Dependence of apparent rate of alternating clicks on azimuthal separation between sources*

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Ten listeners compared the apparent rate of 10/sec clicks, presented alternately from two comparison sources separated horizontally by 12-168 deg with that of clicks presented alternately from standard sources separated by 180 deg. The apparent rate of comparison clicks increased monotonically with decrease in angular separation. This result is consonant with the hypothesis that repetitive shifts of attention between two sound sources depend importantly on oscillating motor adjustments.

When clicks are presented alternately and repetitively to the two ears at rapid but subfusional rates, their apparent combined rate is slower than that of clicks presented at the same objective rate to a single ear (Axelrod, Guzy, & Diamond, 1968; Axelrod & Guzy, 1968). As is the case with dichotically alternating digits (Treisman, 1970, 1971), the listener has difficulty in integrating the two inputs into a single message.

Kahneman (1970) and Guzy & Axelrod (1971) have suggested that repetitive interaural shifting of attention may depend upon oscillating, side-to-side orientational movements, e.g., of the eyes. If this is the case, then the efficiency of integrative processing of alternating auditory stimuli might be expected to increase as the sound sources are brought closer together than 180 deg, because the underlying orienting movements would then be of smaller amplitude.

In the present study, we measured points of subjective equality (PSEs) between clicks presented alternately at 10/sec from two standard sources separated by 180 deg, and clicks presented alternately from comparison sources separated by varying amounts. The expectation was that PSE would decrease systematically with decreasing angular separation between the comparison sources.

METHOD

The Ss were 10 women whose participation in the experiment fulfilled a requirement of an undergraduate introductory

psychology course. None admitted to any hearing deficit.

The click-generating and monitoring apparatus has been described elsewhere (Axelrod, Guzy, & Diamond, 1968; Guzy & Axelrod, 1971). Three Clevite "Brush" earphones were mounted on a perimeter whose diameter was 24 in. The perimeter was centered in the horizontal interaural plane of the S, who sat facing the perimeter with her chin on a support and her forehead against a restraining cushion. Two of the phones were fixed in position 180 deg apart, one directly opposite each ear. The third phone was movable and could be placed at one of five positions along the perimeter: 12, 45, 90, 135, or 168 deg from the right phone. The experimental room was quiet but not sound-treated.

On each trial, two 3-sec trains of clicks (100 microsec, approximately 58 dB at the phone) were presented, first a standard train (St) whose clicks alternated between the right and left phones, and then a comparison train (Co), whose clicks alternated between the right and movable phones. A silent interval between trains lasted 0.5 sec. The S's task was to judge whether Co was faster or slower than St; equality judgments were not permitted.

The total repetition rate of St (combined across phones) was always 10/sec. The total rate of Co varied from trial to trial between 6/sec and 11/sec in steps of 0.5/sec, making 11 Co rates in all. In each block of 11 trials, each Co rate was presented once in a different random order for each block, 10 blocks being given to each S at each of two angular separations of the Co phones. Ss were assigned randomly, one to each of the 10 combinations of five Co separations taken two at a time, each separation being therefore given to four Ss. For each S, the sequencing of the blocks with the two angles was according to a Gellerman (1933) series; five Ss began

with the smaller angle and five with the larger.

The judgments were treated according to a method of constant stimulus differences. For each S at each Co separation, the PSE between the St and Co rates was determined as the abscissa value of the point of intersection of the functions relating percentage "faster" and percentage "slower" judgments to the rate of the Co train. The invariant sequence, St-Co, allowed for possible time-error effects in the determination of any single PSE, but such effects would not influence the differences between PSEs obtained with different angular separations.

Table 1
PSE as a Function of Separation Between Comparison Phones

	Separation (in Degrees)				
	12	45	90	135	168
Mean	8.72	8.82	9.22	9.38	9.52
SEM	0.36	0.34	0.26	0.23	0.11

RESULTS AND DISCUSSION

Table 1 gives the means and standard errors of the obtained PSEs. Mean PSE decreased directly and monotonically with angular separation of the Co phones. In terms of apparent rate, then, $168 < 135 < 90 < 45 < 12$ deg. The probability that five randomly determined means would fall into monotonic order is $1/5! = 1/120$. Because each S experienced only two of the five Co separations, the data were not amenable to a 5 by 10 Treatments by Ss analysis of variance. However, a 2 by 10 analysis (Smaller Angle vs Larger Angle, for each S, by Ss) yielded a significant effect of angle size ($\bar{X}_{\text{smaller}} = 8.94$, $\bar{X}_{\text{larger}} = 9.33$, $F(1,9) = 14.07$, $p < .005$). Although the differences between the two PSEs for each S were small, 9 of the 10 Ss ($p < .02$) had, as expected, a lower PSE at the smaller of her two angles than at the larger; the one exception was a difference of 0.1 click/sec, with a one-step difference between the Co separations (135, 168 deg).

The results are consistent with the view that shifting attention repetitively between sound sources involves actual motor responses and that the larger the excursion of the motor responses, the more difficult it is to follow rapidly alternating stimuli.¹ More direct test of the view might be made by disrupting the motor orientations while listeners are attempting to integrate alternating inputs.

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NOTE

1. The results also nicely complement the finding by Treisman that, where selective attention to a signal message is required (rather than interdigitation of the elements of two messages), the degree of interference from a simultaneous "noise" message is an inverse monotonic function of the difference in localization between the signal- and noise-producing sources (Treisman, 1961; personal communication, 1971). Treisman's finding has been summarized by Moray (1969, p. 57). See also Spieth, Curtis, & Webster, 1954.