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Grouping

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Consider what happens during an orchestral performance in a concert hall. The sounds that are generated by the different instruments are mixed together as they travel through the air. The listeners then need to disentangle the components of sound mixtures that reach their ears, so that they hear, for example, the first violins playing one set of notes, the clarinets another, and the flutes another. They also need to group together the sounds that they perceive: Instead of hearing unrelated notes they hear melodies, harmonies, instrument timbres, and rhythms. This article discusses the principles whereby such groupings are formed.

Grouping of components of sound mixtures

One issue that has been addressed by researchers concerns the relationships between the components of a sound mixture that cause listeners to fuse them together so as to perceive a single tone, and those that cause listeners to perceive two or more simultaneously sounding tones. One cue that listeners employ is termed harmonicity. When a note is played on an instrument such as a violin or a flute, or when a note is sung, many frequency components are produced. These are termed harmonics, and they are whole number multiples of the lowest frequency component, which is termed the fundamental frequency. In line with this, listeners fuse simultaneous tones that stand in harmonic relation into a single tone, and they perceive a pitch that corresponds to the fundamental frequency. Furthermore, the simpler the ratio between the frequencies that combine to form the complex tone, the more likely it is that listeners will fuse them perceptually.

Another cue that listeners employ concerns the relative onsets of the components of a sound mixture. Components that begin at the same time are likely to have arisen from the same source, and those that begin a different times are likely to have arisen from different sources. Accordingly, listeners tend to fuse together components of a sound mixture whose onsets are synchronous, and to separate out those that begin at different times.

Composers have exploited these grouping principles. For example, in polyphonic music different melodic lines are played in parallel, and it is important that each line be clearly heard. Interestingly, Johann Sebastian Bach in his polyphonic keyboard works tended to avoid simultaneous tones that stand in simple harmonic relation, and to avoid tones with simultaneous onsets. Other composers such as Claude Debussy and Maurice Ravel have produced impressionistic effects in their orchestral pieces by creating combinations of tones that are likely to fuse perceptually.

Grouping of sequences of tones

Researchers have also explored how listeners group tones that are presented in sequence. One cue that is used here is pitch proximity. Sounds that are close in pitch are more likely to be coming from the same source than are sounds in different pitch ranges. Accordingly, listeners tend to link together tones that are close in pitch, and to separate out those that are further apart. This effect is particularly strong when tones are presented at a rapid tempo. Instead of hearing a single stream of connected tones, listeners hear two melodic lines in parallel, one corresponding to the lower tones and the other to the higher tones. This perceptual effect, termed pseudopolyphony, was exploited by composers of the Baroque era, such as Bach and Georg Philipp Telemann, and excellent examples occur in Bach's cello suites. The effect is also exploited in classical and romantic guitar music, such as composed by Francisco Tarrega and Augustin Barrios. An excellent example is provided in Tarrega's piece *Recuerdos de la Alhambra*. In such pieces, listeners perceive two melodic lines from a rapid sequence of single tones. This effect of perceptual separation in turn produces further effects. For example, listeners have difficulty in combining the higher and lower tones in such a sequence so as to perceive the overall rhythm, and instead perceive the timings of the two melodic lines separately.

Perceptual groupings of sequences of tones are also formed on the basis of instrument timbre. This effect is exploited widely by composers, so that listeners follow the melodic lines that are produced by different instruments, even when their pitch ranges overlap. A good example occurs at the beginning of Beethoven's *Spring Sonata* for violin and piano, Opus 24. Here the notes played by the two instruments overlap heavily in pitch; however listeners perceive two melodic lines in parallel, corresponding to the notes played by each instrument. Many examples of grouping by timbre occur in Franz Schubert's Lieder, in which the singer is accompanied by piano.

When two simultaneous sequences of tones are presented from different positions in space, grouping by pitch proximity can give rise to striking illusions. A clear example is provided by Diana Deutsch's *Scale Illusion*. A scale is repeatedly presented through earphones in simultaneously ascending and descending form. The notes from each scale alternate from ear to ear, such that when a note from the ascending scale is in the right ear and note from the descending scale is in the left ear; and vice versa. Most righthanded listeners perceive a melody that corresponds to the higher tones as though in the right ear, together with a melody that corresponds to the lower tones as though in the left ear. This illusion can also occur when the tones are generated by natural instruments in concert halls. Furthermore, similar illusions have been found to occur in orchestral pieces. For example, at the start of the last movement of Pyotr Ilyich Tchaikovsky's Sixth Symphony, *The Pathetique*, the notes from the theme and accompaniment alternate between the first and

second violin sections; yet the theme is heard as coming from one set of instruments and the accompaniment as from the other.

See Also: Fusion, Harmonicity, Illusion, Perception

Further Readings

Bregman, Albert. *Auditory Scene Analysis: The Perceptual Organization of Sound*. Cambridge, MA, MIT Press

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