Real-time Visualization of Musical Expression.

Roberto Bresin

Department Speech Music and Hearing(TMH), Royal Institute of Technology (KTH), Stockholm
E-mail: roberto@speech.kth.se, http://www.speech.kth.se/~roberto

Abstract

A system for real-time feedback of expressive music performance is presented. The feedback is provided by using a graphical interface where acoustic cues are presented in an intuitive fashion. The graphical interface presents on the computer screen a three-dimensional object with continuously changing shape, size, position, and colour. Some of the acoustic cues were associated with the shape of the object, others with its position. For instance, articulation was associated with shape, staccato corresponded to an angular shape and legato to a rounded shape. The emotional expression resulting from the combination of cues was mapped in terms of the colour of the object (e.g., sadness/blue). To determine which colours were most suitable for respective emotion, a test was run. Subjects rated how well each of 8 colours corresponds to each of 12 music performances expressing different emotions.

Introduction

This work is part of a research project[1] that aims at developing a computer system for teaching students to play expressively. Part of the system is a tool for automatic extraction of acoustic cues that are considered important for the analysis of performance expression. These cues include duration, sound level, articulation, and vibrato. For example, staccato articulation may be typical of a happy performance, while legato articulation may be typical of a tender performance. It is important that music students are trained to control acoustic cues effectively to achieve different expressive performances.

Results from analyses of acoustic cues can be presented to the performer in a variety of ways, for example in term of graphs or tables representing mean values and deviation curves after a post-processing of the performance. This can be useful for a more analytical understanding of what the performer did. In the present work, a system for real-time feedback of musicians' expressive intention is proposed. In order to map intended emotions a visual display was designed in which emotions are mapped to colours. For a meaningful association of intended emotions in music performance to colours, an experiment was needed. This is presented in the following sections.

[1]Feedback-learning of Musical Expressivity
http://www.psyk.uu.se/hemsidor/musicpsy/

Method

An experiment was designed in which it was tested how subjects associated different emotionally expressive performances to different colours. The experiment was conducted with the help of a specially designed computer program.

Material

For this experiment performances of two melodies were used, Brahms' theme of the *poco allegretto* Opus 3 no 3, and Haydn's theme from first movement of Quartet in F major for strings, Op 74:2. Brahm's melody is in minor tonality and Haydn's in major. In a previous experiment (Juslin & Lindström, 2004) the two melodies were performed with piano, guitar, and saxophone by nine professional musicians, three musicians for each instrument. Musicians were asked to perform the two melodies with twelve different emotional intentions, namely happiness, love, contentment, pride, curiosity, indifference, sadness, fear, shame, anger, jealousy, and disgust. In a listening, subjects were asked to rate these performances with regards to their emotional character. Analysing

the results from this listening test it emerged that some performers were better in communicate certain emotions. The performaces that received highest rate for each instrument and each emotion were chosen for the present experiment. Thus the musical material for the experiment consisted in twelve performances for each instrument and each melody (12 x 3 x 2) for a total of seventy two performances.

Equipment

Colours were used for rating each performance. Colours used were red, orange, yellow, green, cyan, blue, violet, and magenta, and their bright and dark versions, for a total of 8 x 3 colors (see Table 1). Low saturation and low brightness were codified with value 0,5. High saturation and high brightness were codified with value 1. For an example see the color list in Table 1. The combination with low values for both saturation and brightness, and the used of value 0 of saturation or brightness, were not included since they led to undistinguishable colour or to black and white.

Colours were presented on the computer screen with the help of a computer program, COLORANCE (COLOR and performANCE perception test), specially designed for this experiment, see Figure 1. COLORANCE presents to the subject 8 colors, with same saturation and brightness values, at a time. The subject can listen to a music performance and rate it with the sliders associated to each color corresponding to a scale from 0 to 10. If the subject does not like a specific color, she can hide it by clicking on it, and the color is rated with value 0. The program window covers the entire screen so that it is the only visible window to the subject.

The computer screens were calibrated with Pantone Spider with luminance of about 90 cd/m2.

Method

Subjects

Two groups of subjects took part to the experiment. One group (in the following called Group 1) consisted of eleven students of psychology, 7 females and 4 males, aged 21 – 49. The second group of subjects (in the following called Group 2) was composed of researchers and student of Speech and Music Acoustics, 5 females and 6 males, aged 24 – 42.

Listening test

Subjects were instructed to judge how well different colours fit a particular music performance by rating each of seventy-two performances using the color palettes shown on the computer screen. For each performance three color palettes were presented, one for each combination of hue, saturation, and brightness, as presented in Table 1. The order of the performances was randomized for each subject. The order of the three-color palettes was also randomized for each subject, as well as the placing on the screen of the colours forming a specific color palette (see Figure 1). Colours with same hue appear in randomized positions in color palettes with different combinations of saturation and brightness, i.e. the red color will appear in different positions for default (saturation 1, brightness 1), dark (saturation 1, brightness 0.5) and light (saturation 0.5, brightness 1) color palettes.

Group 1 listened to Brahms' melody and Group 2 to Haydn's.

Table 1. List of colours used in the experiment and their combination of hue, saturation and brightness.

Color	Hue	Saturation	Brightness
red	0	1	1
dark red	0	1	0,5
light red	0	0.5	1
orange	0,083	1	1
dark orange	0,083	1	0,5
light orange	0,083	0.5	1
yellow	0,166	1	1
dark yellow	0,166	1	0,5
light yellow	0,166	0.5	1
green	0,333	1	1
dark green	0,333	1	0,5
light green	0,333	0.5	1
cyan	0,5	1	1
dark cyan	0,5	1	0,5
light cyan	0,5	0.5	1
blue	0,666	1	1
dark blue	0,666	1	0,501961
light blue	0,666	0.5	1
violet	0,749	1	1
dark violet	0,749	1	0,5
light violet	0,749	0.5	1
magenta	0,833	1	1
dark magenta	0,833	1	0,5
light magenta	0,833	0.5	1

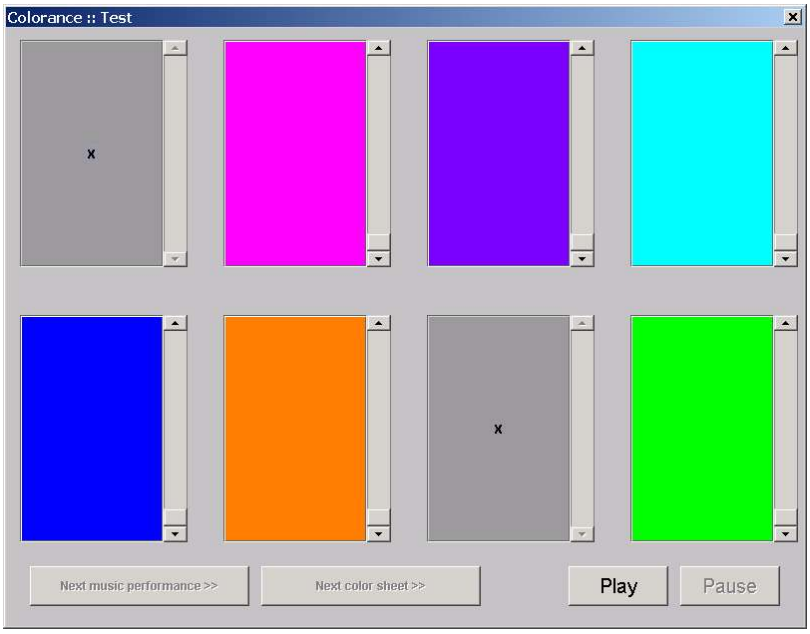

Figure 1. Screenshot of the Colorance program. Performances are rated with tewntyfour colours that are displayed eight at a time.

Table 2. Correlations between colour components (hue, saturation and brightness) and emotional intentions of performances. Marked correlations are significant at p < .05000.

Emotion	Hue	Saturation	Brightness
Happiness	-0.25	-0.04	-0.19
Love	-0.08	-0.28	**0.68**
Pride	-0.20	0.07	**-0.30**
Tenderness	0.10	-0.09	**0.39**
Curiosity	-0.10	0.03	0.24
Contentment	-0.08	-0.17	**0.31**
Anger	-0.19	**-0.44**	0.04
Sadness	0.16	-0.15	**0.47**
Fear	0.19	0.06	**0.38**
Disgust	**0.30**	-0.25	0.20
Shame	-0.03	**-0.32**	**0.57**
Jealousy	0.09	-0.12	**0.29**

Results

The emotional intetion of the performances (the independent variable) had a considerable effect on the listener's ratings of the performances (the dependent variables hue, saturation and brightness).

An analysis of correlation between emotional intentions and color components hue, saturation and brightness, reveals some significant correlations, as shown in Table 2. Significant correlations were found for brightness and the expressive performances performed with love, pride, tenderness, contentment, sadness, and fear. Significant was the correlation between saturation and intentions anger and shame. There was only one significant correlation for hue, with disgust.

In the following a more detailed analysis of the effect of the hue, saturation and brightness are presented.

Hue

Table 3 presents the hue values that received highest mean rating for each emotional expression. Results were independent from the melody while some differences emerged between instruments.

Table 3. Hue values that received highest mean rating for each emotional expression.

EMOTION	HUE
Happiness	0.167 (Yellow)
Love	*0.667 (Blue), 0.75 (Violet)*
Pride	0.167 (Yellow)
Tenderness	*0.75 (Violet)*
Curiosity	*0.5 (Cyan)*
Contentment	*0.083 (Orange)*
Anger	*0 (Red)*
Sadness	*0.75 (Violet)*
Fear	*0.667 (Blue)*
Disgust	*0.75 (Violet)*
Shame	*0.083 (Orange)*
Jealousy	*0 (Red)*

Saturation

A general observed tendency for saturation is that the minor tonality composition (Brahms) tends to be associated to colors with higher saturation (dark and default colors). This tendency is independent from the instrument.

When taking into account also the instrument variable, it emerges that Brahm's melody ratings follow a different trend for piano, for which colors with lower saturation level seem to be preferred.

Brightness

A general observed tendency for brightness is that the minor tonality composition (Brahms) tends to be associated to dark colours, and the major tonality melody (Haydn) to light colors. This tendency is independent from the instrument.

Discussion

Studies on synesthetic experiences related to music perception have reported non-consistent association between music, usually music events, and colours. Results from the present study show that subjects indeed used different color profiles for classifying the same piece of music, but these differences depended mainly on the performance (and on the instrument). This result could raise the question if differences reported in studies about color hearing could be explained in terms of differences in the expressive content of performances.

Visual feedback

The results emerged from the experiment discussed in this work open a challenging possibility to explore the possibility of providing real-time feedback about a performance by using a graphical interface where acoustic cues are presented in an intuitive fashion with the used of colors.

A graphical interface, called the ExpressiBall, was developed. It presents on the computer screen a three-dimensional object with continuously changing shape, size, position, and color. Some of the acoustic cues were associated with the shape of the object, others with its position. For instance, articulation was associated with shape: staccato corresponded to an angular shape and legato to a rounded shape. The emotional expression resulting from the combination of cues was mapped in terms of the color of the object (e.g., sadness/violet). See Figure 2 for an example of a possible real-time graphical feedback.

Such a tool provides real-time feedback regarding the expressive strategies used during a performance, and offers an interesting complement to traditional teaching strategies. In previous studies it has demonstrated that auditory-visual interaction speeds stimuli discrimination capabilities (Marks, 1974, 1987) and that the surface color of an object affects its recognition (Tanaka, Weiskopf and Williams, 2001). Therefore, an interactive tool such the ExpressiBall is expected to speed the process of learning to play with expression. For example, subjects will learn to associate red hue and square shapes to angry performances, and blue hue and round shapes to sad performances. This hypothesis will be tested in a future usability test.

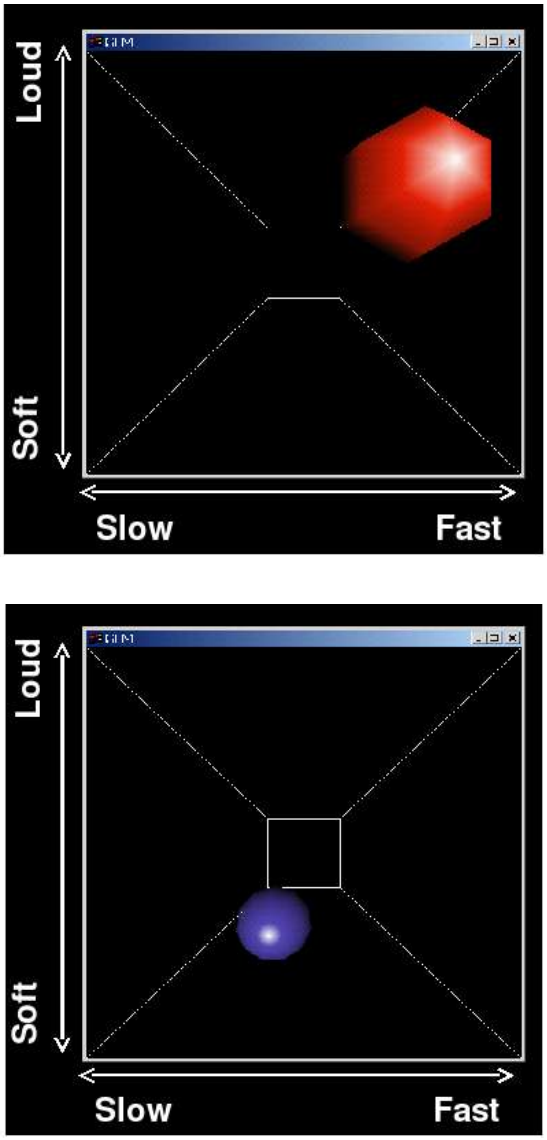

Figure 2The Expressiball: graphical interface for real-time feedback of expressive music performance. Dimensions used in the interface are; X = tempo, Y =sound pressure level, Z =spectrum (attack time & centroid), Shape = articulation, Color = emotion. Left figure shows the feedback for a sad performance. Right figure shows the feedback for an angry performance.

References

Juslin, P. N., & Lindström, E. (2004). Musical expression of emotions: Modeling composed and performed features. Manuscript in preparation.

Marks, L.E. (1974). Sensory Processes: The New Psychophysics. New York: Academic Press

Marks, L.E. (1987). On cross-modal similarity: Auditory-visual interactions in speeded discrimination. Journal of Experimental Psychology: Human Perception and Performance, 13, 384-394.

Tanaka, J., Weiskopf, D., & Williams, P. (2001). The role of color in high-level vision. Trends in Cognitive Sciences, 5:5, May 2001, 211-215.