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From emotion perception to emotion experience: Emotions evoked by pictures and classical music

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Abstract

Most previous neurophysiological studies evoked emotions by presenting visual stimuli. Models of the emotion circuits in the brain have for the most part ignored emotions arising from musical stimuli. To our knowledge, this is the first emotion brain study which examined the influence of visual and musical stimuli on brain processing. Highly arousing pictures of the International Affective Picture System and classical musical excerpts were chosen to evoke the three basic emotions of happiness, sadness and fear. The emotional stimuli modalities were presented for 70 s either alone or combined (congruent) in a counterbalanced and random order. Electroencephalogram (EEG) Alpha-Power-Density, which is inversely related to neural electrical activity, in 30 scalp electrodes from 24 right-handed healthy female subjects, was recorded. In addition, heart rate (HR), skin conductance responses (SCR), respiration, temperature and psychometrical ratings were collected. Results showed that the experienced quality of the presented emotions was most accurate in the combined conditions, intermediate in the picture conditions and lowest in the sound conditions. Furthermore, both the psychometrical ratings and the physiological involvement measurements (SCR, HR, Respiration) were significantly increased in the combined and sound conditions compared to the picture conditions. Finally, repeated measures ANOVA revealed the largest Alpha-Power-Density for the sound conditions, intermediate for the picture conditions, and lowest for the combined conditions, indicating the strongest activation in the combined conditions in a distributed emotion and arousal network comprising frontal, temporal, parietal and occipital neural structures. Summing up, these findings demonstrate that music can markedly enhance the emotional experience evoked by affective pictures.

Keywords: EEG; Emotion; Perception; Feelings; Picture; Music; Psychophysiology

1. Introduction

Most of the published neuroimaging papers examining emotional processes have used visual stimuli in order to evoke emotions. In the majority of these studies either the Pictures of Facial Affect by Ekman and Friesen (1976) or the International Affective Picture System (IAPS) by Lang et al. (1995) have been used as stimulus material (e.g. Lee et al., 2004; Esslen et al., 2004; Hariri et al., 2002). This material is composed of stimuli using either facial expressions or scenes thought to evoke basic emotions (positive or negative). However, it is obvious that real-life emotional experiences mostly rely on the presence of combined stimuli coming from different modalities. For example, music is often used to enhance the emotional impact of movies. Although this enhancing effect of combined presentation of emotional music and visual stimuli is intuitive, modern neuroimaging research has mostly ignored the neurophysiological underpinnings of this enhancement effect. Even the neurophysiological study of emotional experiences associated with the perception of music has been understudied. Emotional appreciation of music is a new research avenue in neuropsychology and neurophysiology (Peretz, 2001). Nevertheless, the results of these few studies are remarkable. It has been shown that music elicits intense emotional responses that activate brain regions thought to be involved

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in reward/motivation, emotion and arousal, including ventral striatum, midbrain, thalamus, orbitofrontal cortex, anterior cingulate cortex and the insula (Brown et al., 2004; Blood and Zatorre, 2001). These brain structures are known to be active in response to other euphoria-inducing stimuli, such as food, sex, and drugs of abuse (e.g. Small et al., 2001).

Although these few studies have demonstrated that music is in fact a powerful elicitor of emotions and especially emotional feelings (Altenmuller et al., 2002; Krumhansl, 1997), there is (to our best knowledge) to date no neuroimaging study which examined the influence of the combined presentation of emotional visual and musical stimuli on the central brain processing. Based on the subjective experience that combined presentation of congruent emotional musical excerpts and visual stimuli might enhance emotional experiences (as compared to the presentation of emotional stimuli from one modality) we designed the present study. In this study, we recorded EEG to measure the oscillatory brain activity while subjects were listening to emotional musical excerpts of fear, happiness and sadness and while they were viewing at emotionally laden visual pictures of the same emotional categories. In addition, psychometrical ratings and psychophysiological measures (skin conductance responses, heart rate, respiration and temperature) were collected after and during the experimental conditions, respectively. We hypothesized that activity in emotional brain structures are increased when the two emotional stimuli modalities are presented in combination compared to the separated presentation of the two modalities. Furthermore, we believe that this increased brain activation is accompanied by increased subjective and psychophysiological arousal and involvement measures because recent findings have strongly supported the idea that the subjective process of feeling emotions is partly grounded in neural maps which represent aspects of the organism's internal state (Damasio et al., 2000; Craig, 2002). Thus, measures from the autonomic nervous system can help to objectively discriminate processes of cognitively evaluating emotions on the one hand or strongly feeling and experiencing emotions on the other hand.

2. Materials and methods

2.1. Subjects

24 right-handed (tested with standard handedness tests revealing consistent right-handedness in all subjects) females (mean ± S.D. age, 26.1 ± 5.3) were examined in the experiment, most of them students of psychology, biology or medicine. Females were chosen because it is known that they show stronger emotional reactions than males. All subjects underwent a physical evaluation to screen out chronic diseases, mental disorders, medication, drug or alcohol abuse. Furthermore, depression, anxiety and alexithymia were assessed by the German versions of the Self-Rating Depression Scale (SDS; Zung, 1965), the State-Trait Anxiety Inventory (STAI; Laux et al., 1981) and the Toronto-Alexithymia Scale (TAS; Taylor et al., 1985). Two of the original 26 subjects had to be excluded because their score in these tests were not within the normal range for the general population. Each subject received 30 Swiss Francs for the participation. The study was carried out in accordance with the Declaration of Helsinki principles, approved by the ethics committee of the University of Zurich. All subjects gave written, informed consent and were informed of their right to discontinue participation at any time.

2.2. Stimuli and study design

The musical stimulus material consisted of excerpts of exactly 70 s duration and were taken from the following classical orchestral pieces: 1) Gustav Holst: Mars—*the Bringer of War* from *The Planets*, 2) Samuel Barber, *Adagio for Strings*, 3) Beethoven, *Symphony no.6 (3rd mvt)*. The excerpt by Holst was chosen to evoke fear, the one by Barber was chosen to evoke sadness, and the one by Beethoven was chosen to evoke happiness. Various psychological and psychophysiological experiments have shown that these excerpts are capable of evoking the mentioned three basic emotions (e.g. Krumhansl, 1997; Peretz et al., 1998). In order to avoid startling the participants, the beginning (2 s) and the end (2 s) of each stimulus were faded in and out, respectively. The visual stimulus material consisted of 48 pictures from the same three emotional categories as the musical stimuli: fear, happiness and sadness. The pictures were taken from the International Affective Picture System (IAPS) or had been collected by the author. The IAPS numbers for the stimuli included in the study are the following: happy pictures had the numbers 2030, 2040, 2091, 2165, 2303, 2345, 2352, 2530, 8120, 8350, 8370, 8380, 8461, 8496, 8497; sadness pictures had the numbers 2141, 2205, 2276, 2312, 2700, 2900, 6010, 9220, 9415, 9530; fear pictures had the numbers 3500, 6211, 6212, 6250, 6312, 6313, 6510, 6540, 6570, 6821, 6834, 6838, 6940. All pictures contained humans or human faces, were matched for complexity and rated for emotional content in a pilot experiment by 48 subjects on 9-point scales for valence and arousal. A "9" on the scales indicated that subjects felt very happy and aroused, respectively. The mean ratings (± S.D.) for the three picture categories were as follows: valence: 2.2 ± 0.76 (fear picture), 3.3 ± 0.69 (sadness picture), 7.8 ± 0.70 (happy picture); arousal: 6.5 ± 0.94 (fear picture), 5.2 ± 0.84 (sadness picture), 6.1 ± 0.81 (happy picture). Fear-inducing pictures depicted for example a man attacking a woman with a knife or a man pointing a pistol to the viewer. The "happiness" pictures showed for example a man holding his smiling baby, laughing children playing on the beach, or athletes in a victory pose. Sadness