INFLUENCE OF SPECIFIC SPECTRAL VARIATIONS OF MUSICAL TIMBRE ON EMOTIONS IN THE LISTENERS

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ABSTRACT

Background: Musical timbre allows us to recognise different auditory sources. Timbre, as a multidimensional factor, is correlated with the other music parameters and influences definitely the elaboration processes of musical material. Timbre has a central role in contemporary music.

Several studies are meant to investigate how and which timbre characteristics influence music experience. The common timbre variation proposed concern the spectral energy.

Aim: The aim of this study is to investigate musical timbre's effect on listeners'emotions

Method:, CRM - Centro Ricerche Musicali (Centre for Musical Researches) created expressly for this study three new pieces characterised by unpublished and controlled spectral variation of timbre, by varying not only spectral energy (A), but also spectral structure (B) and spectral density (C), while maintaining under an extreme control: Frequency, amplitude, duration and phase patterns.

Subjects, Italian and French, were divided in three groups (electronic, classic and non musicians) and were presented with 3 stimuli and a list of 8 emotions; the experimental task was that of evaluating the intensity of emotions perceived while listening to the stimuli and the intensity of the general activation.

Results: An ANOVA was calculated. We observed that different emotional responses correspond to timbre variations, electronic musicians differ from the others, women differ for the variables "sad" and "scared",.

Conclusions: The performance is influenced by: specific timbre variations: in particular an inharmonic sound elicits sadness and disgust; the performance is also influenced by gender and musical training.

1. INTRODUCTION

The present study is the result of the collaboration with CRM. Common interest was the study and the comprehension of musical timbre. The activity of CRM concerns new techniques of composition and diffusion (ex. Planofoni and Olofoni) of sound. The Electro-acoustic music has, in last years, an increased diffusion and appreciation by a larger audience. In this "new music", timbre is the target of composing. Therefore, it is experienced as "musical form". The new systems for the music composition, using computer-synthesized or computer-processed sound instead of classic instruments, permit the "composer-performer" to manipulate the single components of sound: "The timbre is no more an indivisible structure […] unpublished timbres are proposed […]" (Lupone 2000). Listener's attention is no more directed to the melody but to the timbre's evolutions and transformations. But what's musical timbre? We can say that musical timbre is an attribute of sound that allows us to distinguish musical instruments when pitch, loudness and duration remain identical. Helmoltz called "timbre" of the sound what makes for us a sound the same sound even at different intensities or pitches. This definition allows us to think that timbre is associated almost exclusively with the spectral wave. This approach is today considered not completely satisfactory. It is in fact not true that all those sounds with similar or even identical spectra have similar or identical timbre: The timbre of a recorded piano tone is perceived as completely different when it is played backward even though the original and the reversed sound have the same spectra (Berger 1964). Furthermore it's true that radical changes of the spectrum (ex: an output of a radio transistor) don't prevent a listener from recognizing a musical instrument just by changing in the pitch, like vibrato, in this case, in fact, the relative amplitude of harmonics change when the fundamental frequency oscillates (Pierce 1988). These results indicate that musical timbre does not depend upon a single physical dimension. Several studies provide support for the notion of multidimensionality of timbre. Other attributes, such as amplitude, phase patterns, decay and attack time, temporal characteristics of a tone may influence the perception of this psychological attribute as well. More recent studies investigate musical timbre using the multidimensional scaling technique identificating two-dimensional solutions (Ehresman and Wessel 1978; Rasch and Plomp 1982; Wedin and Goude 1972; Wessel 1973; 1979; Wessel and Grey 1978) or three dimensional ones (Grey 1977; Miller and Carterette 1975; Krumhansl 1989; Plomp 1970; McAdams and Cunibile 1992) of the perceptual characteristics along which a listener rates the sound. Harmonics seem to be fundamental components in the timbre elaboration. The timbre space resulting from the studies of Miller e Carterette (1975) revealed a three dimensional model in which two dimensions were related to the harmonic structure. Similar results were obtained by Samson, Zatorre e Ramsay (1997) according to the studies of Ehresman and Wessel (1978), Grey (1977), Grey and Gordon (1978) Krumhansl (1989) and Wessel (1973,1979). Furthemore several studies underline the role of the distribution of spectral energy in dissimilarity and similarity judgments (Plomp 1970; Zatorre and Samson 1997; Wedin and Goude 1972; Grey 1977; Krumhansl 1989; Wessel 1979). It is now possible to produce many kinds of complex sounds by controlling specific acoustical properties thanks to the modern systems of music composition.

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Even in the Electro-acoustic music, in which tonality and acoustic instruments are no more the base of music language, the composer still needs to communicate with the audience (Milecevic 1998; Whalley 2000). A basic issue about music as an emotive language concerns whether music produces emotional changes in listeners, (the "emotivist" position) (Krumhansl 1997; Cacioppo et al. 1993; Pansepp 1995), or simply expresses emotions that listeners recognize in the music: the "cognitivist" position (Kivy 1990; Meyer 1956; Zajonc and McIntosh 1992; Ekman and Davidson 1994).

The aim of this study is to investigate the influence of particular and controlled timbre variations on listeners' emotional responses. Single sounds are used without a musical context. We hypothesize that emotional response are therefore influenced by:

1. Musical training, in particular we hypothesize that electronic musicians differ from the other subjects

2. Number of hearings: in particular we hypothesize a general decreasing of emotions because of repetition

3. Gender

4. State and Trait Anxiety, in particular we hypothesized that to high levels of anxiety correspond higher emotional activation.

2. METHOD

2.1. Subjects

110 subjects (age 18-38) participated in this experiment. 90 were Italian students 30 of which had an extensive electronic musical training (23 males, 7 females), 30 had an extensive classical musical training (15 males, 15 females) and 30 had any musical training (15 males, 15 females).

20 subjects were French students (age 18-28) none of which had any extensive musical training.

2.2. Apparatus

Stimuli were composed and realized by CRM (Center of Musical Researches) expressly for this study. The "musical cells" were recorded on CD and were of 30 sec. in length. They used the software Super-Collider for MacIntosh, interface RME 44.1 KHz, 24 bit resolution, 2 channels. To listen to the music we used the Technics RP-F200 headphones.

The stimuli were created without references to any existing timbre, in absence of melodic contour and maintaining constant frequency, amplitude, duration and phase patterns.

Stimulus A: Called "Formanti" it is characterized by a variation of Spectral Energy; harmonic ratios are invariable but the harmonics' amplitude changes. Stimulus B: Called "Arminarm" it is characterized by a variation of Spectral Structure; harmonic ratios vary in the absence of change of harmonics' number and amplitude. This sound is defined as an inharmonic sound. Stimulus C: Called "Texture", it is characterized by a variation of spectral density, the ratios among partials change while their amplitudes are costant.

STAI (State and Trait Anxiety Inventory) was used as anxiety's auto valuation test and GEFT (Groups Embedded Figures Test) as distracting task.

Therefore an emotional autovaluation test in Likert scale (1-7) was presented. It consisted of a list of 8 emotions (happy, scared, angry, interested, disgusted, sad, surprised, well-disposed) (Plutchik 1994). For each emotion the level of intensity of feeling had expressed. Even the level of general activation was asked to be evaluated (Likert 1-7).

2.3. Procedure

Each Italian subject followed the same schedule:

First section

1. Compilation of STAI

2. Listening of 3 stimuli. Each stimulus was presented three times in random sequences (Tot 9 hearing)

3. At the end of each hearing the emotional evaluation test was presented

Second section

4. Compilation of GEFT used as distracting task

5. A new section of hearing was presented (see points 2, 3)

French subjects were presented just the first section of the experiment.

3. RESULTS

Analyses of variance (ANOVAs) were performed as repeated measures tests with 4 factors: Stimuli (3level), musical training (3level), gender, number of hearing (2level: First one and last one). Tukey's HSD test was used for post hoc analyses.

Stimulus A differs for the variable "happy" (M_a=2.61, M_b=2.15, M_c=2.1; $F(2,168)=9.97$; $p<.001$), stimuli A and B differ from each other for the variable "disgusted" (M_a=2.02, M_b=2.74; ($F(2,168)=7.59$; $p<.001$) and scared (M_a=1075, M_b=2.32; ($F(2,168)=17.15$; $p<.001$). Stimulus B differs for the variable "angry" (M_a=1.69, M_b=2.7, M_c=1.88; ($F(2,168)=41.83$; $p<.001$). Women result more surprised 5F(1,84)=4.89; $p<.05$) and scared ($F(1,84)=11.26$; $p<.05$). For the factor musical training: Electronic musicians are less disgusted ($F(2,84)=11.56$; $p<.001$) surprised ($F(2,84)=5.65$; $p<.05$). Subjects without any musical training are sadder ($F(2,84)=8.13$; $p<.001$) and more scared ($F(2,84)=3.17$; $p<.05$). For the variable "well-disposed" there is a significative difference among electronic musicians (M=4.35) and classic musicians (M=3.28) ($F(2,84)=7.08$; $p<.001$). The three groups differ for the variable "angry" (M elett=1.35; M class=2.01; M naives=2.91; $F(2,84)=1.39$; $p<.001$). Subjects at last listening are less surprised ($F(1,84)=114.26$; $p<.001$), scared ($F(1,84)=16.94$; $p<.001$), interested ($F(1,84)=52.08$; $p<.001$), well-disposed ($F(1,84)=52.09$; $p<.001$) and angrier ($F(1,84)=11.1$; $p<.001$). The level of "general activation" decreases across listening just for the stimulus C ($F(2,168)=7.77$; $p<.001$). There is not significative effect of the State and Trait Anxiety ($p<.05$), no correlation with the performance to the GEFT ($p<.05$) and not differences between French and Italian samples ($p<.05$).

4. DISCUSSION

A progressive inharmonicity of sound (Stimulus b) arouses emotions that we can define as "negative" (disgust, fear, anger). A similar pattern is observed with the stimulus C characterized by a changing of spectral position. Variations of spectral energy (Stimulus A) tend to arouse "happiness". Moreover we observe that emotional responses are influenced by musical training: Familiarity and interest for a particular kind of music, as in the case of electronic musicians, arouse a pattern of emotions, overall more "positive". Classic musicians and non-musicians present higher levels of sadness, disgust, fear and anger, whereas the level of the variable "well-disposed" are really low. Naturally they are more surprised than electronic musicians, hearing an unknown type of music. A difference between females and males emerges: Women are more surprised and scared than males. A repeated presentation of stimuli tend to increase the level of anger probably because of fatigue, whereas surprise, interest and fear decrease. Is important to underline that the effect of repetition varies according to the musical training. We can suppose that the "education to listening", influences the hearing processes. In terms of "general activation" there are not differences among stimuli. Observing the means of "general activation" of each stimulus we can say that they generate an important emotional response.

4. CONCLUSION

In this study the interaction of timbre variations and emotions was investigated by examining the effect of spectral energy, spectra structure and spectral density on emotional responses. Changes of harmonic dynamic (Stimulus C) and harmonic ratios (Stimulus B) aroused "negative". Changing of the distribution of spectral energy (Stimulus A) arouses to high level of "happiness". It is important to observe that the harmonic components and the spectral energy are fundamental factors in the task of perceptive judgment as of emotive responses.

Our first hypothesis has been confirmed: In particular electronic musicians differ for a lower intensity of the emotions of disgust, fear, sadness and surprise. The results are not in accord with the studies of Gaver and Mandler (1987) e Robazza, Macaluso and D'Urso (1994). That's probably because of the different tasks required. In the study of Robazza, Macaluso and D'Urso in fact, subjects were asked to associate an emotion to the stimuli but not to evaluate the intensity of emotion. Anyway our results aren't in disagreement with the concept of music as a "common language" but underline a different reception of the "message" in term of intensity.

Our second hypothesis has been only partly confirmed: Repetition of stimuli arouses not a general decreasing of emotions, but a different pattern. We observe an increasing of the intensity of "negative" emotions (anger, disgust, sadness) and a decreasing of "positive" emotions (interest, happiness) and of "fear" and higher level of "surprise" because of familiarity with the stimuli.

Differences for gender are observed (third hypothesis): Overall women are easier upset.

Correlation between subjects' performance and their level of state and trait anxiety (fourth hypothesis) has not been confirmed.

This study underlines the richness and complexity of relation between music and emotions. Our focus of interest has been "the timbre". It is not only an important parameter in cognitive processing of music, but has a central role in electronic music. Thanks to the "new music" the possibilities of creation and control of sound are increased, helping the comprehension of processes of music perception. Composers can also use this information in their musical choices.

It would be interesting investigate the influence of musical context using the same type of stimuli.

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