# The perceived height of octave-related complexes

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Subjects were presented with two-part patterns consisting of tones whose partials stood in octave, or near-octave relation. The perceived heights of the tones in the patterns were found to vary depending on their positions along the chroma circle, so that the patterns were perceived quite differently depending on which of two keys they were in. Implications of these findings are discussed.

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## INTRODUCTION

It has been argued, on both psychological and music-theoretic grounds, that the pitch of a tone should be represented along two dimensions. First, the rectilinear dimension of height defines the position of a tone on a continuum from high to low. Second, the circular dimension of the chroma, or pitch class, defines the position of a tone within the octave (Meyer, 1904, 1914; Revesz, 1913; Ruckmick, 1929; Bachem, 1948; Babbitt, 1960, 1965; Shepard, 1964, 1982; Deutsch, 1969, 1982; Forte, 1973; Ward and Burns, 1982). This bidimensional representation is implicit in Western musical notation. Here, a note is designated first by a letter name, which refers to its position within the octave, and then by a number, which refers to the octave in which it is placed. Thus, for example, D2, D3, and D4 designate notes having the same chromas or pitch classes which are placed in different octaves, and C3, F#3, and A3 designate notes having different chromas or pitch classes which are placed in the same octave.

As evidence for the psychological reality of the chroma dimension, people with absolute pitch sometimes make octave errors while assigning the correct letter names to notes (Baird, 1917; Bachem, 1954; Ward and Burns, 1982). Conditioning studies employing both human and animal subjects have obtained generalization of response to tones that stand in octave relation (Humphreys, 1939; Blackwell and Schlosberg, 1943). Interference effects in short-term memory for pitch exhibit octave generalization (Deutsch, 1973). Tone pairs that are presented in a musical context are judged as closely similar when they are separated by octaves (Krumhansl, 1979).

In order to accommodate the dimensions of height and chroma in a single spatial representation, it has been suggested that pitch be described as a helix which completes one full term per octave, so that tones which are separated by octaves are represented as in spatial proximity (Drobisch, 1855; Shepard, 1965, 1982). It has alternatively been suggested that the monotonic dimension of height and the circular dimension of chroma be represented as two separate arrays, the chroma array being formed out of projections from the height array (Deutsch, 1969, 1982). Both of the above models assume (as has generally been assumed) that the perceived heights of tones are invariant with respect to pitch class. However, there is very little experimental evidence on this issue.

One study which addressed the relationship of pitch class to perceived height was performed by Shepard (1964). He generated a series of tones, each of which consisted of ten octave-related sinusoidal components. The amplitudes of these components differed according to a fixed bell-shaped spectral envelope, such that those in the middle of the musical range were highest, and those at the extremes were lowest. The pitch classes of the tones were then varied by shifting the components up and down in log frequency. Since the spectral envelope remained fixed, Shepard argued, the perceived heights of the tones would be expected to remain unchanged as the sinusoidal components shifted along the log frequency continuum.

Subjects were presented with ordered pairs of such tones, and they judged for each pair whether it formed an ascending or a descending sequence. When the tones were separated by one or two steps along the chroma circle, judgments of relative height were found to be almost entirely determined by proximity (see also Burns, 1981; Risset, 1971; Schroeder, 1986). Thus, when the second tone was displaced one or two steps clockwise from the first, the sequence was judged to be ascending. Similarly, when the second tone was displaced one or two steps counterclockwise from the first, the sequence was judged to be descending. With increasing distance along the chroma circle, the tendency for judgments to be determined by proximity lessened, but still persisted. When, however, the tones were separated by exactly a half-octave, ascending and descending judgments occurred equally often.

Shepard concluded that for such octave-related complexes, the perceived attribute of height was entirely suppressed, with pitch class alone remaining. However, since judgments in this situation were overwhelmingly determined by proximity, other factors which might have given rise to differences in perceived height could have been masked. Further, the results were obtained by averaging over both subjects and pitch classes, so that individual differences in perceived height would have been lost in the averaging process.

  

Deutsch *et al.* (1984) have provided evidence that pitch class does indeed exert an influence on perceived height. They performed an experiment using tones constructed in a fashion similar to those of Shepard (1964), but consisting of six octave-related sinusoids rather than ten. Two-part patterns based on such tones were found to be perceived quite differently depending on which of two keys they were in. Specifically, two such patterns were employed. The first was in the key of C major, and consisted of the ascending sequence (D–E–F) played simultaneously with the descending sequence (B–A–G). The second was an exact transposition of the first to the key F# major, and so consisted of the ascending sequence (G#–A#–B) played simultaneously with the descending sequence (E#–D#–C#). Listeners who perceived these patterns unambiguously fell into two categories. Type A listeners heard the C major pattern with the ascending (D–E–F) line as higher in pitch, and the descending (B–A–G) line as lower. However, they instead heard the F# major pattern with the descending (E#–D#–C#) line as higher in pitch, and the ascending (G#–A#–B) line as lower. Thus, when the pattern was transposed from one key to another, the relative heights of the tones in the different regions of the chroma circle were preserved, which resulted in a perceived interchange of voices. Type B listeners obtained percepts which were the converse of those of type A. They heard the C major pattern with the descending (B–A–G) line as higher in pitch, and the ascending (D–E–F) line as lower. However, they instead heard the F# major pattern with the ascending (G#–A#–B) line as higher in pitch and the descending (E#–D#–C#) line as lower. Thus, again, the relative heights of the tones in the different regions of the chroma circle were preserved under transposition, resulting in an apparent interchange of voices.

In order to investigate the possible influence of the spectral envelope on these judgments, patterns were constructed with envelopes centered at four different positions along the spectrum, with peaks spaced at $\frac{1}{2}$ octave intervals, and so ranging altogether over $1\frac{1}{2}$ octaves. It was found that the results did not vary with such differences in the position of the spectral envelope.

The present study was undertaken as a replication and extension of the one just described. In particular, two further questions were addressed. First, the stability of the effect was examined over a broader region of the spectrum. To this end, six rather than four spectral envelopes were employed, which were spaced at half-octave intervals, so spanning a $2\frac{1}{2}$ octave range. Second, the generality of the effect was examined for tone complexes whose components were not exactly in octave relation. To this end, a second experiment was performed in which tones were constructed whose sinusoidal components were related by powers of 2.01. Since the phase relationships between the components of such tones were constantly changing, this condition also served as a control for possible interpretations of the effect in terms of phase.

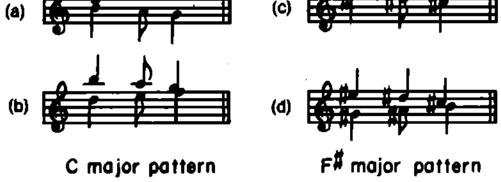


FIG. 1. Pitch patterns employed in the study. Each pattern is notated in accordance with two alternative perceptual organizations. In (a) and (c), the higher line is heard as ascending, and the lower line as descending. In (b) and (d), the higher line is heard as descending, and the lower line as ascending.

## I. EXPERIMENT 1

### A. Method

#### *1. Stimulus patterns*

Two basic pitch patterns were employed. Both patterns consisted of three chords which were presented in succession, with no gaps between chords. The durations of the first and third chords were 500 ms, and the duration of the second chord was 250 ms. The first pattern was in C major, and consisted of the chords D/B, E/A, and F/G. The second was an exact transposition of the first to F# major, and so consisted of the chords G#/E# (F), A#/D#, and B/C#. It had been found in preliminary work that most listeners organize such patterns into two melodic lines on the basis of pitch proximity. Thus the C major pattern sounded as one line which ascended by a minor third, corresponding to the sequence D–E–F, played together with another line which descended by a major third, corresponding to the sequence B–A–G. However, some listeners heard the pattern with the higher line corresponding to the ascending sequence and the lower line to the descending [as in Fig. 1(a)], whereas others heard it with the higher line corresponding to the descending sequence and the lower line to the ascending [as in Fig. 1(b)]. Similarly, the F# major pattern was heard as a line which ascended by a minor third corresponding to the tones G#–A#–B, together with another line which descended by a major third, corresponding to the tones E# (F)–D#–C#. However, some listeners heard the pattern with the higher line corresponding to the ascending sequence and the lower line to the descending [as in Fig. 1(c)], whereas others heard it with the higher line corresponding to the descending sequence and the lower line to the ascending [as in Fig. 1(d)].

Each tone consisted of six octave-related sinusoids, the amplitudes of which were scaled by a fixed bell-shaped spectral envelope. Mathematically, the spectral envelope was defined as a raised, inverted cosine curve, logarithmically scaled to lie in a specified frequency range. The general form of the equation can be stated as

$$A(f) = 0.5 - 0.5 \cos\left[\frac{2\pi}{\gamma} \log_\beta \left(\frac{f}{f_{\min}}\right)\right], \quad f_{\min} \leqslant f \leqslant \beta^\gamma f_{\min},$$

where $A(f)$ is the relative amplitude of a sinusoid at frequency $f$ Hz, $\beta$ is the frequency ratio between adjacent sinusoidal components (e.g., for octave spacing, $\beta = 2$), $\gamma$ is the number of $\beta$ cycles to be spanned, and $f_{\min}$ is the minimum frequency for which the amplitude is to be nonzero. The maximum frequency for which the amplitude is nonzero is

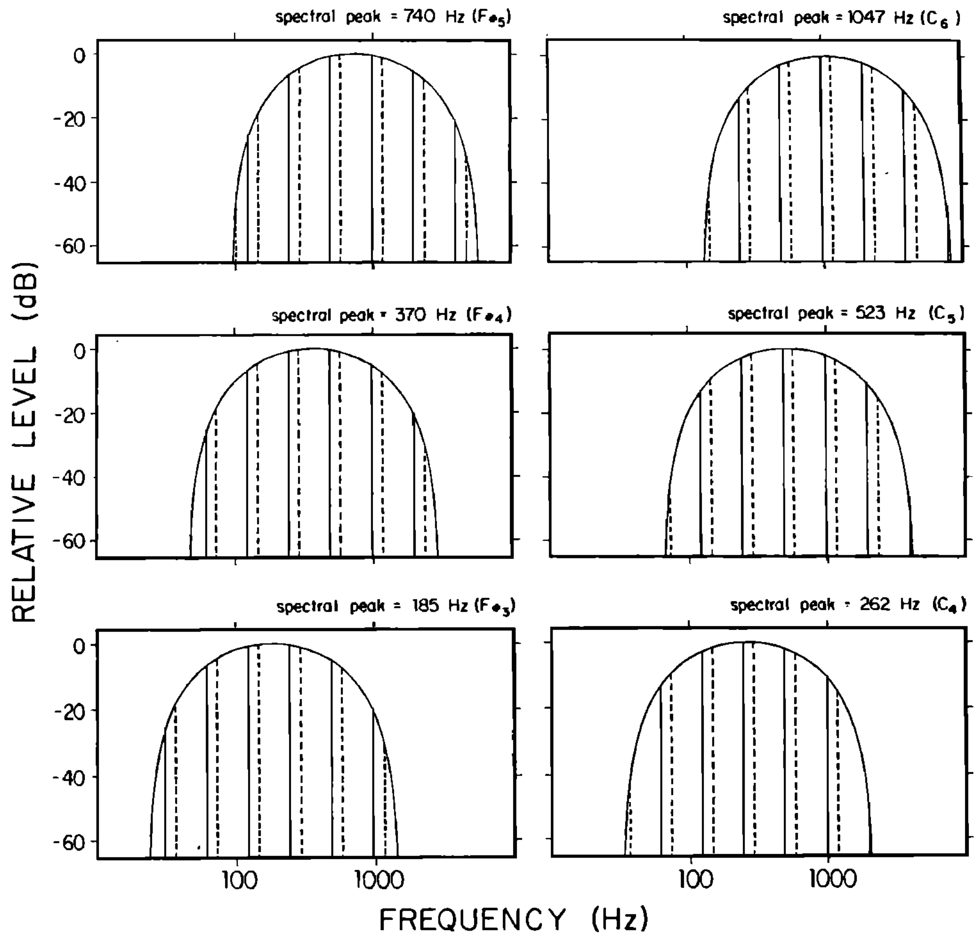


FIG. 2. Representation of the spectral compositions of the tones used in experiment 1 for the chord (D/B), generated under all six spectral envelopes. The solid lines indicate tones of pitch class B, and the dashed lines indicate tones of pitch class D. The position of the spectral envelope varied over a 2½ octave range, resulting in substantial differences in the overall heights of the patterns.

then $\gamma\beta$ cycles above $f_{min}$. Throughout experiment 1, the values $\beta = 2$ and $\gamma = 6$ were used. Thus the spectral envelope always spanned precisely six octaves from $f_{min}$ to $64 f_{min}$.

The C major and the F# major pitch patterns were each generated under envelopes which were placed at six different positions along the spectrum. As shown in Fig. 2, these positions were spaced at half-octave intervals, so that the envelopes peaked at F#3 (185 Hz, $f_{min} = 23.1$ Hz), C4 (262 Hz, $f_{min} = 32.7$ Hz), F#4 (370 Hz, $f_{min} = 46.2$ Hz), C5 (523 Hz, $f_{min} = 65.4$ Hz), F#5 (740 Hz, $f_{min} = 92.4$ Hz), and C6 (1047 Hz, $f_{min} = 130.8$ Hz).[1] The Appendix presents the frequencies of the sinusoidal components of the tones generated under all six envelopes, together with their relative amplitudes.

The employment of envelopes which were spaced at half-octave intervals served to counterbalance for possible effects of the relative amplitudes of the different sinusoidal components on the judgments. Thus the amplitudes of the components of tones comprising the C major pattern generated under envelopes centered on C4, C5, and C6 (hereafter referred to as C envelopes) were identical to those comprising the F# major pattern generated under envelopes centered on F#3, F#4, and F#5 (hereafter referred to as F# envelopes). For example, the amplitudes of the components of the tone D generated under a C envelope were identical to those of the tone G# generated under an F# envelope; and so on. This point is illustrated in Fig. 3. The left-hand portion of the figure represents the sequence of chords comprising the C major pattern generated under the spectral envelope centered on C5, and the right-hand portion represents the sequence of chords comprising the F# major pattern generated under the spectral envelope centered on F#5. It can be seen that the two patterns were spectrally identical, except that the right-hand pattern was a rigid translation of the left-hand pattern along the log frequency continuum. Analogously, the relative amplitudes of tones comprising the C major pattern generated under an F# envelope were identical to those comprising the F# major pattern generated under a C envelope.

### 2. Procedure

Subjects were tested in soundproof booths. On each trial, one of the twelve patterns was presented three times in succession, and the subjects judged whether the higher of the two melodic lines formed an ascending or a descending sequence. Within each trial, the three presentations were separated by 750-ms pauses. Trials were separated by 10-s intertrial intervals, during which the subjects made their responses.

Each session consisted of two blocks of 24 trials each, with a 5-min break between blocks. In the first block, the six patterns generated under envelopes centered on C5, F#5,

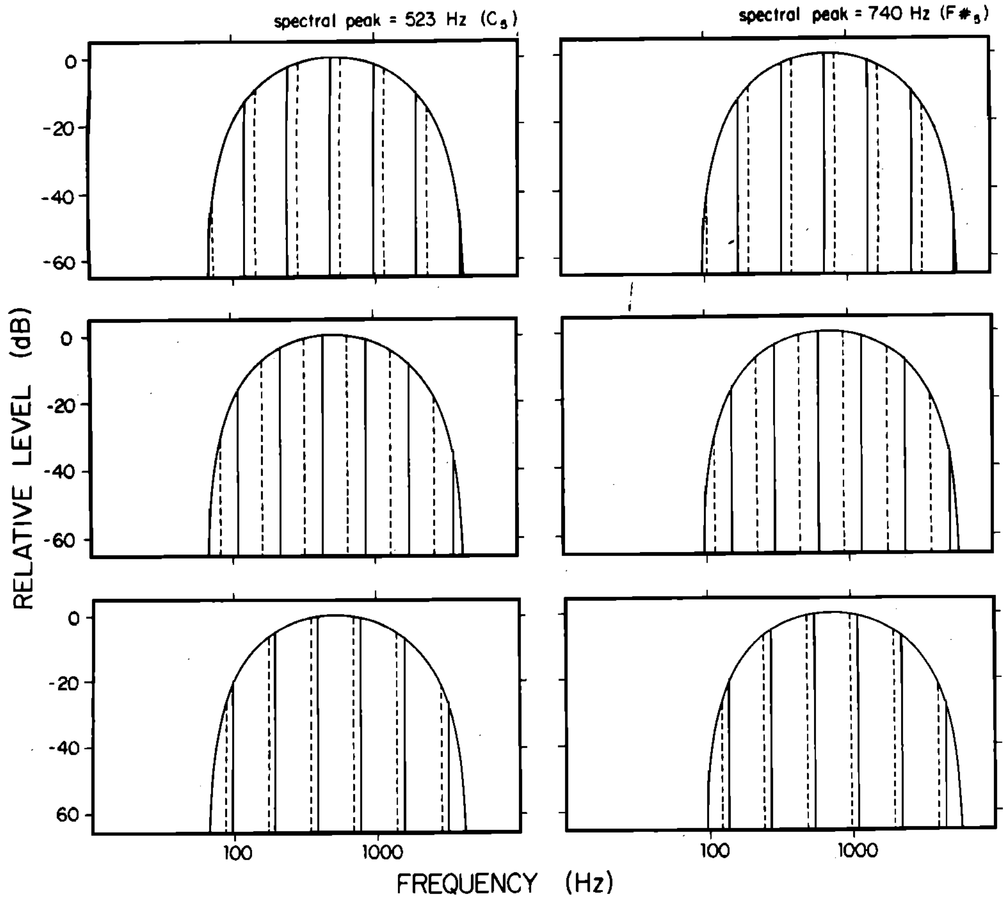


FIG. 3. Representation of the spectral compositions of the tones comprising two of the patterns used in experiment 1. Reading downward, the pattern on the left consists of the sequence (D–E–F), shown by the dashed lines, played simultaneously with the sequence (B–A–G), shown by the solid lines. This pattern, which was in C major, was here generated under the spectral envelope centered on C5. Also reading downward, the pattern on the right consists of the sequence (G#–A#–B), shown by the dashed lines, played simultaneously with the sequence (E#–D#–C#), shown by the solid lines. This pattern, which was in F# major, was here generated under the spectral envelope centered on F#5. Note that the pattern on the right is a rigid translation of the pattern on the left along the log frequency continuum.

and C6 were presented four times in succession, each time in a different random order. In the second block, the six patterns generated under envelopes centered on F#3, C4, and F#4 were presented four times in succession, again each time in a different random order. Each subject participated in two sessions, which were held on separate days, and the results were averaged. A few practice trials were given at the beginning of each session.

### 3. Subjects

Two groups of musically trained subjects were selected for the experiment, on the basis of their percepts of the C major and F# major patterns with envelopes centered on C5. Their percepts were documented both by their verbal descriptions, and also by their informal notations of the patterns. All subjects heard both patterns as two melodic lines which moved in contrary motion. One group (type A subjects) heard the C major pattern with the higher line ascending by a minor third, and the lower line descending by a major third. These subjects also heard the F# major pattern with the higher line descending by a major third and the lower line ascending by a minor third. The second group (type B subjects) heard the C major pattern with the higher line descending by a major third, and the lower line ascending by a minor third. They also heard the F# major pattern with the higher line ascending by a minor third, and the lower line descending by a major third. About 50% of those who tried out for the experiment fell into one of these two categories.[2] Of the eight subjects selected, seven were students at the University of California, San Diego, and were paid for their services. One of the authors (DD) also served as subject. All subjects had normal hearing, and all but one denied having absolute pitch.

### 4. Equipment

Stimuli were generated on a VAX 11/780 computer with the music sound synthesis system developed by one of the authors (Moore, 1982). They were recorded and played back on a Sony PCM-F1 digital audio processor, the output of which was passed through a Crown amplifier, and presented to the subjects binaurally through Grason–Stadler TDH-49 headphones, at a level of approximately 72 dB SPL.

## B. Results

Table I displays, for the two groups of subjects, the percentages of judgments that the higher line formed an ascending sequence, both as a function of key, and also as a function of position of the spectral envelope. It can be seen that, for both groups of subjects, judgments were almost entirely determined by the key in which the pattern was presented. Type A subjects showed a strong tendency to hear the C major pattern with the higher line ascending, and so heard tones D, E, and F as higher, and B, A, and G as lower. Further, they heard the F# major pattern with the higher line descending instead, and so heard tones E# (F), D#, and

TABLE I. Percentages of judgments that the higher line formed an ascending pattern; experiment 1.

| | | Spectral peak | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | F#3 | C4 | F#4 | C5 | F#5 | C6 | |
| Key | C major[a] | 100 | 100 | 100 | 97 | 94 | 100 | type A subjects |
| | F# major[b] | 0 | 0 | 0 | 0 | 0 | 0 | |
| | | Spectral peak | | | | | | |
| | | F#3 | C4 | F#4 | C5 | F#5 | C6 | |
| Key | C major | 3 | 9 | 0 | 3 | 6 | 0 | type B subjects |
| | F# major | 97 | 97 | 97 | 97 | 97 | 100 | |

[a] C major pattern: ascending line formed of tones D, E, and F; descending line formed of tones B, A, and G.

[b] F# major pattern: ascending line formed of tones G#, A#, and B; descending line formed of tones E# (F), D#, and C#.

TABLE II. Percentages of judgments that the higher line formed an ascending pattern; experiment 2.

| | | Spectral peak | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | F#3 | C4 | F#4 | C5 | F#5 | C6 | |
| Key | C major[a] | 91 | 97 | 100 | 100 | 100 | 100 | type A subjects |
| | F# major[b] | 3 | 3 | 3 | 0 | 0 | 0 | |
| | | Spectral peak | | | | | | |
| | | F#3 | C4 | F#4 | C5 | F#5 | C6 | |
| Key | C major | 13 | 6 | 0 | 3 | 3 | 3 | type B subjects |
| | F# major | 97 | 97 | 100 | 94 | 97 | 100 | |

[a] C major pattern: ascending line formed of tones D, E, and F; descending line formed of tones B, A, and G.

[b] F# major pattern: ascending line formed of tones G#, A#, and B; descending line formed of tones E# (F), D#, and C#.

C# as higher, and G#, A#, and B as lower. This pattern was obtained consistently for envelopes situated at all six positions along the spectrum. As illustration, the left-hand portion of Fig. 4 shows the chroma circle oriented with respect to height so as to produce this pattern of results. Type B subjects, in contrast, produced results which were the converse of those of type A. They consistently heard the C major pattern with the higher line descending, and so heard tones B, A, and G as higher and tones D, E, and F as lower. Further, they consistently heard the F# major pattern with the higher line ascending, and so heard tones G#, A#, and B as higher and E# (F), D#, and C# as lower. Again, this pattern was consistently obtained for all six positions of the spectral envelope. The right-hand portion of Fig. 4 shows the chroma circle oriented with respect to height so as to reflect the judgments of this group of subjects.

## II. EXPERIMENT 2

### A. Method

Experiment 2 was undertaken to examine the generality of the findings to tones whose partials did not stand exactly in octave relation. To this end, the spectral envelope was stretched slightly, so that the partials were related by powers of 2.01, their relative amplitudes being unchanged. This corresponding to setting $\beta = 2.01$ in the equation for $A(f)$, and using sinusoids spaced according to powers of 2.01 rather than 2.0. The Appendix presents the frequencies of the components of the tones generated under all six stretched envelopes, together with their relative amplitudes. Since the phase relationships between these sinusoids were constantly varying, the experiment also provided a control for effects of phase. Other aspects of the experimental design were identical to those of experiment 1, and the same subjects were employed.

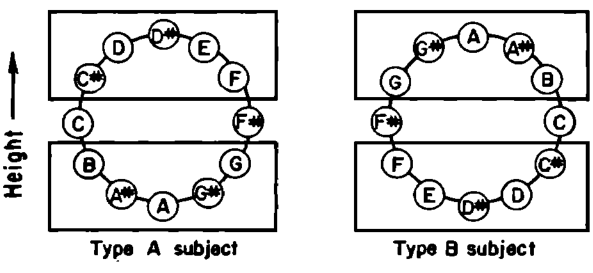


FIG. 4. Different orientations of the chroma circle with respect to the height, reflected in the judgments of the two types of subject. Tones bounded by the upper rectangle were heard as higher, and tones bounded by the lower rectangle were heard as lower.

### B. Results

Table II displays, for the two groups of subjects, the percentages of judgments that the higher line formed an ascending sequence, as a function both of key and also of the position of the spectral envelope. It can be seen that the results were virtually identical to those of experiment 1. Thus the effect of pitch class on perceived height was found to hold also for tone complexes whose components did not stand strictly in octave relation, and where the phase relationships varied randomly.

## III. DISCUSSION

Two factors have previously been shown to contribute to the perceived height of a complex tone. First, a fundamental is extracted from the harmonic components, giving rise to a pitch which corresponds to the fundamental frequency. This factor has been found to contribute mostly for tones with fundamentals below roughly 900 Hz. Second, the partials of the tone are weighted on the basis of their relative amplitudes, so giving rise to spectral pitch. This factor has been found to predominate for tones with fundamentals above roughly 900 Hz (Goldstein, 1973; Wightman, 1973; Terhardt *et al.*, 1982). The present study has provided evidence that, under certain circumstances, another factor can be involved. For complex tones consisting of partials which stand in octave, or near-octave relation, variations in perceived height may be found which depend on their positions along the chroma circle.

The mechanism responsible for this effect is at present unknown. However, we should emphasize that the employment of envelopes which were spaced at half-octave intervals controlled for simple interpretations based on the relative amplitudes of the individual spectral components. Further, since the effect was shown to occur consistently with envelope positions varying over a $2\frac{1}{2}$ octave range, it cannot be based in any simple way on loudness or salience differences between these components. In addition, since the effect also occurred with tones whose partials were not strictly in octave relation, it cannot be based on the processing of phase information. It should also be emphasized that the judgments reflected clear differences in height at the phenomenological level, and were not simply a product of task factors. This was evidenced both by the verbal descriptions given by the subjects, and also by their informal musical notations of the patterns as they perceived them.

Since the subjects were referring to the absolute positions of the tones along the chroma circle in making judgments of height, they were, in a sense, drawing on absolute pitch to perform the task. However, only one of the eight subjects in the experiment claimed to possess absolute pitch, in the sense of being able to attach verbal labels to notes presented in isolation. It would appear, therefore, that this is a complex faculty which may frequently be present in partial form. A related point has recently been made by Terhardt and Ward (1982) and Terhardt and Seewann (1983). These authors found that musicians were able to judge whether or not a passage was played in the correct key, even when differences as small as a semitone were at issue. This was true even though most of the subjects claimed not to have absolute pitch. The authors concluded that absolute pitch is, in this regard, considerably more common than is generally supposed.

Apart from its implications for pitch perception, the findings described here provide us with an interesting musical paradox. In general, when a musical passage is transposed from one key to another, the perceived relationships between the tones are unchanged (Von Ehrenfels, 1890). Our present pattern represents an exception to this rule, since its transposition results in an apparent interchange of voices. A convincing informal demonstration of this paradoxical effect may be achieved by tape recording an example of the pattern and then playing it back at different speeds. Specifically, if the tape is first played at normal speed, and is then sped up so that the pitches are transposed up a half-octave, those listeners who had first heard the pattern with the higher line ascending now hear it with the higher line descending, and those listeners who had first heard the pattern with the higher line descending now hear it with the higher line ascending! This demonstration works particularly well in a group situation, where clear differences are also apparent between listeners in how the pattern is perceived in any one key.

## ACKNOWLEDGMENTS

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## APPENDIX

Frequencies and relative amplitudes of the sinusoidal components of the tones employed in the two experiments, listed by pitch class and by spectral envelope.

**EXPERIMENT 1**

| | spectral peak = F#3 | | spectral peak = C4 | | spectral peak = F#4 | | spectral peak = C5 | | spectral peak = F#5 | | spectral peak = C6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C# | | | | | | | | | | | | |
| | 34.6 Hz | -21 dB | 34.6 Hz | -55 dB | 69.3 Hz | -21 dB | 69.3 Hz | -55 dB | 138.6 Hz | -21 dB | 138.6 Hz | -55 dB |
| | 69.3 Hz | -5 dB | 69.3 Hz | -10 dB | 138.6 Hz | -5 dB | 138.6 Hz | -10 dB | 277.2 Hz | -5 dB | 277.2 Hz | -10 dB |
| | 138.6 Hz | 0 dB | 138.6 Hz | -2 dB | 277.2 Hz | 0 dB | 277.2 Hz | -2 dB | 554.4 Hz | 0 dB | 554.4 Hz | -2 dB |
| | 277.2 Hz | 0 dB | 277.2 Hz | 0 dB | 554.4 Hz | 0 dB | 554.4 Hz | 0 dB | 1108.7 Hz | 0 dB | 1108.7 Hz | 0 dB |
| | 554.4 Hz | -6 dB | 554.4 Hz | -3 dB | 1108.7 Hz | -6 dB | 1108.7 Hz | -3 dB | 2217.5 Hz | -6 dB | 2217.5 Hz | -3 dB |
| | 1108.7 Hz | -26 dB | 1108.7 Hz | -13 dB | 2217.5 Hz | -26 dB | 2217.5 Hz | -13 dB | 4434.9 Hz | -26 dB | 4434.9 Hz | -13 dB |
| D | | | | | | | | | | | | |
| | 36.7 Hz | -18 dB | 36.7 Hz | -42 dB | 73.4 Hz | -18 dB | 73.4 Hz | -42 dB | 146.8 Hz | -18 dB | 146.8 Hz | -42 dB |
| | 73.4 Hz | -4 dB | 73.4 Hz | -9 dB | 146.8 Hz | -4 dB | 146.8 Hz | -9 dB | 293.7 Hz | -4 dB | 293.7 Hz | -9 dB |
| | 146.8 Hz | 0 dB | 146.8 Hz | -1 dB | 293.7 Hz | 0 dB | 293.7 Hz | -1 dB | 587.3 Hz | 0 dB | 587.3 Hz | -1 dB |
| | 293.7 Hz | -1 dB | 293.7 Hz | 0 dB | 587.3 Hz | -1 dB | 587.3 Hz | 0 dB | 1174.7 Hz | -1 dB | 1174.7 Hz | 0 dB |
| | 587.3 Hz | -7 dB | 587.3 Hz | -3 dB | 1174.7 Hz | -7 dB | 1174.7 Hz | -3 dB | 2349.3 Hz | -7 dB | 2349.3 Hz | -3 dB |
| | 1174.7 Hz | -30 dB | 1174.7 Hz | -15 dB | 2349.3 Hz | -30 dB | 2349.3 Hz | -15 dB | 4698.6 Hz | -30 dB | 4698.6 Hz | -15 dB |
| D# | | | | | | | | | | | | |
| | 38.9 Hz | -16 dB | 38.9 Hz | -35 dB | 77.8 Hz | -16 dB | 77.8 Hz | -35 dB | 155.6 Hz | -16 dB | 155.6 Hz | -35 dB |
| | 77.8 Hz | -4 dB | 77.8 Hz | -8 dB | 155.6 Hz | -4 dB | 155.6 Hz | -8 dB | 311.1 Hz | -4 dB | 311.1 Hz | -8 dB |
| | 155.6 Hz | 0 dB | 155.6 Hz | -1 dB | 311.1 Hz | 0 dB | 311.1 Hz | -1 dB | 622.3 Hz | 0 dB | 622.3 Hz | -1 dB |
| | 311.1 Hz | -1 dB | 311.1 Hz | 0 dB | 622.3 Hz | -1 dB | 622.3 Hz | 0 dB | 1244.5 Hz | -1 dB | 1244.5 Hz | 0 dB |
| | 622.3 Hz | -8 dB | 622.3 Hz | -4 dB | 1244.5 Hz | -8 dB | 1244.5 Hz | -4 dB | 2489.0 Hz | -8 dB | 2489.0 Hz | -4 dB |
| | 1244.5 Hz | -35 dB | 1244.5 Hz | -16 dB | 2489.0 Hz | -35 dB | 2489.0 Hz | -16 dB | 4978.0 Hz | -35 dB | 4978.0 Hz | -16 dB |
| E | | | | | | | | | | | | |
| | 41.2 Hz | -15 dB | 41.2 Hz | -30 dB | 82.4 Hz | -15 dB | 82.4 Hz | -30 dB | 164.8 Hz | -15 dB | 164.8 Hz | -30 dB |
| | 82.4 Hz | -3 dB | 82.4 Hz | -7 dB | 164.8 Hz | -3 dB | 164.8 Hz | -7 dB | 329.7 Hz | -3 dB | 329.7 Hz | -7 dB |
| | 164.8 Hz | 0 dB | 164.8 Hz | -1 dB | 329.7 Hz | 0 dB | 329.7 Hz | -1 dB | 659.3 Hz | 0 dB | 659.3 Hz | -1 dB |
| | 329.7 Hz | -1 dB | 329.7 Hz | 0 dB | 659.3 Hz | -1 dB | 659.3 Hz | 0 dB | 1318.5 Hz | -1 dB | 1318.5 Hz | 0 dB |
| | 659.3 Hz | -9 dB | 659.3 Hz | -4 dB | 1318.5 Hz | -9 dB | 1318.5 Hz | -4 dB | 2637.0 Hz | -9 dB | 2637.0 Hz | -4 dB |
| | 1318.5 Hz | -42 dB | 1318.5 Hz | -18 dB | 2637.0 Hz | -42 dB | 2637.0 Hz | -18 dB | 5274.0 Hz | -42 dB | 5274.0 Hz | -18 dB |
| F | | | | | | | | | | | | |
| | 43.7 Hz | -13 dB | 43.7 Hz | -26 dB | 87.3 Hz | -13 dB | 87.3 Hz | -26 dB | 174.6 Hz | -13 dB | 174.6 Hz | -26 dB |
| | 87.3 Hz | -3 dB | 87.3 Hz | -6 dB | 174.6 Hz | -3 dB | 174.6 Hz | -6 dB | 349.2 Hz | -3 dB | 349.2 Hz | -6 dB |
| | 174.6 Hz | 0 dB | 174.6 Hz | 0 dB | 349.2 Hz | 0 dB | 349.2 Hz | 0 dB | 698.5 Hz | 0 dB | 698.5 Hz | 0 dB |
| | 349.2 Hz | -2 dB | 349.2 Hz | 0 dB | 698.5 Hz | -2 dB | 698.5 Hz | 0 dB | 1396.9 Hz | -2 dB | 1396.9 Hz | 0 dB |
| | 698.5 Hz | -10 dB | 698.5 Hz | -5 dB | 1396.9 Hz | -10 dB | 1396.9 Hz | -5 dB | 2793.8 Hz | -10 dB | 2793.8 Hz | -5 dB |
| | 1396.9 Hz | -54 dB | 1396.9 Hz | -20 dB | 2793.8 Hz | -54 dB | 2793.8 Hz | -20 dB | 5587.7 Hz | -54 dB | 5587.7 Hz | -20 dB |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **G** | | | | | | | | | | | |
| 24.5 Hz | -55 dB | 49.0 Hz | -21 dB | 49.0 Hz | -55 dB | 98.0 Hz | -21 dB | 98.0 Hz | -55 dB | 196.0 Hz | -21 dB |
| 49.0 Hz | -10 dB | 98.0 Hz | -5 dB | 98.0 Hz | -10 dB | 196.0 Hz | -5 dB | 196.0 Hz | -10 dB | 392.0 Hz | -5 dB |
| 98.0 Hz | -2 dB | 196.0 Hz | 0 dB | 196.0 Hz | -2 dB | 392.0 Hz | 0 dB | 392.0 Hz | -2 dB | 784.0 Hz | 0 dB |
| 196.0 Hz | 0 dB | 392.0 Hz | 0 dB | 392.0 Hz | 0 dB | 784.0 Hz | 0 dB | 784.0 Hz | 0 dB | 1568.0 Hz | 0 dB |
| 392.0 Hz | -3 dB | 784.0 Hz | -6 dB | 784.0 Hz | -3 dB | 1568.0 Hz | -6 dB | 1568.0 Hz | -3 dB | 3136.0 Hz | -6 dB |
| 784.0 Hz | -13 dB | 1568.0 Hz | -26 dB | 1568.0 Hz | -13 dB | 3136.0 Hz | -26 dB | 3136.0 Hz | -13 dB | 6272.0 Hz | -26 dB |
| **G#** | | | | | | | | | | | |
| 26.0 Hz | -42 dB | 51.9 Hz | -18 dB | 51.9 Hz | -42 dB | 103.8 Hz | -18 dB | 103.8 Hz | -42 dB | 207.7 Hz | -18 dB |
| 51.9 Hz | -9 dB | 103.8 Hz | -4 dB | 103.8 Hz | -9 dB | 207.7 Hz | -4 dB | 207.7 Hz | -9 dB | 415.3 Hz | -4 dB |
| 103.8 Hz | -1 dB | 207.7 Hz | 0 dB | 207.7 Hz | -1 dB | 415.3 Hz | 0 dB | 415.3 Hz | -1 dB | 830.6 Hz | 0 dB |
| 207.7 Hz | 0 dB | 415.3 Hz | -1 dB | 415.3 Hz | 0 dB | 830.6 Hz | -1 dB | 830.6 Hz | 0 dB | 1661.2 Hz | -1 dB |
| 415.3 Hz | -3 dB | 830.6 Hz | -7 dB | 830.6 Hz | -3 dB | 1661.2 Hz | -7 dB | 1661.2 Hz | -3 dB | 3322.4 Hz | -7 dB |
| 830.6 Hz | -15 dB | 1661.2 Hz | -30 dB | 1661.2 Hz | -15 dB | 3322.4 Hz | -30 dB | 3322.4 Hz | -15 dB | 6644.9 Hz | -30 dB |
| **A** | | | | | | | | | | | |
| 27.5 Hz | -35 dB | 55.0 Hz | -16 dB | 55.0 Hz | -35 dB | 110.0 Hz | -16 dB | 110.0 Hz | -35 dB | 220.0 Hz | -16 dB |
| 55.0 Hz | -8 dB | 110.0 Hz | -4 dB | 110.0 Hz | -8 dB | 220.0 Hz | -4 dB | 220.0 Hz | -8 dB | 440.0 Hz | -4 dB |
| 110.0 Hz | -1 dB | 220.0 Hz | 0 dB | 220.0 Hz | -1 dB | 440.0 Hz | 0 dB | 440.0 Hz | -1 dB | 880.0 Hz | 0 dB |
| 220.0 Hz | 0 dB | 440.0 Hz | -1 dB | 440.0 Hz | 0 dB | 880.0 Hz | -1 dB | 880.0 Hz | 0 dB | 1760.0 Hz | -1 dB |
| 440.0 Hz | -4 dB | 880.0 Hz | -8 dB | 880.0 Hz | -4 dB | 1760.0 Hz | -8 dB | 1760.0 Hz | -4 dB | 3520.0 Hz | -8 dB |
| 880.0 Hz | -16 dB | 1760.0 Hz | -35 dB | 1760.0 Hz | -16 dB | 3520.0 Hz | -35 dB | 3520.0 Hz | -16 dB | 7040.0 Hz | -35 dB |
| **A#** | | | | | | | | | | | |
| 29.1 Hz | -30 dB | 58.3 Hz | -15 dB | 58.3 Hz | -30 dB | 116.5 Hz | -15 dB | 116.5 Hz | -30 dB | 233.1 Hz | -15 dB |
| 58.3 Hz | -7 dB | 116.5 Hz | -3 dB | 116.5 Hz | -7 dB | 233.1 Hz | -3 dB | 233.1 Hz | -7 dB | 466.2 Hz | -3 dB |
| 116.5 Hz | -1 dB | 233.1 Hz | 0 dB | 233.1 Hz | -1 dB | 466.2 Hz | 0 dB | 466.2 Hz | -1 dB | 932.3 Hz | 0 dB |
| 233.1 Hz | 0 dB | 466.2 Hz | -1 dB | 466.2 Hz | 0 dB | 932.3 Hz | -1 dB | 932.3 Hz | 0 dB | 1864.7 Hz | -1 dB |
| 466.2 Hz | -4 dB | 932.3 Hz | -9 dB | 932.3 Hz | -4 dB | 1864.7 Hz | -9 dB | 1864.7 Hz | -4 dB | 3729.3 Hz | -9 dB |
| 932.3 Hz | -18 dB | 1864.7 Hz | -42 dB | 1864.7 Hz | -18 dB | 3729.3 Hz | -42 dB | 3729.3 Hz | -18 dB | 7458.6 Hz | -42 dB |
| **B** | | | | | | | | | | | |
| 30.9 Hz | -26 dB | 61.7 Hz | -13 dB | 61.7 Hz | -26 dB | 123.5 Hz | -13 dB | 123.5 Hz | -26 dB | 246.9 Hz | -13 dB |
| 61.7 Hz | -6 dB | 123.5 Hz | -3 dB | 123.5 Hz | -6 dB | 246.9 Hz | -3 dB | 246.9 Hz | -6 dB | 493.9 Hz | -3 dB |
| 123.5 Hz | 0 dB | 246.9 Hz | 0 dB | 246.9 Hz | 0 dB | 493.9 Hz | 0 dB | 493.9 Hz | 0 dB | 987.8 Hz | 0 dB |
| 246.9 Hz | 0 dB | 493.9 Hz | -2 dB | 493.9 Hz | 0 dB | 987.8 Hz | -2 dB | 987.8 Hz | 0 dB | 1975.5 Hz | -2 dB |
| 493.9 Hz | -5 dB | 987.8 Hz | -10 dB | 987.8 Hz | -5 dB | 1975.5 Hz | -10 dB | 1975.5 Hz | -5 dB | 3951.1 Hz | -10 dB |
| 987.8 Hz | -20 dB | 1975.5 Hz | -54 dB | 1975.5 Hz | -20 dB | 3951.1 Hz | -54 dB | 3951.1 Hz | -20 dB | 7902.1 Hz | -54 dB |

**EXPERIMENT 2**

| spectral peak = F#3 | | spectral peak = C4 | | spectral peak = F#4 | | spectral peak = C5 | | spectral peak = F#5 | | spectral peak = C6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **C#** | | | | | | | | | | | |
| 34.5 Hz | -21 dB | 34.5 Hz | -55 dB | 69.3 Hz | -21 dB | 69.3 Hz | -55 dB | 139.3 Hz | -21 dB | 139.3 Hz | -55 dB |
| 69.3 Hz | -5 dB | 69.3 Hz | -10 dB | 139.3 Hz | -5 dB | 139.3 Hz | -10 dB | 280.0 Hz | -5 dB | 280.0 Hz | -10 dB |
| 139.3 Hz | 0 dB | 139.3 Hz | -2 dB | 280.0 Hz | 0 dB | 280.0 Hz | -2 dB | 562.7 Hz | 0 dB | 562.7 Hz | -2 dB |
| 280.0 Hz | 0 dB | 280.0 Hz | 0 dB | 562.7 Hz | 0 dB | 562.7 Hz | 0 dB | 1131.1 Hz | 0 dB | 1131.1 Hz | 0 dB |
| 562.7 Hz | -6 dB | 562.7 Hz | -3 dB | 1131.1 Hz | -6 dB | 1131.1 Hz | -3 dB | 2273.5 Hz | -6 dB | 2273.5 Hz | -3 dB |
| 1131.1 Hz | -26 dB | 1131.1 Hz | -13 dB | 2273.5 Hz | -26 dB | 2273.5 Hz | -13 dB | 4569.6 Hz | -26 dB | 4569.6 Hz | -13 dB |
| **D** | | | | | | | | | | | |
| 36.5 Hz | -18 dB | 36.5 Hz | -42 dB | 73.4 Hz | -18 dB | 73.4 Hz | -42 dB | 147.6 Hz | -18 dB | 147.6 Hz | -42 dB |
| 73.4 Hz | -4 dB | 73.4 Hz | -9 dB | 147.6 Hz | -4 dB | 147.6 Hz | -9 dB | 296.6 Hz | -4 dB | 296.6 Hz | -9 dB |
| 147.6 Hz | 0 dB | 147.6 Hz | -1 dB | 296.6 Hz | 0 dB | 296.6 Hz | -1 dB | 596.2 Hz | 0 dB | 596.2 Hz | -1 dB |
| 296.6 Hz | -1 dB | 296.6 Hz | 0 dB | 596.2 Hz | -1 dB | 596.2 Hz | 0 dB | 1198.3 Hz | -1 dB | 1198.3 Hz | 0 dB |
| 596.2 Hz | -7 dB | 596.2 Hz | -3 dB | 1198.3 Hz | -7 dB | 1198.3 Hz | -3 dB | 2408.6 Hz | -7 dB | 2408.6 Hz | -3 dB |
| 1198.3 Hz | -30 dB | 1198.3 Hz | -15 dB | 2408.6 Hz | -30 dB | 2408.6 Hz | -15 dB | 4841.4 Hz | -30 dB | 4841.4 Hz | -15 dB |
| **D#** | | | | | | | | | | | |
| 38.7 Hz | -16 dB | 38.7 Hz | -35 dB | 77.8 Hz | -16 dB | 77.8 Hz | -35 dB | 156.3 Hz | -16 dB | 156.3 Hz | -35 dB |
| 77.8 Hz | -4 dB | 77.8 Hz | -8 dB | 156.3 Hz | -4 dB | 156.3 Hz | -8 dB | 314.2 Hz | -4 dB | 314.2 Hz | -8 dB |
| 156.3 Hz | 0 dB | 156.3 Hz | -1 dB | 314.2 Hz | 0 dB | 314.2 Hz | -1 dB | 631.6 Hz | 0 dB | 631.6 Hz | -1 dB |
| 314.2 Hz | -1 dB | 314.2 Hz | 0 dB | 631.6 Hz | -1 dB | 631.6 Hz | 0 dB | 1269.6 Hz | -1 dB | 1269.6 Hz | 0 dB |
| 631.6 Hz | -8 dB | 631.6 Hz | -4 dB | 1269.6 Hz | -8 dB | 1269.6 Hz | -4 dB | 2551.9 Hz | -8 dB | 2551.9 Hz | -4 dB |
| 1269.6 Hz | -35 dB | 1269.6 Hz | -16 dB | 2551.9 Hz | -35 dB | 2551.9 Hz | -16 dB | 5129.3 Hz | -35 dB | 5129.3 Hz | -16 dB |
| **E** | | | | | | | | | | | |
| 41.0 Hz | -15 dB | 41.0 Hz | -30 dB | 82.4 Hz | -15 dB | 82.4 Hz | -30 dB | 165.6 Hz | -15 dB | 165.6 Hz | -30 dB |
| 82.4 Hz | -3 dB | 82.4 Hz | -7 dB | 165.6 Hz | -3 dB | 165.6 Hz | -7 dB | 332.9 Hz | -3 dB | 332.9 Hz | -7 dB |
| 165.6 Hz | 0 dB | 165.6 Hz | -1 dB | 332.9 Hz | 0 dB | 332.9 Hz | -1 dB | 669.2 Hz | 0 dB | 669.2 Hz | -1 dB |
| 332.9 Hz | -1 dB | 332.9 Hz | 0 dB | 669.2 Hz | -1 dB | 669.2 Hz | 0 dB | 1345.1 Hz | -1 dB | 1345.1 Hz | 0 dB |
| 669.2 Hz | -9 dB | 669.2 Hz | -4 dB | 1345.1 Hz | -9 dB | 1345.1 Hz | -4 dB | 2703.6 Hz | -9 dB | 2703.6 Hz | -4 dB |
| 1345.1 Hz | -42 dB | 1345.1 Hz | -18 dB | 2703.6 Hz | -42 dB | 2703.6 Hz | -18 dB | 5434.3 Hz | -42 dB | 5434.3 Hz | -18 dB |
| **F** | | | | | | | | | | | |
| 43.4 Hz | -13 dB | 43.4 Hz | -26 dB | 87.3 Hz | -13 dB | 87.3 Hz | -26 dB | 175.5 Hz | -13 dB | 175.5 Hz | -26 dB |
| 87.3 Hz | -3 dB | 87.3 Hz | -6 dB | 175.5 Hz | -3 dB | 175.5 Hz | -6 dB | 352.7 Hz | -3 dB | 352.7 Hz | -6 dB |
| 175.5 Hz | 0 dB | 175.5 Hz | 0 dB | 352.7 Hz | 0 dB | 352.7 Hz | 0 dB | 709.0 Hz | 0 dB | 709.0 Hz | 0 dB |
| 352.7 Hz | -2 dB | 352.7 Hz | 0 dB | 709.0 Hz | -2 dB | 709.0 Hz | 0 dB | 1425.1 Hz | -2 dB | 1425.1 Hz | 0 dB |
| 709.0 Hz | -10 dB | 709.0 Hz | -5 dB | 1425.1 Hz | -10 dB | 1425.1 Hz | -5 dB | 2864.4 Hz | -10 dB | 2864.4 Hz | -5 dB |
| 1425.1 Hz | -54 dB | 1425.1 Hz | -20 dB | 2864.4 Hz | -54 dB | 2864.4 Hz | -20 dB | 5757.4 Hz | -54 dB | 5757.4 Hz | -20 dB |
| **G** | | | | | | | | | | | |
| 24.3 Hz | -55 dB | 48.7 Hz | -21 dB | 48.7 Hz | -55 dB | 98.0 Hz | -21 dB | 98.0 Hz | -55 dB | 197.0 Hz | -21 dB |
| 48.7 Hz | -10 dB | 98.0 Hz | -5 dB | 98.0 Hz | -10 dB | 197.0 Hz | -5 dB | 197.0 Hz | -10 dB | 395.9 Hz | -5 dB |
| 98.0 Hz | -2 dB | 197.0 Hz | 0 dB | 197.0 Hz | -2 dB | 395.9 Hz | 0 dB | 395.9 Hz | -2 dB | 795.8 Hz | 0 dB |
| 197.0 Hz | 0 dB | 395.9 Hz | 0 dB | 395.9 Hz | 0 dB | 795.8 Hz | 0 dB | 795.8 Hz | 0 dB | 1599.6 Hz | 0 dB |
| 395.9 Hz | -3 dB | 795.8 Hz | -6 dB | 795.8 Hz | -3 dB | 1599.6 Hz | -6 dB | 1599.6 Hz | -3 dB | 3215.2 Hz | -6 dB |
| 795.8 Hz | -13 dB | 1599.6 Hz | -26 dB | 1599.6 Hz | -13 dB | 3215.2 Hz | -26 dB | 3215.2 Hz | -13 dB | 6462.5 Hz | -26 dB |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G# | | | | | | | | | | | | |
| | 25.7 Hz | -42 dB | 51.7 Hz | -18 dB | 51.7 Hz | -42 dB | 103.8 Hz | -18 dB | 103.8 Hz | -42 dB | 208.7 Hz | -18 dB |
| | 51.7 Hz | -9 dB | 103.8 Hz | -4 dB | 103.8 Hz | -9 dB | 208.7 Hz | -4 dB | 208.7 Hz | -9 dB | 419.5 Hz | -4 dB |
| | 103.8 Hz | -1 dB | 208.7 Hz | 0 dB | 208.7 Hz | -1 dB | 419.5 Hz | 0 dB | 419.5 Hz | -1 dB | 843.1 Hz | 0 dB |
| | 208.7 Hz | 0 dB | 419.5 Hz | -1 dB | 419.5 Hz | 0 dB | 843.1 Hz | -1 dB | 843.1 Hz | 0 dB | 1694.7 Hz | -1 dB |
| | 419.5 Hz | -3 dB | 843.1 Hz | -7 dB | 843.1 Hz | -3 dB | 1694.7 Hz | -7 dB | 1694.7 Hz | -3 dB | 3406.3 Hz | -7 dB |
| | 843.1 Hz | -15 dB | 1694.7 Hz | -30 dB | 1694.7 Hz | -15 dB | 3406.3 Hz | -30 dB | 3406.3 Hz | -15 dB | 6846.7 Hz | -30 dB |
| A | | | | | | | | | | | | |
| | 27.2 Hz | -35 dB | 54.7 Hz | -16 dB | 54.7 Hz | -35 dB | 110.0 Hz | -16 dB | 110.0 Hz | -35 dB | 221.1 Hz | -16 dB |
| | 54.7 Hz | -8 dB | 110.0 Hz | -4 dB | 110.0 Hz | -8 dB | 221.1 Hz | -4 dB | 221.1 Hz | -8 dB | 444.4 Hz | -4 dB |
| | 110.0 Hz | -1 dB | 221.1 Hz | 0 dB | 221.1 Hz | -1 dB | 444.4 Hz | 0 dB | 444.4 Hz | -1 dB | 893.3 Hz | 0 dB |
| | 221.1 Hz | 0 dB | 444.4 Hz | -1 dB | 444.4 Hz | 0 dB | 893.3 Hz | -1 dB | 893.3 Hz | 0 dB | 1795.5 Hz | -1 dB |
| | 444.4 Hz | -4 dB | 893.3 Hz | -8 dB | 893.3 Hz | -4 dB | 1795.5 Hz | -8 dB | 1795.5 Hz | -4 dB | 3608.9 Hz | -8 dB |
| | 893.3 Hz | -16 dB | 1795.5 Hz | -35 dB | 1795.5 Hz | -16 dB | 3608.9 Hz | -35 dB | 3608.9 Hz | -16 dB | 7253.9 Hz | -35 dB |
| A# | | | | | | | | | | | | |
| | 28.8 Hz | -30 dB | 58.0 Hz | -15 dB | 58.0 Hz | -30 dB | 116.5 Hz | -15 dB | 116.5 Hz | -30 dB | 234.2 Hz | -15 dB |
| | 58.0 Hz | -7 dB | 116.5 Hz | -3 dB | 116.5 Hz | -7 dB | 234.2 Hz | -3 dB | 234.2 Hz | -7 dB | 470.8 Hz | -3 dB |
| | 116.5 Hz | -1 dB | 234.2 Hz | 0 dB | 234.2 Hz | -1 dB | 470.8 Hz | 0 dB | 470.8 Hz | -1 dB | 946.4 Hz | 0 dB |
| | 234.2 Hz | 0 dB | 470.8 Hz | -1 dB | 470.8 Hz | 0 dB | 946.4 Hz | -1 dB | 946.4 Hz | 0 dB | 1902.2 Hz | -1 dB |
| | 470.8 Hz | -4 dB | 946.4 Hz | -9 dB | 946.4 Hz | -4 dB | 1902.2 Hz | -9 dB | 1902.2 Hz | -4 dB | 3823.5 Hz | -9 dB |
| | 946.4 Hz | -18 dB | 1902.2 Hz | -42 dB | 1902.2 Hz | -18 dB | 3823.5 Hz | -42 dB | 3823.5 Hz | -18 dB | 7685.2 Hz | -42 dB |
| B | | | | | | | | | | | | |
| | 30.6 Hz | -26 dB | 61.4 Hz | -13 dB | 61.4 Hz | -26 dB | 123.5 Hz | -13 dB | 123.5 Hz | -26 dB | 248.2 Hz | -13 dB |
| | 61.4 Hz | -6 dB | 123.5 Hz | -3 dB | 123.5 Hz | -6 dB | 248.2 Hz | -3 dB | 248.2 Hz | -6 dB | 498.8 Hz | -3 dB |
| | 123.5 Hz | 0 dB | 248.2 Hz | 0 dB | 248.2 Hz | 0 dB | 498.8 Hz | 0 dB | 498.8 Hz | 0 dB | 1002.7 Hz | 0 dB |
| | 248.2 Hz | 0 dB | 498.8 Hz | -2 dB | 498.8 Hz | 0 dB | 1002.7 Hz | -2 dB | 1002.7 Hz | 0 dB | 2015.3 Hz | -2 dB |
| | 498.8 Hz | -5 dB | 1002.7 Hz | -10 dB | 1002.7 Hz | -5 dB | 2015.3 Hz | -10 dB | 2015.3 Hz | -5 dB | 4050.8 Hz | -10 dB |
| | 1002.7 Hz | -20 dB | 2015.3 Hz | -54 dB | 2015.3 Hz | -20 dB | 4050.8 Hz | -54 dB | 4050.8 Hz | -20 dB | 8142.2 Hz | -54 dB |

[1]In accordance with musical convention, C4 corresponds to Middle C, C5 to the octave above Middle C, and so on.

[2]In the experiment of Deutsch *et al.* (1984), a group of subjects was included who heard the patterns ambiguously. However, since the purpose of the present experiment was to examine the behavior of the effect in the case of listeners who obtain it in the first place, such a group was not included here.


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