The perception of relative pitch of octave-complex tones in a dichotic listening experiment.

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Introduction

In two pair-comparison experiments subjects had to judge pairs of octave-complex tones with respect to their relative pitch as ascending or descending. Octave-complex tones, first devised by Shepard [2], are composed of octave spaced sinusoids whose amplitudes are determined by a bell-shape spectral envelope. According to Shepards theory the relative pitch of a pair of octave-complex tones depends on the distance between individual partials.

- The primary goal of our experiment was to test the theory proposed by Shepard. If the distance between individual partials is the key assumption for estimating relative pitch judgments, it should even hold for longer distances (more than one octave) or in dichotic listening conditions.
- The secondary goal of our experiment was to restate the question if there are two independent pitch extraction mechanisms or, according to Houtsma and Goldstein [1], one central.

Methods

A set of 12 octave-complex tones (C, Cis, D, Dis, ... , A, Ais, B) each composed of 10 sinusoids in sinusphase were digitally generated at 48 kHz samplingrate. The spectral amplitudes were determined by a fixed bell-shaped envelope with an f_{min} of 16.4 Hz.

Experiment 1 and 2 only differed in distance in semitonesteps between adjacent partials of the first and second tone. In experiment 1 distances 2 and 10 (e.g. C-D, Cis-Dis, ... , Ais-C, B-Cis) were used. In experiment 2 the distance between tones was set to 4 and 8 semitonesteps (e.g. C-E, Cis-F, ... , Ais-D, B-Dis) and 6 semitonesteps, the tritone interval, (e.g. C-Fis, Cis-G, ... , Ais-E, B-F). In the first experiment 7 subjects participated, 6 subjects participated in the second experiment.

The Stimuli were presented via closed headphones, with a duration of 400 ms and a gap of 200 ms between each two.

The division of the partials into two sets (Fig. 1) resulted in three experimental conditions.

ORIGINAL Original Shepard-tones. All partials of an octave-complex tone are presented to both ears (diotic).

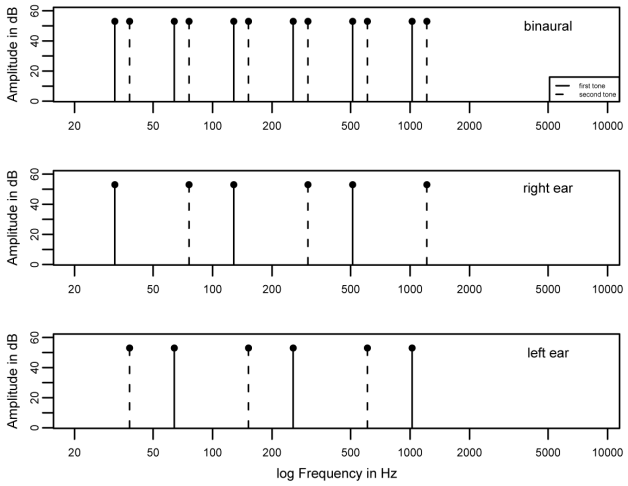

Figure 1: TOP: Spectra of the octave-complex tones C (first tone, solid) and D (second tone, dashed). The tone pair C-D will be perceived as ascending, D-C as descending. MIDDLE/BOTTOM: Partials are splitted into two sets each presented to one ear. This leads to a reversal in distance between successive partials which should change perceived relative pitch. The pair C-D should now be perceived as decending, D-C as ascending.

SPLIT Partials are divided into two sets, each presented to one ear (dichotic). In contrast to the ORIGINAL condition tones show a reversed adjacend-partial-distance.

CONTROL Stimuli of one side of the SPLIT condition are presented to both ears (diotic). This condition was introduced to control possible effects of splitted octave-complex tones.

If partials of each tone of a pair are compared *central* the information from both ears are combined, stimuli of the SPLIT and ORIGINAL condition should lead to equal results in relative pitch judgements. On the other hand, if partials of each tone of a pair are compared *peripheral* pitch judgements of SPLIT and ORIGINAL conditions should differ.

Results

According to the distance criterion proposed by Shepard (1964) the pitch of pairs of octave-complex tones is perceived with respect to the distance of adjacent partials. This is the case for the judgements made in the ORIGINAL condition (solid line), where smaller distances are perceived as ascending and larger distances as descend-

ing (Fig. 2). With some more variation this is also true for the SPLIT condition (dashed line). The stability of the judgements varies between conditions (ORIGINAL > SPLIT > CONTROL).

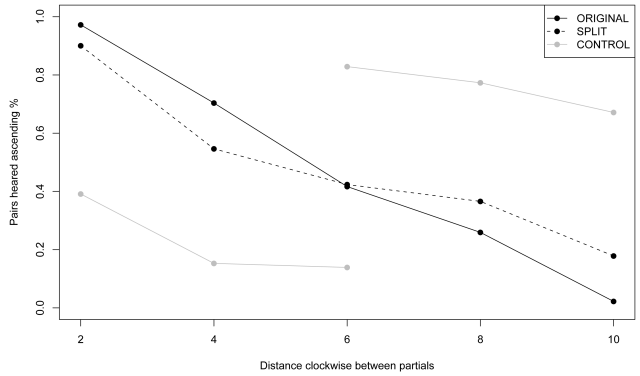

Figure 2: Combined results from Exp.1 and Exp. 2. Mean answer "pairs heared ascending" as a function of the clockwise (upward) distance between adjacent partials of an octave-complex tone. Each condition is represented by a single line except the CONTROL condition. The two data points shown at distance 6 are the result of a splitting by starttone > 6.

In the CONTROL condition (gray line) a reversed pattern was found. Large and small distances are perceived less stable than intervals near distance 6.

Discussion

The distance between adjacent partials is a good predictor for the perceived relative pitch of octave-complex tones, dichotic octave-complex tones and complex tones with partials separated by more than one octave. Although the perception of dichotic tones does not differ substanially from original Shepard tones, judgements are less stable. One reason might be the loss of partials from ORIGINAL to SPLIT to CONTROL condition. The results provide clear evidence for a central pitch mechanism.

References

[1] Houtsma, A. J. M. & Goldstein, J. L.: The central origin of the pitch of complex tones: Evidence from the musical interval recognition. Journal of the Acoustical Society of America. **51** (1971), 520-529

[2] Shepard, R. N.: Circularity in judgments of relative pitch. Journal of the Acoustical Society of America, **36** (1964), 2346-2353