Self-monitoring of speech of adults who stutter

Automonitoramento da fala de adultos que gaguejam

Auto monitoreo del habla de los adultos que tartamudean

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Abstract

Introduction: Frequently, the natural flow of speech is interrupted by pauses, hesitations and revisions. These elements, usually considered common dysfluencies are evidence of an internal system of self-monitoring that repairs the speech in real time to ensure their intelligibility. The strategies used by fluent speakers to revise his speech are similar to the characteristics that define stuttering. However, few studies were conducted in order to investigate the self-monitoring of speech of people who stutter. **Objective:** To compare the self-monitoring of speech of adults who stutter and adults who do not stutter. **Material and method:** This is case-control study that included 35 adults who stutter, compared to 35 adults who do not stutter. All participants performed an oral reading task of a Brazilian Portuguese text. The task was recorded, transcribed and the examination of samples allowed the identification of errors, its repairs and their classification. The data were submitted to descriptive and analytical statistics. **Results:** Adults who do and do not stutter show no significant differences regarding the number of explicit errors, in oral reading task ($p = 0.74$). Significant differences were observed between the groups with regard to attempts to repair these errors, either explicit ($p = 0.04$) and covert ($p = 0.002$). **Conclusion:** Adults who do and do not stutter share a common system of self-monitoring of speech. However, adults who stutter proved more sensitive to errors and made anexcessive number of repairs, suggesting failures in adaptation and phonological planning.

Keywords: speech; stuttering; perception.

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Resumo

Introdução*: Com frequência, o fluxo natural da fala é interrompido por pausas, hesitações e revisões. Esses elementos, normalmente denominados disfluências comuns, são indícios de um sistema interno de automonitoramento que corrige o discurso em tempo real para garantir sua inteligibilidade. As estratégias usadas por falantes fluentes para revisar seu discurso são semelhantes às características que definem a gagueira, entretanto poucos estudos foram conduzidos a fim investigar o automonitoramento da fala de pessoas que gaguejam.* ***Objetivo:*** *Comparar o automonitoramento da fala de adultos que gaguejam com o desempenho de adultos fluentes.* ***Material e método:*** *Trata-se de um estudo caso-controle que contou com 35 adultos que gaguejam comparados a 35 adultos fluentes. Todos os participantesrealizaram a leitura oral de um texto padronizado para o português brasileiro. A tarefa foi gravada, transcrita literalmente e o exame das amostras possibilitou a identificação dos erros, seus reparos e sua classificação. Os dados foram submetidos à estatística descritiva e analítica.* ***Resultados****: Adultos que gaguejam e adultos fluentes não apresentaram diferenças significativas quanto ao número de erros explícitos, em tarefa de leitura oral (p=0,74). Foram observadas diferenças significativas entre os grupos no que diz respeito às tentativas de reparar esses erros, tanto explícitos (p=0,04) quanto encobertos (p=0,002).* ***Conclusão****: Adultos que gaguejam e adultos fluentes evidenciam a existência de um sistema comum de automonitoramento da fala. No entanto, adultos que gaguejam mostraram-se mais sensíveis aos erros e realizaram um número excessivo de correções, sugerindo falhas de adaptação e planejamento fonológico.*

Palavras-chave:*fala; gagueira; percepção*

Resumen

Introducción: *Con frecuencia, el flujo natural del discurso es interrumpido por pausas, vacilaciones y revisiones de segmentos. Estos elementos, generalmente llamados disfluencias comunes, indican un sistema interno de auto monitoreo que corrige el habla en tiempo real para asegurar su inteligibilidad. El tartamudeo es definido como un trastorno de la fluidez del habla y caracterizado por la presencia de pausas, bloqueos, repeticiones de sonidos o silabas y prolongamientos. Esta definición indica que las estrategias utilizadas por los hablantes fluyentes a fin de revisar su discurso son similares a las características que definen la tartamudez. Sin embargo, se han realizado pocos estudios para averiguar el auto monitoreo del habla de las personas que tartamudean.* ***Objetivo:*** *Investigar el auto monitoreo del habla de los adultos que tartamudean.* ***Material y métodos:*** *Se trata de un estudio casos-control que incluyó a 35 adultos que tartamudean comparados con 35 adultos fluyentes. Todos los participantes realizaron la lectura oral de un texto estándar para el portugués de Brasil. La tarea fue grabada, transcrita literalmente y el examen de las muestras permitió la identificación de los errores, sus reparaciones y clasificación. Los datos fueron sometidos a estadística descriptiva y analítica.* ***Resultados:*** *Adultos que tartamudean y adultos con fluidez no mostraron diferencias significativas en el número de errores explícitos en la terea de lectura oral (p=0,74). Se observaron diferencias significativas entre los grupos con respecto a los intentos de reparar estos errores, sea explícitos (p=0,04) o encubiertos (p=0,002).* ***Conclusión****: Adultos que tartamudean y adultos fluyentes mostraron la existencia de un sistema común de auto monitoreo del habla. Sin embargo, los adultos que tartamudean se han mostrado más sensibles a los errores e hicieron demasiadas correcciones, lo que sugiere fallas de adaptación y planificación fonológica.*

Palabras clave: *habla; tartamudeo; percepción.*

Introduction

The term monitoring refers to the ability to inspect the actions in real time and is used in psycholinguistic models to describe one of the aspects of the linguistic system[1]. In communicative situations, the speakers keep control of its own speech in order to detect and correct possible errors from linguistic processing failures and ensure intelligibility[2].

As a result of self-monitoring, the natural flow of speech is interrupted by pauses, unfinished words, hesitations, repetitions, interjections and revisions of segments. Strategies used by speakers to correct speech errors are similar in different languages, which allows the hypothesis that it is a universal model[2,3].

In recent years, studies of self-monitoring of speech, including its role in the acquisition of a second language[4] or in the early detection of psychiatric disorders[5], were conducted. In Brazil, it is possible to find research in the areas of Arts and Linguistics[6] and there were founded only two studies handled by speech therapists[7,8].

The use of the terms *monitoring or monitor*, referring to the speaker's ability to inspect its own performance, are common in speech therapy. Despite the recognition of the existence and relevance of the self-monitoring, the processes that sustain its operation are not discussed, creating an important gap for those who wish to act in the rehabilitation of the communication disorders.

The Perceptual Loop Theory is a theoretical model that explains the relations between production, perception and self-monitoring of speech.This theoretical construction considers the existence of a system composed of three modules: the Conceptualizer, the Formulator and the Articulator[9].

The Conceptualizer transforms the communicative intention into preverbal message that will be stored in working memory for a short period of time and available for comparisons with the output. This message is transmitted to the preverbal Formulator, which will give the intention a linguistic form, thanks to its components: the grammatical and the phonological encoder. The phonological encoder is responsible for developing a phonetic plan. The Articulator receives this phonetic plan and converts it to articulation, triggering neuromotor commands[3,10].

The speech is monitored in any one of the steps: on preverbal message, in phonological encoding or articulation, through three perceptual loops. [9.10]The conceptual and phonological loops are internal, checking the message before it is articulated. The external articulatory loop is responsible for checking if the production corresponds to the intention. Whereas the loops work *on line*[2], the flow of speech depends on the rapid integration between the processes of production and perception.[11]

In theory, the loops follow the basic rule of interrupting the speech as soon as an error is detected. Empirically, it is observed that the faults detected by the loops may result or not in interruption and reformulation of the speech. Thus, many errors are ignored by the speaker and it is likely that this strategy has as its purpose to maintain fluency. The fix, in turn, will result in an interruption, followed by repair and the resumption of the flow of speech.[9, 11]

Noting the repair strategies in speech, the errors are classified as overt or covert. In overt errors, it is possible to identify the failure, because it is articulated by the speaker and then fixed. However, in covert errors it is not possible to identify the failure that led to the repair because it is inspected and canceled by the internal loops before being produced, being audible only the interruption and the fix[9, 11].

Based on the Perceptual Loop Theory[9,10], there are two different explanatory theories for stuttering, the Covert Repair Hypothesis (CRH)[12] and the Vicious CicleHyphotesis (VCH)[13]. From the CRH, disfluencies that characterize stuttering are covert errors, produced during phonological planning[12]. The VCH proposes that adults who stutter have a hypervigilant monitor and a lower threshold for errors. A consequence of this hypervigilant monitoring would interpret the interruptions as new errors, causing even more unnecessary reformulations[13].

Although the proposals have offered two explanatory models for stuttering, few studies[12,13,18, 22] were conducted in order to test them with adults who stutter. One of the difficulties lies in the fact that the phonological planning can't be directly observable, requesting that his investigation occurs through alternative processes that are a reflection of its functioning[14].

The study of the strategies used in the self-monitoring of speech, by fluent speakers and

speakers who stutter, can provide clues about the functioning of the systems of perception and production of language and reveal some mechanisms underlying the behavior of stuttering. Thus, the main objective of this study was to examine the self-monitoring of speech of adults who stutter, compared with normal controls.

Material and method

This is anobservational and analytical case--control study with the purpose of investigates the self-monitoring of speech of adults who stutter. It was approved by the Research Ethics Committee of a public university under the CAAE 0181.0.107.000-11 and does not involve any experimental or invasive procedure, characterized as without risks to participants, which were oriented towards the study and signed an informed consent form.

The inclusion criteria for all participants were: male native speaker of Brazilian Portuguese, graduated from high school and no history of visual, cognitive, auditory or language impairments, with the exception of stuttering for the research group. The decisive factor to the exclusion of female participants was the higher prevalence of stuttering among males in a ratio of 4:1[15].

Considering the inclusion criteria and the prevalence rate of 1% of stuttering in adults[16], sample calculation was carried out using the Epi Info program, version 7.1.3.10, with two-tailed significance level of 99.99% and a power of 95%, resulting a number of 34, for cases and control group.

The volunteers were recruited through posters displayed at the main *campus* of the University. All participants who stutter were looking for attendance in the Voice, Speech and Fluency Laboratory at the Speech Therapy Department of the University and some of them were not part of the university community. The study included a total of 70 participants, allocated into two groups: the study group, with 35 adults who stutter and the control group, with 35 fluent adults.

Each participant was invited to perform an oral reading task of a Brazilian Portuguese standardized text[17]. The choice of oral reading task came from the observation that many adults who stutter are relatively fluent when reading. In this sense, oral reading is a task that induces fluency, decreasing the frequency and severity of stuttering[18].

Oral reading is considered a rapid naming task, namely, the decoding and conversion of the graphic signs into a phonological sequence are immediate[19]. Neuroimaging demonstrates that milliseconds after activation of occipital region, the temporal region adjacent illuminates and, theoretically, this immediate conversion would occur without the intervention of other levels of linguistic formulation[20].

The task of oral reading was recorded through a professional microphoneTSI, PROBR model, installed on pedestal and coupled to a converter and audio amplifier Shure®, allowing speech samples were collected and stored in wav format. The speech samples were transcribed and every deviant production, in relation to the standard text, were considered an error and highlighted.

Such errors were subsequently classified as overt -ignored or fixed-and covert, as proposed by Levelt[9]. The results about the number of errorsfor each of the participants were recorded on the worksheet and submitted to statistical treatment.

The data were examined in order to determine their distribution through the Kolmogorov-Smirnov test. Considering the normal distribution of the data, we used the Mann-Whitney test for comparison among groups. The significance level was set at $p < 05$, for all tests**.**

Results

The mean age of the adults who stutter was 26.89 (SD, 10.41) and 29.08 (SD, 10.0) for the control group. Figure 1 shows the distribution of participants according to age and per group.

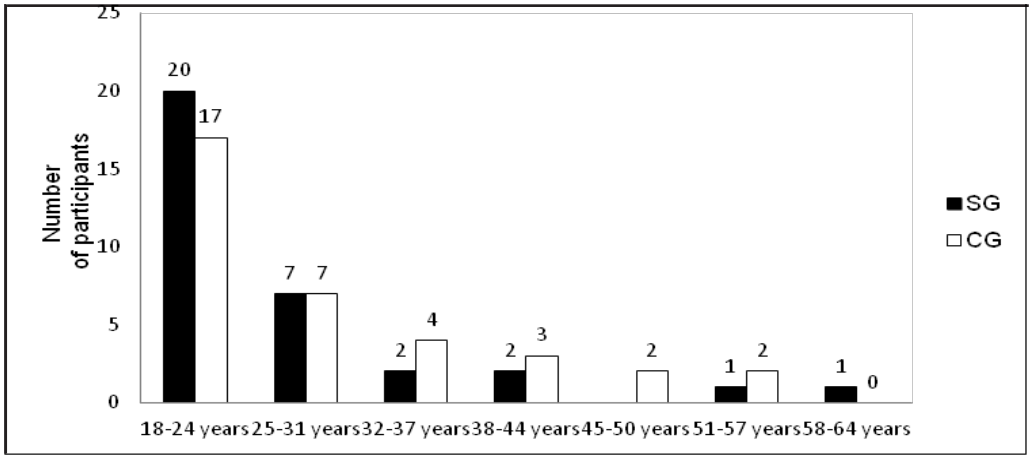

Figure 1.Participants' age distribution.
Legend: SG: study group, adults who stutter; CG: control group, fluent adults.

The average time taken for the oral reading task was one minute and nine seconds (SD, 0.78) for adults who stutter and 40.35 seconds (SD, 6.12) for the control group. It was observed a total of 155 errors in reading conducted by the study group and control group errors for 107. The association between the reading time and the number of errors was analyzed by the Spearman's rank correlation coefficient ($rs = 1$; $p < 0.0001$), indicating a strong positive correlation between these variables.

The distribution of the total number of errors, according to their classification, can be observed in Figure 2.

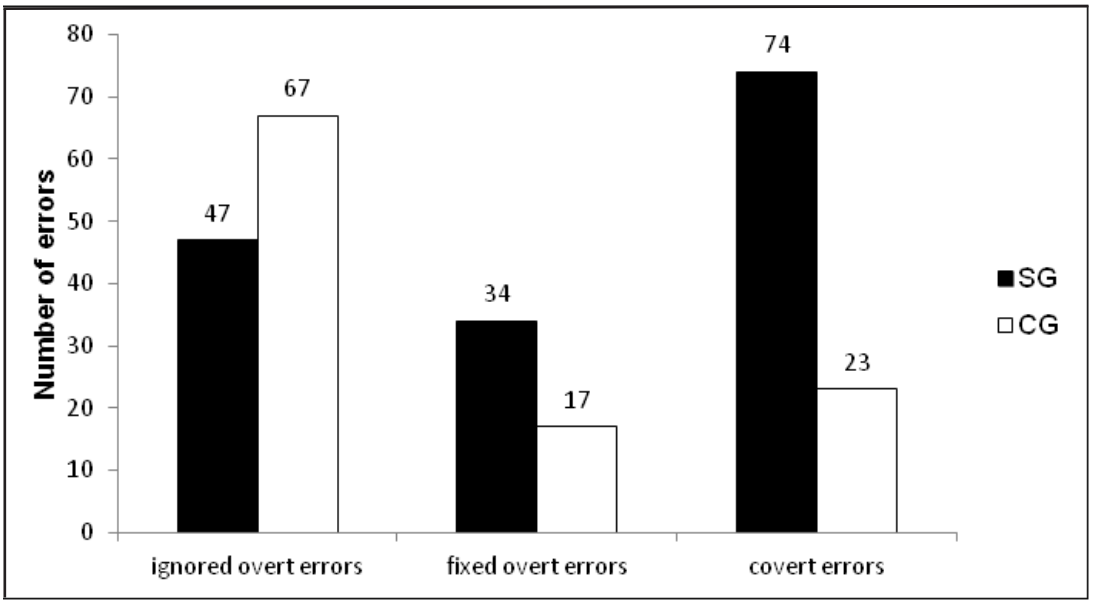

Figure 2.Absolute values of the errors presented by the two groups.
Legend: SG: study group, adults who stutter; CG: control group, fluentadults.

The overt errors are those that can be identified in the speech, because they were effectively articulated by the speaker. In the study group was accounted for a total of 81 explicit errors (52.26% of total errors) and for the control group, 84 errors (78.5% of the total number of errors).

Whereas the overt errors can be corrected or ignored, it was observed that the study group has 42% of these errors, while the control group has corrected 20%. The statistical analysis shows significant difference only for the fixed overt errors (Table 1).

Table 1 - Comparison between the overt errors identified for groups

Overterrors		Median (min-max)	p
total	GE	1 (0-8)	0,74
	GC	1 (0-5)	
ignored	GE	1 (0-5)	0,13
	GC	2 (0-5)	
fixed	GE	1 (0-3)	0,04*
	GC	0 (0-2)	

Mann-Whitney Test; * significant at p<0,05
Legend: SG = Study group; CG = Control group; (minimum-maximum).

Covert errors are so called because it is not possible to identify the failure that led to its correctness since it is not spoken by the speaker. 74 covert errors were observed in the study group (47.74% of total errors) and 23 (21.5% of the total number of errors), in the control group. There is significant difference between the two groups, whereas this type of error (Table 2). An intra-group analysis displays significant differences for covert and overt errors corrected only for the study group (Table 3).

Table 2 - Comparison between the covert errors identified for groups

		Median (min-max)	*p*
Coverterrors	GE	2 (0-9)	0,0002*
	GC	0 (0-4)	

Mann-Whitney Test; * significant at p<0,05
Legend: SG = Study group; CG = Control group; (minimum-maximum).

Table 3 - Comparison between fixed overt errors and covert errors identified for each of the groups

Participants	Errors	Mediana (mín-máx)	*p*
GE	fixedoverterrors	1 (0-3)	0,01*
	coverterrors	2 (0-9)	
GC	fixedoverterrors	0 (0-2)	0,65
	coverterrors	0 (0-4)	

Mann-Whitney Test; * significant at p<0,05)
Legend: SG = Study group; CG = Control group; (minimum-maximum).

Discussion

The occurrence of pauses, unfinished words, interjections and repetitions are evidence of an internal system of self-monitoring that inspects, continuously and in real time, the production of speech. Its purpose is to detect errors and do the necessary reviews in order to ensure proper understanding and intelligibility of speech.

For the purpose of investigating self-monitoring of speech and errors repair, this study compared the performance of thirty five adults who stutter and thirty five fluent adults (control group) in an oral reading task. The results suggest that adults who stutter and with normal speech fluency, feature similar abilities to detect and correct errors.

This study is not without limitations. The main one is related with the task performed by the participants. In methodological terms, the oral reading facilitates the identification and classification of errors, but hinders the generalization of the findings for spontaneous speech. However, a recent research [14] that compared the number of errors committed by adults who do and do not stutter, in oral reading tasks and monologue, didn't find significant differences between them.

The similarities observed between the groups suggest the existence of a common system of self-monitoring of speech. Strategies for repairing the errors, however, differ significantly and can serve to clarify some mechanisms underlying the behavior of stuttering.

The first aspect to be considered concerns the corrections of overt errors, for which it was found a significant difference ($p = 0.04$). In absolute figures, the fluent adults committed more overt errors than adults who stutter. The study group, however, interrupted the flow of the speech with a frequency greater than the fluent speakers in order to repair these errors. That strategy, in fact, is compatible with the basic rule of the perceptual loops: to interrupt and correct an error as soon as it is detected[2,9].

This interruption, however, has a cost since it requires a new phonological planning and demand a longer time of elocution. It is quite likely that the fluent speakers develop mechanisms capable of changing this cycle, adapting the functioning of the perceptual loops in order to avoid excessive corrections and ensure the flow of speech. Such adaptation would include an ability to judge which errors are sufficiently important to justify the interruption of speech.

The significant number of overt errors corrected by the study group suggests a functioning poorly adapted the perceptual loops and it is plausible to assume that this is not a hyper vigilant system, but rather a system that fails to measure the magnitude of errors[21].

This argument can be corroborated by the study of Postma& Kolk[22] which also found no differences for the number of overt errors produced by adults who do and do not stutter when instructed to speak normally. This behavior changed when the groups were asked to speak with the greater precision that articulatory was possible and the adults who stutter showed a significant increase in the number of repairs for both overt and covert errors.

The findings of this study suggest that the ability to monitor speech is similar in both groups and, by means of overt errors one realizes that the adults who stutter are correcting real bugs (and no false alarms). What the results show is that the filter used by adults who stutter is not very permeable, with very strict acceptability criteria and that lead to a large number of unnecessary repairs these error[13, 18].

The second point to be discussed concerns the covert errors. To the CRH[12], covert errors characterize stuttering and this can be corroborated by the significant difference observed between the groups for this type of error ($p = 0.002$). The bug fixes cloaked signaling that this fix has been internally during the phonological planning and inspected by the articulatory pre handle. As previously observed for the explicit errors, it can be concluded that the covert errors are also real bugs, result of phonological planning failures and cancelled before his execution. Additionally, the intra-group analysis allowed identifying a greater frequency of bug fixes cloaked in the speech of adults who stutter. This suggests that the auditory information which would be inspected by the handle does not have an articulatory post paper as relevant to this group, whichever is the functioning of the internal handle and would explain why not all people who stutter are benefits with delayed auditory feedback devices[23].

Pelczarski[14] investigated various aspects of phonological processing skills of adults who stutter concluding that these abilities are significantly different from those found in fluentadults, characterizing them as slower and more prone to

failure. In this sense, it could be argued that the phonological planning difficulties result in a greater number of errors, inspected by amaladapted system, causing several disruptions to speech. Difficulties to recast initial plan prevent the errors to be properly repaired and the flow of speech is taken up spontaneously, resulting in disfluencies that characterize stuttering.

Studies focusing on phonological processing skills are needed in order that they may, in the future, support new proposals for rehabilitation.

Conclusions

With the purpose of analyzing the self-monitoring of speech, this study compared the performance of 35 adults who stutter and 35 fluent adults in an oral reading task. The results suggest that adults who stutter and fluent adults feature similar abilities to detect and correct errors, indicating the existence of a common system of self-monitoring of speech.

Adults who stutter have proved more sensitive to errors in speech, interrupting and revising his speech with a significantly higher frequency than fluent adults. Repairing covert errors predominated in adults who stutter and, combined with the large number of fixed overt errors, suggests that phonological planning faults and a low threshold for acceptance of these failures are important aspects to be considered in stuttering and in the therapeutic approach of these patients

References

1.Riès S, Janssen N, Dufau S, Xavier-Alano F, Bulle B. General-purpose monitoring during speech production. J Cognitive Neurosci. 2011;23(6):1419-36.

2.Postma A. Detection of erros during speech production: a review of speech monitoring models. Cognition. 2000;77:97-131.

3.Moniz HGS. Contributo para a caracterização dos mecanismos de (dis)fluência no português europeu [dissertação]. Lisboa (Lisboa): Universidade de Lisboa. Faculdade de Letras. Departamento de Linguística Geral e Românica. 2006.

4.Acheson DJ, Ganushchak LY, Christoffels IK, Hagoort P. Conflict monitoring in speech production: physiological evidence from bilingual picture naming. Brain Lang. 2012;123(2):131-6.

5.Johns LC, Allen P, Valli I, Winton-Brown T, Broome M, Woolley J et al. Impaired verbal self-monitoring in individuals at high risk of psychosis. Psychol Med. 2010;40:1433-42.

6.Delfino A, Magalhães JO. Estudo prosódico das disfluências de reparo. ReVEL. 2010;8(15):181-207.

7.Mansur LL. Formulação e reformulação: contribuições ao estudo da linguagem oral de indivíduos com demência do tipo Alzheimer [tese]. São Paulo (SP): Universidade de São Paulo. Faculdade de Filosofia, Letras e Ciências Humanas. 1996.

8.Steiner VAG. Efeito da idade no monitoramento da fala [dissertação]. São Paulo (SP): Universidade de São Paulo. Faculdade de Medicina. 2008.

9.Levelt WJM. Monitoring and self-repair in speech. Cognition. 1983;14:41-104.

10.Levelt WJM. Speaking: from intention to articulation. Cambridge (Mass.): MIT Press, 1989.

11.Dhanjal NS, Handunnetth L, Patel MC, Wise RJS. Perceptual systems controlling speech production. J. Neurosci. 2008;28(40):9969-75.

12.Postma A, Kolk H. The covert repair hypothesis: prearticulatory repair processes in normal and stuttered disfluencies. J. Speech Hear Res. 1993;36(3):472-87.

13.Vasic N, Wijnen F. Stuttering as a monitoring deficit. In Hartsuiker RJ, Bastiaanse YA, Postma A, Wijnen F. (eds.). Phonological encoding and monitoring in normal and pathological speech. Hove: East Sussex Psychology Press. 2005. pp. 226-47.

14.Pelczarski KM. Phonological processing abilities of adults who stutter [dissertation]. Pittsburgh (PA): University of Pittsburgh. School of Health and Rehabilitation Sciences. 2011.

15.Wittke-Thomson JK et al. Genetic studies of stuttering in a founder population. J Fluency Disord. 2007;32(1):33-50.

16.Bückel C, Sommer M. What causes stuttering? PLoSBiol. 2004; 2: e46. doi:10.1371/journal.pbio.0020046.

17.Jakubovicz R. A técnica surdo/sonoro para descondicionar bloqueios. In: Meira I. (org.) Tratando gagueira: diferentes abordagens. São Paulo: Cortez; 2002. p. 125-33.

18.Brocklehurst PH, Corley M. Investigating the inner speech of people who stutter: evidence for (and against) the Covert Repair Hypothesis. J. Commun. Disord. 2011;44:246-60.

19.Balasubramanian V, Cronin KL, Max L. Dysfluency levels during repeated readings, choral readings, and readings with altered auditory feedback in two cases of acquired neurogenic stuttering. J Neuroling. 2010;23(5):488-500.

20.Anthony JL, Willians JM, McDonald R, Francis DJ. Pronological processing and emergente literacy in younger and older preschool children. Ann. Dyslexia. 2007;57(2):113-37.

21.Lickley RJ, Hartsuiker RJ, Corley M, Russel M, Nelson R. Judgement of disfluency in people who stutter and people who do not stutter: results from magnitude estimation. Lang Speech. 2005;48(Pt 3):299-312.

22.Postma A, Kolk H. Speech errors, disfluencies and self--repairs of stutterers in two accuracy conditions. J. Fluency Disord. 1990;15:291-303.

23.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.