Musical Timbre can Enhance the Emotion Conveyed by a Melody

Vincent Bujor, Timo Grothe[1]

[1] *Hochschule für Musik Detmold, Erich-Thienhaus-Institut, Neustadt 22, 32756 Detmold*
info@vincentbujor.com, grothe@hfm-detmold.de

Abstract

This paper describes a listening experiment in which emotional ratings of melodies were collected. As an attempt to investigate the emotions conveyed by the musical timbre, a two-step listening test was performed. To examine the emotions conveyed by the musical content only, several melodies synthesized from sine tones in an assumedly "timbre-less" manner were rated on a semantic differential. In the second step, the rating procedure was repeated for one of these melodies which was played by five different instruments. In contrast to similar studies [6,7], the stimuli for this second test consisted of recordings from musicians, who were instructed to play the melody in a "neutral" manner, thus avoiding any differences timing and intonation.

A total of 96 participants, divided into two groups, rated each of these stimuli "with timbre" and "without timbre" in regards to their perceived strength of emotion. Significant changes in the emotional rating between the first test (melody "without timbre") and second step (melody "with timbre") point to a relation with musical timbre. Consistent emotional ratings between the two groups of trained (N=20) and normal (N=76) listeners were found for the saxophone, the flute, and the violin. Both groups did not attribute emotional changes to the melody when played by the oboe. Further studies are needed on the effects of variations in micro-timing and vibrato which are difficult to control while recording stimuli with musicians.

Introduction

Terminologies of emotion and timbre are widely used within the psychoacoustical context. Whereas emotion has multiple but very similar definitions (recent studies describe it as a complex pattern of personal reactions [1]), the discussion about timbre continues. Scholars criticize Helmholtz' classical definition of timbre being neither pitch nor loudness through which it became a psychoacoustical "wastebasket category" [3,2]. A more recent research suggests to locate timbre as a perceptual attribute in the mind of the listener rather than studying physical properties of sounds [4].

Only few studies have been reported which address the relation between timbre features and emotion, e.g. by Hailstone et al. [6] and Chau et al. [7]. Hailstone et al. (2009) proposed 4 novel melodies, which were to convey a single emotion only ("happiness", "sadness", "anger" or "fear") [6]. Their initial assumption that timbre does not affect the perception of emotion was contradicted: If one plays a "happy" melody on both the piano and the violin, more people suggest that the melody is "happy" after hearing the piano (and not the violin) play it. A similar study by Chau et al. (2014) compared naturally decaying with non-decaying instrument tones (e.g. piano vs. violin). Using synthetic library sounds, Chau et al. compared stringed instruments, keyboard instruments and mallet percussion sounds and found that "different acoustic structures contribute to evoke different emotions" [7]. Wu et al. (2014) studied emotional ratings of sustained tones and related these to spectral characteristics of the sounds [8]. The orchestrational point of view is highlighted by Reuter (2002) who collected numerous verbal descriptions related to specific musical instruments. A few of them, which overlap with emotional scales are to be shown here. E.g. the saxophone sound is described as "melancholic", and "with a tendency to sadness". The violin is considered "calm", the oboe "neutral", the trumpet "happy" and the flute with "relatively little characteristic" [9].

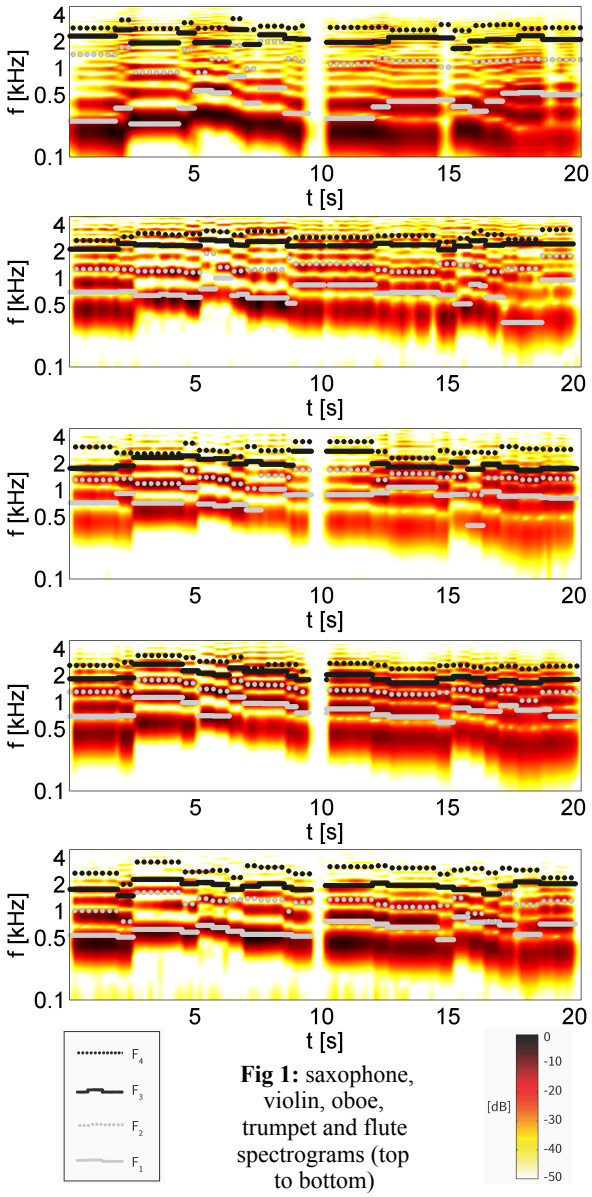

Fig 1: saxophone, violin, oboe, trumpet and flute spectrograms (top to bottom)

The purpose of the present study was investigate if musical timbre changes the emotion by answering the question whether or not people would rate the emotion conveyed by a melody “with timbre” differently than “without timbre”.

Methodology

The relation between a melody, a musical instrument and emotional perception is elaborate and can be addressed by using a so-called “model of emotion”. Different models, such as Russell’s “Model of Affect" (1980) and his “Illustration of Core Affect" (1999) had bridged the gap between the theory of emotions and empiric evidence. Based on these foundations, we decided to use a model consisting three bipolar emotional pairs, also considered as “basic” emotions [11], namely sad/happy, calm/tense and shy/heroic.

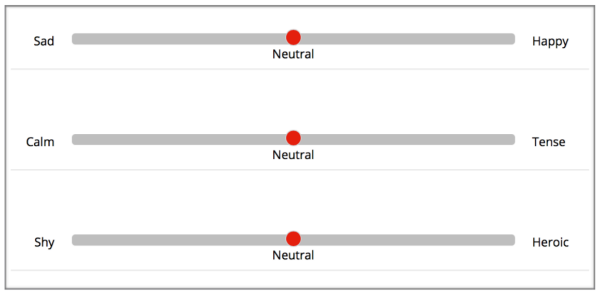

Fig. 2: Model of emotion, implemented in the GUI, for a two-step listening test. Software used: SurveyGizmo [13]

For the listening test, five different sustained-tone instruments were chosen as representatives for the sound generation principles single-reed, double-reed, lip-reed, air jet and the bowed string.

These were the saxophone, the oboe, the trumpet, the flute and the violin. To show the spectral dimension of timbre, the spectral density of their tones is illustrated in Fig. 1. The spectrograms were computed with Praat [10], using a window width of three times the periodic time of the lowest note in the melody (165 Hz for saxophone, 330 Hz for the other instruments), and a step size of 60 times the periodic time. The power spectral density output is displayed here in dB/Hz. The formant analysis was also completed with Praat, using Burgers algorithm in default settings for female speech (window width 25ms; time step size 6.3 ms).

Before any emotional “change” can be captured, it is necessary to rate the melody itself in regards to emotional perception. This was the first step of the listening experiment. Four melodies were taken from a previous study, referring to four basic emotions [11], the fifth was the theme / intro from Felix Mendelssohn’s *Variations sérieuses*, Op. 54. [12]. All five melodies were played back through a computer with pure sines per pitch, and therefore assumed to have no timbre. Subjects were asked to use our rating system consisted of three emotional pairs, covering two polar opposites each, which formed an apt model to distinguish individual reactions from all melodies. By adding Mendelssohn as a “classical" melody to the four novel melodies [6], a reference for the second step was created.

For the second part of the listening test, Mendelssohn’s melody was played by the saxophone, the violin, the oboe, the trumpet and the flute. The above shown rating system was used again. Differences in timing and loudness were avoided by using a metronome and leveling all recordings according to DIN45631. Music students from the local music university were recruited to play all melodies.

Then, a total number of N=96 participants consisted of two groups: (A) experienced listeners, e.g. music students, Tonmeister students and professors at a music university (N_1=20); and (B) unexperienced listeners, e.g. randomly chosen individuals at an airport in Germany (N_2=76). Participants asked to rate the melodies on a scale from -50 to 50 (“very sad” to “very happy”). Both groups first rated all five melodies auralized with sines (and therefore assumed to have “no timbre”), and then all five instruments playing the second melody (The theme of Mendelssohn’s *Variations sérieuses* (Fig. 3)

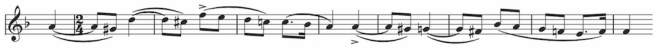

Fig. 3: This melody (theme taken from Mendelssohn’s *Variations sérieuses*, Op. 54,) was used as a reference.

Results

Significant changes in the emotional rating between the first and second step point to a relation between emotional musical timbre. Figure 4 on the following page shows how the emotional perception in the dimensions sad-happy (top), calm-tense (middle) and shy-heroic (bottom) changed when the melody was played “with timbre”, i.e. by musical instruments. The vertical shadow represents a probability density estimation of the emotional rating for the melody played “without timbre” (data from both group A and B), the black line marks the median. The grey horizontal boxes show the spread in the rating of the two groups (95% confidence intervals). Group means are marked by o (group A: trained listeners) and x (group B: untrained listeners). The red boxes mark results which were significant in both groups (p values for all tests are shown in Table 1).

Consistent ratings between the two groups of trained and normal listeners were found for the saxophone, the violin, and the flute. For the saxophone and the flute, emotional ratings of the melody were stronger compared to the melody composed of sines: The melody was rated slightly more sad when played by the saxophone, and slightly more shy when played by the flute or the saxophone. It can be hypothesized that instrumental timbre enhanced the emotion conveyed by melodic content. The opposite effect is observed for the violin: the melody was rated slightly less calm when played by the violin.

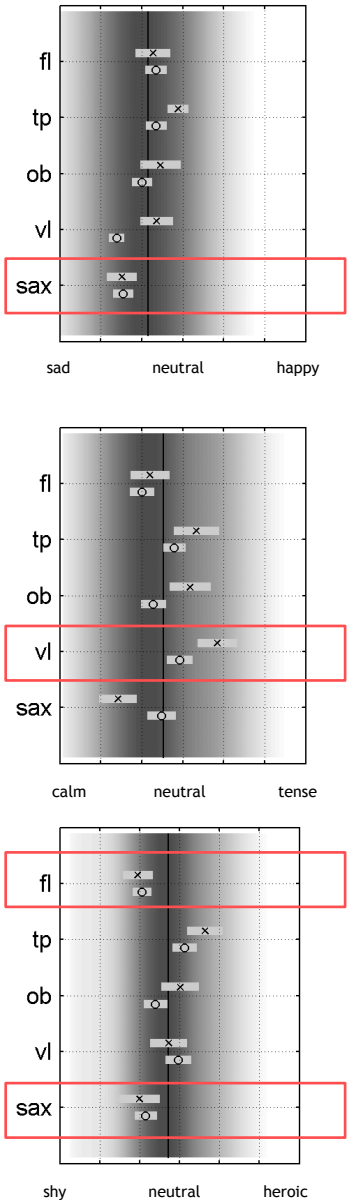

Fig. 4: Vertical black line represents the sine mean, all small horizontal boxes are group ratings (group A displayed by o; group B by x).

Inconsistent ratings between the two groups were found for the violin in the sad-happy dimension; and flute in the calm-tense dimension, and the trumpet in the shy-heroic dimension. The trained listeners in group A did not judge the melody played by a trumpet to be significantly more heroic than the same melody composed of sines (see Table 2).

Interestingly, the test persons in both groups were not assigning any specific emotion to the melody when played by the oboe. This finding is in accordance with the earlier study by Wu et al. [8], and further fits to the description of a "neutral" timbre in the orchestration literature reported by Reuter [9]. Generally, trained listeners seemed to be more familiar with the emotional rating than ordinary listeners. The majority of individuals in group B could not distinguish our three parameters from one another, which is backed up by ANOVA tests for one instrument, comparing all three pairs of emotions. The rate for music students was higher ($F_1 = 43.6$) than for randomly chosen individuals ($F_2 = 15.2$).

	trained		
	sad/ happy	calm/ tense	shy/ heroic
sa	0.000	0.000	0.001
vl	0.001	0.002	0.374
ob	0.081	0.466	0.968
tp	0.339	0.225	0.007
fl	0.002	0.002	0.000

	randomly chosen		
	sad/ happy	calm/ tense	shy/ heroic
sax	0.000	0.003	0.000
vl	0.000	0.647	0.822
ob	0.000	0.000	0.000
tp	0.018	0.135	0.401
fl	0.000	0.000	0.000

Table 1: p-values of a one-sample t-test to show the significant difference between each emotional rating and zero.

	trained		
	sad/ happy	calm/ tense	shy/ heroic
sa	0.006	0.001	0.001
vl	0.887	0.001	0.167
ob	0.678	0.129	0.621
tp	0.028	0.067	0.146
fl	0.896	0.190	0.000

	randomly chosen		
	sad/ happy	calm/ tense	shy/ heroic
sax	0.002	0.952	0.014
vl	0.000	0.043	0.071
ob	0.511	0.315	0.273
tp	0.218	0.141	0.001
fl	0.224	0.019	0.002

Table 2: p-values of a two-sample t-test on the mean difference in the emotional rating between a melody "without timbre" (concatenated sine tones) and "with timbre" (sax, violin, oboe, trumpet, flute). The saxophone, the violin and the flute means are all significantly different from their respective sine means.

Discussion

Based on the assumption that all musicians played the melody by Mendelssohn in a "neutral way", results point to a connection between specific musical timbres and emotions. Certain instruments, such as the saxophone and the flute enhanced the previously conveyed emotion. The observed effects are small but significant. What this experiment certainly fails to establish is a constant connection between a musical instruments' timbre and a specific emotion attached to it. For this, multiple melodies of different genres need to be taken into consideration, but it can be assumed that the mood expressed by the musician will have a paramount effect over the timbre.

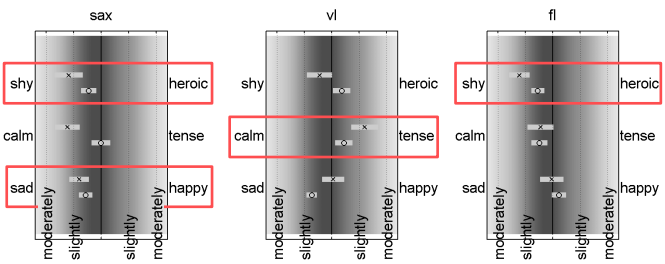

Fig. 5: Changes in the emotional ratings of a melody composed of sine tones, when played by a musical instrument. For the three instruments shown here, at least one emotional rating was significantly different after "adding" musical timbre.

From the present study it can be concluded that the effects observed in listening tests [6,7] with synthetic tones are preserved even for real-world stimuli obtained under much less controllable conditions. Further investigations are also needed on the effects of variations in micro-timing and vibrato, which are difficult to control while recording stimuli with musicians. Although a metronome and headphones were used for all stimulis and clear instructions on how to play each melody were given, some musicians took more time and used more vibrato than others. Further studies should use more than one musician per instrument for studio recordings.

Another interesting finding relates to the four melodies composed by Hailstone that were to evoke a single, dominant emotion [6], namely “happiness”, “anger”, “sadness” and “fear”. These melodies were used in the present work as a reference. However, for some of these melodies the emotional ratings of the test persons did not match with the emotions intended of the composer (Figure 6). The melody “sadness” was hardly recognized as sad, and the melody “anger” was rated only slightly sad, while the ratings on the other bipolar emotional scales were not significantly different from zero.

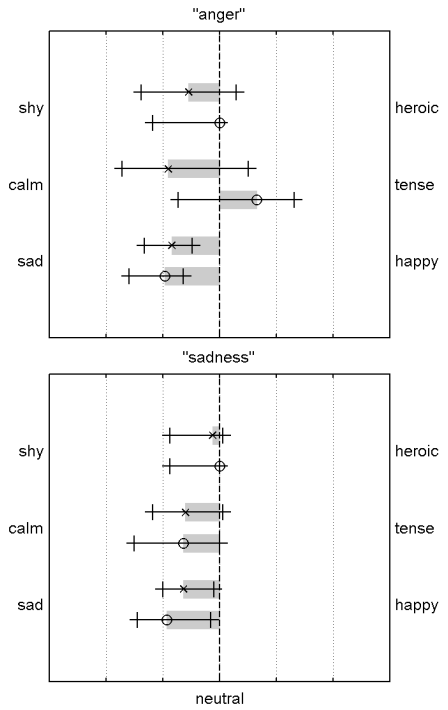

Fig. 6: Ratings of the test persons in group A and B on the reference melodies “anger” and “sadness” [6]. (group A displayed by o; group B by x).

Questions arise if or to what degree the suggested melodies can serve the purpose of defining basic emotions and how suitable our model of emotion was for Hailstone’s melodies.

Conclusion

Musical timbre can enhance or attenuate the emotion conveyed by a melody. A melody once rated “sad” was perceived slightly more sad when the saxophone and the flute played it. The same melody, originally rated as calm was perceived to be more “tense” when played by a violin. On the shy-heroic scale, the melody was rated even more shy when played by the flute. The results also point to the conclusion that the timbre of the oboe does not affect the emotional rating, which is in accordance with earlier studies.

Further research can focus on a specific instrument such as the saxophone and prove whether or not it evokes a specific emotion, even if many melodies of different genres are taken into consideration. Another interesting question arises to which degree spectrotemporal characteristics of the instrumental sounds influence emotional ratings, and to what degree these are given by the sound generation principle, or can be altered by the playing technique.

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