Lateralization of pure tones as a function of prolonged binaural intensity mismatch

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Abstract

Pre-exposure of the right ear to amplification of auditory input by means of a hearing aid produced decrements in the ability to lateralize pure tones under dichotic presentation. The decrement in lateralization function increased with an increase in pre-exposure duration. Lateralization decrement was not affected by the signal frequency.

Problem

When a tone equated for frequency, intensity and phase is presented simultaneously to each ear via earphones, the S typically perceives a single sound source at or near the central sagital plane in the head. If the intensity at one ear is increased in relation to the other, the sound source will appear to move toward the more intense side. When a certain intensity imbalance is reached the sound will appear to have its source at or near the ear receiving the greater intensity. The term "lateralization" designates the above phenomenon. In the study of cues of localization of sound sources employing dichotic presentation (as above) the stimulation corresponds to what would be preceived in the open air from two differently located sources of sound, as stated by Woodworth & Schlosberg (1954). Past research has shown that localization of sound sources depends upon both ears (Englemann, 1928: Willey et al: 1937, and Starch, 1908). There is a universal complaint of the inability to localize a sound on the side of the head which has a deafened ear as shown by Saltzmann (1949). The present study investigates the effect of prolonged binaural intensity mismatch on the subsequent ability to lateralize a sound source.

Method

Four students from advanced courses in Psychology at Kent State University served as Ss. All Ss exhibited hearing ability within the normal range, and demonstrated an ability to localize sound sources under dichotic presentation. Each of the two tonal signals was led from its audio-oscillator (Hewlett-Packard, 241A, 204B) through decade attenutators, to transformers and earphones in an audiometric testing room (IAC, 1201) where the S listened. The frequencies of the signals were matched on a dual-beam oscilloscope (Dumont, 322). An electronic timer was used to program a 1-sec. duration signal. Behind-the-ear hearing aids (Zenith, Arcadia T), matched for acoustic gain, were used to produce the binaural intensity imbalance. The average acoustic gain for the four hearing aids at 400, 600, 1,000, 2,000 and 4,000 cps was 25, 34, 45, 52, and 32 db respectively.

Several pre-experimental sessions were run on each S for practice in localization of the sound source under dichotic presentation. During the final pre-experimental session absolute thresholds were determined for each ear for the above mentioned frequencies. The binaural intensity imbalance required for lateralization of the above frequencies was then determined in the following manner: The matched frequencies were presented to each ear at 40 db sensation level. For this condition the S usually reported the sound source to be in the center of the head. (A 1 or 2 db correction was sufficient to center the signal in all cases). Attenuation was then increased to the right ear until the S perceived the source of the sound at the left ear. Each S was then fitted with a hearing aid on the right ear. Absolute thresholds and lateralization tests of the various frequencies, presented in random order with the hearing aid removed, were run after 2, 4, 6, 12 and 24 hr. of wearing the aid. The S wore the aid at all times except for one night's sleep which occurred between the 12th and 24th hr. of test trials. Tests were also run 1 and 4 hr. after removal of the hearing aid.

Results

Table 1 shows the mean attenuation in db required to move the apparent sound source from the mid-line of the head to the left ear for the various frequencies and durations of binaural intensity mismatch. The results of an analysis of variance of the obtained data show the duration of intensity mismatch has a significant effect on lateralization ($F = 58.3$; df, 4,75; $p < .01$). Although visual inspection of Table 1 shows a regular increase in attenuation over pre-exposure durations, a Duncan Range Test shows that the only significant effect between adjacent durations is that between 2 and 6 hr. However, the effects of pre-exposure durations are significant for all comparisons greater than the adjacent ones. No significant effect of signal frequency on lateralization was found, but three of the four Ss required greater binaural intensity imbalance in order to lateralize the 4,000 cps signal before pre-exposure. No appreciable differences in absolute threshold for frequencies of 400, 600, or 1,000 cps were noted as a function of wearing the aid. However, two of the Ss demonstrated large decreases in sensitivity in the right ear for frequencies of 2,000 and 4,000 cps as a function of the prolonged exposure to the amplified output of the hearing aid. No appreciable changes in absolute threshold were noted in the left ear at any time during the experiment. One hr. after removal of the hearing aids, three of the four Ss demonstrated substantial recovery

Table 1. Attenuation in Db Required for Lateralization of the Sound Source

Frequency cps	Hours of Pre-exposure to Binaural Intensity Mismatch				
	0	2	6	12	24
400	11.1	14.2	21.0	24.8	29.2
600	10.6	14.5	22.0	23.5	28.2
1,000	10.8	15.0	21.8	24.2	29.8
2,000	11.6	15.5	20.7	25.0	31.2
4,000	13.2	18.0	22.7	28.2	29.8

of the ability to lateralize; 4 hr. after removal, all Ss demonstrated substantial recovery of lateralization function.

Discussion

It is clearly apparent that prolonged exposure to a binaural intensity mismatch produces a decrement in the ability to localize a sound source. Analagously, it may be predicted that prolonged exposure to a binaural intensity mismatch should produce a decrement in the ability to localize a sound source in open air. It is also apparent in the case of the 400, 600 and 1,000 cps tones that the decrement in ability to lateralize is not a simple function of acoustical input as no differences were detected in the absolute thresholds of these signals as a function of exposure to the amplified output of the hearing aid. A model of binaural interaction such as forwarded by van Bergeijk (1962), which places the locus of lateralization processes in the accessory nucleus and which allows for cross-ear inhibition appears most applicable.

References

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