# Processing of Musical Chords in the Human Brain Studied with fMRI

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This PhD dissertation was accepted by the Faculty of Health Sciences of the University of Aarhus, and defended November 24, 2008.

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Dan Med Bull 2009;56:73

ABSTRACT

The PhD dissertation is based on four studies: a behavioural study of the emotional connotations of major and minor musical chords and three fMRI (functional magnetic resonance imaging) studies of the neural processing of major, minor and dissonant musical chords. The experiments were conducted at Helsinki Brain Research Center and had as their main aim to study the processing of musical chords as a function of the mental context and the individual competence.

The pattern of brain activity was measured during rest (passive perception of the stimuli) and during two cognitive conditions that involved comparisons and memorization of the stimuli. Moreover, by comparing musicians and non-musicians, the brain activity pattern during cognition as a function of individual differences was studied.

Study 1 confirmed the hypothesis that brief, individually presented major and minor chords appropriately elicit distinguishable emotional responses even in musically untrained listeners. This shows both that the sound parameters that contain the emotional cues are present in these musical sound units, and that the emotional cues are coded also by listeners that do not possess explicit musical knowledge.

Study 2 further showed that dissonant and minor chords elicit greater responses in brain structures including the amygdala than major chords. The differential responses were only detectable during passive listening, i.e., not during working memory, hence confirming the hypothesis that the coding of emotions is diminished during cognition.

Study 3 confirmed that decreases in brain activity during working memory comprise a network of limbic and neocortical brain structures, commonly referred to as "the default system". Compared to previous studies, the observed decreases involved a prominent representation of limbic and paralimbic regions, most likely due to the introduction of emotionally charged stimuli. Furthermore, the controlled manipulation of both the cognitive load and the emotional stimulus connotation in the current study led to confirming evidence that the magnitude of the observed task-related decreases depends on the cognitive load. The results also indicated that the emotional stimulus connotation may counteract the task-related decreases in structures associated with emotion processing.

Study 4 showed that musical competence, even when not implying a task advantage related to processing of musical sounds features, leads to both enhanced behavioural performance and greater brain activity in lateral prefrontal and parietal cortical areas. This suggests that musicians possess superior cognitive control skills, possibly achieved via musical training. More generally, this result suggests that individual differences manifest in the observed pattern of brain activity in several ways.

This PhD project has contributed with new knowledge about processing of musical sounds and about the context dependency of emotional and cognitive processes.