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The glissando illusion and handedness

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Abstract

This article reports the first study of the glissando illusion, which was created and published as a sound demonstration by Deutsch [Deutsch, D. (1995). *Musical illusions and paradoxes*. La Jolla: Philomel Records (compact disc)]. To experience the illusion, each subject was seated in front of two stereophonically separated loudspeakers, with one to his left and the other to his right. A sound pattern was presented that consisted of a synthesized oboe tone of constant pitch, together with a sine wave whose pitch repeatedly glided up and down (the glissando). These two components alternated continuously between the loudspeakers such that when the oboe tone emanated from the loudspeaker on the left, the glissando emanated from the loudspeaker on the right; and vice versa. The oboe tone was perceived correctly as switching between loudspeakers; however, the segments of the glissando appeared to be joined together seamlessly, such that a single, continuous tone was heard, which appeared to be moving slowly around in space in accordance with its pitch motion. Right-handers ($n = 22$) tended strongly to hear the glissando move between left and right, and also between low and high in space, as its pitch moved between low and high. More specifically, it was frequently heard as tracing an elliptical path aligned diagonally between a position low and to the left when its pitch was lowest, and high and to the right when its pitch was highest. Non-right-handers ($n = 42$) perceived the illusion in statistically different ways. The handedness correlates and other implications of the glissando illusion are discussed.

Keywords: Glissando; Sound; Illusion; Handedness; Spatialization

1. Introduction

In our natural environment, we are constantly presented with multiple streams of sound that arise in parallel from different regions of space. In interpreting the complex, time-varying spectra that reach our ears, we have two basic tasks to perform: first, we need to combine together those components of the sound spectra that are emanating from the same source, and to separate out those that are emanating from different sources; i.e., we need to reconstruct *what* sounds are being generated. Second, we need to determine the location of each sound; i.e., to reconstruct *where* each sound is coming from.

Much progress has been made in investigating the types of information employed to determine *what* sounds are being produced in such situations. As is frequently acknowledged, the auditory system here makes extensive use of cues that lead to the most probable conclusions about our sound environment. As one example, when sounds are presented in succession, those that are proximal in frequency are likely to be coming from the same source; correspondingly, we tend to link together perceptually sounds that are proximal in frequency and to separate out those that are further apart (Bregman, 1990; Bregman & Campbell, 1971; Deutsch, 1975; Van Noorden, 1975). As another example, sounds with similar spectral characteristics are likely to be coming from the same source; correspondingly, we tend to link together successive sounds that are of similar spectral composition and to separate out those with different spectral characteristics (Warren, Obusek, Farmer, & Warren, 1969).

In contrast, although much information has been gathered concerning the ways in which we localize sounds that are presented in isolation, much less is known about the ways in which we localize multiple streams of sound that arise from different locations in space. It has, however, been shown that powerful illusions can be obtained under these conditions (Deutsch, 1974, 1975, 1983a, 1983b; Hartmann & Rakert, 1989; Litovsky, Colburn, Yost, & Guzman, 1999; Wallach, Newman, & Rosenzweig, 1949). Those that are most relevant to the present

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paper are the *octave illusion* (Deutsch, 1974, 1983a, 1983b) and the *scale illusion* (Deutsch, 1975, 1983b).

In the octave illusion, two sinusoidal tones that are spaced an octave apart (at 400 and 800 Hz) are repeatedly presented in alternation. The identical pattern is presented via headphones to both ears simultaneously; however, when the right ear receives the high tone the left ear receives the low tone; and vice versa. A number of illusory percepts are obtained, and the type of percept varies in correlation with the handedness of the listener. The majority of listeners obtain the *simple* percept of a single tone that alternates from ear to ear, whose pitch simultaneously alternates between high and low. In other words, these listeners perceive a single high tone in one ear that alternates with a single low tone in the other ear. Other listeners obtain *complex* percepts, such as two low tones that are close in pitch which alternate from ear to ear, together with an intermittent high tone in one ear. The percepts of right- and left-handers differ statistically in two ways: first, right-handers tend more than left-handers to obtain *simple* percepts. Second, among right-handers who obtain *simple* percepts there is a strong tendency to hear the high tone on the right and the low tone on the left; however, this is not true of left-handers.

In the scale illusion (Deutsch, 1975, 1983b), a major scale, also composed of sinusoidal tones, is presented repeatedly in both ascending and descending form. The pattern is presented via headphones, and its component tones alternate from ear to ear such that when a tone from the ascending scale is in the right ear a tone from the descending scale is in the left ear; and vice versa. Again, a number of illusory percepts are obtained, which vary in correlation with the handedness of the listener. The majority of listeners obtain a *simple* percept that consists of all the tones, heard as two separate melodies – a higher one and a lower one – that move in contrary motion. Furthermore, all the higher tones appear to be coming from one earphone and all the lower tones from the other. Other listeners obtain a variety of *complex* percepts, such as a single stream of tones that correspond to the higher tones but not the lower ones, with the tones localized in a variety of idiosyncratic ways. The illusory percepts experienced by right-handers and left-handers again differ statistically in two ways. First, right-handers tend more than lefthanders to obtain *simple* percepts. Second, of those who obtain *simple* percepts, right-handers tend strongly to hear the higher tones as on the right and the lower tones as on the left, whereas this is not true of left-handers.

The present paper reports the first study of the *glissando illusion*, which was created and published as a sound demonstration by Deutsch (1995).[1] To experience this illusion, the listener is seated in front of two stereophonically separated loudspeakers, with one to his left and the other to his right. The sound pattern that gives rise the illusion consists of two components: a synthesized oboe tone of constant pitch, and a sine wave whose pitch glides up and down. The two components are presented simultaneously via the two loudspeakers, and alternate continuously between the speakers such that when the oboe tone is coming from the speaker on the left, a portion of the glissando is coming from the speaker on the right; and vice versa.

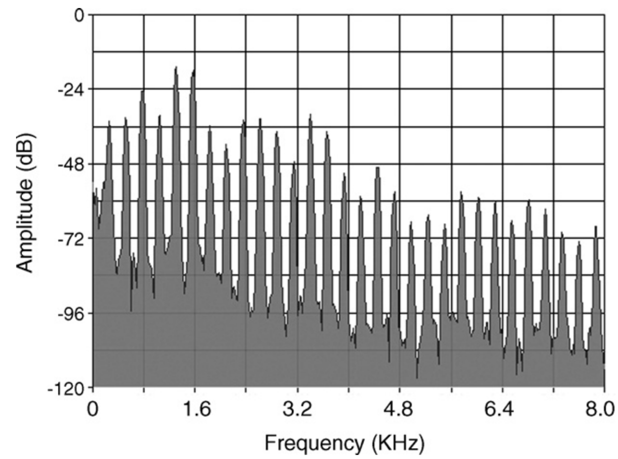

Fig. 1. Sound spectrogram of the synthesized oboe tone.

As will be shown, the glissando illusion has characteristics that differ from those of the octave and scale illusions in important ways. First, the oboe tone, being rich and broadband in spectrum (Fig. 1) is in principle much better localized than is a sinusoid. It was therefore chosen as one component of the configuration on the hypothesis that it would not be subject to a localization illusion; this hypothesis was confirmed in the present experiment. Second, the octave and scale illusions are both created from steady state tones, which leaves open the question of whether or not a tone of continuously varying frequency would be subject to an illusion with similar characteristics. As will be described, the glissando does indeed give rise to a localization illusion; however, in contrast to the octave and scale illusions it is perceived as moving slowly through space – both between left and right and between high and low – in accordance with its pitch motion.

More specifically, the following hypotheses were addressed in the present experiment: first, informal observations had indicated that the oboe tone was perceived correctly as switching back and forth between the loudspeakers; however, the successive portions of the glissando appeared to be joined together quite seamlessly, so that a single, continuous tone was heard, that appeared to be moving around in space in accordance with its pitch motion. It also appeared from informal observations that there were substantial differences between listeners in terms of the direction of apparent left-right spatial motion of the glissando in relation to its pitch motion. It was hypothesized that despite the phenomenological differences described above, individual differences in perception of the glissando illusion would correlate with handedness, analogous to those for the octave and scale illusions.

Second, it appeared from informal observations that listeners often perceived the glissando as traveling between a high point in space when its pitch was highest and a low point in space when its pitch was lowest. These observations were in accordance with reports by others indicating that sounds of higher pitch were

[1] The booklet accompanying the CD by Deutsch (1995) contained a brief (<200 words) informal description of the glissando illusion, but no formal experimental findings, and no handedness correlates, were reported.