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Original Article

Artigo Original

Phonological and semantic verbal fluency: a comparative study in hearing-impaired and normal-hearing people

Fluência verbal semântica e fonológica: estudo comparativo em deficientes auditivos e ouvintes

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Keywords

Hearing aids
Cognition
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ABSTRACT

Purpose: To compare the performance of hearing-impaired and normal-hearing people on phonologic and semantic verbal fluency tests. **Methods:** A cross-sectional study was conducted with 48 hearing-impaired adults and 42 individuals (control group) with no hearing or language complaints. Sociodemographic data were collected, as well as the characteristics of hearing loss and of the electronic auditory device (hearing aids or cochlear implant), when relevant. Verbal fluency was tested in two different tasks: by semantic category (animals) and by phonology (letter F). **Results:** Educational level has influenced the results of fluency tests in both groups, with more evidence in the hearing-impaired subjects ($p<0.001$). Hearing-impaired subjects showed worse performance in verbal fluency tests when compared to normal-hearing people in groups with up to 10 years of schooling. In the comparison of performance in the two tests, both groups showed better results in the semantic fluency task. **Conclusion:** The hearing-impaired subjects with low educational level evoked fewer words in semantic and phonologic verbal fluency tests in comparison to normal-hearing subjects. Educational level is a relevant issue to the study of verbal fluency in deaf and hearing-impaired people.

Descritores

Auxiliares de Audição
Cognição
Perda Auditiva
Testes de Linguagem
Fonoaudiologia

RESUMO

Objetivo: Comparar o desempenho de deficientes auditivos e ouvintes nas provas de fluência verbal semântica e fonológica. **Métodos:** Realizou-se um estudo transversal com 48 indivíduos adultos deficientes auditivos e 42 indivíduos (grupo comparação) sem queixas de audição e/ou linguagem. Foram levantados dados sociodemográficos e as características da perda auditiva e do dispositivo auditivo eletrônico (aparelho de amplificação sonora individual ou implante coclear), quando pertinente. Aplicaram-se os testes de fluência verbal por pista semântica (categoria animais) e fonológica (letra F). **Resultados:** A escolaridade influenciou os resultados das provas nos dois grupos, sendo mais evidente nos deficientes auditivos ($p<0,001$). Os deficientes auditivos apresentaram pior desempenho nas provas de fluência verbal em comparação aos ouvintes nos grupos com até dez anos de escolaridade. Na comparação do desempenho nos dois testes, os dois grupos apresentaram melhores resultados na fluência verbal semântica. **Conclusão:** Os deficientes auditivos de menor escolaridade evocaram um número inferior de palavras pela pista semântica e fonológica em relação aos ouvintes. O nível de escolaridade é relevante para o estudo de fluência verbal em deficientes auditivos.

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INTRODUCTION

Language forms the variable content of our experiences, which makes the vivid world real. It is the symbolic process that conveys meaning to things, allowing interpersonal communication.

A specific language, in turn, is the communication medium that allows the expression of language. It consists of an organized system of linguistic symbols — words — and rules for combining them[1]. Phonological, morphological, syntactic, and semantic processes allow the equilibrium between form, content, and use, giving functionality to the language[2].

Every human being has a mental lexicon of the language, which is accessed when you want to represent, by means of words, a certain object, or action. The access to the name of an object depends on phonological skills, especially memory. Language acquisition, in turn, is related to the ability to understand and produce various kinds of meanings[3].

A relationship exists between learning vocabulary and categorizing it in the lexicon, because categorization requires the existence of mental representations of meaning, which are mapped to form lexical items, supported by linguistic labels that provide additional signals[4].

In this respect, tests such as the verbal fluency test can provide information about the storage capacity of the memory system, the ability to retrieve the stored information, the ability to organize thinking, and the strategies used to search for words[5].

Lexicon and vocabulary are part of every language, whether oral or gestural. Socially, however, the spoken language is the primary form of communication used in interaction, and hearing is the basis for oral communication.

The perception of speech sounds includes several aspects, such as reception and interpretation of speech patterns, discrimination between sounds, recognition, memorization, and comprehension of speech units within a given linguistic system.

In the hearing-impaired people, limited opportunities to hear information deprive them of experiencing things, causing negative effects on vocabulary acquisition[6]. Thus, their language production, in general, is simple and based on what is concrete[7].

People with hearing disabilities have more difficulty acquiring the lexicon and updating it with routine vocabulary, hence the greater difficulty to access words stored in memory.

Given the importance of these facts, the aim of this study was to compare the performance of hearing-impaired and normal-hearing people on phonological verbal fluency (PVF) and semantic verbal fluency (SVF) tests.

METHODS

This study was approved by the Research Ethics Committee of the Universidade Federal de São Paulo (UNIFESP), under protocol number 1366/11, and all participants signed a free and informed consent form.

It is a cross-sectional study, whose study group (here called hearing-impaired group, HIG) was composed of 48 hearing-impaired adults, aged between 18 and 60 years (Mean=42.8; standard deviation, SD=12.9). All patients were from the Center for the Hearing Impaired, Universidade Federal de São Paulo (CDA-UNIFESP).

The participants were recruited by convenience sampling by the researchers during their annual monitoring in that Center, from November 2011 to November 2012. All patients who had appointments at the Center went through a preselection by analysis of medical records, and those who met the inclusion criteria of this study were invited to participate. Inclusion criteria for the HIG were the following: having had a hearing loss diagnosis, obtained through audiological exam, and using oral language to communicate, with domain of the routine vocabulary. Hearing-impaired people with preferred daily use of the Brazilian Sign Language (LIBRAS) were excluded from the study.

A comparison group (CG) comprised 42 subjects with normal hearing and no complaints or indications of changes in the development of speech and language, with age range similar to that of HIG (Mean=37.6; SD=12.6; p=0.057).

For the exclusion of cognitive impairments that could influence the results of this study and for standardization of the sample, all participants (CG and HIG) responded to the Mini-Mental State Examination test[8]. Of the initial total subjects included, six hearing-impaired and five normal-hearing subjects were excluded for not reaching the cutoff scores of the test, according to the recommendations of the Brazilian Academy of Neurology[9], resulting in the sample shown earlier.

Verbal fluency was assessed in two categories: semantic and phonological. The SVF was analyzed through elocution, in 1 min, with words of the "animal" semantic class. This category is the most widely used in this test, and it is highly sensitive for the evaluation of access and semantic organization of the mental lexicon[10]. Participants received the following instruction: "Tell me as many animals as you can remember, any kind of animal is valid," and the time was recorded by the researcher.

The PVF was evaluated after the first test, by the utterance of words beginning with the letter "F" in 1 min. This phoneme has been selected by its frequency of occurrence in Brazilian Portuguese, being part of the Phonemic Fluency Test (FAS), which also uses the letters "A" and "S"[11]. In this evaluation, participants were given the following instruction: "Tell me as many words as you know that begin with the letter F, every word is valid".

Both tests were timed with a common clock, and the emission was registered using a recorder, in an audio file, for later analysis and transcription by the researchers.

Furthermore, the characteristics of the study population, such as age, gender, education, type and degree of hearing impairment, age of onset, time of sensory deprivation, and use of an electronic hearing device (hearing-aid device or cochlear implant (CI)), when relevant, were collected with a questionnaire with closed questions.

The correlation analysis was done between the following variables: age, education, and characteristics of hearing loss and auditory electronic device, with performance on verbal fluency tests, by analysis of variance and Pearson correlation. As for the comparison between tests, after pairing the subjects, a paired Student's *t*-test was adopted. The analysis of the distribution of the sample by gender, use of hearing-aid devices/CI, degree and type of hearing loss was also performed, by testing the equality of two proportions. The level of significance was set at 0.05, with confidence intervals of 95% (95%CI).

RESULTS

In the sample studied, there was a prevalence of male subjects in the HIG (54.2%) and a higher proportion of female subjects (54.2%) in the CG.

The characteristics of hearing loss and auditory electronic device used by the HIG are given in Table 1. The average age of hearing loss was 27.6 years (SD=17.2 years) and the age of adaptation of hearing aids or CI was 32.8 years (SD=14.9 years), indicating that most of the subjects lost their hearing during adulthood, although there is great variability in the data (coefficient of variation: 62% and 45%, respectively).

The characteristics of age and schooling and their comparison between groups are given in Table 2. The relationship between education level and performance on verbal fluency tests is given in Table 3, for each group studied.

Observing the difference between groups for education (Table 2) and considering the influence of this factor on test performance, for both HIG and CG (Table 3), the groups were categorized into two educational ranges, defined by the value of median: ≤10 and ≥11 years of study.

A comparison between the performances of the HIG and the CG in PVF and SVF tests is shown in Graph 1, considering the educational ranges described. There is difference in the mean words spoken between groups for both SVF (p=0.003) and PVF (p=0.011) only in up to 10 years of education, with no difference for those with 11 or more years of education (p=0.558 for SVF and p=0.894 for PVF).

Table 1. Audiological characteristics of the hearing-impaired group

Audiological characteristics	n	%
Degree of hearing loss		
Mild	6	12.5
Moderate	20	41.7
Severe	8	16.7
Deep	14	29.2
Type of hearing impairment		
Sensorineural	38	79.2
Mixed	10	20.8
Hearing aid/cochlear Implant		
None	23	47.9
Unilateral hearing aid	5	10.4
Bilateral hearing aids	16	33.3
Cochlear implant	4	8.3

Table 2. Comparison of groups of hearing-impaired and normal-hearing people regarding age and education

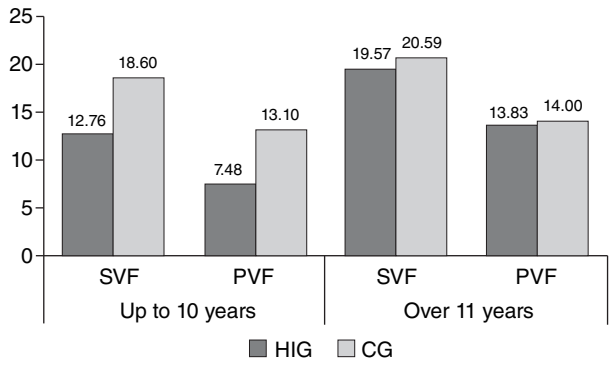
Variables	Mean	Median	Standard deviation	p-value
Age				
HIG	42.85	47	12.91	0.057
CG	37.64	39.5	12.60	
Education				
HIG	8.85	10	4.66	0.013*
CG	11.05	11	3.36	

*Statistically significant value: p<0.05. ANOVA test.
Caption: HIG = hearing-impaired group; CG = normal-hearing group (comparison roup)

Table 3. Correlation between education level and the verbal fluency tests, by group

	Education	
	% of correlation	p-value
CG		
Semantic fluency	35.0	0.023*
Phonological fluency	29.9	0.054
HIG		
Semantic fluency	55.0	<0.001*
Phonological fluency	58.8	<0.001*

*Statistically significant value (p<0.05). Pearson's correlation test
Caption: HIG = hearing-impaired group; CG = normal-hearing group (comparison group)



Caption: SVF = semantic verbal fluency; PVF = phonological verbal fluency; HIG = hearing-impaired group; CG = comparison group
Graph 1. Comparison of groups by level of education in mean words in semantic and phonological verbal fluency tests

It is noteworthy that, in both groups, a greater number of words was evoked in the SVF test than in the PVF tests, with differences between tests (p<0.001).

The degree and type of hearing loss, as well as the fact that patients use hearing aids or CI or the time of acquisition of the electronic hearing device, did not correlate with performance on verbal fluency tests, even when categorized by educational level (Table 4).

Table 4. Correlation between type and degree of hearing loss, use and age of acquisition of electronic hearing device, and the results on verbal fluency tests in the study group

Variables	Semantic verbal fluency				Phonological verbal fluency			
	Mean	Median	Standard deviation	p-value	Mean	Median	Standard deviation	p-value
Degree of hearing loss								
Mild	18.00	17.5	5.76		11.17	10.5	7.47	
Moderate	16.10	15.5	6.77	0.734	11.05	9.5	6.05	0.596
Severe	14.00	13.0	6.78		7.75	4.5	7.92	
Deep	16.21	16.0	6.74		11.07	11.0	4.70	
Type of hearing impairment								
Sensorineural	16.61	16.5	6.59	0.231	10.61	10.0	6.25	0.855
Mixed	13.80	12.0	6.14		10.20	9.5	6.03	
Electronic hearing device								
None	15.87	15.0	6.90		10.00	9.0	6.32	
Unilateral hearing aid	16.40	18.0	4.83	0.998	10.40	8.0	5.98	0.948
Bilateral hearing aids	16.06	14.5	7.18		11.13	10.0	6.98	
Cochlear implant	16.25	16.5	5.50		11.25	11.0	1.26	
	Correlation		p-value		Correlation		p-value	
Time of acquisition of the EHD	-31.5%		0.165		-23.0%		0.315	

Pearson's correlation test

Caption: EHD = electronic hearing device

The age of onset of hearing loss showed a slight negative correlation (-30.9%) with the results of the PVF test (p=0.032).

DISCUSSION

The verbal fluency test aims to assess the ability of lexical storage and provides information about the recovery of information and processing of executive functions. Thus, it has been used for cognitive screening and aid in diagnosis for various diseases, such as attention deficit hyperactivity disorder, Parkinson's disease, schizophrenia, cognitive impairment, and bipolar disorder[12-16]. No reports are available about the application of this test in the hearing-impaired individuals, or about the possible variables that affect the performance of these cases.

The main findings of this study show education as a determinant in the SVF and PVF tests in hearing-impaired and normal-hearing people. In the comparison between groups (HIG and CG), the HIG showed poorer performance on tests when considering up to 10 years of education.

The relationship between education and the number of words evoked in verbal fluency tasks has been broadly studied, being shown in healthy normal-hearing individuals, in the elderly, and in subjects with various pathologies[5,10,11,17-19].

The best performance in normal-hearing individuals in relation to the hearing-impaired people would be expected due to the greater difficulty of the former in acquiring and updating the lexical and the reduction in the number of auditory experiences, which is reflected in a reduced vocabulary[6]. However, considering the characteristics of the study sample, composed of hearing-impaired individuals since early adulthood, which thus secured an acquisition and development of language that is analogous to the CG, similar results in language tests can be expected when there are higher educational levels.

The contrast observed between the two groups only for subjects with up to 10 years of education indicates that higher levels of education serve as a protective factor that ensures a greater number of linguistic experiences and contexts, allowing the maintenance of lexical and phonological organization, before and after hearing loss. The educational level has been shown, in another study, as the factor that provides greater cognitive and memory reserve during adulthood[20].

Comparing the evidence, it was observed that both groups achieved a better performance in the semantic category ("animals") compared to the phonological test ("F"), which is in line with the findings of the other studies conducted in healthy individuals[18,21]. Although the PVF test allows a greater amount of words to be evoked, the SVF category follows a hierarchical organization in memory, having subcategories ("farm animals," "pets," "marine animals," "land animals," among others) and enabling a greater range of responses[22]. The literature states that, even in the phonological tasks, there is a tendency for word generation in streams, often generated by semantic relations[19].

In contrast, studies of verbal fluency in diseases such as Alzheimer's disease and schizophrenia[14,15,23] showed better results in phonological fluency in comparison to semantic fluency. The authors relate these findings to the degradation of semantic memory caused by the disease, which does not occur in hearing impairment. The SVF seems to be more related to semantic memory, whereas the PVF to the executive control.

To determine how the audiological data could influence the results of the verbal fluency tasks, the performance of the HIG was related to the characteristics of the hearing loss and of the auditory electronic device used (hearing aid or CI).

No differences were found in the number of words evoked among the different degrees of loss, though a better performance was expected of individuals with mild/moderate hearing impairment. A mild hearing impairment enables the perception of some consonants and vowels, being less inhibitive than other degrees[24]. In this study, the small number of subjects with this degree of hearing loss associated with age of acquisition of hearing impairment may have contributed to this lack of correlation.

Regarding the use of an electronic hearing device and the type of resource used (unilateral or bilateral hearing aids and CI), no difference in performance was observed in the tests, because all individuals have mastered the routine of linguistic activity.

From all the data presented, we believe that the results of this study provide indications of the behavior of the hearing-impaired population in verbal fluency tests, which has been little studied in our field. It is important to propose studies with more extensive populations, and which include other biosocial factors to strengthen the role of this test in the clinical context with the hearing-impaired subject.

CONCLUSION

The hearing-impaired people, with up to 10 years of education, evoke fewer words in semantic and phonological tests in comparison to normal-hearing people. Thus, education positively influences the performance on the PVF and SVF tests in the hearing impaired. Both groups achieved a better performance in the SVF test than in the PVF test.

**IMMS and JSCC drafted the project, collected the data, and revised the manuscript; ADS and LNO participated in the data collection, drafting, and revision of the manuscript; BMC guided all stages of this study.*

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