

AN OCTAVE DISCRIMINATION AS DISCLOSED BY SUBJECTIVE
TONAL JUDGMENT OF MUSICAL AND
NON-MUSICAL SUBJECTS

by

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ABSTRACT

A subjective differential rating technique was used to determine differences in octave discriminability between musical and non-musical male college students. Ss rated 23 test tones to a standard tone by means of a seven-point scale on a relative "similarity" criterion. The test frequencies extended two and one-fifth octaves above and below the standard 1,000 cycles per second (Hz) tone at equal interval fifths, and were presented for 200 milliseconds (ms) each at constant intensity. An analysis of variance performed on the nested 2x2 design data indicated highly significant differences between the judgmental performance by musical and non-musical Ss at octave and non-octave test points. A significant interaction (while open to multiple interpretation) at least substantiates the existence of an "octave effect" with the musical group. One possible mechanism which might partially account for the phenomenon in musical persons is discussed in terms of information processing procedures.

INTRODUCTION

The literature on auditory stimulus generalization (SG) has included at least two references to a peculiar empirical "octave effect" whereby responses to test stimuli are suddenly seen to increase at points corresponding to octaves, i.e., successively halved or doubled frequencies of a given tonal stimulus (Humphreys, 1939; Blackwell and Schlosberg, 1943). This increase in response strength at octaves to a conditioning stimulus would, if found on both slopes of the gradient of stimulus generalization (GSG), result in a novel, symmetrically "scalloped" gradient quite unlike any previous empirical or theoretical gradients found or hypothesized (Hovland, 1937; Spence, 1937; Schlosberg and Solomon, 1943). Further, if it could be shown to possess some inherent predictability, such an octave effect would prove useful as an explanatory device in much auditory experimentation utilizing response measures taken at or even near the octaves to a previously presented tonal stimulus.

The experimental situation in the present study differs in some ways from a pure stimulus generalization procedure; however, similarities will become obvious as the description proceeds and the subsequent interpretation in terms of SG will facilitate the accompanying discussion.

METHOD

Subjects

Having been selected arbitrarily from a population of many qualified students, a total of twenty male University of Arizona undergraduates were used as Ss. One group (musical) consisted of ten students who were on scholarship in the music department and fulfilling their obligations as applied musicians within that department. The second group (non-musical) was comprised of ten male undergraduates having had no previous formal training in music.

Apparatus and Materials

Experimentation was accomplished in a soundproof room in the psychology laboratory at the University of Arizona. The frequency and stability of the pure tone sinusoid emitted from a Hewlitt Packard model 200 CD audio oscillator was monitored by an electronic counter (Hewlitt Packard model 522B). The stimulus, of 200 ms duration, was fed directly into a Roberts model 990 stereophonic tape recorder. Only one of the two available channels was used, however, in order to facilitate binaural equalization through the Calrad headphones. Intensity was held constant by means of voltage control at the output of the oscillator

while 100 KHz white noise was presented for ten seconds after the presentation of the test tone in order to minimize tonal retention and maximize between-trial separation. A knife switch allowed selection of the source (tone or white noise) to the input of the recorder. The response measure adopted was a one through seven differential rating scale where 1 = completely different; 2 = quite different; 3 = fairly different; 4 = neutral; 5 = fairly similar; 6 = quite similar; and 7 = identical.

The standard stimulus (S_0) was 1,000 Hz and adjacent test stimuli separation was constant at equal-interval fifths of each octave. A total of 23 different test stimuli were used beginning at 225 Hz and extending to 4,800 Hz thereby incorporating a total range of two and one-fifth octaves above and below S_0 (see Figure 2 for a complete account of all intermediate frequencies employed). Each single trial consisted of the following sequence (see Figure 1): white noise (10 seconds), delay (800 ms), S_0 (200 ms), delay (1200 ms), test tone (200 ms), response interval (10 seconds).

Procedure and Design

Four tapes were recorded, each employing a different random order of the test stimuli with each individual test stimulus being presented only once per 15 minute tape. Two tapes were given to each S individually. The order of

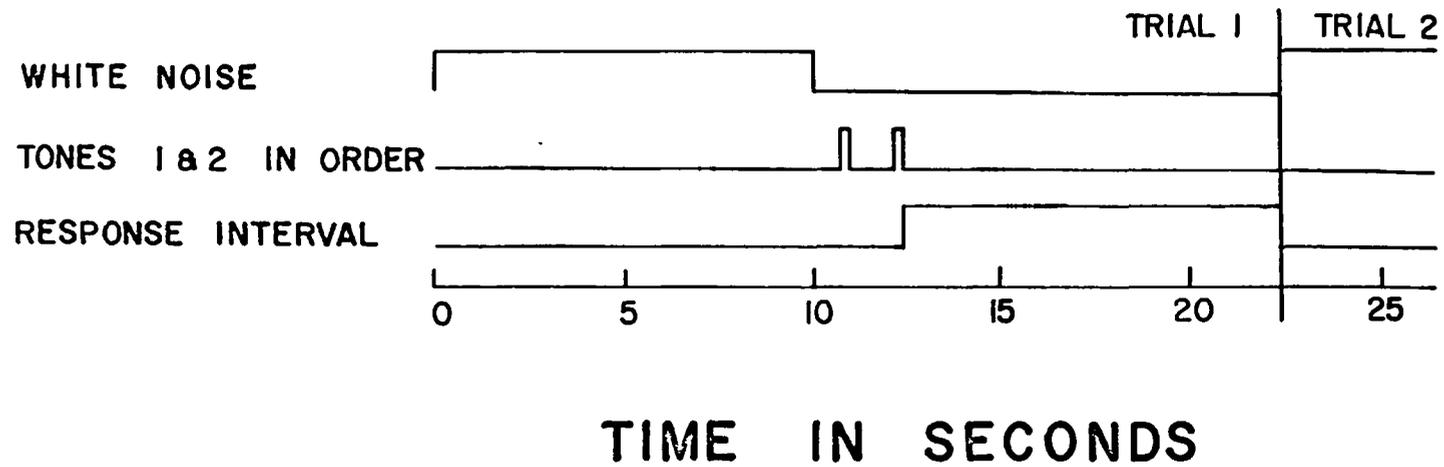


Fig. 1. Schematized sequence of events for a single trial

presentation of the tapes was counterbalanced to assure that equal numbers of Ss in both groups were tested on all four tapes an equal number of times. S was given the following instructions:

Place the headphones over your ears and adjust them until they are comfortable. When the tape starts, you will hear a hissing sound for approximately ten seconds after which you will hear two tones presented one at a time. Your task for each trial is to circle the appropriate number under the rating given at the top of your score sheet for the second tone's relative similarity to the first. For example, after the hissing sound you hear tone 1, then tone 2. If you think that tone two was "quite similar" to tone one for that trial, then circle number six (6) in that row (since 6 corresponds to the "quite similar" rating at the top of the page). There are seven different ratings to choose from ranging from "completely different" (1) to "identical" (7). Be sure you make one and only one rating per trial; but you must make one rating per trial and it cannot be changed once it is made. There are twenty-three trials altogether. Are there any questions?

Before testing, S was requested to interpret the instructions orally.

RESULTS

The mean ratings for every S in each group for both tape orders and at each octave frequency are recorded in Table 1 and graphically shown along with all non-octave mean ratings in Figure 2. Inspection of Figures 2 and 3 shows the rather dramatic separation of the performance of the two groups at the octaves, while clearly showing the approximate equality of their performance on the same parameter at the non-octave stimuli.

An analysis of variance was performed on the 2x2 nested design data. The F-interaction between octave and non-octave mean scores by musical and non-musical Ss (see Figure 3) yielded a value of 52.9 where 8.28 was required to demonstrate significance at $\alpha = 0.01$. There was also significance demonstrated beyond the 0.01 level for both pooled octave vs non-octave groups ($F = 60.8$) as well as musical vs non-musical ($F = 18.5$). The data suggest clearly that real differences do in fact exist between the perception of similarity of octaves to non-octaves in musical and non-musical Ss.

Table 1
Octave Mean Ratings for Musical and Non-musical Groups

	Octaves				
	-2	-1	$0(S_o)$	+1	+2
Musical	5.20	5.25	6.80	5.40	4.45
Non-Musical	2.00	3.80	6.75	2.85	2.00

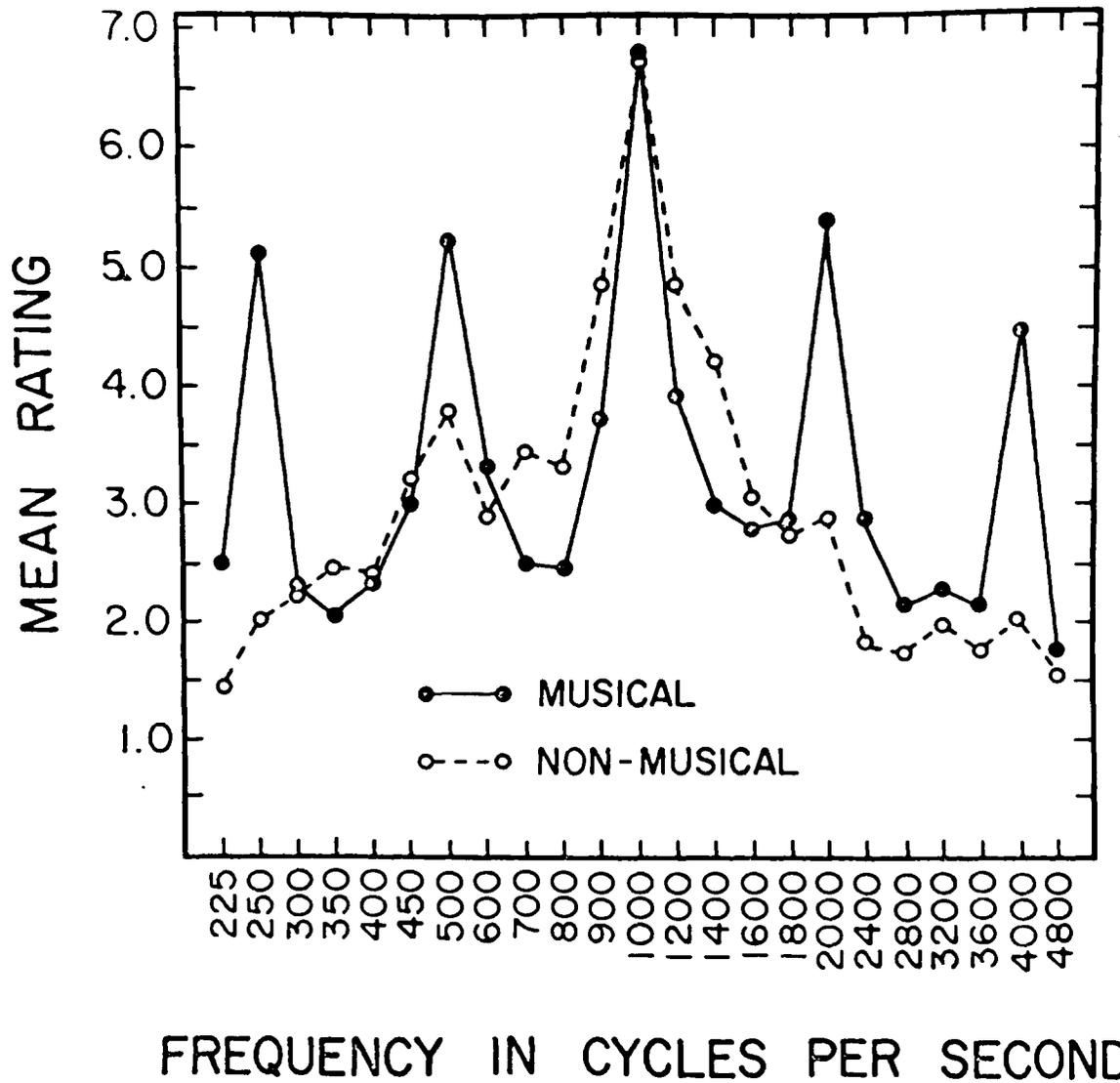


Fig. 2. Subjects' performance at each test frequency

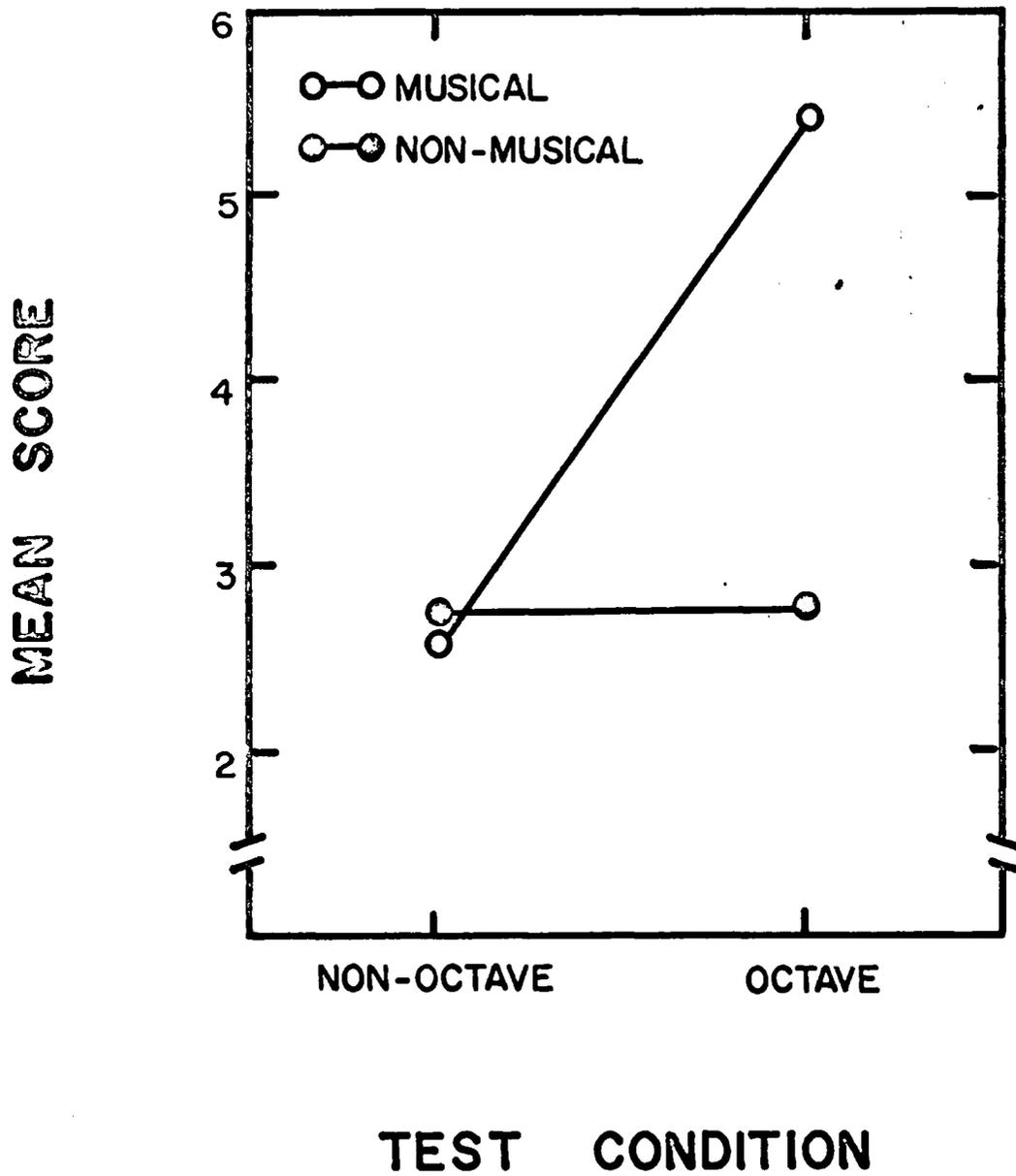


Fig. 3. Interaction between groups across octave and non-octave test conditions.

DISCUSSION

Exactly how to regard the performance difference between the two groups is by no means clear. One could easily say that the musical group "generalized" more to the octaves than the non-musical group. On the other hand, one could argue that the results reflect nothing more than a discriminability difference between the two groups. Or one might waive claim to any interpretive device whatever, and be content with a purely expository presentation of the empirical data. However, description without explanation is rather like acknowledging a fact without its *raison d'etre*. Thus, admittedly transcending the realm of pure science, it seems probable that the previous training advantage together with possibly some innate advantages of the musical over the non-musical Ss, accounts in part for the performance difference. Further, in terms of information processing, according to our accepted occidental "music system," it is hypothesized that music students tend to place a perceived single tone (when they know it is to be followed by another tone) into the framework of a scale

initiated by that tone.¹ Music students, being more accustomed to such organized placement of tones relative to certain other tones, must have a far greater probability of such accurate relational organization than do the non-musical students who are, then, more apt to judge tones in terms of their absolute differences to a given standard. In other words, it seems likely that musical students are responding mostly to note differences whereas the non-musical students appear to be responding more to pitch differences. For the musician, the standard stimulus, S_0 , is interpreted as a note, probably because the oscillator is producing a sound whose most obvious quality--pitch--is also the most obvious quality of musical notes; and the musician in his studies thinks in terms of notes, not frequencies. The difference between responding to notes (which inherently include pitch) and to pitch alone, shows itself mainly through the nature of the musical scale. When a single sound which has a pitch is presented to the

1. Exactly which scale, whether major or minor, for example, would depend largely on the second tonal stimulus. If the two presented tones were C and E, then supposedly the musician would be more likely to think in terms of the C major scale. If, however, the second tone had been an E flat, then it would be more likely for the musician to be thinking in terms of the C minor scale since E flat is a natural constituent of the C minor scale where an E is not. On the basis of the presentation of only the first tone, one supposedly could only predict that some scale beginning with that note was going to provide the template for the subsequent ordered relational judgment.

musician, he puts it immediately into a place at the beginning of a scale initiated by that pitch.² It is then that the pitch becomes no longer only a pitch, it becomes a note. Now, if another sound which has pitch is presented shortly after this first sound, a place is found for it within that scale or in the scale whose initial note is the appropriate octave to the first (reference) pitch heard. The musician uses the octave because the octave is the same note as the original tone heard (middle C is the same note as high C, but their pitches are vastly different).

The within-group mean ratings to the between-octave test stimuli would seem to indicate especially with the musical Ss, that the tones immediately adjacent to each side of an octave from S_0 anticipate that octave. That is, they are rated on the whole, as more similar to S_0 than are the next adjacent tones further from the octave. The one exception to this in the musical group is the mean response at 3,200 Hz which was slightly higher than that at 2,800 and 3,600 Hz (see Figure 2). The point to be made here, however, is the apparently less systematic nature of the between-octave response patterns in the non-musical group, and how this differs so markedly from the apparently octave-generalized between-octave response patterns characteristic of the musical Ss.

2. Ibid.

It might well be argued that, strictly speaking, the generalization interpretation is mis-applied here since the study involves no actual experimental pre-training to the conditioning stimulus (1,000 Hz). This may be true holding to a strict definition of SG, but the SG interpretation makes good sense considering the obvious homologues of the present design to the SG paradigm. For example, SG holds that the greater the degree of similarity between the original stimulus and those in the test situation, the greater the likelihood that a response similar to the conditioned response at the CS (S_0) will occur. The parallel is obvious. This study requires S to rate the relative similarity of two tones where the first tone is always the reference tone (CS). In strict SG studies, the perceived relative similarity of stimuli are inferred from the response data. Here, however, the perceived relative similarity of stimuli is directly measured from S's response.

In defense of the SG interpretation, however, it could be maintained that training to the CS actually was accomplished through habits acquired pre-experimentally. The design of the experiment merely took advantage of such pre-conditioning just as many studies in verbal learning are doing today.

Evidence for such pre-conditioning exists in the comparison of the insignificant response differences at S_0

for each group (see Table 1). Still, it is essential to recognize that whether to consider this study from a strict SG viewpoint or to interpret the results by consideration of mere discriminability differences is unimportant for present purposes.

While research in audition is young, much progress has been made towards the uncovering of many of its lawful psychophysical relationships. And while such progress is contingent upon an appreciation of related prior psychophysical findings, the confirmation here of an octave effect, if only in some Ss, will demand careful consideration in the results of continuing auditory experimentation.

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