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Original Article
Artigo Original

Bilingualism and speech recognition in silence and noise in adults

Bilinguismo e reconhecimento de fala no silêncio e no ruído em adultos

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Keywords

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ABSTRACT

Purpose: To compare the ability to recognize sentences in silence and in noise in monolingual normal-hearing Brazilian Portuguese speakers, and bilingual speakers of Brazilian Portuguese and German, and bilingual speakers of Brazilian Portuguese and Italian, as well as to analyze the influence of age of second language acquisition on the performance of bilinguals. **Methods**: 87 normal-hearing individuals aged between 18 and 55 years participated of this research. They were categorized into: Control Group, composed by 30 monolingual Brazilian Portuguese speakers; German Research Group, 31 simultaneous bilingual native speakers of Portuguese and speakers of German as a second language and; Italian Research Group, consisting of 26 successive bilinguals, native speakers of Portuguese and speakers of Italian as a second language. The Sentence List Test in Brazilian Portuguese was used to measure their Sentence Recognition Thresholds in Silence and Noise. **Results**: In silence, there were no statistically significant differences in performance when comparing the bilingual to the monolingual individuals, and when comparing the bilingual speakers among themselves. On the other hand, in noise, there was a significant difference between the bilingual groups and the monolingual one. However, there were no significant differences between the bilingual groups when their performance was compared. **Conclusion**: Bilingualism positively influenced the development of language and listening skills, which led the bilinguals to outperform in speech recognition in the presence of noise. Also, the period of a second language acquisition did not influence bilingual performance.

Descritores

Bilinguismo
Adulto
Testes Auditivos
Percepção da Fala
Testes de Discriminação da Fala

RESUMO

Objetivo: Comparar a habilidade de reconhecimento de sentenças no silêncio e no ruído em indivíduos normo-ouvintes monolíngues, falantes do português brasileiro e, bilíngues, falantes do português brasileiro e do alemão, e do português brasileiro e italiano, bem como analisar a influência do período de aquisição da segunda língua no desempenho dos bilíngues. **Método**: Participaram da pesquisa 87 indivíduos entre a faixa etária de 18 e 55 anos de idade, normo-ouvintes, os quais foram distribuídos em: grupo controle, composto de 30 monolíngues falantes do português brasileiro; grupo estudo alemão, 31 bilíngues simultâneos falantes do português e do alemão como segunda língua; grupo estudo italiano, formado por 26 bilíngues sucessivos, falantes do português e do italiano como segunda língua. Por meio do teste Listas de Sentenças em Português Brasileiro, foram obtidos seus Limiares de Reconhecimento de Sentenças no Silêncio e no Ruído. **Resultados**: No silêncio, não houve diferenças estatisticamente significantes de desempenho tanto quando comparados os indivíduos bilíngues e monolíngues como quando comparados os grupos bilíngues. Por sua vez, no ruído, verificou-se diferença significante entre os grupos bilíngues, em relação ao monolíngue. Entretanto, quando comparado o desempenho dos grupos bilíngues, não se observou diferença significante entre eles. **Conclusão**: O bilinguismo influenciou positivamente o desenvolvimento de habilidades auditivas, que repercutiram em desempenhos superiores dos bilíngues no reconhecimento de fala na presença de ruído, e o período de aquisição da segunda língua não influenciou o desempenho dos bilíngues.

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INTRODUCTION

The increase in the number of bilingual speakers is a worldwide phenomenon that largely stems from globalization and immigration, leading to ever stronger social and cultural changes that require people to learn more foreign languages because they are exposed to diversity. According to previous research data[1], there are currently 7,097 living languages. Among them, about 200 languages are spoken in Brazil, and they are called minority languages because they are not the country's official language[1,2]. In the state of Rio Grande do Sul, the presence of communities with speakers of immigrant minority languages - especially German and Italian - can be said to be quite significant.

Bilingualism can be considered to be a complex multidimensional phenomenon involving linguistic, psychological and sociocultural aspects[3]. A bilingual individual is the one who has the ability to use two languages in social interactions, without necessarily having the same level of proficiency in them or equal performance at all language levels[3].

The author further states that the definition of bilingualism should take into account the function and use of languages, as well as code switching - i.e., how and how often and under which conditions an individual switches from one language to another - as well as interference between languages.

Much has been said in recent years about the linguistic effects of bilingualism and the shift towards a more positive approach to these effects, especially the intellectual benefits. Such an approach, seen today as a "turning point" in research in different fields, began in the 1960s, when a study was conducted[4] about the effects of bilingualism on intellectual functioning. This study had great impact on fields such as psychology, neuroscience, education, language and speech therapy, among others. Based on findings of previous research conducted at the time, the authors assumed that both monolinguals and bilinguals that were going to be tested would achieve the same scores on nonverbal cognitive measures, while bilinguals were expected to perform better on verbal measures. However, contrary to previous evidence, this study found significantly better performance of bilinguals compared to that of monolinguals on verbal and nonverbal intelligence tests, thus demonstrating the benefits of bilingualism[4].

Considering the linguistic aspects, previous studies have shown that bilingual individuals had an advantage over monolingual individuals in tasks with linguistic stimuli[5-8]. This occurs in tasks in which interference needs to be suppressed for effective processing of the target stimulus, thus evidencing the advantage of bilingual speakers in inhibitory control tasks[9].

During the last decade, there has been a remarkable increase in the amount of research addressing language and cognitive processing of bilingual speakers[10]. However, from the perspective of the auditory system and the influence on auditory skills, the number of studies is still small. Previous studies have shown that exposure to two different languages can benefit the development of a person's auditory system[6-11,12]. This is because such person faces situations in which his or her mother tongue promotes a linguistic context that makes information processing faster and more effective[12,13].

The literature has shown that bilinguals perform better than monolinguals in verbal stimulus tasks presented in conflicting situations, e.g., dichotic listening[6-12]. However, when faced with noise and reverberation, this fact is not evidenced. In terms of speech recognition, previous research has reported that bilingual individuals performed similarly to monolinguals when performing tasks in silence; however, in unfavorable listening conditions (noise), bilinguals had more difficulty compared to monolinguals[14-16].

As a determinant for learning a second language, the age factor is subject of controversy[17-19]. References can be found in the literature for various critical periods, each based on a specific language component, including phonological development[17].

Based on this period, bilingualism can be divided into early acquisition, in which both languages are learned simultaneously since early childhood, and late or sequential childhood, in which the second language is acquired after the critical period. Different authors have reported advantages in simultaneous compared to sequential learning of a second language[20].

Considering the above-mentioned scenario, and in order to identify the contribution of bilingualism to the development and improvement of auditory skills, this research was aimed at investigating and comparing the ability to recognize sentences in silence and in noise of monolingual normal-hearing speakers of Brazilian Portuguese, and bilingual normal-hearing speakers of Brazilian Portuguese and German, as well as Brazilian Portuguese and Italian. Another goal was to analyze the influence of the second language acquisition period on the performance of the bilingual speakers.

METHODS

This quantitative, descriptive and cross-sectional observational study was approved by the Research Ethics Committee, Federal University of Rio Grande do Sul, protocol number 0098.0.243.000-11. The participants were informed about the objectives and procedures to be performed. After they agreed to voluntarily participate in the research, they signed an informed consent form.

These were the criteria for inclusion of participants in the sample: male and female adults, aged between 18 and 59 years, with normal hearing, with thresholds less than or equal to 25 dBHL (decibel hearing level), in the frequency range from 250 to 8,000 Hz, with a high school diploma. Based on these criteria, 30 monolingual speakers of Brazilian Portuguese and 57 bilingual speakers of Brazilian Portuguese /German, and Brazilian Portuguese/Italian. The bilingual individuals were invited to participate by telephone and email. Contact information was provided by associations of German and Italian descendants.

To enable a comparative analysis between these individuals, they were divided into three groups, according to the following criteria: control group (CG): monolingual normal-hearing speakers

of Brazilian Portuguese, with no oral fluency or comprehension of any other foreign language, with a high school diploma. German study group (GSG): bilingual normal-hearing speakers of Brazilian Portuguese as their mother tongue and German as their second language (which they learned before the age of 6), with a high school diploma. Italian Study Group (ISG): bilingual normal-hearing speakers of Brazilian Portuguese as their mother tongue and Italian as their second language (which they learned between the ages of 6 and 19), with a high school diploma.

The criterion for determining the critical period for second language acquisition was phonological[17]; it establishes the age of 6 years, approximately, for SLA development, thus defining the groups of simultaneous (GSG) and successive (ISG) speakers. This criterion was taken into account because it is important in the learning process of a second language. The reason is that, in the case of simultaneous learning, it allows a person to be able to spontaneously identify the phonological differences between the languages and, in the cases of successive learning, phonological knowledge of the mother tongue is used to compare/facilitate the learning of the second language.

These were the exclusion criteria: evident neurological disorders; presence of earwax or other changes in the external acoustic meatus; audiological disorders; inability or difficulty to answer the test or memorize the sentence of the Sentence List Test in Portuguese. For the study groups, another criterion was no proficiency in the second language.

Based on the criteria mentioned above, the individuals were organized as follows: CG: 30 female and male monolinguals, aged between 20 and 52 years old; GSG: 31 simultaneous female and male bilinguals, aged between 18 and 55; ISG: 26 successive female and male bilinguals, aged between 18 and 50 years.

Firstly, information on personal data, level of education, otological history and hearing complaints were collected through a medical history interview. Then, in order to determine language fluency and establish criteria to distinguish bilingual from monolingual speakers, a specific questionnaire was applied, with questions about bilingualism. The questionnaire was designed to collect information about first and second language acquisition, such as age, form and context of second language acquisition, as well as daily situations and time spent when using the second language. Finally, there were also questions about the self-assessment of their performance in language skills such as speaking, comprehension, reading and writing. These questions were designed according to the aspects proposed in the literature[3] to define bilingual speakers of German and Italian based on the eligibility criteria mentioned above.

Subsequently, they were submitted to the following evaluations: visual inspection of the external acoustic meatus, Pure Tone Audiometry (PTA) and Speech Audiometry. Then, the Sentence Recognition Threshold in Silence (SRTS) and in Noise (SRTN) were measured using the Portuguese Sentence Lists Test (PSL)[21]. It consists of a list of 25 sentences and seven lists of ten sentences and speech-spectrum noise. The sentences and the noise are recorded on a CD, in independent channels, allowing their presentation in both silence and noise[22].

The subjects were assessed in a soundproof booth using a two-channel Fonix Hearing Evaluator FA 12 I digital audiometer and a TDH-39P Telephonics earphones. The sentences were presented using a Toshiba 4149 Digital Compact Disc Player, fitted to the audiometer.

The PSL test was applied in a sound field, with the individual positioned one meter away from the sound source, facing it at an azimuth angle of 0º to 0º. First, a training session was conducted to help the subjects to familiarize with the test and determine the approximate SRTS, by presenting the first five sentences of list 1A. Then, based on this measure, a list with ten sentences was applied. To determine the thresholds, the procedure called "ascending-descending" was used, which allows the determination of the speech recognition threshold, i.e., the level required for a person to correctly identify around 50% of the speech stimuli presented in a certain condition (silence or noise). The first sentence was presented, using as a reference the speech recognition threshold measured with the earphone in the subject's best ear. Then, when the speech stimulus was correctly recognized, the stimulus level was decreased or increased[21], depending on the case. This procedure was repeated until the end of the sentence list, initially using 5 dB intervals and then 2.5 dB, after the first change in the patient's response pattern. This procedure was used for sentence recognition measures both in silence and in noise, according to the availability of intervals of the equipment being used.

The same procedure was used to measure SRSN, but in the presence of competitive noise that was kept constant at 65 dB SPL (A)[21]. SRSN was expressed through the S/R ratio, which represents the difference between the average intensity of sentence presentation and noise. Therefore, for calculation of the S/R ratio, the calculated mean speech intensity was subtracted from the noise intensity (65 dB HL)[21].

Data were analyzed using descriptive statistics and treated statistically using the software Statistic version 9.1. The Shapiro-Wilk test was applied to check the normality of the variables. To compare the performance of monolingual (GC) and bilingual (GEA) and (GEI) speakers, as well as the performance between bilingual groups, the SRSN and S/N variables and the independent variables were used when these variables presented normal distribution (T-Test). For independent groups, the Mann-Whitney U Test was used for the variables without normal distribution. The statistical significance level was set at $p < 0.05$ (5%).

RESULTS

Similar performance was found when comparing monolingual (CG) and bilingual speakers of German (GSG) and Italian (ISG) in speech recognition in silence, while for the measurements collected in the presence of noise, there was a significant difference between monolingual (GC) and bilingual groups (Table 1).

There was no difference between simultaneous bilinguals (GSG) and successive bilinguals (ISG) in silent and in noise speech recognition tasks (Table 2).

Table 1. Comparison of performance in sentence recognition in silence and noise between monolinguals (CG) and bilingual speakers of German (GSG) and between monolinguals (CG) and bilingual speakers of Italian (ISG) assessed in sound-field conditions

	CG (n = 30)		GSG (n = 31)			ISG (n = 26)		
	Mean	SD	Mean	SD	*p-value*	Mean	SD	*p-value*
SRTS	20.05	3.98	19.76	4.43	0.785	19.22	3.08	0.387
S/N	-11.89	1.84	-13.31	2.16	0.014*	-13.39	2.20	0.001*

Student's t-test (SRTS); Mann-Whitney U Test (S/R); *: statistically significant value
Caption: CG: monolingual control group; n: number of individuals; GSG: German Study Group; ISG: Italian Study Group; SRTS: sentence recognition threshold in silence; S/R: signal-to-noise ratio; SD: standard deviation

Table 2. Comparison of sentence recognition performance in silence and noise between normal-hearing bilingual speakers of German (GSG) and Italian (ISG) assessed in sound-field conditions

	GSG (n = 31)		ISG (n = 26)		
	Mean	SD	Mean	SD	*p-value*
SRTS	19.76	4.43	19.22	3.08	0.600
S/N	-13.31	2.16	-13.39	2.20	0.619

Student's t-test (SRTS); Mann-Whitney U test (S / R)
Caption: GSG: German Study Group; n: number of individuals; ISG: Italian Study Group; SD: standard deviation; SRTS: sentence recognition threshold in silence; S/N: signal-to-noise ratio

DISCUSSION

Previous studies have shown positive effects on cognitive control, language[8,9-23] and the auditory system of individuals exposed to two different languages[6-11,12]. Therefore, understanding speech recognition performance of bilinguals in different acoustic situations is extremely important to shed light on the influence of second language acquisition on the auditory system.

Therefore, the influence of bilingualism on performance in SRTS was investigated, and no statistically significant difference was found in the performance of bilinguals (GSG and ISG) in comparison to monolinguals (CG), when they were evaluated in silence (Table 1). Thus, it was evident that bilinguals did not differ from monolinguals when the main aspect evaluated was related to audibility, since all participants in the study were normal-hearing individuals.

These results agree with the findings reported in the literature[16-24,25], in which bilingual and monolingual groups had similar results when evaluated in silence. Previous studies have attributed[26,27] such findings to the major parameter for speech recognition in silence, which is the audibility threshold.

The analysis of the measures obtained in the presence of competitive noise showed a statistically significant difference, suggesting that bilinguals have better performance in this condition (Table 1). Such finding contradicts studies[15,16] which reported worse bilingual performance in speech perception in noise. On the other hand, studies conducted with the presence of conflicting information, in dichotic listening, found better performance of bilinguals when compared to monolinguals[6-12,13].

Based on the findings cited above, it was found that individuals with the same speech recognition skills in silence may have different recognition skills in noisy environments, motivated by various biopsychosocial aspects. Previous studies have reported that contact with speakers of different languages was advantageous, because cognitive characteristics, such as executive functions of inhibitory control, attention and memory, were more evident in bilinguals[11-28].

Some authors further argue that attention and memory make it easier to focus on a target sound in the presence of noise[11]. Considering the performance of bilinguals in the present study in conflicting situations, it can be inferred that the advantages mentioned above contributed to their auditory performance, since such aspects are fundamental for the improvement of auditory skills.

Still, regarding the perception of speech in unfavorable listening situations, references were found in the literature, showing that bilingual individuals presented worse speech discrimination performance in noisy or degraded situations[15.16-29], but most of these studies used stimuli in the second language of the bilingual participants[16-29], which may justify the difficulty in noise situations found in the above-mentioned studies.

Considering these aspects, two points of view are discussed in the literature, justifying the possible disadvantage of bilinguals in speech recognition tasks under unfavorable conditions: the first is related to the proficiency level; however high, bilinguals will have more difficulty in their second language[16]. The second aspect concerns the age of second language acquisition[15,20-29], pointing to a disadvantage when the second language is acquired after the critical learning period.

Thus, it is noteworthy that, in the present study, the evaluation was performed in Portuguese, the mother tongue of all participants, a fact that may have positively influenced the results of these individuals.

An alternative view is that bilingualism itself is responsible for the disadvantages of speech perception, and such disadvantages are not limited to late acquisition or assessment, when using subjects' first or second language, as previously mentioned. This view was discussed in a study[30] with vocal audiometry in bilingual subjects, which suggests that bilinguals perform tasks of speech perception in noise more slowly and less accurately, because they need a longer reaction time, because of the need to search their lexicon. Some of these causes may be perceptive, which may include maintaining attention to the language presented or the need to select appropriate phonemes

according to a larger set of potential targets or the need to stop and search in their lexicon, which is broader[30].

As regards second language acquisition period, the findings show that the two bilingual groups - GSG (simultaneous bilinguals) and ISG (successive bilinguals) - had statistically significant results; they performed better than the monolinguals, but there was no difference between the bilingual groups. These data suggest that age of second language acquisition was not a determining factor for bilingualism to produce effects on speech perception in the study groups (Table 2).

In turn, the results found by other authors[15,20-29] showed better performance in simultaneous bilinguals in comparison to successive (late) ones. As fa as second language acquisition is concerned, neuroscientists claim that children are more efficient learners than adults. According to them, children's brains have a specialized ability to acquire language, especially in the critical period, and such ability is evident until puberty, but there is a gradual and continuous decline that occurs as they grow older[17].

The findings of the present study and of the literature reviewed, showed that learning a second language most often influences auditory, linguistic and cognitive skills, although there is no consensus among researchers. Also, there is still a small number of studies focused on the influence of second language acquisition on the auditory system.

Thus, it is noteworthy that, given the divergences found in bilingual performance in speech recognition in noise, it is extremely important to conduct new studies that seek to compare the performance of these individuals with instruments whose verbal stimuli are in their mother tongue and their second language. They should be investigated in situations of both silence and noise, as well as with different levels of fluency, as such data will contribute to a better understanding of the influence of bilingualism on auditory skills.

CONCLUSION

Bilingualism positively influenced the development of auditory skills that resulted in better performance of bilinguals in speech recognition in the presence of noise, and the second language acquisition period did not influence bilingual performance in this study.

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Author contributions

GCF: data analysis and interpretation, drafting and critical revision of the article; EMOT: design of the study; data collection, analysis and interpretation; drafting and critical revision of the article; MVG: data interpretation; critical revision and final approval of the version to be published; SNS: data interpretation; critical revision and final approval of the version to be published; MJC: design of the study; data analysis and interpretation; drafting, critical revision and final approval of the version to be published.