COMPUTERIZED ASSESSMENT OF FLUENCY DISORDERS

Elka Goranova
South-West University "Neofit Rilski", Blagorvgrad, Bulgaria, elkalogo@swu.bg

Abstract. The Fluency Disorder is not among Communication Disorders preferred by speech therapists on a worldwide scale. The diagnostic instruments are subjective, and the exact and objective data are processed slowly and laboriously (St.Louis et al., 2012). It is impossible to assess the effectiveness of the implemented therapy within the Bulgarian conditions. The reasons are complex but the basic one is the lack of automated processing of the data obtained from the diagnosis instruments. After the repeated listening to the audio scripts, the information is written on paper forms and then, the degree of stuttering severity is manually scored. The purpose of this investigation is to suggest computerized processing of one of the most popular instruments for diagnosing the degree of stuttering severity SSI-4 (Scoring of Stuttering Severity-4): from collecting the data to their complete processing. The audio scripts of individuals who stutter are listened to through the software programme for sound processing *Audacity* (free Internet access), that allows to create, edit and delete a "trace" with pieces of texts synchronized with the sound length. The text file with the pieces of text is exported directly in MSExcel with no manual typing a text. The whole data processing to scoring the severity and all logopedic parametres of interest are based in the tables. SSI-4 is the best diagnostic instrument that was compared (filling in and processing data following the instructions in the manual) with the computerized variant mentioned here. The computerized processing offers easy, fast and exact scoring and storing of the data with the aim to solve various research problems and tasks. The computerization of the diagnostic instrument SI-4 allows not only the faster data processing and better scoring of stuttering severity, but it also opens new horizons for more intensive scientific research on stuttering.
Keywords: fluency disorder; stuttering; SSI-4; optimization of stuttering research

1. INTRODUCTION

Understanding the ICF model (International Classification of Functioning, Disability and Health) in terms of speech impairment requires interdisciplinary interpretation and competence WHO, 2001; 2007. ICF applications are a constructive framework for quality, science-based diagnostics in a number of advanced well-developed countries such as the USA, Australia and some of the members of the European Union. In the speech therapy literature Yaruss adapted ICF for the needs of the language and speech pathology as a health specialty (Yaruss, 1999). They suggested that the classification should be adopted and adapted as a constructive framework for reporting the effectiveness of speech therapy in terms of impaired speech fluency. The ICF model describes the ways in which stuttering and cluttering can be interpreted according to the following parameters: 1) presumed etiology; 2) impairment in body functions (observable Stuttering Behaviors); 3) personal factors/reactions - affective, behavioral, cognitive; 4) environmental factors; and 5) activity limitation / participation restriction. The ICF model requires definitely scientific-based assessments and therapy in speech therapies, and the application of the Evidence-Based Practice of effectiveness. According to Bothe (Georgieva, 2010) an Evidence-Based Practice should be used in three aspects: 1) diagnostics and therapy in health specialties, based on evidence available in reference journals; 2) it includes personal and client's experience; and 3) it requires evidence of effectiveness during and after the/certain/a speech therapy. In order to demonstrate the effectiveness of a speech therapy, it is necessary to make a diagnostic evaluation and a comparative analysis of the therapeutic outcomes during and after treatment and to develop evidence-based treatment approaches. Some of these scales deal with the emotional and psychological impacts of stuttering while others deal with the audible and visible features of stuttering (e.g., stuttering like disfluencies and physical behaviors accompanying stuttering). The literature overview of publications from the last two decades shows that the application of different assessment procedures for the assessment of stuttering in one person may cause variations in the stuttering frequency score thus calculated, (Neumann et al., 2017).
The same was shown in three studies published by Rousseau et al. (2008), O'Brian et al. (2015), and Rezai, et al. (2017). PRAAT is a computer program for analyzing, synthesizing, and manipulating speech. It analyzes the speech sample and expresses them as waveforms and spectrograms that are displayed on a screen. PRAAT allows measuring the duration of the speech segments in any length - syllable, word, phrase, sentence, and paragraph (Yaruss, 1999).
The Computerized Scoring of the Stuttering Severity (Version 2; CSSS-2.0) software is provided to facilitate the calculation of frequency and duration. The CSSS-2.0 automatically produces a record of the percentage of syllables

stuttered (frequency) and the duration of the three longest stuttering events (Bakker, 2009). However, CSSS-2 cannot observe the physical concomitants and naturalness of the individual's speech.

True-Talk, Disfluency Frequency Counter, Stuttering Measurement System (SMS), and Stopwatch are also used to calculate the number of stuttered and fluent syllables Speech and language pathologists mostly used a Syllable and Disfluency Counter - free software application to easily count and calculate the number of syllables and disfluencies a person has when they talk (Rezai, 2017; Manning, DiLollo, 2018). SSI-4 is a reliable and valid norm-referenced stuttering assessment that can be used for both clinical and search purposes. It measures stuttering severity in both children and adults in the four areas of speech behavior: (1) frequency, (2) duration, (3) physical concomitants, and (4) naturalness of the individual's speech. Frequency is expressed in a percentage of syllables stuttered and converted to scale scores of 2-18. Duration is timed to the nearest one tenth of a second and converted to scale scores of 2-18. The four types of Physical Concomitants are and converted to scale scores of 0-20. Then the Total co-efficient is obtained (which is equal to the sum of the frequency, duration, and concomitant movements) and is expressed in percentages that determine the degree of stuttering severity - very mild, mild, moderate, severe, very severe (O'Brian, 2015). Research on this issue conducted by Rezai, H, et al. (p: 81-82) shows that "...of the three components required for obtaining an SSI score, %SS was most often chosen as the main variable. This meant that Mean Duration of the Three Longest Stuttering Events (MDTLSE) or Physical Concomitants (PC) was excluded in most stuttering measurement studies. It was also noted that concerns regarding objective scoring, ambiguity of assessment procedures, and finally having the lowest reliability compared with %SS or MDTLSE, have made the PC, as the least studied component of SSI...".

2. PURPOSE
The purpose of this investigation is to suggest computerized processing of one of the most popular instruments for diagnosing the degree of stuttering severity SSI-4 (Scoring of Stuttering Severity-4): from collecting the data to their complete processing.

3. METHOD
The speech of the investigated persons was recorded with a condenser microphone PC308 and Audacity 2.0.6 software, a free access and an open source software for recording and processing of acoustic signals http://audacity.sourceforge.net/. The recordings were made at 16 kHz and mono mode filtered from the background noise of the room recorded just before the start of the investigation. The audio tracks were recorded in files .wav format for further processing. A computerized processing of speech recording followed when each recording was repeatedly listened to and further processed in the Audacity 2.0.6 audio software. Spreadsheets were made in MS Excel that fully compute all SSI-4 parameters after importing the text file with the transcription of the audio record. The audio scripts of individuals who stutter are listened to through the software programme for sound processing Audacity (free Internet access) that allows to create, edit and delete a "trace" with pieces of texts synchronized with the sound length. The text file with the pieces of text is exported directly in MSExcel. The whole data processing to scoring the severity and all logopedic parametres of interest are based in the tables.

4. PARTICIPANTS
A total number of 33 persons were investigated, they were divided into two groups: people who stutter (PWS) and people who do not stutter (PWNS). The total number of the members of PWS is 17 (5 female and 12 male). Their average age is 29.53, and a standard deviation–8,99. The total number of the members of PWNS is 16 (5 female and 11 male). Their average age is 29,63 and a standard deviation–9,68.

5. COMPUTERIZED SPEECH PROCESSING
The investigation took place in a speech pathology study room with no noise. Each recording was listened repeatedly and processed in the Audacity 2.0.6 audio and sound editor program. In the "Tracks" menu, the "Caption Track" command is selected which appears immediately below the audio track with the audio track. The indices of typical and atypical speech-sound repetitions, syllable or word, prolongations, blocks, start and end of the speech task, etc., are entered in the track with inscriptions. After tagging the speech task (start-end) with the mouse in the audio track, the command "New inscription on the selection" from the "Tracks" menu is selected. A cursor appears on the track and "D" "dialogue" or "B" (blocks) or "P" (repetition) or "rest" are accordingly entered as shown in Fig. 1.
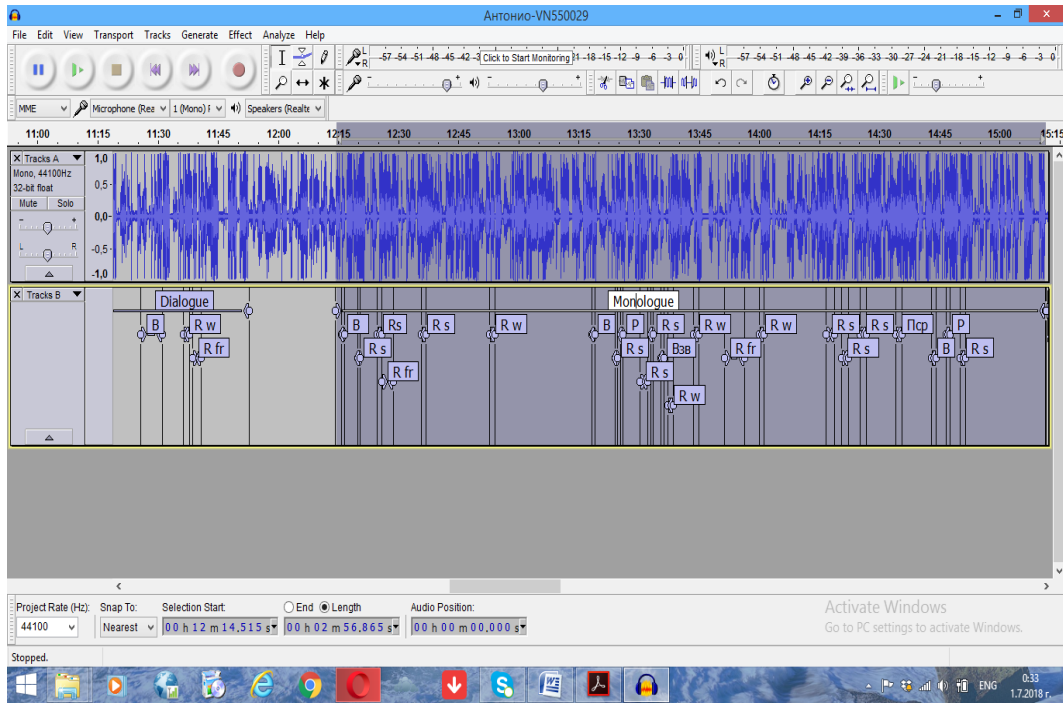
Fig. 1. Processing of the recorded acoustic signal of the speech of the investigated persons with the Audacity 2.0.6 program. A). Audio track with the registered acoustic signal; B). A record track showing all symptoms of impaired speech fluency.

After the complete transcription of all the disfluencies and the necessary data for subsequent speech therapy analyses, the record track is exported to the menu "File", "Exporting records" The program generates a text file * .txt (Figure 2) which is then exported to Excel for a full automated logopedic analysis.
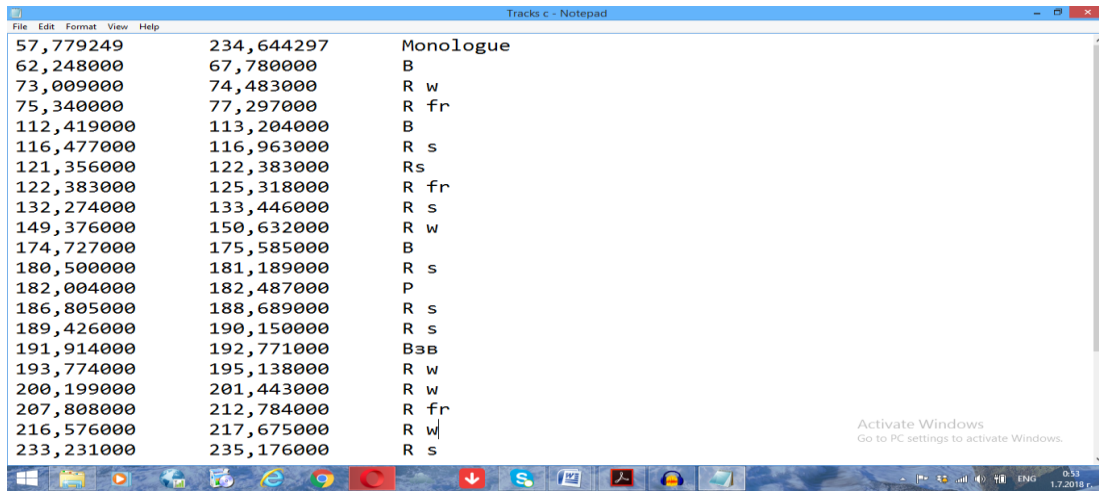
Fig. 2. Text file with full transcription of the audio track generated by the Audacity 2.0.6 program. Start Transcription Event (in sec); End of an event with transcription. Transcription of an event - speech task, typical or atypical anomalies - blocking, repetition, etc

Automated Speech Therapy Analysis of the Transcription of the Spreadsheet Audio Recordings
MSExcel spreadsheets were made to fully compute all the parameters of the diagnostic tools used in the study - SSI-4 after importing the transcription text file. They were grouped separately for each person under investigation and then for all the persons from the control and experimental groups. The summarized results for both groups were evaluated using different statistical criteria (Fig. 3).

Fig 3. Spreadsheets in MSExcel, which automatically calculate four areas of speech behavior: (1) frequency, (2) duration, (3) physical concomitants, and (4) naturalness of the individual's speech.

The time for completing and calculating the data according to the instructions provided in its user manual was compared to our computerized version.

6. CONCLUSION

SSI-4 is the best diagnostic instrument that was compared (filling in and processing data following the instructions in the manual) with the computerized variant mentioned here. The computerized processing offers easy, fast and exact scoring and storing of the data with the aim to solve various research problems and tasks. The computerization of the diagnostic instrument SSI-4 allows not only the faster data processing and better scoring of stuttering severity, but it also opens new horizons for more intensive scientific research on stuttering.

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