Emotional responses to sounds and music

Stefan Koelsch
Brain structures involved in emotion

Koelsch, Fritz & Siebel, 2008
Brain structures involved in emotion
Brain structures involved in emotion

- ACC
- Fornix
- Septal Nuclei
- Mammillary body
- Amygdala
- Hippocampus
- Corpus Callosum

Hippocampus of right hemisphere (ghosted in)
Intensely pleasurable experiences („Chills“) modulate activity in central „limbic“ structures

Blood & Zatorre, PNAS 98(20), 2001
Pleasant (joyful) music modulates activity in central „limbic“ structures

Koelsch et al., *Human Brain Mapping*, 2006
Emotional responses to music are stronger when paired with visual information

Eldar et al., *Cerebral Cortex* 2007
Eldar et al., Cerebral Cortex 2007
Violations of musical regularities elicit emotional responses

First, the original version of a piano sonata was played by a pianist. This original version contained an unexpected chord as arranged by the composer (see middle panel in the lower right). After the recording, the MIDI file with the unexpected (original) chord was modified offline using MIDI software so that the unexpected chord became expected, or very unexpected chord (see top and bottom panels). From each of these three versions, another version without musical expression was created by eliminating variations in tempo and keystroke velocities (excerpts were modified offline using MIDI software). Thus, there were six versions of each piano sonata: Versions with expected, unexpected, and very unexpected chords, and each of these versions played with and without musical expression.
Skin conductance responses (SCRs)

A: Grand-average of SCRs elicited by expected, unexpected (original), and very unexpected chords (averaged across expressive and non-expressive conditions). Compared to expected chords, unexpected and very unexpected chords elicited clear SCRs. Notably, the SCR elicited by very unexpected chords was larger than the SCR to unexpected (original) chords, showing that the magnitude of SCRs is related to the degree of harmonic expectancy violation. B: Grand-average of SCRs elicited by expressive and non-expressive chords (averaged across expected, unexpected, and very unexpected conditions). Compared to non-expressive chords, chords played with musical expression elicited a clear SCR.

Koelsch et al., *PLoS-ONE* 2008
Amygdala activated by unexpected harmonies

unexpected > expected

p < .005, uncorr.
SCRs elicited by pleasant / unpleasant music
Electrodermal activity modulated by valence and arousal

Chocolat

Grewe et al., Emotion 2007
Pleasant and unpleasant music affects the heart rate

Sammler et al., *Psychophysiology* 2007
Autonomic responses to pleasant / unpleasant music
Modulation of autonomic responses by music

Bernardi et al., *Heart* 2006