Original Article
Artigo Original

Research about suppression effect and auditory processing in individuals who stutter

Pesquisa do efeito de supressão e do processamento auditivo em indivíduos que gaguejam

Cláudia Fassin Arcuri[1]
Ana Maria Schiefer[1]
Marisa Frasson de Azevedo[1]

Keywords

Stuttering
Hearing
Otoacoustic Emissions
Auditory-perceptual Disorders
Hearing Tests

ABSTRACT

Purpose: To verify the auditory processing abilities and occurrence of the suppression effect of Otoacoustic Emissions (OAE) in individuals who stutter. **Methods:** The study sample comprised 15 adult individuals who stutter, aged 18-40 years, with stuttering severity ranging from mild to severe, paired according to gender, age, and schooling with individuals without speech complaint or disorder. All participants underwent conventional clinical evaluation, specific stuttering assessment, and basic (audiometry, imitanciometry, and measurement of acoustic reflexes) and specific (auditory processing evaluation and measurement of suppression effect of OAEs) audiological assessments. Data were statistically analyzed with application of the Fisher's Exact Test and the Mann-Whitney Test. **Results:** The group of individuals who stutter (Study Group – SG) presented higher incidence of auditory processing disorders. The auditory processing assessments used to differentiate the groups of stutterers and non-stutterers (Control Group – CG) were the Nonverbal Dichotic Test and the Frequency Pattern Test. The SG presented higher incidence of absence of suppression effect of OAEs, indicating abnormal functioning of the efferent medial olivocochlear system. **Conclusion:** The auditory processing abilities investigated in this study differentiate individuals who stutter from non-stutterers, with greater changes in the first. Functioning of the efferent medial olivocochlear system showed a deficit in stutterers, indicating difficulties in auditory discrimination, especially in the presence of noise.

Descritores

Gagueira
Audição
Emissões Otoacústicas Espontâneas
Transtornos da Percepção Auditiva
Testes Auditivos

RESUMO

Objetivo: Verificar as habilidades do processamento auditivo e a ocorrência do efeito de supressão das emissões otoacústicas em indivíduos com gagueira. **Método:** Participaram 15 adultos com gagueira, de 18 a 40 anos, com grau de severidade variando de leve a severo, pareados por gênero, faixa etária e escolaridade com indivíduos sem queixa ou alteração de comunicação. Todos passaram por avaliação fonoaudiológica convencional, avaliação específica da gagueira, avaliação audiológica básica (audiometria, imitanciomentria e pesquisa dos reflexos acústicos) e específica (avaliação do processamento auditivo e pesquisa do efeito de supressão das emissões otoacústicas). Os dados foram submetidos à análise estatística, com aplicação do Teste Exato de Fisher e do Teste de Mann-Whitney. **Resultados:** O grupo de gagos apresentou maior ocorrência de alterações de processamento auditivo. Os testes do processamento auditivo que diferenciaram os grupos de gagos e não gagos foram o Teste Dicótico não Verbal e o Teste Padrão de Frequência. O grupo de gagos apresentou maior ocorrência de ausência do efeito de supressão das emissões otoacústicas, indicando anormalidade do funcionamento do sistema eferente olivococlear medial. **Conclusão:** As habilidades do processamento auditivo investigadas neste estudo diferem indivíduos gagos e não gagos, com maior alteração nos gagos. O funcionamento do sistema eferente olivococlear medial mostrou-se deficitário nos indivíduos gagos, indicando dificuldade de discriminação auditiva, principalmente na presença de ruído.

Correspondence address:
Cláudia Fassin Arcuri
Rua Botucatu, 802, Vila Clementino,
São Paulo (SP), Brazil, CEP: 04023-900.
E-mail: clauarcuri@gmail.com

Received: November 19, 2016

Accepted: January 25, 2017

Study carried out at Programa de Pós-graduação em Distúrbios da Comunicação Humana, Universidade Federal de São Paulo – UNIFESP - São Paulo (SP), Brazil.

[1] Universidade Federal de São Paulo – UNIFESP - São Paulo (SP), Brazil.

Financial support: *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES), Institucional Quota.
Conflict of interests: nothing to declare.

INTRODUCTION

Stuttering is described as the involuntary disruption of continuous speech production. It is directly associated with desynchronized neuropsycholinguistic processes that do not allow the speaker to avoid interruptions in the continuous flow of speech[1,2]. Stuttering is a complex disorder that can be easily recognized as an impairment of motor nature due to its characteristic disruptions. However, aiming at a better understanding of the framework of this disorder, the numerous models currently seeking to explain stuttering consider atypical neurophysiology, genetic and environmental factors, learning abilities, auditory processing, and speech and language production skills[1,3].

Some studies have investigated the sensory abilities of individuals who stutter focusing on aspects related to sight, touch, movement, and hearing, indicating how these mechanisms contribute and act in conjunction with the motor mechanism to achieve adequate speech production[2].

Due to studies that have verified improvement in stuttered speech during auditory feedback modifications in some individuals who stutter, auditory skills have become the subject of increasingly complex investigations. Studies have investigated auditory complaints, the action of middle ear muscles, and the functioning of the central auditory system, also using imaging tests[4,5], aiming to associate hearing development with dysfluent speech[6].

Some studies have demonstrated the relationship between auditory information processing and stuttering[3,6]. However, no studies have been conducted on the suppression effect of otoacoustic emissions on stuttering individuals.

Research on the suppression effect of otoacoustic emissions provides information on the functioning of the efferent medial olivocochlear system, which is associated with auditory processing and tasks of auditory discrimination, high frequency selectivity, and speech intelligibility, especially in noisy environments[7-9]. Absence of suppression has been observed in individuals with learning disabilities and language disorder, as well as in patients with speech discrimination impairment in noisy environments, but no studies investigating it in stuttering have been found.

The understanding of these auditory mechanisms could assist with better adaptation of the mechanisms of auditory feedback modification in individuals who stutter.

Based on these assumptions, the objective of the present study was to verify the auditory processing abilities and occurrence of the suppression effect of otoacoustic emissions in individuals who stutter.

METHODS

This transversal, observational, analytical study with comparison between groups was approved by the Research Ethics Committee of the aforementioned Institution under protocol no. 0604/09. All participants signed an Informed Consent Form (ICF) prior to study commencement. Data collection occurred at the Speech-language Pathology and Audiology Assessment and Diagnostics Outpatient Clinics of a public hospital located in the municipality of Sao Paulo between 2009 and 2011.

The study sample was composed of 30 adult individuals equally divided into two groups: Study Group (SG) and Control Group (CG). The SG comprised 15 individuals who stutter, of both genders, aged 18 to 40 years. The following inclusion criteria were applied to compose the study sample: pure-tone audiometry within the normality patterns and type A tympanometry curve; complaint about stuttering with manifestation onset during childhood and condition persistence; a minimum of 3% of atypical dysfluencies in the samples of spontaneous speech and reading; and minimum score of 18 points in the Stuttering Severity Instrument-3 (SSI-3)[10]. Fifteen individuals were selected in the community to composed the CG and were paired according to age, gender, and schooling with those of the SG; they should present no complaint and/or communication disorders, pure-tone audiometry within normality patterns and type A tympanometry curve, and a minimum of 2% of atypical dysfluencies in the samples of spontaneous speech and reading.

All individuals in the SG and CG underwent conventional speech-language pathology evaluation (anamnesis and communication assessment), specific fluency assessment, and basic and specific audiological assessments.

Specific speech fluency assessment was performed through the mapping of typical (hesitation, interjection, revision, repetition of words, phrase repetition, and unfinished words) and atypical (repetition of the same word three or more times, syllable repetition, sound repetition, prolongation, intrusion, and block) dysfluencies[10,11]. To this end, recordings of spontaneous speech and reading were performed in an acoustically treated room using a Sony® manufactured digital camcorder connected to a headset microphone. Subsequently, 200 fluent syllables of the speech samples were canonically transcribed and the dysfluencies were mapped into typical and atypical according to the criteria described in the specific scientific literature[10,11]. The diagnostic criterion for stuttering considered the presence of at least 3% of atypical dysfluencies. The degree of severity of stuttering was estimated by the Stuttering Severity Instrument-3 (SSI-3) protocol[10]. A minimum score of 18 points was adopted with the intention to exclude mild degree stuttering.

Pure-tone audiometry was conducted using an MA-41 audiometer in acoustic booth with search for 250 to 8000 Hz thresholds. Acoustic immittance measures included tympanometry with a 226 Hz probe tone and contralateral and ipsilateral acoustic reflex thresholds at frequencies of 500, 1000, 2000 and 4000 Hz, using an AZ-7 immittanciometer.

In the Auditory Processing assessment, behavioral tests were conducted in acoustic booth using a two-channel clinical audiometer connected to a CD player; these tests evaluated the performance of individuals in the solution of a task of difficult listening. Tests involving different auditory processes were used, both with verbal and non-verbal stimuli. The following tests were selected: Speech-in-noise (SIN) Test, Nonverbal Dichotic Test, Alternate Dissyllable Dichotic Test (Staggered Spondaic Word - SSW), Duration Pattern Test; Synthetic Sentence Identification (SSI) tests under the conditions of competitive contralateral message (SSI-CCM) and ipsilateral competitive message (SSI-ICM), Frequency Pattern Test, and Random Gap Detection Test (RGDT).

The search for Transient-evoked Otoacoustic Emissions (TEOAE) was conducted in acoustic booth using the ILO96-Otodynamics analyzer. The search used non-linear clicks with regular pulses of 80 milliseconds (ms) of duration, with rarefied polarity, presented in a series of 260 cycles per second, within a 20 ms window. Emission spectrum of the standard stimulus contained energy distributed between 0.5 and 5 kHz. Presence of response was considered for occurrence of emissions higher than 3 dB of noise in the frequency bands of 1000 to 4000 Hz[12], with response reproducibility and probe stability >70%.

Regarding the suppression effect of otoacoustic emissions, the technique used followed the same aforementioned procedures; however, TEOAEs were performed in threefold: two with no noise with a 30 second-interval between procedures and one with contralateral broadband noise at 60 dBNPS. Stimulation was conducted using clicks at 75 dBpeNPS and the noise was emitted through a TDH-39P headset of an MA-18 audiometer.

In order not to alter the placement of the probe between procedures, the handset and the probe were previously positioned, without modification throughout the examination. The analysis was performed in both ears, with the test starting in the right ear for half of the participants and in the left ear for the other half.

Recording of the TEOAEs, with determination of the amplitudes of responses, was performed at three moments: at time 1 (T1), the responses, named Responses 1 (R1), were obtained in the absence of contralateral noise; 15 seconds after the end of R1 assessment, that is, at time 2 (T2), the Responses 2 (R2) were recorded under the same conditions previously described; 15 seconds after the end of R2 assessment, that is, at time 3 (T3), the Responses 3 (R3) were obtained in the presence of suppression noise (Figure 1).

Occurrence and amplitude of suppression effect were verified comparing the variation of the general response values in each ear, in the presence and absence of suppression noise, according to international recommendation[13].

To this end, the following calculation was performed: difference between the R1 and R2 values (D1) and difference between the R1 and R3 values (D2) (Figure 2).

Therefore, attenuation of the overall response amplitude of the TEOAEs by the suppression noise, the so-called suppression effect, was considered present when D2 > D1. A minimum variation of 0.5 dB NPS in the overall response should also occur for the suppression effect be considered present. In this case, it was considered that the efferent medial olivocochlear auditory system would be functioning.

T1 <	15s	>T2<	15s	>T3
R1			R2	R3

Figure 1. Sequence of Recordings of Otoacoustic Emissions (OAE)

R1 – R2 = Difference 1 (D1)

R1 – R3 = Difference 2 (D2)

Figure 2. Calculation of the variation of general response values

For the inferential statistical analysis of the sample data, the nature of the variables (qualitative/quantitative) and their subtypes, e.g., continuous, ordinal, and discrete, were verified. The discrete variables were considered continuous due to their approximation to normality. In the case of the continuous quantitative variables, normality (Kolmogorov-Smirnov test) and homogeneity (Levèné test) of variance were explored aiming to verify the assumptions for the use of parametric or non-parametric testing for the difference of means between the groups of individuals who stutter and non-stutters; when both characteristics of the variables were preserved (normality and homogeneity), the Student's *t*-test was applied, whereas when at least one of those characteristics was violated, the Mann-Whitney test was used. The Chi-square test and, when necessary, the Fisher's exact test, were applied to verify the association between two dichotomous variables. A significance level of 5% (p<0.05) was adopted for all statistical analyses.

RESULTS

Table 1 shows the results of the Auditory Processing assessment comparing the study and control groups. No difference was observed between the Study (SG) and Control (CG) Groups regarding their performance in the verbal tests, as presented in Table 2.

With respect to the non-verbal tests, statistically significant difference was found between the groups (Table 3) especially for the Nonverbal Dichotic Test (p=0.04) and the Frequency Pattern Test (p=0.05), with worse performance in the SG. No statistically significant differences were observed between the groups in the other tests: Random Gap Detection Test (RGDT) and Duration Pattern Test (p>0.999).

The occurrence of suppression effect of otoacoustic emissions in both groups is presented in Table 4.

Table 1. Incidence of auditory processing disorder in the study and control groups

Group	AP		Total	Fisher's Exact Test
	Altered	Normal		
Study Group	14	1	15	<0. 001*
Control Group	3	12	15	
Total	17	13	30	

*p value ≤ 0.05; Odds-ratio=60.667 with 95% confidence interval from 5.582 to 659.310
Caption: AP = auditory processing

Table 2. Comparison between groups on performance in verbal tests

Group	Verbal Tests		Total	Fisher's Exact Test
	Normal	Altered		
Study Group	9	6	15	0.80
Control Group	14	1	15	

Table 3. Comparison between groups on performance in non-verbal tests

Group	Non-verbal Tests		Total	Fisher's exact Test
	Normal	Altered		
Study Group	2	13	15	<0.001*
Control Group	13	2	15	

*p value ≤ 0.05

Table 4. Occurrence of suppression effect of otoacoustic emissions in the study and control groups

Group	Suppression Effect		Total	Fisher's Exact Test
	Absent	Present		
Study Group	8	7	15	0.014*
Control Group	1	14	15	
Total	9	21	30	

*p vale≤0.05; Odds-ratio=16.00 with 95% confidence interval from 1.656 to 154.601

DISCUSSION

The findings of the present study indicated higher incidence of auditory processing disorders in the group of individuals who stutter. These alterations are characterized as a differential in the comparison between individuals who stutter and non-stutters, and the chance of adult individuals who stutter present this disorder is approximately 60.7 times that of non-stutters. This result was expected, considering that national and international studies have reported auditory processing difficulties in children and adults who stutter[3,13-16].

Such changes in auditory processing result in decreased ability to produce auditory perception patterns in individuals who stutter. Temporal inaccuracy in speech perception may lead to moments of dysfluency, and decreased processing skills may be related to the inability to maintain fluent speech[14,17].

Disabilities of auditory nature are manifested in a variety of ways. Some studies have shown evidence of decreased activity in the left auditory cortex prior to speech-language therapy and normal or improved activity levels immediately after therapy[3].

Other studies have indicated neuroanatomical differences between individuals who stutter and non-stutterers[18,19]. Some other studies have demonstrated decreased auditory cortex activation and hyperactivation of the motor regions[5]. Greater left hemisphere activity and differences in wave amplitude have also been observed in P300 analyses after therapeutic interventions[20]. These analyses are directly related to the areas activated during auditory and speech processing and provide evidence of anomalous brain functioning not only during speech production, but also during reception. Differences in brain responses directly associated with the processing of auditory information are observed either during auditory tasks or during speech[3,14,17,21].

Statistically significant differences were observed between the Study (SG) and Control (CG) groups in the tests that use non-verbal stimuli (p<0.001). In addition, comparative inferential analysis of the performance of the SG and CG in relation to each of the auditory processing tests verified that, in the present study, only the Non-verbal Dichotic Test and the Frequency Pattern Test presented statistically significant differences, with inferior performance of the SG.

Both the Frequency Pattern Test and the Non-verbal Dichotic Test are related to the so-called suprasegmental aspects of speech, in which prosody and speech rhythm are involved (non-verbal aspects). The changes found in these types of tests can be attributed to the difficulty in acquiring or storing pieces of information that occur over time, which may interfere with the tonicity aspects of the language, as well as affect the speech of individuals. A study demonstrated that prosodic processing is one of the fundamental elements to understand stuttering, with regard to its rhythmic impairment characteristic[11].

A survey conducted with children who stutter[14] verified lower performance in the Frequency Pattern Test, a result similar to that obtained in this study with adults.

Temporal processing is directly related to speech perception; therefore, it is important to apply this type of test to individuals who stutter.

Some studies have associated the occurrence of difficulties in auditory information processing with absence of the suppression effect[9,22-24]. Because of this, and based on the extensive discussion on the occurrence of auditory processing disorders in individuals who stutter found in the literature, suppression effect was investigated comparing the individuals in the study and control groups (Table 4). Inferential statistical analysis performed using the Fisher's exact test verified lower occurrence of the suppression effect in individuals who stutter (46.6%). It was also possible to observe that the chance of an individual in the SG not exhibit suppression effect is 16 times that of an individual in the CG not exhibit the same effect.

Therefore, it can be stated that the Efferent Medial Olivocochlear System of the studied individuals who stutter presented hearing physiological inadequacy owing to absence of the suppression effect, which results in reduction of the inhibitory effect of the efferent system.

No reports on suppression effect in individuals who stutter have been described in the literature. However, it is known that the suppression effect is one of the ways to analyze the Efferent Medial Olivocochlear System, whose role in auditory performance has not yet been fully defined, but some functions have already been clearly attributed to it, such as location of the sound source, improved sensitivity, auditory attention, protection, and improved detection of acoustic signals in the presence of noise[9,23-25].

Higher occurrence of processing disorders and suppression of emissions was observed in the investigated individuals who stutter. Based on these findings, further research is needed to better understand the correlation between auditory and stuttering disorders in order to establish a clearer relationship between them and, consequently, provide a better indication of systems of auditory feedback modification as a therapeutic resource - a theme that has been frequently addressed by studies in this area[26-30].

CONCLUSION

In conclusion, the auditory aspects of individuals who stutter are different from those of non-stutterers, with deficient functioning of the efferent medial olivocochlear system and greater incidence of auditory processing alterations.

ACKNOWLEDGEMENTS

The authors are grateful to CAPES for the financial support and to the *Departamento de Fonoaudiologia* of UNIFESP.

REFERENCES

1. Yairi E, Seery CH. Stuttering foundations and clinical applications. 2nd ed. Boston: Pearson; 2015.
2. Guitar B. Stuttering: an integrated approach to its nature and treatment. 4th ed. Baltimore: Lippincott Williams Eilkins; 2013.
3. Hampton A, Weber-Fox C. Non-linguistic auditory processing in stuttering: evidence from behavior and event-related brain potentials. J Fluency Disord. 2008;33(4):253-73. PMid:19328979. http://dx.doi.org/10.1016/j.jfludis.2008.08.001.
4. Jansson-Verkasalo E, Eggers K, Järvenpää A, Suominen K, Van den Bergh B, De Nil L, et al. Atypical central auditory speech-sound discrimination in children who stutter as indexed by the mismatch negativity. J Fluency Disord. 2014;41:1-11. PMid:25066139. http://dx.doi.org/10.1016/j.jfludis.2014.07.001.
5. Chang S, Zhu DC. Neural network connectivity differences in children who stutter. Brain. 2013;136(12):3709-26. PMid:24131593. http://dx.doi.org/10.1093/brain/awt275.
6. Andrade AN, Gil D, Schiefer AM, Pereira LD. Avaliação comportamental do processamento auditivo em indivíduos gagos. Pró-Fono. 2008;20(1):43-8. PMid:18408863. http://dx.doi.org/10.1590/S0104-56872008000100008.
7. Sahley TL, Nodar RH, Musiek FE. Efferent auditory system: structure and function. London: Singular Publishing Group; 1997. p. 228.
8. Guinan JJ Jr. Cochlear mechanics, otoacoustic emissions, and medial olivocochlear efferents: twenty years of advances and controversies along with areas ripe for New Work. In: Popper AN, Fay RR, editors. Perspectives on auditory research. New York: Springer; 2014. p. 229-246.
9. Henin S. Using otoacoustic emissions to evaluate efferent auditory function in humans [dissertation]. New York: University of New York, 2014. 135 p.
10. Riley GD. Stuttering severity instrument for children and adults-SI. Austin: Pro Ed; 1994.
11. Andrade CRF. A gagueira do desenvolvimento. In: Andrade CRF. Gagueira infantil – risco, diagnóstico e programas terapêuticos. Carapicuíba: Pró-Fono; 2006. p. 5-10.
12. Finitzo T, Albright K, O'Neal J. The newborn with hearing loss: detection in the nursery. Pediatrics. 1998;102(6):1452-60. PMid:9832584. http://dx.doi.org/10.1542/peds.102.6.1452.
13. Hill JC, Prasher DK, Luxon LM. Evidence for efferent effects on auditory afferent activity, and their functional relevance. Clin Otolaryngol Allied Sci. 1997;22(5):394-402. PMid:9372248. http://dx.doi.org/10.1046/j.1365-2273.1997.00078.x.
14. Silva R, Oliveira CMC, Cardoso ACV. Aplicação dos testes de padrão temporal em crianças com gagueira desenvolvimental persistente. Rev CEFAC. 2011;13(5):902-8. http://dx.doi.org/10.1590/S1516-18462011005000045.
15. Cai S, Beal DS, Ghosh SS, Tiede MK, Guenther FH, Perkell JS. Weak responses to auditory feedback perturbation during articulation in persons who stutter: evidence for abnormal auditory-motor transformation. PLoS One. 2012;7(7):e41830. PMid:22911857. http://dx.doi.org/10.1371/journal.pone.0041830.
16. Roob MP, Lynn WL, O'Beirne GA. An exploration of dichotic listening among adults who stutter. Clin Linguist Phon. 2013;27(9):681-93. PMid:23806131. http://dx.doi.org/10.3109/02699206.2013.791881.
17. Neef NE, Sommer M, Neef A, Paulus W, von Gudenberg AW, Jung K, et al. Reduced speech perceptual acuity for stop consonants in individuals who stutter. J Speech Lang Hear Res. 2012;55(1):276-89. PMid:22337496. http://dx.doi.org/10.1044/1092-4388(2011/10-0224).
18. Chang S, Horwitz B, Ostuni J, Reynolds R, Ludlow CL. Evidence of left inferior frontal-premotor structural and functional connectivity deficits in adults who stutter. Cereb Cortex. 2011;21(11):2507-18. PMid:21471556. http://dx.doi.org/10.1093/cercor/bhr028.
19. Choo AL, Kraft SJ, Olivero W, Ambrose NG, Sharma H, Chang SE, et al. Corpus callosum differences associated with persistent stuttering in adults. J Commun Disord. 2011;44(19):470-7. PMid:21513943. http://dx.doi.org/10.1016/j.jcomdis.2011.03.001.
20. Sassi FC, Matas CG, Mendonca LI, Andrade CR. Stuttering treatment control using P300 event-related potentials. J Fluency Disord. 2011;36(2):130-8. PMid:21664531. http://dx.doi.org/10.1016/j.jfludis.2011.04.006.
21. Beal DS, Quraan MA, Cheyne DO, Taylor MJ, Gracco VL, De Nil LF. Speech-induced suppression of evoked auditory fields in children who stutter. Neuroimage. 2011;54(4):2994-3003. PMid:21095231. http://dx.doi.org/10.1016/j.neuroimage.2010.11.026.
22. Yalçinkaya F, Yilmaz ST, Muluk NB. Transient evoked otoacoustic emissions and contralateral suppressions in children with auditory listening problems. Auris Nasus Larynx. 2010;37(1):47-54. PMid:19411150. http://dx.doi.org/10.1016/j.anl.2009.02.010.
23. Markevych V, Asbjørnsen AE, Lind O, Plante E, Cone B. Dichotic listening and otoacoustic emissions: Shared variance between cochlear function and dichotic listening performance in adults with normal hearing. Brain Cogn. 2011;76(2):332-9. PMid:21474228. http://dx.doi.org/10.1016/j.bandc.2011.02.004.
24. Rostami S, Pourbakht A, Kamali M, Jalaee B. The effects of auditory selective attention on contralateral suppression of stimulus-frequency otoacoustic emissions. Audiology. 2011;20(2):63-71.
25. Butler BE, Purcell DW, Allen P. Contralateral inhibition of distortion product otoacoustic emissions in children with auditory processing disorders. Int J Audiol. 2011;50(8):530-9. PMid:21751943. http://dx.doi.org/10.3109/14992027.2011.582167.
26. Carrasco ER, Schiefer AM, Azevedo MF. O efeito do feedback auditivo atrasado na gagueira. Audiol Communic Res. 2015;20(2):116-22.
27. Unger JP, Glück CW, Cholewa J. Immediate effects of AAF devices on the characteristics of stuttering: a clinical analysis. J Fluency Disord. 2012;37(2):122-34. PMid:22531287. http://dx.doi.org/10.1016/j.jfludis.2012.02.001.
28. Andrade CRF, Juste FS. Análise sistemática da efetividade do uso da alteração do feedback auditivo para a redução da gagueira. J Soc Bras Fonoaudiol. 2011;23(2):187-91. PMid:21829937. http://dx.doi.org/10.1590/S2179-64912011000200018.
29. Gallop RF, Runyan CM. Long-term effectiveness of the SpeechEasy fluency enhancement device. J Fluency Disord. 2012;37(4):334-43. PMid:23218216. http://dx.doi.org/10.1016/j.jfludis.2012.07.001.
30. Chon H, Kraft SJ, Zhang J, Loucks T, Ambrose NG. Individual variability in delayed auditory feedback effects on speech fluency and rate in normally fluent adults. J Speech Lang Hear Res. 2013;56(2):489-504. PMid:22992711. http://dx.doi.org/10.1044/1092-4388(2012/11-0303).

Author contributions

CFA was responsible for the study design and data collection; AMS was the study co-adviser, in charge of the Speech-language Pathology Assessment Outpatient Clinic of Hospital São Paulo - place of data collection; MFA was the study adviser.