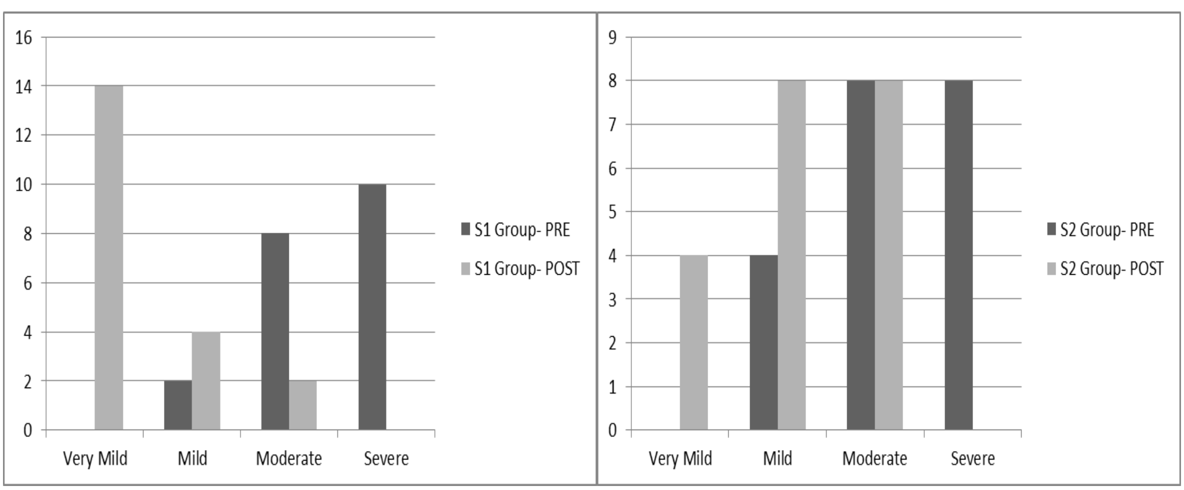
	Groups	n	Mean	Median	SD
Reduction in disfluency (%)	S1	20	9.15	8	3.08
	S2	20	5.75	5	3.09
	Total	40	7.45	7	3.5
Gain in TPI (word/min)	S1	20	23	11.5	24.1
	S2	20	10.75	13.5	15.13
	Total	40	6.12	4	26.39

Table 3. Mean values reduction in a typical disfluency, the gains in speed articulatory rates and production information for S1 and S2

Therapy	n	Mean (SD)	
		Stuttering (%)	Word per minute
Pre	20	13.45 (4.46)	106 (33.28)
Post	20	4.3 (2.83)	129 (19.24)
Pre	20	12.5 (5.05)	117 (43.06)
Post	20	6.75 (2.84)	106 (29.73)

Table 4. The pre and post therapy values of the two groups S1 (with device) and S2 (without device)

Further, Repeated measure ANOVA Test was employed to compare between the the two groups i.e., S1 and S2 and the results revealed that there was significant difference ($p<0.01$) in spontaneous speech task in the clinical condition when compared the percentage of disfluency and words per minute.

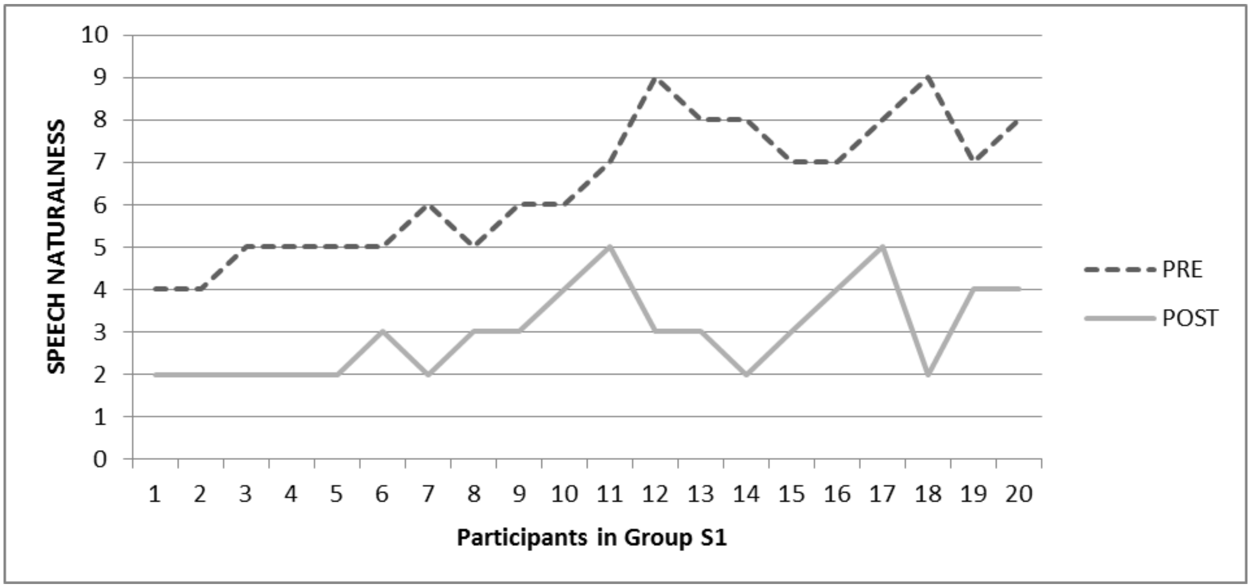


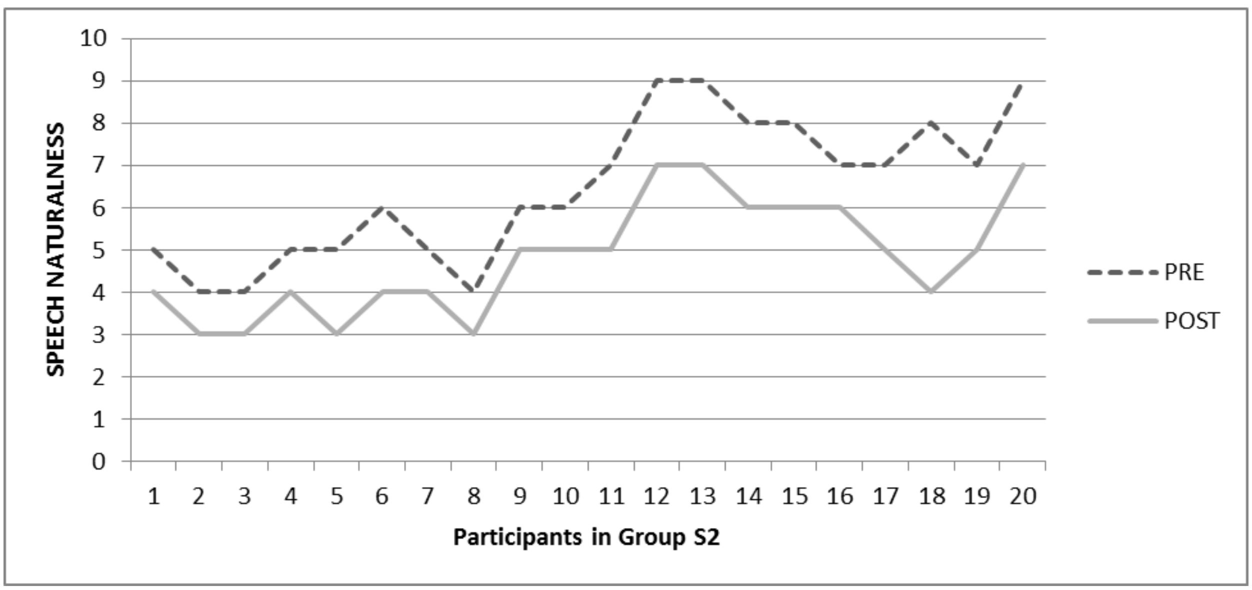
Graph 1- Pre and Post Comparison of stuttering severity in both groups

Graph 1 represents the number of subjects having different severity of stuttering based on SSI-4 in both groups before and after the therapy. Post therapy the number of people shifted to very mild stuttering were reported more in group S1 i.e. the group with device than compared to group S2.

Fluency shaping techniques has brought good results and provided basal fluency (Perkins, 1984). This line of therapy was effective for both S1 and S2 groups. The group using device SpeakFluent (S1) showed a higher tendency of reduction in disfluencies and higher gain in rate of speech (words per minute) as compared to S2. This reveals that both the groups had positive results with the fluency therapies, but the group that used the device obtained greater benefits. This reduction in disfluencies using the device is in agreement with literature as several studies show improved fluency under altering auditory feedback (Armson J. & Kiefte M., 2008; Armson J., Kiefte M., Mason J., De CroosD., 2006, Perkins W.H. 1984). Due to the reduction of disfluency, the decrease in percentage disfluency was observed, especially in S1. In previous studies there is improvement of 17 words per minute (Carasco et al., 2015) whereas, the improvement seen in present study is 23 words per minute. This can be credited to the fact that the person with stuttering gets the live visual feedback of the words spoken by him/her. Therefore, there was significant reduction in the level of stuttering and disfluencies in the post-training evaluation, compared to the pre training assessment of the group using SpeakFluent. The results also found that the more severe the level of stuttering, lower rates of production information that is stutterers have minor speech rates when compared to fluent individuals. They also observed a significant difference in speech rates, taking into account the different levels of severity of stuttering. Individuals with mild and moderate stuttering have similar speech rates, whereas those with severe stuttering, have lower rates.

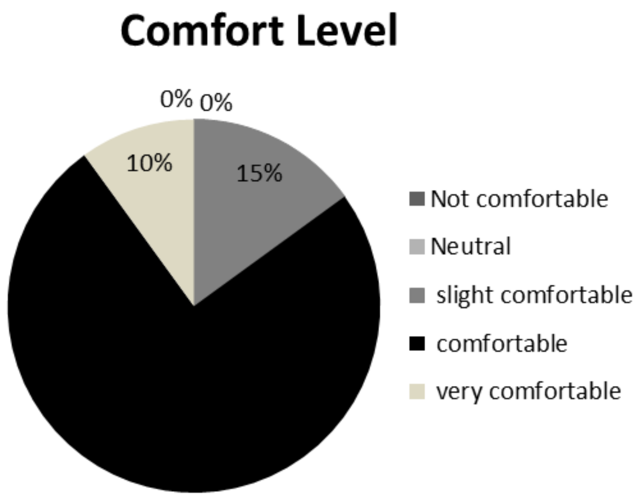
The perception of speech naturalness is in acceptance with the older studies (Stuart et al, 2004; Armson et al, 2008). Graphs 2 and 3 indicate the speech naturalness score of the subjects as depicted by SSI 4 (Riley, 2009). The results reveal that speech naturalness has improved for both groups. Mean speech naturalness ratings improved markedly for Device conditions for conversational task for group S1. Inspection of ratings for individual participants in group S1 revealed that 40% and 30% individuals were given the score of 2 and 3 respectively on speech naturalness rating scale in SSI 4 (Riley, 2009). In group S2 20% individuals scored 3 on the same scale. These findings indicate that speech quality was perceived more positively in group S1.





Graph 2- Speech naturalness at pre and post therapy level of two groups

A subjective analysis was done to check the comfort level of individuals using the device using the 4 point rating scale. The persons with stuttering in group S1 marked on scale where 0 was not comfortable, 1 was neutral, 2 being slight comfortable, 3 comfortable and 4 being very comfortable. In the population of 20, 2 individuals rated using the device as very comfortable. 3 of the subjects rated as slight comfortable and 15 rated comfortable.



Graph 3- Depicting the comfort level (in %) of the participants using the device

Limitation

The small sample of participants included in the study warrants caution against any generalization. Clearly, the findings require replication with a larger sample size. The influence of factors such as socioeconomic status and home language experience are inevitable and were not measured in the current study. Due to time constraints of individuals with stuttering, the transfer of the effect of device could not be seen at home and work environment.

Future Directions

Future studies may investigate the prolonged effect of the device on the person with stuttering at home and work conditions. Other alterations for the device like masking with noise as the input and difference in the presentation monoaurally and binaurally can be also studies.

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