Original Article

Artigo Original

Time-compressed speech test in the elderly

Teste de fala comprimida em idosos

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Keywords

Speech Intelligibility
Speech Perception
Aging
Presbycusis
Hearing Tests

ABSTRACT

Purpose: The present study aimed to evaluate the performance of elderly people in the time-compressed speech test according to the variables ears and order of display, and analyze the types of errors presented by the volunteers. **Methods:** This is an observational, descriptive, quantitative, analytical and primary cross-sectional study involving 22 elderly with normal hearing or mild sensorineural hearing loss between the ages of 60 and 80. The elderly were submitted to the time-compressed speech test with compression ratio of 60%, through the electromechanical time compression method. A list of 50 disyllables was applied to each ear and the initial side was chosen at random. **Results:** On what concerns to the performance in the test, the elderly fell short in relation to the adults and there was no statistical difference between the ears. It was found statistical evidence of better performance for the second ear in the test. The most mistaken words were the ones initiated with the phonemes /p/ and /d/. The presence of consonant combination in a word also increased the occurrence of mistakes. **Conclusion:** The elderly have worse performance in the auditory closure ability when assessed by the time-compressed speech test compared to adults. This result suggests that elderly people have difficulty in recognizing speech when this is pronounced in faster rates. Therefore, strategies must be used to facilitate the communicative process, regardless the presence of hearing loss.

Descritores

Inteligibilidade da Fala
Percepção da Fala
Envelhecimento
Presbiacusia
Testes Auditivos

RESUMO

Objetivo: Avaliar o desempenho de idosos no teste de fala comprimida segundo as variáveis orelha, ordem de apresentação e idade, além de analisar a ocorrência de erros. **Método:** O estudo é caracterizado como observacional, descritivo, quantitativo, analítico e do tipo transversal primário, o qual envolveu 22 idosos entre 60 e 80 anos de idade, portadores de audição normal ou com perda neurossensorial de grau leve. Os idosos foram submetidos à aplicação do teste de fala comprimida apenas com dissílabos e com taxa de compressão de 60%, por meio do método de compressão de tempo eletromecânico. Em cada orelha, foi aplicada uma lista de 50 dissílabos, sendo a ordem de início de teste aleatória. **Resultados:** Quanto ao desempenho no teste, verificou-se que não houve diferença estatística entre as orelhas e os idosos apresentaram resultados aquém do encontrado na população adulta. Encontrou-se significância estatística de melhor desempenho para a segunda orelha de início de teste. A maior ocorrência de erros se deu para as palavras que iniciaram com os fonemas /p/ e /d/. A presença de encontro consonantal na palavra também aumentou a ocorrência de erros. **Conclusão:** Os idosos apresentam pior desempenho na habilidade de fechamento auditivo, quando avaliados por meio do teste de fala comprimida, em comparação aos indivíduos adultos. Este resultado sugere que os idosos têm dificuldades para reconhecer a fala quando esta lhe é apresentada numa velocidade aumentada. Sendo assim, estratégias devem ser utilizadas para facilitar o processo comunicativo, independentemente da presença de uma perda auditiva.

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INTRODUCTION

The process of aging is inherent to individuals. Variables such as lifestyle, chronic diseases and socioeconomic conditions can accelerate or slow down this process[1,2]. As a result of aging, the autonomy in daily life activities often decreases and the person becomes gradually more dependent on the family[3].

Besides having vital importance, the ability to communicate is related to the capacity to work and to the psychological balance of the human being[4]. Psychological factors are also related to some hearing abilities that undergo changes with aging[1,5].

The auditory system consists of sensory and central components and is divided into peripheral and central components. The peripheral system, responsible for sensing different sound stimuli, is composed of the outer, middle and inner ear and the auditory nerve. The central auditory system, responsible for decoding the received message and concomitant recoding, is closely linked to the processing of language and other cognitive and emotional functions[6]. This system involves the auditory pathways of the brainstem and cortical areas. In addition to communication, the hearing ability serves for safety, to alert on eventual risk situations. The hearing decline caused by aging, known as presbycusis, occurs due to changes in the peripheral and/or central auditory system[7].

Central auditory processing is characterized by the brain's ability to recognize and interpret sounds. It is a mental activity, that is, a brain function. A failure in this neural mechanism may give rise to a Central Auditory Processing Disorder - CAPD[8-10]. Over the years, the difficulties increase and hearing abilities become impaired. The loss of the ability to perform temporal processing of general sounds becomes the main complaint among the elderly, as they explain as "listening, but not understanding"[11].

Auditory closure stands out among the auditory abilities. This refers to the ability of normal listeners to use intrinsic or extrinsic redundancies to fill in missing or distorted parts of a hearing signal and recognize the complete message[4]. Auditory closure plays an important role in the daily activities of listeners because acoustic environments are only rarely considered ideal[4]. A change in this ability may interfere with the ability to decode the phonemic aspects of a speech signal, that is, it may lead the listener to difficulties in understanding speech in a noisy acoustic environment, however without impairing the perception of speech in an ideal acoustic environment[4].

Different tests have been created to analyze this ability, among them, the time-compressed speech test, which is one of the monaural low-redundancy speech tests. The test stimuli are degraded by electromechanical time compression. This test exists for more than 30 years, but only in 2007 was translated and adapted to Brazilian Portuguese for the adult population[12].

According to American standardization, normal scores for adults are above 82% of correct answers for each ear. In a Brazilian study, the pattern of normality found for adults was 90%[13].

Research on the performance of adults in this test has been carried out in Brazil, but nothing with the elderly population[12]. In the international literature, one study was found addressing the time-compressed speech test in the elderly, in which the results suggest that the elderly are at a disadvantage compared to young people to hear at faster speech rates[14].

The continuous increase of the elderly population results also in the increase in life expectancy. Thus, health professionals must gain more knowledge about this population in order to offer adequate treatments and/or rehabilitations and promote a better quality of life[15]. The knowledge of these difficulties, of the committed aspects, indicates a great need for a speech-language intervention.

Thus, the present study had as objective to evaluate the performance of the elderly in the time-compressed speech test according to the variables ear, order of presentation and age, and analyze the occurrence of errors.

METHODS

This is an observational, descriptive, quantitative, analytical and primary cross-sectional study carried out at the Clinical School of Speech-Language Pathology and Audiology of the Federal University of Santa Catarina in Florianópolis. The project was initially analyzed and approved by the Research Ethics Committee on Human Beings under the number 870,664.

Twenty-two elderly individuals aged 60 to 80 years who met the following inclusion criteria participated in the study: presence of auditory thresholds within the normal standards or mild bilateral sensorineural hearing loss[16,17]; type A tympanometric curve and contralateral acoustic reflex present in the bilateral mode; Portuguese as the first language; minimum score of 36 points in the *Scale of Auditory Behaviors* - SAB[18] and without evident neurological and/or cognitive alterations. Exclusion criteria were illiteracy, presence of speech sound substitution and use of hearing aid. The elderly who were willing to participate received clarifications about the study and signed the Free and Informed Consent Form to express their agreement.

The Time-Compressed Speech Test can be performed with two types of stimuli: monosyllabic or disyllabic. In the present study, we used a list of 50 compressed disyllables using the electromechanical time compression method with compression ratio of 60%, which presents a modified duration pattern. The list of 50 disyllables selected is available in tracks 8 and 9 of the *compact disc (CD)* Behavioral Hearing Tests for Evaluation of Central Auditory Processing. The tracks 8 and 9 were applied to the right and left ears, respectively. A 40dBSL intensity was used in the test[13].

The performance in the test was registered in a protocol, in which the response of the patient (correct or incorrect), the first ear tested, and the percentage of correct answers per ear

were recorded. It is noteworthy that half of the sample started the test with the right ear.

To perform the research, an Interacoustics audiometer model AC40 and TDH39 headphones were used. All the tests were performed in an acoustic cabin. A *laptop* coupled to the audiometer and the CD was used to apply of the time-compressed speech test[13].

The data obtained were analyzed for performance in the test, considering the following variables: ear, influence of the order of presentation and age, and occurrence of errors. Descriptive measures, the non-parametric Mann-Whitney Test and the Spearman Correlation Test were used in the statistical analyses. The level of significance was set at 5% ($p < 0.05$). Significant values were marked with an asterisk (*).

RESULTS

The initial population of this study consisted of 50 individuals; 28 were excluded because they did not meet all the inclusion criteria. Thus, the final population of the study consisted of a total of 22 elderly people, of whom 16 were female (72.72%) and six were male (27.27%).

The mean age of participants was 66.5 years (SD = 4.31), with a minimum age of 61 and a maximum of 75. The mean score in the SAB questionnaire was 44.77 (SD = 6.97), with a minimum of 36 and a maximum of 58 points.

As to the audiological characteristics, 10 subjects presented hearing thresholds within normal patterns bilaterally; 10 subjects had mild sensorineural hearing loss; and two individuals had asymmetric hearing, presenting normal hearing in the left ear and mild sensorineural hearing loss in the right ear.

Table 1 presents the descriptive measures of the quadritonal means (500, 1000, 2000 and 4000Hz) of the tonal thresholds and of the speech recognition index (SRI) of each ear in the elderly (n = 22). The elderly presented good performance in the SRI and symmetrical quadritonal means in the ears.

Table 2 presents the performance of the elderly in the time-compressed speech test for each ear. No differences were observed between right and left ear ($p = 0.742$).

Table 3 shows the analysis of the time-compressed speech test in relation to the first ear tested, to determine if the order of presentation of the test influenced the results. It is worth mentioning that sometimes the test was started in the right ear, and other times in the left ear. Regardless of the ear, the second ear had a statistically significant better performance ($p = 0.029$).

The Spearman Correlation test was applied to verify if the performance in the test was influenced by age. The analysis showed a negative and significant correlation ($r = -0.412$, $p = 0.005$).

The words that presented more than 50% of error in the time-compressed speech test are presented the Figure 1. It is important to note that this analysis took into consideration that each word was presented twice for each individual.

Table 1. Descriptive measures of the quadritonal mean values (500, 1000, 2000 and 4000Hz) of the tonal thresholds and the speech recognition index per ear in the elderly (n = 22)

	SRI (%)		Quadritonal mean (dBHL)	
	RE	LE	RE	LE
Mean	96.36	96.18	21.81	22.89
Median	96	96	27.5	25
Standard deviation	3.88	3.99	11.27	11.44
Minimum	88	88	-5	3.75
Maximum	100	100	36.25	38.75

Legend: RE = Right ear; LE = Left ear; % = Percentage. SRI = speech recognition index; dBHL = Decibel hearing level

Table 2. Results (%) of the time-compressed speech test per ear in the elderly (n = 22)

Time-Compressed Speech Test Performance (%)			
TCST	RE	LE	p-value
Mean	73.81	72.36	
Standard Deviation	10.77	13.36	
Median	76	76	0.742
Minimum	44	42	
Maximum	86	92	

Mann-Whitney Test (Significance level $p < 0.05$)
Legend: RE = Right ear; LE = Left ear; TCST= Time-compressed speech test; % = percentage

Table 3. Results (%) of the time-compressed speech test considering the presentation order (n = 22)

Presentation Order			
TCST (%)	First ear	Second ear	p-value
Mean	69.09	77.09	
Standard Deviation	2.90	2.03	
Median	72	80	0.029*
Minimum	42	52	
Maximum	92	92	

Mann-Whitney Test (Significance level $p < 0.05$)
Legend: TCST= Time-compressed speech test; % = percentage; * = statistically significant

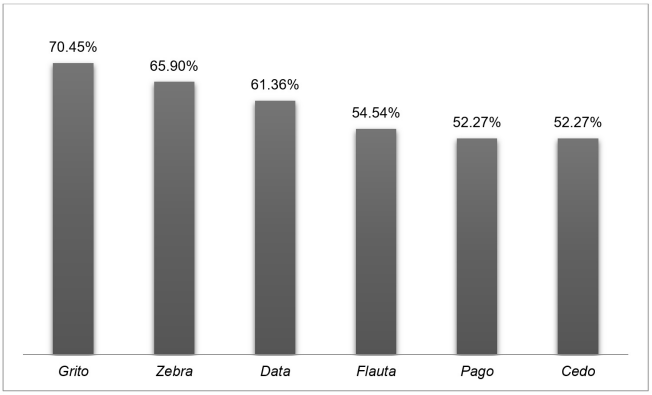

Figure 1. Percentage of errors in the words used in the Time-Compressed Speech Test in the elderly (n = 22)

DISCUSSION

It is known that central auditory processing is defined as what happens to the individual's brain when recognizing and interpreting sounds[8-10]. In daily practice, individuals need fill in the missing or distorted parts of the auditory signal to recognize the complete message, to which good performance of auditory closure ability is essential[4].

The results found in Table 1 show that, although the inclusion criteria defined normal or mild loss of hearing, the study participants presented a good performance in the SRI, with the lowest result equal to 88%. The results were observed to be similar between the sides.

SRI results varying from 92% to 100% suggest that the individual does not present any difficulty to understand the speech, and results between 80% and 88% suggest a discreet difficulty in understanding speech[19]. It is worth mentioning that, in clinical practice, the SRI is performed in a situation of greater redundancy; the test is presented at 40dBSL and in silence, thus helping in the performance of the task, especially in the case of the elderly, despite the presence of a mild hearing loss.

The average found in the time-compressed speech test (73.81% to the right ear and 72.36% to the left ear) for the elderly in the present study was below the standardization for Brazilian adults (90% of correct answers regardless of the ear)[12].

In an international study using the time-compressed speech test in favorable environment with monosyllables carried out with 30 young people (18 to 30 years old) and 32 elderly people (65 to 80 years old) with thresholds within normality, the authors observed that the ability of speech recognition in the elderly was altered in relation to the young[20]. These differences observed in studies between adults and the elderly may be due to the aging process itself, which affects not only speech recognition but also fast speech processing[20]. In this same study, the authors reported that the greatest complaint of the elderly was when the discourse was compressed or temporarily altered, but they had no difficulty when this was presented in low intensity.

Based on these findings from literature and the present study, it is evident that the processing is slower in the auditory system of the elderly. In addition to speech perception, other factors such as memory, attention, and reduced cognitive ability may influence faster speech recognition[20,21].

Comparing the results of the compressed speech test of the right ear (73.81%) with those of the left ear (72.36%) (Table 2), it was observed that there was no significant difference between the ears ($p = 0.742$), but there was a slightly better performance of the right ear. Although the left hemisphere is preferential for language, the time-compressed speech test is a monotic test. Thus, the ipsilateral and contralateral pathways of the central auditory system reach both hemispheres, compensating for the preference of the right ear in relation to the left ear[12]. This justifies the absence of difference between the ears.

A similar behavior was observed in an earlier study conducted with adults; even though there was no statistically significant difference between the ears, higher average scores were obtained with the right ear than with the left ear. In this study, the authors found, for the same speech material and the same compression rate used in the present study, scores of 92.4% for the right ear and 91.8% for the left ear[12].

A previous research with different monotic tests analyzed the auditory closure ability of individuals aged between 13 and 59 years with mild to moderate symmetric bilateral sensorineural hearing loss. They were submitted to the speech recognition test with words in different modalities and to the speech test with white noise with figures. The authors observed that there was also no significant difference between right and left ears for any of the tests. The average accuracy in the speech recognition test with figures, speakerphone and recorded monosyllables was 97.1%; 85.9%; and 76.1%, respectively, and 72.6% of correct answers in the test carried out with noise[22].

As for the initial ear (Table 3), it was decided to start the sample evaluation in a random way, so as to observed if the second ear tested (regardless of whether it was the right or the left) would present a different performance in the test. The analysis revealed a statistically significant difference ($p = 0.029$) with an advantage for the second ear.

It is known that the second ear tends to be slightly better due to the greater use of the auditory closure ability. This shows that the previous experience promotes learning in the time-compressed speech test by the participants, as already observed in previous studies[12,23,24].

The authors of another study that used the same compression ratio (60%) observed a tendency towards better responses in the second ear tested. The first ear scored 87.8% and the second ear 88.4% in the time-compressed speech test with monosyllables. In the case of disyllables, the average of correct answers was 91.6% for the first ear and 92.6% for the second one[12].

The results of the present study show that, although the elderly perform poorly than adults, the behavior was the same. That is, as in the other studies, there was no difference between the ears, and the second ear evaluated presented better performance. This suggests that the elderly benefited from exposure to the test to perform better during the assessment.

The biological age contributes to a low performance in auditory tasks that involve speech stimuli. This is why younger individuals present better speech recognition. Aging interferes in the identification of degraded speech, even when the individual does not present hearing loss[25]. This behavior was also observed within the group of elderly in this study. Furthermore, within the group of elderly people, the performance decreased with increasing age.

Another important factor to emphasize is that, although the test was long, after presenting 50 words in each side, this did not influence the performance in the test. It is known that fatigue is an important factor to be considered in tests that evaluate auditory processing abilities[12].

Aging leads to impairment in the auditory system as a whole[8,26,27]. CAPD is related to aging, regardless of the loss of auditory sensitivity[8,26]. Advanced age can bring some compromises, such as cognitive decline. This, in turn, influences auditory processing tests. Therefore, the vast majority of the elderly complain about the temporal processing of the sound, by claiming "to listen, but not understanding"[8,26,28].

Since no difference in performance was observed between the ears, to analyze the incorrect and correct answers of participants during the test, theto join the results of two ears tested were pooled (n = 22) (Figure 1).

When the words /*data*/ (date) and /*pago*/ (paid) were presented, the elderly presented, respectively, 61.36% and 52.27% of errors. Because they begin with /d/ and /p/, they become, for some individuals, imperceptible. This happens because they are plosive sounds and, with compression, they become too fast, making discrimination difficult[12]. Previous research with adults also found that these phonemes were the most affected by the compression effect, in addition to /b/ and /t/, for both monosyllables and disyllables[12].

A high occurrence of errors was also observed for the words with consonantal encounter: /*grito*/ (shout) (70.45%), /zebra/ (65.90%) and /*flauta*/ (flute) (54.54%) (Figure 1). This may have occurred because, after compression, consonant encounters practically disappear, making it difficult to discriminate[12]. The incorrect answers of the elderly may be associated with coarticulation, which produces overlapping segments of speech with consequent difficulty to reach the phonemic target[14]. It is also known that, from the age of 60, degenerative processes of normal aging arise and decrease the intelligibility of speech, especially when speech becomes faster or is spoken in another language[25].

Considering the results of this research, we highlight important findings such as: lack of significant differences between the performance of the right and the left ear in the Time-Compressed Speech Test with disyllables and the better performance of the second ear in the test. These findings, as well as the types of errors presented, show that the elderly presented the same behavior as the adults in the evaluation, with the exception of performance in the test, evidencing a difficulty in closure ability. Faster speech interferes with the recognition and processing of information.

In daily practice, this impairment in the auditory closure ability can cause damage to speech processing and perception, consequently affecting the communication as a whole and leading to restrictions in the participation of the elderly in many activities, regardless of the presence of hearing loss. Therefore, strategies that facilitate communication should always be used with the elderly in order to increase extrinsic redundancies, since the internal ones are reduced. Among them, we highlight: care with the acoustic environment (noise, reverberation, lighting), with the speaker's speech (articulation, intensity, speed), use of visual cues, mastery of linguistic content, number of speakers, shift changes[29].

Regarding the inclusion criteria established for the research, the sample size was small. Nevertheless, important data were obtained and allow raising new questions for future research.

CONCLUSION

The elderly present a worse performance in auditory closure ability compared to the adults when evaluated with the time-compressed speech test. There is no difference in the performance of the ears. The order of presentation of the lists, regardless the initial ear, influences the performance in the test, and the second ear presents better performance. Plosive phonemes and consonantal encounters with /r/ and /l/ are more difficult to recognize with increasing speech speed.

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Author contributions

RSA was responsible for collection and analysis of data and writing of the manuscript; RCS was responsible for guidance in conducting the study, data analysis and writing of the manuscript.