Performance of elderly individuals with presbycusis in tasks involving inhibitory control

Desempenho de idosos com presbiacusia em tarefas de controle inibitório

Ana Lúcia Pires Afonso da Costa[1], Márcia Cristina Zimmer[2]

ABSTRACT

Purpose: To evaluate the performance of elderly individuals in a non-verbal task related to executive functions, in order to verify the hypothesis that elderly hearing aid users would obtain higher scores in the proposed task than elderly non-hearing aid users. **Methods:** The Simon task, administered individually on a laptop computer using the e-prime software, was used to measure aspects related to executive functions through a control condition and two test conditions. In the control condition, the stimuli – colored squares – were presented in the center of the screen. Test conditions were subdivided into congruent lateral condition – stimuli presented on the same side of the screen as the laptop key to be selected as the correct response – and lateral incongruent condition – in which the stimuli appear on the opposite side of the screen relative to the response key. The difference in reaction time between congruent and incongruent conditions is called Simon effect. The elderly were divided into three groups: a control group of normal hearing individuals; individuals with presbycusis who use hearing aids; and individuals with presbycusis who do not use hearing aids. **Results:** Statistical analysis showed difference between the control group and the group of non-hearing aid users only with regards to the reaction time (RT) in the control condition. In the other comparisons, no differences were found. **Conclusion:** The hypothesis was not corroborated, which indicates the need to use new exploratory methods for observing the studied phenomena.

Keywords: Aging; Presbycusis; Executive function; Attention; Cochlear implants

INTRODUCTION

With the aging of the population, researchers and health professionals have directed their attention to preserving the quality of life of the elderly, who tend to suffer structural and functional modifications[(1)], such as decreased brain weight and volume, neuronal, cellular and molecular losses, and decrement in visual or hearing acuity. Aging can begin around 25 years of age[(2)] and the aging process is faster in the frontal brain regions[(3)], primarily responsible for the executive functions, which undergo their greatest development until early adulthood, remain relatively stable for some time and are then the first to decline over the years. This decline occurs in the natural aging process and, in some cases, may take place more intensely.

The evaluation of executive functions has also been helping in the differential diagnosis between normal aging and dementia of the Alzheimer type[(4)]. These functions consist of a wide variety of cognitive functions that require attention, concentration, stimulus selectivity, abstract reasoning, planning, flexibility, mental control and working memory[(5)]. Executive control is an executive function that operates as a regulatory mechanism, which entails the capacity for planning, initiation, continuation and self-monitoring of behavior directed toward a certain end. We could make an analogy with a business executive who, despite not being an expert in one field in particular, is responsible for overseeing different areas[(6)]. Executive control also consists of inhibitory processes that regulate the interference of new and old information[(7)]. The adequate functioning of inhibitory control depends on other executive functions, such as attention and working memory, for example.

Among sensory losses, hearing loss is the one that generates a deeper and more devastating impact on the communication process of the elderly[(8)]. The deterioration of the auditory function in the elderly is one of the most frustrating limitations there is, and has a negative influence on interpersonal relationships[(9)]. Presbycusis, which is the hearing loss that comes with aging, can take place throughout the entire auditory system, from the middle ear to the auditory pathways,

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Study conducted at the Universidade Católica de Pelotas – UCPel – Pelotas (RS), Brazil.
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(1) Undergraduate Program in Speech-Language Pathology and Audiology, Universidade FEEVALE – Novo Hamburgo (RS), Brazil.
(2) Graduate Program in Applied Linguistics, Universidade Católica de Pelotas – UCPel – Pelotas (RS), Brazil.
Correspondence address: Ana Lúcia Pires Afonso da Costa. R. Dr. Cassiano, 153, Centro, Pelotas (RS), Brasil, CEP: 96015-700. E-mail: anacosta_sul@yahoo.com.br
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including the cortex, and it can occur in single or multiple locations, resulting in decreased auditory sensitivity and reduced speech comprehension at suprathreshold levels*[10]. Difficulties and decreased ability to hear in adverse situations have also been observed, such as speech reception in the midst of noise by elderly people without peripheral hearing loss[11]. In one study, elderly people were given a questionnaire about possible hearing problems. It was found that 15.4% of those without hearing loss reported difficulty hearing in certain situations[11].

Studies have shown that speech recognition, besides occurring as a result of the sensation caused by the physical stimulus and the circumstances of the context, requires a number of conditions to occur satisfactorily. Neurosensorial hearing loss limits this sensation, not only due to the increased audibility threshold, but also the inability of the ear to reproduce the temporal and spectral aspects of the acoustic stimulus[12]. Since individuals use intrinsic and extrinsic redundancies in their ability to hear speech[13], it can be concluded that cognitive and sensory abilities will have a direct influence on these difficulties and the therapeutic result in the intervention with the individual with presbycusis.

Complaints about poor hearing are not only related to sound intensity, but also to speech comprehension, especially in noisy places. Technological advances in hearing aids over the last ten years are not entirely effective when the environment has background noise[14]. Many researchers have been using behavioral tests for auditory processing in an effort to find solutions for speech comprehension difficulties, understand its suprasegmental aspects and monitor rapid changes in sound stimuli[15].

Knowing that in adverse situations individuals use communication cues and compensatory strategies, the access to non-auditory "cues" can be limited in older people with presbycusis by cognitive factors that affect the use of these strategies. A limiting factor might be the decline in executive functions, responsible for the ability to participate selectively in actions and concentrate on a particular task[16]. Problems with the inhibitory system can create difficulties in selecting what is important, preventing older people with hearing loss to focus their attention on the sounds they want to hear and inhibit those that are not important.

This study had the aim to evaluate the performance of elderly people with presbycusis, both users and nonusers of hearing aids (HA), in a non-verbal task related to executive functions (Simon task), investigating whether functions such as inhibitory control are also affected by presbycusis.

METHODS

This experimental research, which is exploratory and cross-sectional in nature, analyzed qualitatively and quantitatively the data obtained. It was approved by the Research Ethics Committee of the Universidade Católica de Pelotas, under number 2009/16, record number five. Differences in performing the Simon task were investigated between three groups of elderly people: elderly with hearing loss who use HA; elderly with hearing loss who do not use HA; and elderly without hearing loss. The hypothesis was that elderly HA users would obtain significantly higher scores in the Simon task than elderly non-HA users.

The participants, who signed a Free and Informed Consent Form prior to the research, were between 60 and 75 years of age, selected by the researcher from users of public and private health care services in the city of Pelotas. The sample comprised three HA users, three non-HA users and 15 individuals without hearing loss, for comparison purposes. Although 200 medical records were assessed and 120 elderly people were examined, only 21 individuals met the inclusion criteria.

The subjects with hearing loss should present signs of presbycusis, namely mild to severe bilateral, sensorineural hearing loss. In addition, the Speech Recognition Index (SRI) should not be lower than 52%, which is a common indicator of retrocochlear loss. Hearing loss was identified by pure tone audiometry and speech audiometry. Illiterate subjects or those with health problems that could affect the results were excluded. Moreover, subjects were submitted to the Mini-Mental State Examination (MMSE), which was administered in order to exclude participants with signs of dementia. The reference parameters used to analyze the MMSE were 24 points from the Bertolucci rating[17] for individuals with some level of education. All selected subjects had completed at least elementary school.

The instrument selected to analyze non-verbal executive functions was the Simon task, which evaluates attention, selection and flexibility, spatial intelligence, and inhibitory control. This particular Simon task[18] has 192 stimuli distributed among four conditions. Conditions A and C present the stimuli – colored squares – in the center of the screen, with two and four colors, respectively. Conditions B and D present the stimuli in the laterals of the screen, with two and four colors, respectively. In conditions A and B, the 0 key corresponds to the color brown and the 1 key, to the color blue. In conditions C and D, the colors yellow and red correspond to the 0 key and the colors green and pink, to the 1 key. Stimuli presented on the same side of the screen as the response key are called congruent, while the stimuli presented on the opposite side of the screen in relation to the response key are called are incongruent.

The Simon effect[19] refers to the difference in reaction time between the responses to incongruent and congruent stimuli. It is expected that the reaction time for responding to congruent stimuli will be less than to incongruent stimuli.

The Simon task measures: 1) the accuracy of the participant's response; 2) reaction time (RT) in responding to the stimulus; and 3) Simon effect, which, as explained above, is the difference between the mean reaction times to incongruent and congruent stimuli. Since a shorter reaction time is expected for responses to congruent stimuli, the Simon effect is generally positive. The Simon effect is only analyzed for the lateral conditions (B and D).

* We will consider as suprathreshold losses those resulting from flaws in central auditory processing, in which the individual, even with audibility in the entire speech spectrum, may have difficulty understanding[9]

The Kruskal-Wallis test was used to compare the results of the three groups (with HA, without HA, and without hearing loss). The Wilcoxon test was used to compare the groups in pairs (group without hearing loss and group of HA users; group without hearing loss and group of non-HA users; group of HA users and group of non-HA users).

RESULTS

In condition A, the HA group demonstrated the best accuracy. The non-HA group had the lowest accuracy and reaction time. In condition C, non-HA users had the most accurate answers, but with relatively high reaction time. HA users registered the lowest accuracy and highest reaction time (Table 1).

In condition B, better performance was noted in the non--HA group, both in terms of accuracy and reaction time, and the Simon effect was positive, as expected (Table 2).

In condition D, the best reaction time performances displayed alternating results between those with normal hearing and non-HA users, with very similar performance between the three groups in terms of accuracy (Table 3).

In calculating the mean accuracy scores for all the trials, we found that the normal hearing group had a mean accuracy of 95.10%, the HA group had 93.05%, and the non-HA group, 95.49%. The same occurred in the analysis of mean reaction times, in which the mean reaction time of the normal hearing group was 886.95 ms, the HA group, 1058.58 ms, and the non-HA group, 758.48 ms. The lack of difference between groups is most likely due to the limited number of participants in each group.

A difference was found only in reaction time (RT) for condition A, between the group without hearing loss and the group of non-HA users. In the other comparisons, no differences were found.

DISCUSSION

As mentioned in the Results section, in condition A, the HA group had the highest accuracy score, and the non-HA group had the lowest reaction time, but also the lowest accuracy. In condition C, the non-HA group had the best accuracy score, but its RT was very high. The HA group had the highest RT and the lowest accuracy. This group demonstrated better accuracy in condition A, but when confronted with a more demanding condition (center four colors), its performance deteriorated, both in accuracy and reaction time. It's important to emphasize that condition C requires more working memory abilities[18,19], since four colored squares are shown and each key corresponds to two of the four squares, while in condition A each key corresponds to only one color. The non-HA group improved in accuracy and almost doubled its reaction time when performing the task in condition C.

In condition B, besides displaying the best performance in both accuracy and RT, the non-HA group also maintained the higher reaction time for congruent stimulus response, which is commonly expected, resulting in a positive Simon effect[19].

Table 1. Results of the Simon task 2 in conditions A and C

Subjects	Condition A: 2 colors center		Condition C: 4 colors center	
	Accuracy (%)	RT (ms)	Accuracy (%)	RT (ms)
Normal hearing	92.33	843.19	92.5	849.7
With HA	97.91	780.7	90.42	1175
Without HA	85.42	551.8	96.7	1032.2

Note: HA = hearing aid; RT = reaction time

Table 2. Results of the Simon Task 2 in condition B in terms of accuracy, reaction time and Simon effect

Subjects	Congruent		Incongruent		Simon effect (ms)
	Accuracy (%)	RT (ms)	Accuracy (%)	RT (ms)	
Normal hearing	97.5	742.1	97.5	984.0	242.1
With HA	91.66	1232.8	80.83	1000.0	-222.8
Without HA	100	557.8	97.5	606.0	48.2

Note: HA = hearing aid; RT = reaction time

Table 3. Results of the Simon task in condition D in terms of accuracy, reaction time and Simon effect

Subjects	4 colors sides				
	Congruent		Incongruent		Simon effect (ms)
	Accuracy (%)	RT (ms)	Accuracy (%)	RT (ms)	
Normal hearing	96.66	860.5	94.16	1042.2	181.7
With HA	97.5	1040.3	100	1122.5	82.2
Without HA	95.83	938.8	97.5	864.3	-74.5

Note: HA = hearing aid; RT = reaction time

In condition D, the best RT performances displayed alternate results between elderly with normal hearing and non-HA users, with very similar performances between the three groups in terms of accuracy (Table 3). In fact, some studies that compared older monolingual and bilingual elderly individuals also reported less difference regarding accuracy[16,18].

In conditions C and D, the accuracy results were very similar between groups, but the absolute RT numbers of the normal hearing and HA groups differed from the RT of the HA group, in all performances. It's important to emphasize that the conditions with four-color stimuli, both in the center and the two-side conditions, require greater activation of working memory. The averages of the groups showed higher scores and lower reaction time in the non-HA group, which might have been significant if the sample was larger.

From the six accuracies measured in all tasks, three of the best were obtained by the HA group and the other three by the non-HA group. However, the HA group presented five of the six worst reaction times, demonstrating the need for more time to respond to the task. The group without hearing loss showed more regularity.

The fact that the non-HA group, in general, performed better than the HA group, even though there were no significant differences, leads us to suggest the possibility that their better performance in executive function tasks could result in non-HA users being able to delay the effects of auditory handicap and the need to use hearing aid.

In presenting better executive function performance with shorter reaction times, the participants, albeit with hearing loss, displayed better resources in the use of compensatory strategies that rely on analysis, precision in stimuli selection, inhibitory control, attention, and concentration[5,6]. Executive control activities, being better preserved, might contribute to the better use of more complex communication cues and in selecting what "should" be heard, thus dealing better with background noise and distracting activities, among other demands placed upon hearing. These findings are in line with research that have required the elaboration of broader auditory evaluations for a more in-depth study of the communicative needs of the elderly and/or those with presbycusis[15].

In noting that HA users accounted for the worst performances in most of the Simon tasks, one must be careful in evaluating this information to not arbitrarily attribute these poor results to the use of hearing aids, in a cause and effect relationship. What seems to occur is that the search for hearing aids is directly dependent on several factors, including low performance in the use of compensatory strategies and cortical tasks, whether auditory or not, which depend on the plasticity of executive functions. This reinforces the findings of other studies that consider the hearing aid a limited resource to handle all the communication difficulties faced by the elderly, especially those that occur in noisy environments, which demand greater agility in cognitive functions beyond the auditory ones[14]. The combination of hearing loss and these factors related to executive functions appear to have a direct relationship with the user seeking after or feeling the need to use a hearing aid. It also appears that these factors do not necessarily depend on the audiometric configuration or discrimination values found in speech audiometry tests, since this variable was controlled in the sample selection.

The results presented here generated some final questions:

1) Does the non-HA group put off the use of hearing aids due to its better executive function performance, or are there other determinant factors?
2) Is it important to add executive functions tasks in the audiological assessment of elderly people with presbycusis?

Answering these questions depends on a more complex evaluation of several factors, both auditory and non-auditory, such as the other executive functions and the ability to use communication strategies.

CONCLUSION

The hypothesis that elderly HA users would obtain significantly higher scores than elderly non-HA users in the tasks proposed was not corroborated by the research and has generated further questions, which reinforces the initial proposal to conduct exploratory studies. The findings of this study are inconclusive, and additional studies of the same nature with a larger number of elderly individuals in the three groups are suggested in order to confirm or not the trends observed here. A larger sample might find other differences between groups.

RESUMO

Objetivo: Avaliar o desempenho de idosos em tarefa não verbal ligada a funções executivas, a fim de verificar a hipótese de que idosos usuários de próteses auditivas obteriam escores mais altos do que idosos não usuários de próteses na tarefa proposta. **Métodos:** A tarefa *Simon*, administrada individualmente em um *laptop* com o software *e-prime*, foi utilizada para mensurar aspectos ligados a funções executivas por meio de uma condição controle e duas condições de teste. Na condição controle, os estímulos – quadrados coloridos – eram apresentados no centro da tela. As condições de teste subdividiam-se em condições laterais congruentes – estímulos posicionados no mesmo lado da tela em que a tecla do computador a ser selecionada para a resposta – e laterais incongruentes – em que os estímulos aparecem no lado da tela oposto ao da tecla a ser selecionada. A diferença de tempo de reação entre as condições congruente e incongruente é chamada de efeito Simon. Os idosos foram agrupados em três grupos: um grupo controle de indivíduos com audição normal; indivíduos com presbiacusia, usuários de próteses auditivas; e indivíduos com presbiacusia não usuários de próteses auditivas. **Resultados:** A análise estatística apontou diferença entre o grupo sem perda auditiva (controle) e o grupo de não usuários de prótese auditiva somente no tempo de reação (TR) na condição controle. Nas demais comparações não foram encontradas diferenças. **Conclusão:** A hipótese levantada não foi corroborada, o que aponta a necessidade de utilização de novos métodos exploratórios de observação dos fenômenos estudados.

Descritores: Envelhecimento; Presbiacusia; Função executiva; Atenção; Implantes cocleares

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