Evidence of Independent Verbal Processors for the Same Stimulus: Insights from Dichotic Verbal Transformations

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Abstract. The illusory changes, or verbal transformations (VTs) heard when a word is repeated exactly over and over can occur independently at the two ears when dichotic presentation is used to produce separate lateralized images of the stimulus. The present study replicates and extends this finding using several dichotic conditions, and eliminates a peripheral explanation of independent VTs.

A clearly enunciated word heard repeating without change undergoes illusory verbal transformations (VTs) to different words or syllables (1). This illusion appears to result from the interaction of two processes invoked by repetition of the word, one process involving the loss or satiation of a perceived verbal form, and a concurrent process involving an assimilative shift in the acoustic criteria corresponding to other organizations (2). Interestingly, when a repeating word is delivered dichotically with an interaural asynchrony of half the word's duration, so as to prevent fusion, the separate lateralized images of the word are first heard accurately and then heard to undergo independent changes, so that "commence" might be heard at one ear while "tress" is heard at the other (3). This independence of dichotic VTs for identical stimuli suggests that, under "cocktail party" listening conditions, utterances produced by spatially distinct sources are processed by independent lexical analyzers. The present study replicates and extends the finding of independent VTs to additional dichotic listening conditions, and rules out a peripheral explanation attributing independent changes to lateral asymmetries in the effects of repetition upon the lower auditory pathways, which might provide conflicting acoustic-phonetic information to a single verbal processor.

EXPERIMENT

Subjects. Participants in the study were 250 Introductory Psychology student volunteers who had passed audiometric screening for normal hearing in each ear.

Stimuli. The repeating stimulus was the word "flame," (492 ms duration) which was produced by a male speaker, digitized and iterated using a stereo delay line (50-kHz sampling, 12-bit precision), and recorded on audio tape under the various presentation conditions.

Listening conditions. The repeating word was presented under five conditions: 1) A standard, diotic condition presented a temporally and acoustically identical signal to both ears, resulting in a single image of the stimulus repeating without pause in the medial plane; 2) A dichotic alternation paradigm presented successive statements of the repeating word to opposite ears along with contralateral pink noise (i.e., "flame" presented left along with noise presented right, then "flame" presented right along with noise presented left...). Although this condition maintained monaural verbal stimulation, the pink noise was 20 dB higher in level than the speech, so contralateral induction (CI) delateralized the voice (4) and all statements of the repeating stimulus were heard as diffusely localized in the medial plane; 3) A second dichotic alternation condition eliminated the contralateral noise (i.e., "flame" presented left with silence right, then flame presented right with silence left), so that CI did not occur, and fully lateralized statements of the stimulus appeared alternately on the left and on the right; 4) A third dichotic alternation condition presented the repeating word to both ears, but with a 0.5 msec interaural delay that reversed between ears with each repetition of the stimulus (i.e., "flame" leading left then "flame" leading right...), so that, although both ears were stimulated by speech, successive statements were lateralized to opposite sides, as in condition 3); 5) A final dichotic condition presented the repeating word to the two ears with an interaural delay of exactly one-half of the word's duration, as in the study of Warren & Ackoff (3), resulting in separate lateralized images of the stimulus heard repeating without pause at each ear. Stimuli were presented through matched, TDH-49 headphones, with speech presented at 60 dBA SPL and pink noise, when present, delivered at 80 dBA SPL.

Procedure. Separate groups of 50 listeners were assigned to each of the five conditions. Stimuli were presented for five minutes, and listeners were instructed to call out all changes that they heard. Listeners in conditions 3-5, which produced lateralized signals, used a pair of telegraph keys to indicated the side(s) on which each change occurred.

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RESULTS AND DISCUSSION

TABLE 1. Means and standard errors (in parentheses) for total transitions (number of illusory changes), total forms (number of different verbal organizations), number of independent transitions (changes to a form on one side not accompanied by the same form on the opposite side), and number of bisyllabic forms (i.e., paired organizations such as "lamp-flame").

<table>
<thead>
<tr>
<th>Stimulus Condition</th>
<th>Total Transitions</th>
<th>Total Forms</th>
<th>Independent Transitions</th>
<th>Bisyllabic Forms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Diotic Presentation</strong></td>
<td></td>
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<tr>
<td>1 Ear 1 FlameFlameFlameFlame Ear 2 FlameFlameFlameFlame</td>
<td>32.4(4.1)</td>
<td>7.8(.70)</td>
<td></td>
<td>1.70(.54)</td>
</tr>
<tr>
<td><strong>Dichotic Alternation with Contralateral Noise</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2 Ear 1 FlameNoiseFlameNoise Ear 2 NoiseFlameNoiseFlame</td>
<td>38.0(4.6)</td>
<td>6.1(.58)</td>
<td></td>
<td>1.72(.51)</td>
</tr>
<tr>
<td><strong>Dichotic Alternation with Contralateral Silence</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3 Ear 1 Flame Flame Ear 2 Flame Flame</td>
<td>18.2(2.7)</td>
<td>3.4(.36)</td>
<td>9.9(1.5)</td>
<td>0.08(.05)</td>
</tr>
<tr>
<td><strong>Dichotic Alternation of 0.5 ms Interaural Delay (Δt)</strong></td>
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<tr>
<td>4 Ear 1 FlameFlameFlameFlame Δt Ear 2 FlameFlameFlameFlame</td>
<td>24.6(3.3)</td>
<td>4.3(.42)</td>
<td>10.9(1.5)</td>
<td>0.08(.04)</td>
</tr>
<tr>
<td><strong>One-half Period Interaural Delay</strong></td>
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<tr>
<td>5 Ear 1 FlameFlameFlameFlame Δt Ear 2 FlameFlameFlameFlameFlame</td>
<td>21.5(3.0)</td>
<td>4.7(.43)</td>
<td>12.2(1.7)</td>
<td>0.06(.28)</td>
</tr>
</tbody>
</table>

Evidence for separate verbal analyzers for identical signals heard at different locations is furnished by conditions 3-5, which demonstrate independent transitions (defined conservatively as changes on one side that were unaccompanied for at least ten seconds by reports of the same form on the opposite side). Additional evidence for independent processing is supplied by regular perceptual alternation to produce bisyllabic forms (e.g., lamp-flame, lamp-flame...), which occurred relatively frequently in conditions 1, 2 & 5 but very rarely in conditions 3 & 4, in which contiguous statements on both sides were lacking. The data also rule out a peripheral explanation of these results. If independent VTs were the result of lateral differences in the effects of repetition upon the lower auditory pathways, then the independent transitions observed in condition 3 (occurring at an average rate of about 10 per subject) would be manifest as alternating forms in condition 2, since contralateral induction would delateralize and interleave the contrasting organizations. However, as can be seen in the table, condition 2 produced a much lower rate of alternating forms, almost exactly equal to that in the diotic condition 1. Finally, scores for transitions and forms were statistically equivalent for conditions 1 and 2 (single spatial image), as they were for conditions 3-5 (separate spatial images). The significantly lower scores for conditions 3-5 vs. 1-2 \(F(1) \geq 16.99, p < .0001\) suggest that splitting of limited resources is required to handle independent processing for the two locations.

ACKNOWLEDGEMENTS

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REFERENCES