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Octave generalization and tune recognition*

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An experiment was performed to investigate whether or not we are able to use octave generalization in recognizing tunes. The first half of the tune "Yankee Doodle" was chosen as the test sequence. This was universally recognized when played in any one of three octaves. However, when the sequence was played in identical fashion except that each note was chosen randomly from one of the same three octaves, the percentage correct recognition was not significantly different from that obtained when the sequence was played as a series of clicks with the pitch information omitted but the rhythmic information retained. It is concluded that tune recognition takes place along a channel which is independent from that which gives rise to octave generalization. The relevance of this finding to the theory of music recognition proposed by Deutsch (1969) is discussed.

It has long been recognized that tones which are separated by octaves (i.e., where their frequencies stand in the ratio of a power of 2:1) have an essential similarity. Indeed, the traditional musical scale is based on this similarity, so that tones which are separated by octaves are given the same name (such as C, D, E, and so on). This generalization forms one of the essential bases of traditional music theory (Rimsky-Korsakoff, 1930). Studies by psychologists using conditioning techniques have also demonstrated octave generalization both in animals and in man (Blackwell & Schlosberg, 1943; Humphreys, 1939). Further, it has recently been shown that memory for pitch is subject to certain highly specific interference effects which generalize across octaves (Deutsch, unpublished observations).

It is clear from the above that octave generalization is a very powerful factor in the processing of musical information. One might therefore make the assumption that it occurs in all musical situations. However, this is not necessarily the case. In a theory of music recognition (Deutsch, 1969) it was proposed that pitch information is processed simultaneously along two independent and parallel channels. Along one of these channels there is convergence of information from units receiving pitch information separated by octaves; this gives rise to octave generalization. Along the other channel there is no such octave convergence, but instead abstraction (and so transposition) of both simultaneous and successive intervals and chords takes place. Since tunes are a series of successive intervals, these would be processed along the latter channel. Such a system would have the consequence that we would be unable to use octave generalization in recognizing tunes. The present experiment was undertaken, first, to test this theory and, second, as a demonstration that is very striking and easily reproducible by anyone with access to a musical instrument.

METHOD

Stimuli and Conditions

The first half of the tune "Yankee Doodle" was chosen as the test sequence. The choice was based, first, on the fact that this tune is almost universally known in the United States

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and, second, because it contains very little rhythmic information. The total sequence comprised 28 tones. It was recorded in five different ways: *Condition A* – The sequence was played in the key of F, starting with the F above middle C. *Condition* B – The sequence was played as in Condition A, only an octave higher. *Condition C* – The sequence was played as in Condition A, only an octave lower. *Condition D* – The sequence was played also in the key of F, except that each tone was played in an octave randomly chosen from among the three octaves employed in Conditions A, B, and C. Thus, every note in the sequence was in its correct position on the scale (i.e., it had the correct name), but the tune varied over a three-octave range. (The only restriction to the random assignment of octaves for each tone was that no two successive tones were chosen which also occurred in identical sequence in any of Conditions A, B, or C. There was therefore no random occurrence of a portion of the tune correctly played.) *Condition E*-The sequence was played as a series of clicks, so that the pitch information was entirely omitted but the rhythmic information was retained.

The tones in Conditions A, B, C, and D were all taken from an equal-tempered scale (International Pitch, A = 435). All tones were of 200-msec duration, and the pauses between them were either of 300 msec or 800 msec duration, as was required by the rhythm of the tune. The clicks in Condition E were generated by 5-msec bursts at 100 Hz. In order for the rhythm and speed in this sequence to be identical to those in the other sequences, the pauses between the clicks were either 495 msec or 995 msec in duration, as was required by the rhythm of the tune.

Apparatus

The tones and clicks were generated by a Wavetek oscillator controlled by a PDP-9 computer. The output was recorded on high-fidelity tape. The tape was played to Ss on a high-quality tape recorder through loudspeakers.

Procedure

In a pilot study, Conditions A, B, and C (the tune played correctly in the medium, high, or low register) were played separately to different groups of Ss. In all conditions, the tune was universally recognized (generally after the first few notes) and was considered to be correctly played.

Experimental group. The Ss were told that they would hear the first half of a well-known tune, except that the octaves in which the tones occurred would vary over a three-octave range. They were instructed to listen to the entire sequence and then to write on paper what they believed the tune to be. They were told to write "Don't know" if they found themselves totally unable to form a hypothesis, but were encouraged to guess if they possible could. The Ss were then asked if they understood the task, and they replied in the affirmative. Condition D (randomized octaves) was then played at a comfortable listening level. After the Ss had handed in their responses, Condition A (sequence played correctly in the middle register) was played to them and they were again asked what they believed the tune to be. Condition D (randomized octaves) was then played again, and the Ss were asked if they were able to follow the tune.

Control group. The Ss were told that they would hear the first half of a well-known tune without the pitch information and that they were to attempt to recognize the tune on the basis of the rhythm alone. Their instructions were otherwise identical to those for the experimental group. Condition E (rhythmic information alone) was then played at a comfortable listening level. After the Ss had handed in their responses, Condition A was played and they were again asked what they believed the tune to be.

Subjects

The Ss were students attending the summer session at the University of California. There were 35 Ss in the experimental group and 16 in the control group.

RESULTS AND DISCUSSION

The results are shown in Table 1. It is quite clear from comparison of performance in Conditions D and E that the Ss were unable to make use of pitch information in recognizing the tune when the octaves were randomized. There was no significant difference in performance between these conditions ($p > .05$ on a trinomial expansion). Indeed, the control group (tested on Condition E, rhythmic information alone) actually showed a higher percentage of correct guesses than did the experimental group (tested on Condition D, randomized octaves), though this difference is clearly attributable to chance variation. However, both the experimental and the control groups recognized the tune universally when it was played correctly (Condition A). In fact, recognition was so immediate that in both groups laughter broke out after the first few notes of Condition A were played!

It should be stressed that the lack of recognition in Condition D (randomized octaves) could not have been due to the pitch levels employed. All the tones in this condition were drawn from the three octaves used in the pilot study described above, in which the tune was shown to be universally recognized, irrespective of the octave in which it was played.

The incorrect guesses made by both groups tended overwhelmingly to be drawn from the same category: that of popular traditional American songs. Of the total nine incorrect guesses, three were "The Star-Spangled Banner," three were "Old McDonald Had a Farm," one was "Dixieland," one was "Swanee River," and only one was in a different category – "Strangers in the Night." It therefore appears that the Ss were forming hypotheses from within the category of tunes of which "Yankee Doodle" is a prominent member. This would make the probability of guessing "Yankee Doodle" by chance higher than if the Ss had been guessing from a larger ensemble. The lack of recognition found in Condition D (randomized octaves) is thus all the more striking.

Another finding of interest is that when the experimental group was played Condition D (randomized octaves) after they had heard Condition A (and so knew the identity of the tune), the Ss reported that they were now able to follow the tune to a large extent. Thus the Ss were able to use octave generalization to *confirm* the identity of the tune, though not to *recognize* it in the absence of prior information. It may be supposed that this was achieved by the Ss' imagining the tune to themselves simulta-

Table 1
Percentage Errors in the Different Conditions of the Experiment

	Conditions	Correct Recognitions (Percent)	Incorrect Guesses (Percent)	"Don't Knows" (Percent)
Experimental Group	A. Tune played in one octave	100	0	0
	D. Tune played in randomized octaves	11.76	17.65	70.59
Control Group	A. Tune played in one octave	100	0	0
	E. Rhythmic information alone presented	18.75	18.75	62.5

neously with hearing the "randomized octaves" version. In this way, they could match each note as it arrived with their auditory image and so could confirm that each note was either correct or separated by exactly an octave from the correct note. This would not require the making of any judgment involving successive intervals or tunes.

It might be suggested that the inability demonstrated in this experiment to use octave generalization for tune recognition may have in some cases been due to a failure to understand what an octave was (though the Ss had all declared prior to playing the test sequence that they understood the task). However, Condition D (randomized octaves) has also been played to several highly competent professional musicians, who have also found (to their great surprise) that they were unable to recognize the tune. The result obtained must therefore have been due to a real lack of octave generalization along the channel that processes tunes.

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