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NOTE

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A methodological study of auditory lateralization¹

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The just-noticeable-shift (JNS) threshold of a centered image was determined for four naive Ss. A two interval forced choice situation was used under the method of constant stimuli. The three manners of presentation of the intensity imbalance were as follows: (1) an increase in intensity at one ear, (2) a decrease in intensity at one ear, (3) an increase in intensity at one ear produced concomitantly with a decrease in intensity at the opposite ear. The sign test demonstrated significant differences between method (2) and methods (1) and (3).

When two identical auditory signals with no phase difference are presented simultaneously to each ear via earphones, a single auditory image is sensed along the midline of the head. A change in intensity at one ear will cause the sound image to shift toward the ear receiving the louder or more intense signal. This phenomenon, sound lateralization, has been used to measure difference limens for intensity (Upton, 1936) and just noticeable movement of a free field sound source (Mills, 1958). The difference limen for movement in auditory lateralization has been termed just-noticeable-shift or JNS.

The procedure used in the determination of JNS is to have the listener judge the instances when the centered sound image moves to one side as a result of a change in intensity at one ear. The image can be shifted from the center toward a specific side by either increasing the intensity at one ear or by decreasing the intensity at the other ear. A third way of inducing such a shift is by a combination of the above. That is, the intensity at one ear is increased at the same time that the intensity at the other ear is decreased. This method of presentation differs from the others in two ways. First, the overall intensity level of the signal presented to the listener remains relatively unchanged, hence, not confounded with the shift in lateralization. Second, a varying signal is presented simultaneously to the two ears rather than to a single ear.

The present study is an attempt to determine whether the three methods of presentation cited above produce similar difference limens for JNS from a center position.

METHOD

Subjects

Four, paid, undergraduate students enrolled in Introductory Psychology courses at Florida State University who could readily lateralize a sound image were employed in the study. All Ss exhibited clinically normal hearing (ISO standards). The Ss were given extended practice in detection of shift from the center of a binaurally produced image.

Procedure

A block diagram of the apparatus appears in Fig. 1. The tone, produced by an audio-oscillator (Hewlett-Packard, model 204B), was passed through electronic switch No. 1 (Grason-Stadler, model 829C) which controlled the onset and offset of the overall signal. A 10-msec rise-decay time was programmed for all signal presentations. The signal was then led through a phase shifter (Grason-Stadler, model E3520B) which served both as a signal splitter and as a compensator for phase differences in the signals led to the earphones. The signals were further split by transformers with one signal from each transformer being passed through precision attenuators (Altec-Lansing, model DA8736, 38, 40) which were adjustable to 0.1 dB. These signals were led to the "A" input on both channels of electronic switch No. 2 (Grason-Stadler, model 829C). These were the test signals that were increased or decreased as the procedure required. The remaining signals from the splitting transformers were led directly to the "B" inputs of electronic switch No. 2 and were employed as the "center" or standard signal.

When switch No. 1 was turned on, switch No. 2 had the "B" (standard) signal on. This was followed by a change to the "A" (test) signal. After switch No. 2 was in the "A" position, switch No. 1 turned the signal off. Two electronic timers (Grason-Stadler, model 471) were used to program the signal durations. A

Fig. 1. Block diagram of the apparatus.

500 msec standard and a 500 msec test signal were employed for all presentations.

The signals from each channel on switch No. 2 were fed through decade attenuators (Hewlett-Packard, model 350D) which set the overall sensation level of the signals at 20 dB SL. The signals were then led through impedance matching transformers to earphones (TDH 49) located in an audiometric testing room (IAC, model 1201A) where S listened.

Two frequencies were used, 600 and 6000 Hz, in order to assess the effect of frequency of the signal on JNS thresholds.

The Method of Constant Stimuli was used to gather the threshold data. Intensity imbalances from 0 to 5 dB, in 1 dB steps, were presented randomly. The S made a judgment as to whether the image shifted to the right or to the left of center. The shift due to increases in intensity and decreases in intensity to the right ear and to the left ear were randomly mixed in order to prevent S from using either a change of intensity or a positional effect (such as change to a particular ear) as a cue to direction of shift. The shifts due to both increases and decreases of intensity were run as blocks of trials among the other trials.

Twenty-four judgments were made for each condition and each intensity imbalance. A total of six conditions were run, consisting of all combinations of the two frequencies and the three methods of stimulus presentation.

RESULTS

The judgment data thresholds for just-noticeable-shift obtained in the study are shown graphically in Figs. 2, 3, 4, and 5. The thresholds were determined as follows: The number of incorrect judgments for each condition was plotted against the intensity difference. Smooth curves were then fitted visually to the data points. Since the same number of judgments were used for each point, the number of incorrect judgments is directly related to the proportion of incorrect judgments. Thus, six incorrect judgments corresponded to 25% incorrect, or 75% correct judgments. Since 50% correct judgment was random responding and 100% correct judgment was absolute accuracy, the points where the curve crosses the 75% correct judgment line were taken as the threshold for just noticing a shift. Individual threshold data for each condition is shown in Table 1. Cursory inspection of the

Fig. 2. Individual threshold of JNS for S N.S. The total errors per 24 choices are plotted against the interaural intensity difference in dBs.

Fig. 3. Individual threshold of JNS for S J.L. The total errors per 24 choices are plotted against the interaural intensity difference in dBs.

Fig. 4. Individual threshold of JNS for S C.L. The total errors per 24 choices are plotted against the interaural intensity difference in dBs.

threshold data shows a range of individual differences of roughly 0.7 dB. There also seem to be consistent differences in thresholds among the methods of presentation of the stimuli for each individual. The measurement accuracy of each threshold was taken as ± 0.1 dB to allow for variations in fitting the curves. Hence, a threshold value was considered different only if it differed by more than 0.1 dB.

In addition to the presented data, the percentage correct was converted to a "z" score and straight line curves were drawn to determine the thresholds. The thresholds determined in this manner were within ± 0.1 dB of those shown in Table 1. Since the difference was small, the raw score (proportion) curves are shown. The data was analyzed employing the sign test. The results of the test which assessed the effect of frequency of the

Fig. 5. Individual threshold of JNS for S.B.K. The total errors per 24 choices are plotted against the interaural intensity difference in dBs.

Table 1
JNS Thresholds for each individual
for each Experimental Condition

frequency	S	Manner of Presentation		
		increase	decrease	increase/decrease
6000 Hz	NS	1.8	1.9	1.7
6000 Hz	JL	1.7	1.6	1.7
6000 Hz	CL	1.5	1.9	1.0
6000 Hz	BK	1.2	1.5	1.4
600 Hz	NS	1.6	2.1	1.3
600 Hz	JL	1.3	1.5	1.3
600 Hz	CL	1.3	2.0	1.9
600 Hz	BK	1.2	1.4	1.2

signal demonstrated a $p > .10$. Likewise, a similar test demonstrated no significant differences between the thresholds obtained by the method of increasing the intensity and the thresholds obtained by changing the intensity at both ears. However, significant differences, $p < .05$ were found between thresholds obtained by the method of decreasing the intensity and the thresholds obtained by the other two methods.

DISCUSSION

The results of the present study indicate that the threshold for JNS is not dependent upon the frequency of the signal. This finding is in agreement with the previous finding of Elfner & Tomsic (1968) where JNS was measured during the transient or onset portion of binaurally presented signals. The auditory system utilizes phase information in lateralization, or localization, of low frequency signals but not for high frequency signals. The phase information in the present experiment indicated no shift; the intensity information showed a shift. Thus, it may be assumed that contradictory information was available for the low frequency signals. This would seem to indicate, that for images

having a locus near the midline of the head, JNS due to intensity difference is not appreciably affected by small errors in phase information.

It is apparent from the results that JNS measured by decreasing the intensity at one ear yields larger thresholds than the other manners of presentation. In the latter cases, at least one ear receives an increase in intensity of the signal. The same effect was noted by Elfner & Perrott (1967). The interaural intensity differences were much greater (5 dB as opposed to approximately 1.5 dB in the present study), but this could be attributed to the psychophysical method employed, namely the Method of Limits rather than the Method of Constant Stimuli. So it appears that the auditory system is more sensitive to increases than decreases in the intensity of a signal.

Even though the differences between the methods of presentation were found to be statistically significant, the practical significance is limited to JNS measurement where the researcher is interested in very fine differences. However, for JNS measurement where the Method of Limits is employed, the investigator should be aware of the large increase in threshold values that occur when the intensity is only decreased.

The values of JNS thresholds found in the present study agree very closely (within a few tenths of a dB) with DL for intensity reported by Riesz (1928).

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NOTE

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