Original Article

Artigo Original

Marcela Lima Silagi[1]
Camila Maia Rabelo[1]
Eliane Schochat[1]
Letícia Lessa Mansur[1]

Effect of education on listening comprehension of sentences on healthy elderly: analysis of number of correct responses and task execution time

Efeito da escolaridade na compreensão auditiva de sentenças em idosos saudáveis: análise do número de acertos e tempo de execução da tarefa

Keywords

Aging
Education
Evaluation
Comprehension
Short-term Memory

ABSTRACT

Purpose: To analyze the effect of education on sentence listening comprehension on cognitively healthy elderly. **Methods:** A total of 111 healthy elderly, aged 60-80 years of both genders were divided into two groups according to educational level: low education (0-8 years of formal education) and high education (≥9 years of formal education). The participants were assessed using the Revised Token Test, an instrument that supports the evaluation of auditory comprehension of orders with different working memory and syntactic complexity demands. The indicators used for performance analysis were the number of correct responses (accuracy analysis) and task execution time (temporal analysis) in the different blocks. **Results:** The low educated group had a lower number of correct responses than the high educated group on all blocks of the test. In the temporal analysis, participants with low education had longer execution time for commands on the first four blocks related to working memory. However, the two groups had similar execution time for blocks more related to syntactic comprehension. **Conclusion:** Education influenced sentence listening comprehension on elderly. Temporal analysis allowed to infer over the relationship between comprehension and other cognitive abilities, and to observe that the low educated elderly did not use effective compensation strategies to improve their performances on the task. Therefore, low educational level, associated with aging, may potentialize the risks for language decline.

Descritores

Envelhecimento
Escolaridade
Avaliação
Compreensão
Memória de Curto Prazo

RESUMO

Objetivo: Analisar o efeito da escolaridade na compreensão auditiva de sentenças em idosos cognitivamente saudáveis. **Método:** Foram avaliados 111 idosos normais, com idades entre 60 e 80 anos, de ambos os gêneros, divididos em dois grupos, de acordo com a escolaridade: baixa escolaridade (0 a 8 anos de ensino formal) e alta escolaridade (9 ou mais anos de ensino formal). Os indivíduos foram examinados por meio do Token Test Revisado, que dá suporte para a avaliação da compreensão auditiva de ordens com diferentes demandas de memória operacional e complexidade sintática. Os indicadores utilizados para análise do desempenho foram números de acertos (análise de acurácia) e tempo de execução da tarefa (análise temporal) nos diferentes blocos. **Resultados:** O grupo de baixa escolaridade apresentou menor número de acertos que o grupo de alta escolaridade em todos os blocos do teste. Na análise temporal, os idosos de baixa escolaridade apresentaram maior tempo para execução das ordens nos primeiros quatro blocos, mais relacionados à memória operacional. Porém, os grupos apresentaram tempo de execução semelhante quanto aos blocos mais relacionados à compreensão sintática. **Conclusão:** A escolaridade influenciou a habilidade de compreensão auditiva de sentenças em indivíduos idosos. A análise temporal permitiu inferir sobre a relação da compreensão com outras habilidades cognitivas e observar que os idosos de baixa escolaridade não utilizam estratégias eficazes de compensação para melhorar o desempenho na tarefa. Portanto, o baixo nível educacional, associado ao envelhecimento, pode potencializar os riscos para o declínio da linguagem.

Correspondence address:
Marcela Lima Silagi
Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional, Faculdade de Medicina – FMUSP, Universidade de São Paulo – USP
Rua Cipotânea, 51, Cidade Universitária, São Paulo (SP), Brazil, CEP: 05360-000
E-mail: marcela_silagi@hotmail.com

Received: November 11, 2016

Accepted: June 21, 2017

Study carried out at Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional, Faculdade de Medicina – FMUSP, Universidade de São Paulo – USP - São Paulo (SP), Brazil.

[1] Departamento de Fisioterapia, Fonoaudiologia e Terapia Ocupacional, Faculdade de Medicina – FMUSP, Universidade de São Paulo – USP - São Paulo (SP), Brazil.

Financial support: This study was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq).

Conflict of interests: nothing to declare.

INTRODUCTION

Language changes in healthy elderly are documented in the literature, where some abilities show major decline whilst others prove more stable during the aging process[1]. A common complaint of elderly is difficulty on listening comprehension, especially involving more complex materials[2]. However, the cognitive causes underlying this difficulty remain unclear.

One of the most widely used tests for assessing listening comprehension is the Token Test, in its original form[3], short version[4] and revised version[5]. Studies of sociodemographic effects on the Token Test have shown the influence of both age and education[6-13]. However, specific studies on the influence of education in the elderly population are scarce[9-11].

The cited studies employed the traditional approach of analyzing performance on the test based on tallying the number of correct responses given by the individual under test. The results of Kim et al.[12] and Silagi et al.[13] showed that temporal analysis of performance, such as response time and command execution time, can be sensitive on detecting the effects of aging and allow observation of aspects underlying the comprehension of language, including attention, memory and executive functions, as well as cognitive reserve mechanisms. However, there are none studies involving temporal analysis of the Token Test and the effect of education on elderly were found in the literature.

Therefore, the objective of the present study was to analyze the effect of education on sentence listening comprehension on cognitively healthy elderly, considering both accuracy and temporal aspects for analysis of performance.

METHODS

Ethics

The study was carried out as part of the project "Envelhecer Mantendo Funções: Idosos do Ano 2020" ("Aging Maintaining Functios: Elderly of 2020"), conducted at the Department of Physical Therapy, Speech Therapy and Occupational Therapy - School of Medicine, University of São Paulo - and the University Hospital - University of São Paulo, Brazil. The study was approved by the Research Ethics Committee of the University Hospital - School of Medicine, University of São Paulo – approval nº. CEP-HU / USP: 1005/10 - SISNEP CAAE: 0034.0.198.000-10. All participants signed the Free and Informed Consent Form after receiving full information about the study procedures.

Participants

The study sample comprised 111 cognitively healthy elderly, aged 60-80 years, of both genders and whose mother language was Brazilian Portuguese. This sample was split into two groups according to educational level: low education (0-8 years of formal education) and high education (≥9 years of formal education). The individuals were assessed between January and June, 2012.

Inclusion criteria

Inclusion criteria were: absence of cognitive complaints or neurological/psychological diseases; absence of recent use of psychoactive drugs; absence of alcoholism and dependency of other illegal drugs; absence of motor, visual and listening deficits; and preserved functionality in everyday life.

Verifying these criteria, individuals also had to attain scores within normal levels for the Brazilian population on the following tests/assessments:

- Mini-Mental State Exam (MMSE)[14,15]: used for global cognitive screening, according to the cut-off scores established for the Brazilian population, namely, 18 points for illiterate individuals, 25 points for individuals with 1-4 years of education, 26 for 5-8 years, 28 for 8-11 years and 29 points for > 11 years of education;
- Geriatric Depression Scale - 15 (GDS-15)[16,17]: used for detecting depressive symptoms. The cut-off score adopted was 5 points;
- Functional Assessment of Communication Skills for Adults (ASHA-FACS)[18,19]: used to establish level of independence or dependence (minimum, moderate and maximum) on the social communication domain. The cut-off score adopted was 6.5 points;
- Audiological assessment: the groups underwent audiological assessments, with hearing thresholds up to 40 dB HL for octave frequencies from 250 to 8000Hz, a symmetrical hearing configuration and similar hearing levels in both ears (i.e. no more than a 10dB difference between the hearing

Chart 1. Examples of the RTT commands in each block

Subtest	Examples	Evaluated ability
1	Touch the black circle	Working (listening) memory - Simple and composite imperative statements that assess the comprehension of color, size and shape.
2	Touch the big green circle	
3	Touch the green square and the black square	
4	Touch the big green square and the little black square	
5	Put the black circle above the white square	Syntactic comprehension - Comprehension of prepositions related to visual-spatial content in the handling of one part (active part) over another (inactive part).
6	Put the big red square in front of the big white circle	
7	Put the black circle to the left of the white square	
8	Put the little green circle to the left of the big red square	
9	Instead of the green square, touch the black square	Syntactic comprehension - Increase in both information as well as linguistic complexity by introducing prepositional phrases, adverbial clauses, compound sentences, combined in heterogeneous commands on many dimensions.
10	Touch the big black square unless you have touched the little red circle	

thresholds of the two ears on each frequency tested). Participants also had to achieve Wave V on the Auditory Brainstem Response (ABR) (difference of up to 0.2ms between ears) and normal P300;

- Ophthalmological and physiotherapeutic assessment: carried out by specialists from the different areas to exclude visual and motor difficulties, which could hamper performance of the test.

Exclusion criteria

Individuals with less than expected scores on the cognitive screening tests, presence of depressive symptoms or other neurological/psychiatric diseases, were excluded. Individuals that failed on listening, visual or motor tests were also ruled out from the sample.

Instrument

The participants were assessed using the Brazilian Portuguese version of the Revised Token Test (RTT)[5], that allows analysis of listening command comprehension, providing a measure of the process of different types of sentences, with different working memory demands, comprehension of specific vocabulary (linguistic elements) and comprehension of syntactic relationships (prepositions, prepositional phrases, conditional adverbial and subordinative conjunctions), as shown in Chart 1. The test comprises 50 commands grouped into 10 blocks. The task entails the handling of different colored pieces (blue, red, white, green and black), shapes (square and circle) and size (large and small).

Procedure

The test was applied according to the recommendation contained in the original manual. Each patient was assessed individually by a speech-hearing language specialist. All commands were given aloud at speech rates considered normal for residents of the city of São Paulo[20], intensity of 60-70dB sound pressure level (SPL) or about 50dB hearing level (HL) and constant prosody when delivering commands.

Data analysis

The following measures were used to analyze performance on the RTT:

1) Number of correct responses (accuracy analysis): 1 (one) point was given for each command carried out correctly. Analysis was based on the sum of correct responses on each block;
2) Task execution time (temporal analysis): time elapsed between delivery of command and complete execution of action (touch or handle the pieces) was timed by chronometer in seconds. The analysis was carried out based on the sum of time taken on each block.

Statistical analysis

For the descriptive analysis, means and standard deviations of all demographic variables, performance on cognitive tests and on the RTT for the two groups were calculated. The distribution of subgroups according to gender was compared by Pearson's Chi-square test. The Mann-Whitney test was used to compare interval variables between the two groups for number of correct responses and task execution time. A 5% level of statistical significance was adopted for all analysis. Analysis were performed using the statistical software program BIOESTAT 5.0[21].

RESULTS

Demographic and cognitive characteristics

The demographic characteristics of the sample and performance on cognitive tests are given in Table 1. The groups differed in educational level, but were not statistically different for age, confirming that the groups were matched and comparable for the variables of interest. No difference in performance by gender was observed. The low education group had lower scores on the MMSE. The groups had similar performance on the GDS and ASHA-FACS.

Performance of groups on RTT

Comparison of the groups for performance on the RTT is given in Table 2. Regarding the analysis of the number of correct responses (accuracy), the low educated group had poorer

Table 1. Demographic and cognitive characteristics of the sample

Variable	Low education Mean (SD)	High education Mean (SD)	*p-value*
Age	68.5 (5.9)	67.7 (5.8)	0.215
Education	4.3 (2.2)	13.3 (3.6)	<0.001*
Gender			
M	17	17	0.068
F	46	31	
MMSE	26.2 (2.4)	28.1 (1.7)	<0.001*
GDS	1.7 (1.5)	1.1 (1.2)	0.057
ASHA-FACS	6.9 (0.2)	6.9 (0.0)	0.130

*Statistical significance
Caption: SD = Standard Deviation; F = Female; M = Male; MMSE = Mini-Mental State Examination; GDS = Geriatric Depression Scale; ASHA-FACS = Functional Assessment of Communication Skills for Adults.

Table 2. Performance of groups on the RTT as measured by number of correct responses and execution time

Block	Number of correct responses			Execution time (seconds)		
	Low education Mean (SD)	High education Mean (SD)	*p-value*	Low education Mean (SD)	High education Mean (SD)	*p-value*
1	4.7 (0.0)	4.9 (0.0)	0.002*	18.0 (3.8)	16.5 (3.7)	0.024*
2	4.6 (0.0)	4.8 (0.0)	0.024*	27.7 (4.4)	21.6 (5.4)	0.021*
3	4.6 (0.0)	4.9 (0.0)	0.009*	32.2 (6.6)	29.6 (8.3)	0.047*
4	4.1 (0.1)	4.7 (0.0)	0.001*	42.1 (11.0)	38.1 (10.2)	0.013*
5	3.5 (1.2)	4.2 (1.0)	<0.001*	54.6 (15.2)	50.9 (11.6)	0.290
6	3.3 (1.3)	3.8 (1.3)	0.048*	62.3 (17.0)	61.7 (23.7)	0.254
7	3.9 (1.2)	4.5 (0.7)	0.003*	49.6 (14.9)	47.4 (12.26)	0.436
8	3.5 (1.3)	4.2 (0.9)	0.001*	57.6 (15.1)	53.4 (11.9)	0.155
9	3.2 (1.4)	3.7 (0.9)	0.004*	47.2 (11.8)	44.7 (9.4)	0.221
10	2.5 (1.5)	3.1(0.7)	0.010*	50.6 (11.3)	50.0 (10.3)	0.767

*Statistical significance
Caption: SD = Standard Deviation

performance than the high educated group on all blocks of the test. In temporal analysis, low educated participants had longer execution time for commands on the first four blocks related to working memory. However, the groups had similar execution time for blocks more related to syntactic comprehension (blocks 5 to 10).

DISCUSSION

The aim of the present study was to determine the effect of education on sentence listening comprehension on elderly, comparing the performance of high and low educated individuals based on the number of correct responses (accuracy analysis) and considering the task execution time (temporal analysis).

Kim et al.[12] used temporal measures to evaluate performance in sentence listening comprehension, allowing qualitative analysis of the cognitive processes underlying this ability. These authors found that the use of this type of measure is sensitive for the detection of difficulties on older individuals, but emphasized that the effect of education has not been studied using this type of analysis.

Our results showed an education effect on all blocks of the test, regarding the number of correct responses (accuracy analysis), and lower educated individuals had poorer performances. In the temporal analysis, the low educated group took more time to perform the orders in blocks 1 to 4, but had similar execution time for blocks 5 to 10.

In general, listening comprehension can be affected on the aging process due to the involvement of linguistic and cognitive aspects, such as semantic and syntactic complexity of sentences, limitations working memory capacity, reduced efficiency of executive functions, difficulties with divided attention and decrease of the overall cognitive processing speed[22,23]. Failures in these cognitive skills that support sentence comprehension are potentialized by low education[24] and may explain the poorer performance of this group, considering the number of correct responses (accuracy analysis).

In the temporal analysis, the issue was: why did the low educated group spend more time to execute the orders in blocks 1 to 4 and had similar performance to the high educated group in blocks 5 to 10?

The RTT version used in this study allows clearer division of the commands into blocks that are more recruited by working memory or more related to syntactic comprehension.

In blocks 1 to 4, the order corresponds to simple and composite imperative statements, simple or coordinated sentences that assess the comprehension of color, size and shape. The length of the stimulus increases gradually, demanding greater recruitment of working memory and practically no recruitment of syntactic comprehension, because the form of the sentences repeats itself. Therefore, these blocks rely more on the effect of temporal processing to provide responses.

In contrast, blocks 5 to 10 require less working memory support and are more related to syntactic comprehension. Blocks 5 to 8 encompass the comprehension of prepositions related to visual-spatial content (above, below, right, left). Blocks 9 and 10 evaluate the comprehension of linguistic complexity by introducing prepositional phrases and adverbial clauses. Although there is an increase on the length of the sentences over the blocks, the need for syntactic comprehension is greater than the demand of working memory.

The fact that less educated patients took more time to perform the orders in blocks 1 to 4 shows that low education is mainly related to worse efficiency in working memory.

Working memory has been identified as one of the most important cognitive functions impacted by aging, while semantic and syntactic linguistic knowledge are more preserved[25]. Elderly individuals may present difficulties with more complex syntactic structures (such as passive, reversible and coordinated sentences)[26], but the syntax required in RTT is simpler (such as space-related adverbial clauses) and related to implicit comprehension systems, which may explain the accomplishment of the task without additional time, even among individuals with lower education. Other studies have confirmed that working memory is impacted by education and it is one of the abilities most strongly associated with cognitive reserve, a recognized compensation mechanism in higher educated elderly individuals[27,28].

Silagi et al.[13] studied a sample of higher educated individuals (mean of 10 years of formal education), in which typical older individuals needed more time to perform the orders in RTT, even though they achieved similar number of correct answers when compared to younger adults, in most blocks of the test. The authors pointed out that typical healthy aging is characterized by the ability to compensate for difficulties in language comprehension. Wingfield and Grossman[29] have discussed the neural compensation strategies that elderly individuals use during sentence comprehension tasks, evidencing plasticity mechanisms.

However, the results of the present study with a lower educated sample (mean of 4.3 years of formal education) showed that this group did not use the strategy of slowing the response to benefit from compensatory strategies, as observed on higher educated elderly.

Considering that sentence comprehension is a predictive ability of the individual's global capacity in terms of functionality[30], it may be suggested that lower levels of schooling represent a situation of vulnerability that should be further studied.

CONCLUSION

There was an education effect on sentences listening comprehension in cognitively normal elderly individuals, considering accuracy and temporal aspects.

Temporal analysis may be useful to detect and elucidate language changes and compensatory strategies. In this study, the poorer performance of the less educated group showed that low educational levels, associated with aging, may potentialize the risks of decline in these abilities.

The results highlight the importance of formal education in cognitive reserve during the aging process, a factor that maintains or reduces the rate of decline of a number of different cognitive abilities.

ACKNOWLEDGEMENTS

Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq). Registro CEP-HU/uSP: *100511* 0 - SISNEP CAAE: 0034.0.198.000-10.

REFERENCES

1. Ska B, Joanette Y. Vieillissement normal et cognition. Med Sci. 2006;22(3):284-7. http://dx.doi.org/10.1051/medsci/2006223284.
2. Wingfield A, Tun PA. Spoken language comprehension in older adults: interactions between sensory and cognitive change in normal aging. Semin Hear. 2001;22(03):287-302. http://dx.doi.org/10.1055/s-2001-15632.
3. Renzi E, Vignolo LA. The Token Test: a sensitive test to detect receptive disturbances in aphasics. Brain. 1962;85(4):665-78. PMid:14026018. http://dx.doi.org/10.1093/brain/85.4.665.
4. De Renzi E, Faglioni P. Development of a shortened version of the Token test. Cortex. 1978;14:41-9. PMid:16295108. http://dx.doi.org/10.1016/S0010-9452(78)80006-9.
5. McNeil MR, Prescott TE. Revised Token Test. Texas: Pro-Ed; 1978
6. Emery OB. Linguistic decrement in normal aging. Lang Commun. 1986;6(1-2):47-64. http://dx.doi.org/10.1016/0271-5309(86)90005-4.
7. Peña-Casanova J, Quiñones-Ubeda S, Gramunt-Fombuena N, Aguilar M, Casas L, Molinuevo JL, et al. Spanish Multicenter Normative Studies (NEURONORMA Project): norms for Boston naming test and token test. Arch Clin Neuropsychol. 2009;24(4):343-54. PMid:19648582. http://dx.doi.org/10.1093/arclin/acp039.
8. Sakellaridou E, Wersching H, Reinholz J, Lohmann H, Knecht S. Comprehension of complex instructions deteriorates with age and vascular morbidity. Age. 2011;33(1):101-6. PMid:20589439. http://dx.doi.org/10.1007/s11357-010-9161-9.
9. Snitz BE, Unverzagt FW, Chang C-CH, Bilt JV, Gao S, Saxton J, et al. Effects of age, gender, education and race on two tests of language ability in community-based older adults. Int Psychogeriatr. 2009;21(6):1051-62. PMid:19586563. http://dx.doi.org/10.1017/S1041610209990214.
10. Carvalho AS, Barreto SM, Guerra HL, Gama ACC. Oral language comprehension assessment among elderly: a population based study in Brazil. Prev Med. 2009;49(6):541-5. PMid:19800364. http://dx.doi.org/10.1016/j.ypmed.2009.09.017.
11. Moreira L, Schlottfeldt CG, Paula JJ, Daniel MT, Paiva A, Cazita V, et al. Normative study of the Token Test (short version): preliminary data for a sample of Brazilian seniors. Rev Psiquiatr Clin. 2011;38(3):97-101. http://dx.doi.org/10.1590/S0101-60832011000300003.
12. Kim H, Sung JE, Kim JW, Park EJ, Yoon JH, Yoo HJ, et al. Response time measurements in the iOS app-based TokenTest, the Brief Token Test in the elderly. Geriatr Gerontol Int. 2014;14(4):969-74. PMid:24261469. http://dx.doi.org/10.1111/ggi.12182.
13. Silagi ML, Rabelo CM, Schochat E, Mansur LL. Healthy aging and compensation of sentence comprehension auditory deficits. BioMed Res Int. 2015;2015:640657. PMid:26605334.
14. Folstein MF, Folstein SE, McHugh PR. Mini-mental state: a practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res. 1975;12(3):189-98. PMid:1202204. http://dx.doi.org/10.1016/0022-3956(75)90026-6.
15. Brucki SMD, Nitrini R, Caramelli P, Bertolucci PHF, Okamoto IH. Sugestões para o uso do mini-exame do estado mental no Brasil. Arq Neuropsiquiatr. 2003;61(3B):777-81. PMid:14595482. http://dx.doi.org/10.1590/S0004-282X2003000500014.
16. Sheikh JI, Yesavage JA. Geriatric Depression Scale (GDS): recent evidence and development of a shorter version. In: Brink TL, editor. Clinical gerontology: a guide to assessment and intervention. New York: The Haworth Press; 1986. p. 165-73.
17. Almeida OP, Almeida AS. Reliability of the Brazilian version of the ++abbreviated form of Geriatric Depression Scale (GDS) short form. Arq Neuropsiquiatr. 1999;57(2B):421-6. PMid:10450349. http://dx.doi.org/10.1590/S0004-282X1999000300013.
18. Fratalli C, Thompson C, Holland A, Wohl C, Ferketic M. Functional Assessment of Communication Skills for Adults (ASHA FACS). Rockville: American Speech-Language-Hearing Association; 1995.
19. Carvalho IA, Mansur LL. Validation of ASHA FACS-functional assessment of communication skills for Alzheimer disease population. Alzheimer Dis Assoc Disord. 2008;22(4):375-81. PMid:19068501. http://dx.doi.org/10.1097/WAD.0b013e31818809b2.
20. Martins VO, Andrade CRF. Speech fluency developmental profile in brazilian Portuguese speakers. Pró-Fono R. Atual. Cient. 2008;20(1):7-12. http://dx.doi.org/10.1590/S0104-56872008000100002.
21. Ayres M, Ayres M Jr, Ayres DL, Santos AS. Bioestat 5.0: aplicações estatísticas nas áreas das ciências biomédicas. Belém: ONG Mamiraua; 2007. 364 p.
22. Caplan D, Waters G. The relationship between age, processing speed, working memory capacity, and language comprehension. Memory. 2005;13(3-4):403-13. PMid:15952262. http://dx.doi.org/10.1080/09658210344000459.
23. Yoon J, Campanelli L, Goral M, Marton K, Eichorn N, Obler LK. The effect of plausibility on sentence comprehension among older adults and its relation to cognitive functions. Exp Aging Res. 2015;41(3):272-302. PMid:25978447. http://dx.doi.org/10.1080/0361073X.2015.1021646.

24. López-Higes S R, Valdehita SR, Aragoneses MTM, Del Río D. Interindividual variability in vocabulary, sentence comprehension and working memory in the elderly: effects of cognitive deterioration. Span J Psychol. 2010;13(1):75-87. PMid:20480679. http://dx.doi.org/10.1017/S1138741600003681.

25. Tyler LK, Shafto MA, Randall B, Wright P, Marslen-Wilson WD, Stamatakis EA. Preserving syntactic processing across the adult life span: the modulation of the frontotemporal language system in the context of age-related atrophy. Cereb Cortex. 2010;20(2):352-64. PMid:19505991. http://dx.doi.org/10.1093/cercor/bhp105.

26. Caplan D, Dede G, Waters G, Michaud J, Tripodis Y. Effects of age, speed of processing, and working memory on comprehension of sentences with relative clauses. Psychol Aging. 2011;26(2):439-50. PMid:21480714. http://dx.doi.org/10.1037/a0021837.

27. Jefferson AL, Gibbons LE, Rentz DM, Carvalho JO, Manly J, Bennett DA, et al. A life course model of cognitive activities, socioeconomic status, education, reading ability, and cognition. J Am Geriatr Soc. 2011;59(8):1403-11. PMid:21797830. http://dx.doi.org/10.1111/j.1532-5415.2011.03499.x.

28. Lopez-Higes R, Rubio-Valdehita S, Prados JM, Galindo M. Cognitive reserve and linguistic skills in healthy elderly persons. Rev Neurol. 2013;57(3):97-102. PMid:23881613.

29. Wingfield A, Grossman M. Language and the aging brain: patterns of neural compensation revealed by functional brain imaging. J Neurophysiol. 2006;96(6):2830-9. PMid:17110737. http://dx.doi.org/10.1152/jn.00628.2006.

30. Pichora-Fuller MK, Singh G. Effects of age on auditory and cognitive processing: implications for hearing aid fitting and audiologic rehabilitation. Trends Amplif. 2006;10(1):29-59. PMid:16528429. http://dx.doi.org/10.1177/108471380601000103.

Author contributions

MLS participated in the data collection, analysis and article writing; CMR participated in the data collection; ES participated in the study design; LLM participated in the study design, analysis, interpretation and revision of the final version of the article.