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RESEARCH ARTICLE

Investigation of temporal resolution laterality

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Abstract

Background and Aim: Auditory temporal resolution skill is calculated according to the minimum required time to analyze or integrate acoustic events. This skill, which is essential for speech perception, was evaluated by gap detection tests. The aim of this study was to determine the presence or absence of any differences between the right and left ear in the gap detection test.

Method: After performing auditory tests to rule out any hearing loss or auditory processing disorders, the gap detection test was administered to 40 adults.

Results: Gap detection thresholds were 5.35 ms and 5.30 ms in the right and left ear, respectively, and the average correct answers percentages were 69.03% and 68.03% in the right and left ear, respectively. According to these data, results were similar for both ears.

Conclusion: There is no laterality in temporal resolution tasks. However, we cannot generalize the results of the present study as being applicable to the whole society.

Keywords: Auditory cortex, gap in noise, temporal resolution, central auditory processing, laterality

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Introduction

The Gap in Noise (GIN) test is a simple, psychoacoustical test that evaluates auditory temporal resolution [1]. Auditory ability of temporal resolution is the ability to detect the minimum required time to analyze acoustical events [2]. To clarify the physiological mechanism of auditory temporal resolution, most researchers believe that auditory nerve fibers interfere highly in this process [3]. Nonetheless, other researchers believe that this is a central process [4].

Auditory temporal resolution depends on the separation of the different auditory stimuli [5].

The human auditory cortex is in the temporal lobe of the brain. The auditory cortex has a central part called the core and other surrounding parts. The core is the primary auditory cortex, which is located in Heschl's gyrus [6].

Heschl's gyrus is highly variable in different individuals and between the two hemispheres of the brain. Heschl's gyrus has one to three gyri in each hemisphere, and the number of gyri is not necessarily the same in the two hemispheres [7]. Many studies have shown that Heschl's gyrus has certain differences between the right and the left hemispheres. Heschl's gyrus is larger in the left hemisphere than in the right hemisphere. Thus, the left primary auditory cortex is larger than the right primary auditory cortex. The larger size of the left primary auditory cortex is due to the larger volumes of the white and gray matters in this hemisphere [8].

Larger neural structures in left hemisphere than right hemisphere provide necessary foundation for language development [8]. Specialization of the left hemisphere for speech may relate to recognition of speech acoustic parameters. The ability to encode and analyze the temporal aspects is related to the left hemisphere contribution in language functions [7].

Various studies have confirmed the dominant role of the left hemisphere in analyzing the temporal aspects of acoustical stimuli. The structural differences between the two hemispheres may justify the capability differences between the right and the left hemisphere [9].

Belin and Zatorre have evaluated the functional differences between the right and the left auditory cortices. Neuroimaging techniques have shown the increased functional activity of the two hemispheres, but the left hemisphere responses to the temporal aspects were more than that of the right hemisphere [9]. However, the spectral changes caused more activity of the superior temporal gyrus in both sides, but the response of the right side was stronger than the left side. These changes are called anatomical changes. Due to the anatomical differences, the left hemisphere is more sensitive to rapid acoustical changes than the right hemisphere [9].

wn and Nicholls used the GIN test to evaluate temporal resolution [10]. The acoustic stimulus was a wide band noise with 300 ms duration. The inter stimulus intervals were 2, 4, 6, and 8 ms. The results showed faster and more accurate responses in the right ear (left hemisphere) than the left ear [10].

Sulakhe et al. found similar results. They used white and narrow band noises. The stimulus duration was 300 ms with 3, 4, and 5 ms intervals. According to the data, asymmetry between the two hemispheres and the right ear advantage for the white noise and symmetry for the narrow band noise were obvious [11].

In some investigations, there was no asymmetry between the two ears. This meant that the right ear advantage for auditory temporal processing and temporal resolution was not observed [12, 13, 14].

The aim of the present study was to investigate the differences between the right and the left ear in the GIN test (gap detection threshold and the percentage of the correct answers).

Method

Forty normal adults aged 18-45 years completed the study. Twenty of them were male (mean age of 22.40) and the other 20 were female (mean age of 22.20). The youngest male was 19 and the youngest female 18 years old. The highest age was 25 in the males and 26 in the female group (p=0.77).

All participants were aware of the aim of the study, the tests used, safety mode of the study, and the publication of the results in scientific journals.

In order to rule out any auditory pathology, clinical history was taken. Pure tone audiometry, immittance audiometry, and dichotic digit tests were also administered. All participants had an audiometric threshold of 20 dBHL or less in all of the tested frequencies (250–8000 Hz), A-type tympanogram, normal ipsilateral and contralateral acoustic reflex, and a score of 90 percent or more in the dichotic digit test in the two ears [2].

Then, the GIN test developed by Musiek was administered. An AC40 interacoustic audiometer instrument and a compact disk player were used. The stimulus intensity was 50 dBHL. The presentation mode was monaural. GIN is composed of white noise of 6 ms duration, which has 0–3 gaps. The noise parts are separated from each other by 5 ms silences and the gap durations can be 2, 3, 4, 5, 6, 8, 10, 12, 15, and 20 ms. Both gap durations and the time the gap occurs are random. The mode of response in the present study was “yes” or “no.” Each gap with a certain duration is repeated six times in a list [14].

Two parameters were measured for each ear: gap detection threshold (the minimum gap detected by the person in at least 50 percent of

Table 1. Mean (SD) gap detection threshold and the percentage of the correct answers in both ears

	ear	Mean (SD)	Minimum	Maximum	Median	p*
Gap detection threshold (ms)	right	5.35 (1.10)	4	8	5	0.65
	left	5.3 (1.04)	4	8	5	
Correct answer percentage	right	69.03 (8.05)	51	78	73	0.20
	left	68.03 (8.31)	51	81	66	

*Wilcoxon signed-rank test

the presentations) and the percentage of the correct answers in every list (the number of all of the detected gaps) [14].
Since there was no normal distribution of data, Wilcoxon nonparametric test was used for data analysis. The difference were considered significant when p> .05.

Results

The right and the left ear results are shown in Table 1. The mean of the gap detection threshold of the right and left ears was 5.35 and 5.30 ms, respectively. The mean of the percentage of correct answers was 69.3 and 68.3 in the right and left ears, respectively. There were no significant differences between the two ears test results (threshold and percentage of correct answer).

Discussion

The aim of the present study was to investigate the effect of handedness of the auditory temporal resolution by means of the GIN test. According to the data, there was no specific ear advantage either in the gap detection threshold or in the percentage of the correct answers. Some previous studies had shown a right ear advantage in the auditory temporal resolution [10–11]. Some studies reported a specific ear advantage—for example, Efron et al., Baker et al., and Musiek et al. found no asymmetry between the two ears in temporal resolution [12–14]. Baran and Musiek have reported that monaural tests are useful for change detection in the auditory system, but do not show the location of the changes [15]. Most researchers believe that the left hemisphere is more prominent in the analyses of the temporal aspects of acoustic stimuli than the right one [7–9]. These researchers have not reported right or left ear advantage in their studies [10, 11]. Brown & Nicholls and Sulakhe et al. reported right ear advantage in the GIN test [10, 11]. However, Efron et al., Baker et al., and Musiek et al. reported no specific ear advantage [12–14].
It might be that one of the reasons for the right ear advantage is that the researchers used the reaction time for gap detection in the data analyses [10,11]. Reaction time analysis can affect the right ear advantage. Furthermore, they evaluated the percentage of the wrong answers, while the percentage of the correct answers is evaluated in the new studies. The reaction time was not evaluated in the present study or in the Efron et al. and Baker et al. studies.
If the left hemisphere has larger neural structures, we can expect quicker temporal processing in the right ear than in the left one, and this has been reported in some studies.
In summary, different parameters have been used in previous studies, which can justify dissimilar results of the various studies. Yet, it does not rule out the left hemisphere advantage in auditory temporal resolution completely. Thus, we cannot specify the ear advantage for temporal resolution by means of such tests. Moreover, because the ipsi and contralateral routes are activated in monaural evaluation, ear advantage specification is not possible. It may be that other cortical regions (the regions near the primary auditory cortex) participate in the

auditory processing of the speed stimuli too.

The symmetry of the gap detection threshold and the percentage of the correct answers between the two ears showed the functional symmetry between the two hemispheres in auditory temporal resolution. We suggest that there is no ear advantage in the GIN test.

Conclusion

The similarity between gap detection and correct answer percentages of the two ears shows the functional asymmetry between the two hemispheres of the brain in auditory temporal detection. In fact, we can conclude that there is not any ear advantage in GIN test. However, we cannot generalize the study results to the population.

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