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The Glissando Illusion: A Spatial Illusory Contour in Hearing

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Picture yourself sitting at a sidewalk cafe. Traffic rumbles past you along the street. Pedestrians stroll by, engaged in lively conversation. Waiters clatter dishes as the food is served, and music emanates softly from inside the building. We perceive all these sounds so effortlessly that it is tempting to think of our ears as microphones and our brain as a passive recorder of the signals that are sent up from our ears. But the process of sound perception is necessarily far more complicated. Sounds are subject to numerous distortions as they travel from their sources, and are mixed in the air before they reach our ears. So our brain is faced with the extraordinarily difficult task of reconstructing the original sounds from the complex signals that it receives. In performing this task we employ many different cues, which enable us to make 'best guesses' about the sounds around us. For the most part, this process of hypothesis formation works very well, but with some sound patterns it causes us to experience striking illusions instead.

We here report the first formal experiment on an illusion known as the glissando illusion, which was discovered and demonstrated in the compact disc *Musical Illusions and Paradoxes* by Deutsch (1995). The illusion shows how a cue that is generally very useful in enabling us to form correct perceptions can instead lead to perceptions that are wildly wrong. It also shows that a simple sound pattern can be perceived by different people in strikingly different ways.

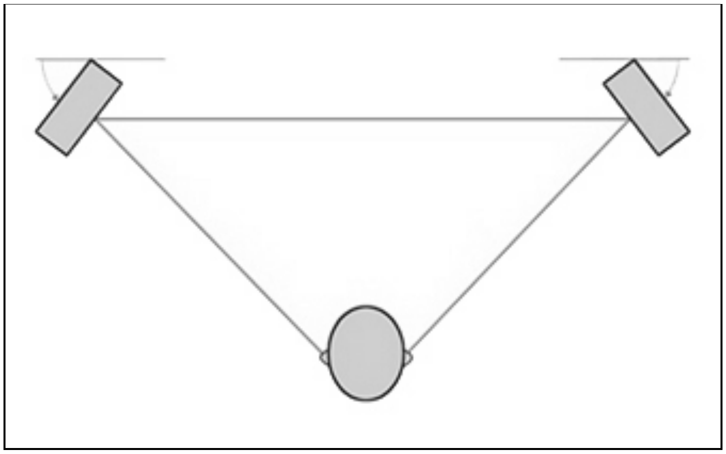

Figure 1. Seating arrangement for experiencing the glissando illusion. The listener is seated in front of two loudspeakers, with one to the left and the other to the right.

To experience the glissando illusion, you should be seated in front of two stereophonically separated loudspeakers, with one to your left and the other to your right, as in Figure 1. The pattern that gives rise to the illusion consists of two components: A synthesized oboe tone of constant pitch (the oboe tone), and a sine wave that repeatedly glides up and down in pitch - rather like a siren (the glissando). The two components are presented simultaneously through the two loudspeakers, and are constantly switching from speaker to speaker such that when the oboe tone is coming from the speaker on the right a portion of the glissando is coming from the speaker on the left; and vice versa. A fragment of this pattern is illustrated in Figure 2.

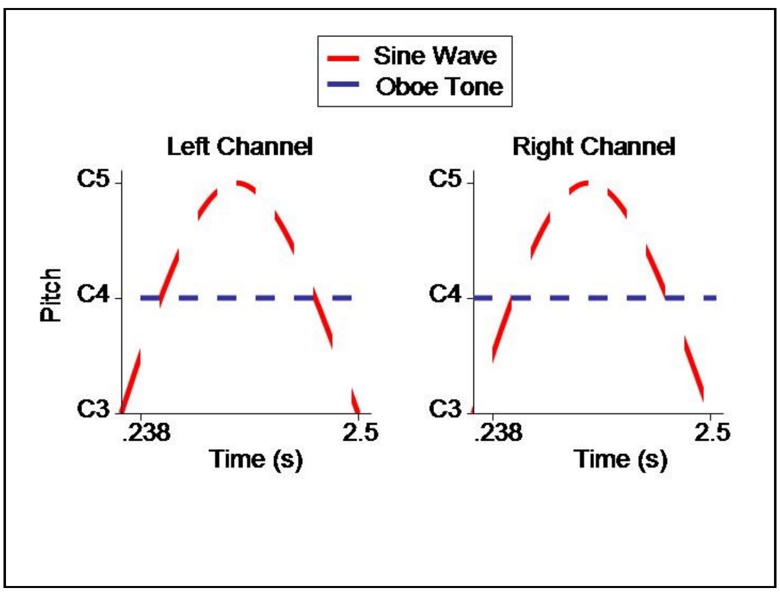

Figure 2. Fragment of the pattern that gives rise to the glissando illusion, as it was presented in the experiment.

Click here to listen to the illusion that was originally presented by Deutsch (1995). (Set the sound level so that it is on the soft side, and make sure that the channels are in balance.) Notice that when only one channel is played - either the left or the right one - you correctly hear the oboe tone alternating with a portion of the glissando. However when both channels are played together, for most people the experience changes dramatically: The oboe tone is heard correctly as switching back and forth between the loudspeakers. However, the portions of the glissando appear to be joined together quite seamlessly, so that a single, continuous tone is heard that appears to be moving around in space in accordance with its pitch motion. Notice, also, that as the rate of switching between the oboe tone and the glissando speeds up and slows down, the apparent speed at which the glissando appears to move through space remains constant, and tied to its pitch motion.

In our formal experiment, the oboe tone was at Middle C (262 Hz) and the sine wave glided up and down in pitch between the octave below Middle C (131 Hz) and the C an octave above (523 Hz). The switching rate between the glissando and oboe tone was held constant at 238 ms, and the duration of one cycle of the glissando was held constant at 2.5 sec. We chose these parameters so that the spatial positions of the glissando when its pitch was highest and lowest would vary throughout the sequence.

Sixty-four listeners with normal hearing listened to this pattern. They were designated as 'righthanded' or as 'nonrighthanded' depending on their responses to a handedness questionnaire. The listeners were tested individually, and were seated as in Figure 1. They listened to the pattern first facing the loudspeakers, and then facing the opposite direction. They reported verbally what they heard, and backed up their verbal descriptions with diagrams.

All the listeners correctly heard the oboe tone as switching back and forth between the loudspeakers. However, the way the glissando was perceived varied from one listener to another. Most righthanders heard it as moving from left to right as its pitch moved from low to high, and as moving from right to left as its pitch moved from high to low. This percept occurred regardless of whether the listener was facing the loudspeakers or facing the opposite direction. Other listeners heard the glissando move around in different ways; for example as moving from right to left as its pitch moved from low to high, or even moving between front and back. Interestingly righthanders and nonrighthanders differed statistically in terms of how they perceived this pattern.

Many listeners also reported that as the pitch of the glissando moved from low to high it appeared to move upward in space, and as its pitch moved from high to low it appeared to move downward. The interaction between the apparent spatial motion along the left-right and the up-down dimensions caused many righthanders to perceive the glissando as tracing an elliptical path that was aligned diagonally between a point low and to the left when its pitch was lowest and a point high and to the right when its pitch was highest. This illusory percept is illustrated in Figure 3, which reproduces the diagram that was drawn by one of the listeners.

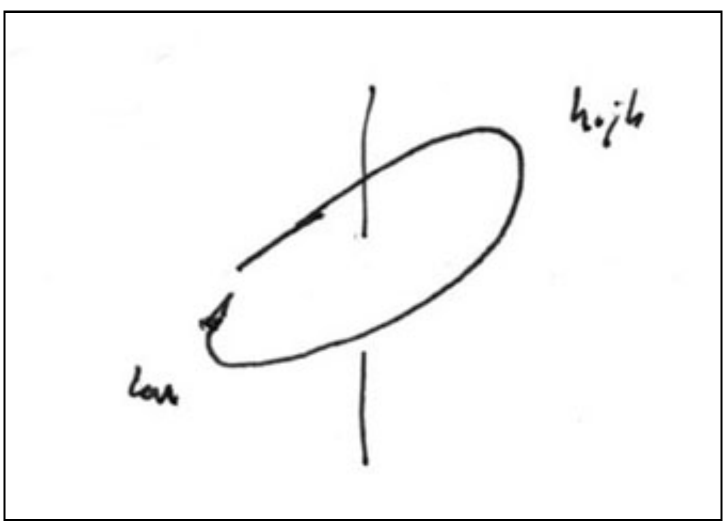

Figure 3. Diagram drawn by a listener to illustrate his perception of the glissando illusion.

Perhaps the most remarkable aspect of this illusion is that, although the portions of the glissando are alternating abruptly between widely different spatial positions, it is perceived as though coming from a single source that moves around in space in accordance with it pitch characteristics. This provides an instance of the brain making a plausible but incorrect 'best guess' about the signals it receives. In everyday life, when we hear a sound that changes slowly in pitch - such as a siren - it is much more likely to be coming from a single source which is either stationary or moving slowly in relation to us, rather than to be alternating rapidly between two widely separated sources. The brain therefore bets on the cues of pitch proximity and pitch continuity between successive portions of the glissando, so as to conclude that it is coming from a single source that is moving slowly through space. The illusion also provides an example of striking differences in sound perception that vary in association with the handedness of the listener, and so reflect differences in brain organization.

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