Perceived Properties of Parameterised Music for Interactive Applications

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ABSTRACT

Traditional implementations of sound and music in interactive contexts have their limitations. One way to overcome these and to expand the possibilities of music is to handle the music in a parameterised form. To better understand the properties of the musical parameters resulting from parameterisation, two experiments were carried out. The first experiment investigated selected parameters' capability to change the music; the second experiment examined how the parameters can contribute to express emotions. From these experiments, it is concluded that users without musical training perform differently from musicians on some of the parameters. There is also a clear association between the parameters and the expressed basic emotions. The paper is concluded with observations on how parameterisation might be used in interactive applications.

Keywords: Human factors, interactive music, musical expression, musical parameters.

1. INTRODUCTION

In the everyday life of today's Western society, music and sound is ubiquitous [1][2]. Not only is it accessible like never before in history, but it is also taking on many new functions – being important components of user interfaces in different types of information systems such as computer games, entertainment systems, applications using auditory feedback etc. In this new "age of media", it has been said that the book is being replaced by the screen as the dominant medium for communication [3]. In the new media today we are making sense, or trying to make sense, not only of the written text but out of an intricate assortment and combination of different media such as image, written and spoken text, video, animations, sound and music. The aurally based media – encompassing everything from simple warning sounds to advanced musical compositions – are thus taking on new important roles concerning many aspects of our lives. Therefore, the study of sonic and musical structure related to its different functions, dimensions and potentialities becomes increasingly important. It is vital to reach a deeper understanding of how sound and music affect us all as ingredients of user interfaces and interactive systems – and to find new and better ways to employ sound and music as active and effective means of expression and communication in the new media.

One way to facilitate the usage of music in different applications is to decompose it into its constituent parts, here referred to as *parameterisation* of music. Music represented by its parameters is a concept proposed as suited to address the emerging challenges of the new media.

This paper seeks to address issues connected with user interfaces, human factors and interactive systems in the domain of music for interactive applications. Initially, some drawbacks of traditional sound and music implementations are discussed followed by a brief overview on the principles and advantages of parameterisation of music. The main part of the paper focuses on two experiments executed by means of the REMUPP software, designed to explore how music in parameterised form can be utilised by investigating the properties of a number of selected musical parameters. The aim of the experiments was to investigate how different parameters are perceived by listeners. The first experiment investigated the parameters' capability to change the music; the second experiment examined how the parameters can contribute to express emotions [4].

2. TRADITIONAL AUDIO

The advent of the recording technology, a little more than 100 years ago, for the first time in history made it possible to capture a musical performance and repeat it exactly – to de-contextualize and re-contextualize the musical sound. At the same time it made the fleeting musical sound available for analysis in ways similar to how a written text or a picture can be examined. However, a conventional audio recording is a relatively static and inflexible medium. As listeners we can at the most influence the playing order of songs on a CD or MP3-player, we can adjust the overall volume and maybe the equalization of treble and bass at playback.

As more media today are geared towards interactivity and based on nonlinear conditions for communication – e.g. the possibility for the user to influence the chain of events in a game by multiple choices – the static nature of the traditional audio recording, that we up until now have learned to take for granted, is gradually challenged. It becomes obvious in many interactive systems (such as computer games), where the music is produced as a complete unit and consequently pre-recorded and stored in the form of fixed audio files. Changes in the music caused by the actions of the user are then realised by simply switching between the different pre-recorded audio files, either by means of a cross-fade or a cut. There is usually a limit to how often such transitions can be performed since too frequent switches will affect the overall sense of continuity. Between the transitions the music is performed in a predetermined manner, often looped, not adapting to the overall narrative or (inter)actions. Such an audio handling strategy may soon be perceived as rigid, monotonous and less interest-evoking, which in turn might affect the perceived overall performance of the particular application. Consequently, the need for a method that enables the musical content to dynamically adapt to the user's interactions is apparent.

3. PARAMETERISED MUSIC

One solution to the challenge of achieving a higher degree of adaptability in music is to facilitate user influence of the music at a finer level of detail [5]. This could be done by representing the music in component or parameterised form, where the parameters are accessible for user control via the application. The concept of *musical parameters* is here defined as structural elements such as tonality, mode (e.g. major or minor mode), intervals, harmonic complexity (consonance – dissonance), rhythmic complexity, register (low or high pitch level) etc. – or performance-related elements such as tempo, timing, phrasing, articulation etc. [7][7]

By manipulating musical parameters in real-time, the musical expression will, directly or indirectly, be affected by the listener/user in ways that is traditionally thought of as being the domain of the composer or performer. The conventional chain of the musical communication process (as seen in Western traditional music) is then challenged. Rather than the traditional one-way communication chain of '*Creator – Performer – Receiver'* we get a situation where the distinction between the roles gets more ambiguous and new relations emerge between the actors/agents involved. This can be thought of as making the music process participatory and inclusive rather than specialized and exclusive (Figure 1).

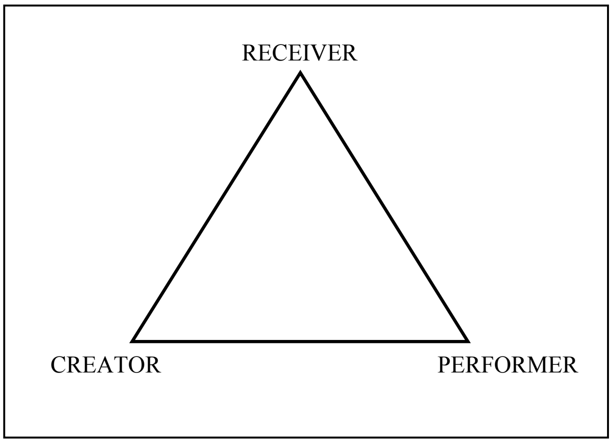

Figure 1: Relational view of participants in act of music.

Altering musical expression by manipulating musical parameters, directly accesses communicational and expressional properties of the music on a level that goes beyond the genre concept. Alteration of the musical performance can be accomplished without disturbing the musical flow and continuity, at the same time as it provides variation and dynamic expressive changes. Regardless of style, the same set of parameters are available, only their settings will be changed – e.g. the parameter *tempo* is a component of any kind of music and by using it to alter the speed of a musical performance it will at the same time alter some aspect(s) of the musical expression.

The representation of music in parameterised form raises a number of issues that has to be addressed to better understand how this kind of approach best can be employed in different applications. A few of these issues that are examined in the studies described in this paper are: 1. When comparing different parameters, which ones are perceived as being more important than others in contributing to musical expression? 2. Which relations can be found between specific musical parameters and the users' emotional experience? 3. Are the properties of musical parameters perceived differently by musically trained people compared to people without any musical training? In addition, the presented studies provided an opportunity to explore the validity and suitability of the REMUPP interface as a means to investigate the properties of musical parameters.

4. REMUPP

In the experiments presented in this paper the software tool REMUPP (Relations between Musical Parameters and Perceived Properties) is being used [8]. REMUPP is an analysis interface designed for non-verbal and interactive testing of various musical functions, for use within several different disciplines of music research. It is developed by the Interactive Institute's studio Sonic in Piteå, Sweden and allows for investigating structural and performance related musical parameters in a musical and situational context. By manipulation of controls presented graphically on a computer screen, the expression of an ongoing musical performance can be changed by adjusting selected musical parameters. The musical control is put into the hands of the test subject, introducing an element of interactivity and creativity into the test situation. The basic musical material, as well as the types and number of musical parameters included with REMUPP, can be varied and tailored by the researcher according to the needs and purpose of the study at hand. The music can also be combined with other media elements such as text or graphics – making it possible to examine interaction mechanisms of music combined with other media. Since the test situation can be set up to resemble playing a computer game, REMUPP provides a useful environment for research related to various forms of new media. Information acquired with REMUPP can be output as numerical data for statistical analysis, but the interface is also suited for use with more qualitatively oriented methods or a combination of different methods.

5. MUSICAL PARAMETERS USED

Based on previous research results, especially in the field of music psychology, the following musical parameters were chosen as suitable for the studies presented.

5.1 Mode

In studies involving the mode parameter, attention is usually directed towards the difference between the major and minor modes. These two modes are in the western culture strongly associated with the emotions of happiness and sadness, respectively. Besides these conventional associations, the major and minor modes are often associated with several other related expressions. The major mode is coupled with expressions of grace, serenity and solemnity, while the minor mode is perceived as expressing dreamy or dignified qualities or tension, disgust and anger [6].

5.2 Instrumentation

The instrumentation parameter involves a complex set of sub-parameters and interrelated dimensions that will all affect the musical experience in different ways. First, there is the aspect of the actual timbre of the individual instrument sound, here defined as differences in overtone spectra ('spectral energy distribution'), including the transient character of the attack and rumble and noise in the sound. Another important factor is that a certain instrument, or group of instruments, is often associated with a specific style, culture or time period – some instruments more so than others. The musical experience evoked by an instrument's sound might be determined as much by taste-related genre associations (i.e. likes or dislikes for a certain genre) as by the perception of the instrument's acoustic properties.

In the present experiments, we wanted to include instrumentation as a parameter emphasizing the timbre factor. The aim was to accomplish this by making the instruments' overall frequency spectra change from 'dull' (few overtones) gradually into 'bright' (rich in overtones) between the three choices of instrument sets given. At the same time we strove to keep the types of instruments as consistent as possible in the three different instrumentations to choose from within each piece of music.

In previous studies it has been shown that sounds with a rich harmonic spectrum may suggest potency, anger, disgust, fear, activity or surprise. Sounds with few, low or suppressed harmonics may be associated with pleasantness or happiness as well as with tenderness, sadness or boredom [6].

5.3 Tempo

In several studies, tempo is often considered to be one of the most important factors for various kinds of musical expression. Fast tempo is frequently associated with emotions such as happiness/joy, activity/excitement, potency, surprise, anger or fear. Slow tempo may be associated with expressions such as sadness, calmness/serenity, dignity/solemnity, tenderness, boredom and disgust [6].

5.4 Accent Evenness

Musical accents can be thought of as musical events, most often notes, which attract the listener's attention. Accents may be the result of various factors such as dynamics, timing or articulation, and can be of *immanent* nature (being a result of e.g. music's metrical or melodic structure) or *performed* (produced by the performer). The parameter *accent evenness* used here, is an example of microstructure dynamics as a result of performance. Previous research has showed that rapid changes in loudness variation often suggest expressions like playfulness, amusement or fear. Few or no changes suggest sadness, peacefulness, dignity or seriousness [6].

5.5 Articulation

The parameter articulation is usually defined as the performance of staccato or legato and is in this study controlled by regulating the overall note-length of the music played. Staccato is often associated with expressions such as gaiety, energy, activity, fear and anger – and legato with sadness, tenderness, solemnity and softness [6].

5.6 Volume

The volume parameter is in these tests defined as the overall sound level (loudness, master volume). Loud music is often associated with expressions of joy, intensity, power, tension or anger – and soft music with sadness, softness, tenderness, solemnity or fear [6].

5.7 Register

The register (pitch level) parameter is in these studies being used with a focus on the timbral qualities of the general pitch level rather than the key or tonality of the music. High pitch is often associated with expressions such as happiness, grace, serenity, dreaminess, excitement, surprise, potency, anger, fear and activity. Low pitch might suggest sadness, dignity, solemnity, boredom or pleasantness [6].

6. FIRST EXPERIMENT – METHOD

The objectives of the first experiment were 1) to find the interrelations of a selected number of musical parameters in terms of their perceived capability to change the music excerpts controlled by these parameters; 2) to investigate whether these interrelations were differently perceived due to differences in the musical background of subjects and differences in musical context.

The fundamentals of the method were to let a group of subjects indicate which of the musical parameters, when presented in pairs, that was perceived as having the greatest influence on the reproduced music.

6.1 Parameters

The following seven parameters were included in the experiment: *mode* (major – minor), *instrumentation*, *tempo*, *accent evenness*, *articulation* (legato – staccato), *volume* and *register* (pitch).

6.2 Subjects

In total, 38 subjects participated in the experiment. The subjects were recruited from the two categories *Musician* (n=20) and *Non-musician* (n=18). Men and women were equally represented in each category.

6.3 Stimuli

Two different music examples were composed for the experiment. The aim was to provide authentic musical contexts that would respond in a musically satisfying manner to the manipulation of the parameters presented. The two examples were created with the purpose of having each one – in their original unaltered form (with no parameters being manipulated) – communicate a different and distinct emotional expression: "happiness" and "sadness" respectively. The music was composed with consideration to factors – such as tempo, articulation, harmony, mode, intervals, pitch level, rhythm, timbre and form – shown by previous research to be important elements in expressing these emotions.

6.4 Listening Experiment

Each subject completed a session comprising 47 trials in total. Prior to a session, four trials for training were completed. In each trial, a piece of music was reproduced to the subject via loudspeakers or headphones. On the computer screen, controls for two of the seven parameters were presented together with two associated buttons marked A and B. The selection of the two parameter controls out of the seven available was made randomly for each trial until all combinations were utilised. The subject was instructed: "By these controls, the music you are hearing can be altered in different ways. Decide which of these two controls that alters the music mostly. Answer by clicking the button (A or B) that corresponds to the chosen control." When the subject had made the choice by clicking button A or B, a new trial followed. After the training session, the actual test commenced, where the trials were repeated randomly for all combinations of music examples and pairs of parameter controls, thus yielding 42 trials. In addition to that, the first five trials in the test session were repeated after the completion of the 42 trials, leading to a total of 42+5 = 47 trials. The reason for the five repetitions was to acquire a coarse indication of the consistency in performance of each subject. Data from the repetition sequence was only used for this purpose and was not included in any of the other analyses.

The outcome of a trial was information about which parameter was chosen expressed as the parameter number. For each trial, the parameter pair compared and the parameter chosen was recorded together with the duration of the trial. For every test session and musical parameter, the number of times that a specific parameter was chosen as a function of the Music Exampl*e* was recorded.

7. FIRST EXPERIMENT – RESULTS

The initial analysis of the experimental data aimed to examine whether the subjects as a group showed any common trends in their judgements on the influence of the musical parameters. The analysis of the whole data set across all subjects showed a significant difference (a Kruskal-Wallis test yielded $p<0.0001$) between the musical parameters in terms of how many times they were chosen. When each subject category was examined, there were significant differences ($p<0.0001$) between the musical parameters for both Musicians as well as for Non-musicians. There were no differences attributable to whether the subjects were men or women. The level of significance in the following statistical tests $p=0.01$.

7.1 Differences between Musicians and Non-musicians

The following significant differences between the medians were observed: The Mode parameter was chosen more frequently by the Musician category, whereas the Non-musician category chose Instrumentation and Accent evenness more frequently.

The difference between the subject categories regarding which parameters were judged more influential indicated that two hierarchies of the parameters existed, depending on the subjects' musical training. These hierarchies cannot be fully established statistically, as the median of some parameters did not differentiate significantly from the medians of others. A Mann-Whitney test of the medians of all pairs of parameters within each subject category yielded three groups of parameters in both categories. In the Non-musician category, two of these groups overlap. The groups and the suggested order of parameters are shown in Table 1.

Table 1. Hierarchy of investigated parameters within each subject category based on median values.

Rank	**Musicians**				**Non-Musicians**			
	Groups			**Parameter**	**Groups**			**Parameter**
	1	**2**	**3**		**1**	**2**	**3**	
1	X			Mode	X			Instrumentation
2	X			Register	X	X		Articulation
3	X			Articulation	X	X		Register
4		X		Instrumentation		X		Tempo
5		X		Tempo		X		Accent evenness
6			X	Accent evenness		X		Mode
7			X	Volume			X	Volume

7.2 Differences Due to Musical Context

In order to investigate the influence on the parameters by the musical context, differences attributable to the factor *Music Example* were examined for every parameter across all subjects as well as within each of the subject categories.

The analysis showed that the parameters Instrumentation and Tempo were judged to be more influential on the music example "Happiness" across all subjects.

7.3 Trial Duration

The duration of each trial is of interest, as it may serve as an indicator of the perceived difficulty of the trial. In the analysis, the parameter Volume occurred in the pairs with the shortest durations, which indicated that Volume was evaluated most easily. The longest durations were found for the parameter pair Mode – Register and the pairs that comprised the Accent evenness parameter, which seemed to pose more difficulties to the subjects.

7.4 Conclusion of the Experiment

The REMUPP tool used, in combination with the experimental design, was able to produce statistically significant differences between the parameters. Considering the results of experiment, it can be concluded that musical parameters are perceived differently depending on the musical background of the subject, as well as the musical context, i. e. the musical 'style'.

8. SECOND EXPERIMENT – METHOD

The objective of the second experiment was to explore a selected number of musical parameters in terms of their perceived capability to contribute to expressing the emotions of 'happiness' and 'sadness', here included in the variable Basic Emotion, BasEmo.

In brief, the experiment comprised a group of subjects who was instructed to adjust the parameter controls to make the music express one of the specified emotions. These parameter settings were recorded.

8.1 Parameters

The following six parameters were included in the experiment: *mode* (major – minor), *instrumentation*, *tempo*, *articulation* (legato – staccato), *volume* and *register* (pitch).

8.2 Subjects

In total, 31 subjects completed a session. The subjects were both men and women recruited from the two categories *Musician* (n=15) and *Non-musician* (n=16). The subjects in the *Musician* category were students enrolled at the School of Music at Piteå, whereas the *Non-musician* category had no formal musical training.

8.3 Stimuli

The same stimuli as in the first experiment were used (see section 0).

8.4 Listening Experiment

The listening experiment comprised two sessions: training and the actual test. The purpose of the training session was to make the subject familiar with the test interface and to give the subject an initial notion of how the music in the experiment was influenced by manipulation of the parameters. In the training session, two trials randomly selected from the sequence in the upcoming test were presented to the subject. After the training session, the actual test comprising 84 trials commenced.

In each trial, a piece of music was reproduced to the subject via loudspeakers or headphones. On the computer screen, controls (sliders or buttons) for the selected parameter(s) were presented together with a representation of an emotion in the form of a text and an image of a face. The representation was either the text "happiness" ("glädje" is Swedish) and a happy face, or the text "sadness" ("sorg" in Swedish) and a sad face. There were two types of trials depending on the number of parameter controls presented to the subject; For Trial Type 1, only one parameter control was displayed, and for Trial Type 2, a pair of the parameters was shown. In a session, all combinations of Trial Type 1 (the six single parameters) and the experimental factors (Basic Emotion and Music Example) were presented to the subject before Trial Type 2 (the 15 possible pairs of the six parameters) were combined with these factors. The presentation order within each Trial Type was randomised. The subject was instructed: "Place the slider or press the button so that the music as much as possible expresses Sadness". When the subject was satisfied with the setting of the parameter control(s) and indicated this by clicking an "OK" button, a new trial followed.

For each trial, the current experimental factors, the identity of the single parameter or the parameter pair and the parameter setting(s) generated by the subject were recorded together with the duration of the trial.

In all cases, the subject's identity, category and sex were also recorded together with the data above.

8.5 Initial parameter settings

Only the parameters displayed to the subject had an effect on the music reproduced. The currently non-displayed parameters remained in their original position as created by the composer, i.e. the variables outside the subject's control were held constant and equal for all trials. To decrease the risk of systematic errors, the start value of the parameter(s) displayed to the subject was randomly set within the range specified for every trial.

9. SECOND EXPERIMENT – RESULTS

The data was subjected to analyses of significant differences attributable to the experimental factors. For analysis of data on ratio scales, Analysis of Variance was initially employed, whereas the Chi^2 test was used for nominal data. The level of significance in the statistical tests p=0.01. In no case, except for Volume, was any significant difference between the male and the female subject group encountered. For some parameters, the data showed both floor and ceiling effects, indicating that subjects frequently used the endpoints of this parameter control. As a consequence of this may be the absence of normally distributed data, parametric analysis methods should be avoided. Therefore, the Mann-Whitney test of medians was used in these cases.

It was observed that there were no significant differences in parameter settings caused by different Trial Type, i.e. whether a parameter was presented singularly or in combination with another parameter. The results are given in summary below.

9.1 Mode

The analysis showed that Basic Emotion caused a significant effect (p<0.001) on the Mode parameter. The major mode was associated with Happiness and the minor mode with Sadness.

9.2 Instrumentation

The analysis showed that Basic Emotion had a significant effect (p<0.001) on the Instrumentation parameter. Subjects avoided the dark instrumentation for BasEmo=Happiness, whereas they preferred it for BasEmo=Sadness.

A difference between musicians and non-musicians was observed for BasEmo=Happiness and MusEx=Happy, where non-musicians preferred the brighter instrumentation in favour of the medium instrumentation, whereas the musicians chose the medium instrumentation.

9.3 Tempo

It showed that the Basic Emotions had a significant effect (p<0.001) on Tempo. Happiness was associated with a faster tempo, whereas a slower tempo was significant for Sadness.

9.4 Articulation

The analysis showed that Basic Emotion caused significant differences (p<0.001) in Articulation. From this, it is concluded that shorter length of the notes is preferred for the expression of Happiness.

A further analysis showed that the difference above mainly was attributable to the data from the Musician category. Non-musicians did not use articulation to express a significant difference between the Basic Emotions.

9.5 Volume

The analysis showed that Basic Emotion had a significant effect (p<0.001) on Volume. A higher sound level was associated with Happiness.

For BasEmo=Sadness, a difference between the subject categories was encountered, where non-musicians prefer a lower sound level (25 % of max volume) compared to musicians (39 % of max volume). This difference was mainly attributable to MusEx=Sad.

Another difference for BasEmo=Sadness was observed between men and women within the Musician category, where the median values of Volume were 27.5 % for women and 52 % for men.

9.6 Register

The analysis showed that BasEmo had a significant effect (p<0.001) on Register. A high register was preferred for BasEmo=Happiness, whereas Sadness induced the choice of a low register.

An analysis of the effect of the subject categories showed that the difference in Register caused by BasEmo was larger for the Musician category.

9.7 Trial Duration

As previously mentioned, the duration of a trial may serve as an indicator of the degree of difficulty associated with the trial. The longer time elapsed, the more difficult the parameters in the current trial were to evaluate.

Parameters that were less time-consuming to evaluate singularly (Trial Type 1) also had this feature when presented together in pairs (Trial Type 2).

Parameters more time-consuming to evaluate were: Register, Articulation and Instrumentation, whereas less time-consuming parameters were: Mode, Volume and Tempo.

9.8 Summary
From the experiment, it was clear that the examined parameters were differently set depending on the expressed emotion.

10. DISCUSSION

The experiments show that certain musical parameters are perceived to have different weights when compared to one another. A clear association between expressed emotions and the selected parameters exist. The results indicate that parameters of music are possible to consider as a means to control the music performance to express emotions.

In the first study, the volume parameter shows less significance compared to some earlier results [6][9]. One reason for this might be that the present study examines the overall (but static) volume level, while the earlier studies examined dynamic volume changes within a performance - which to a greater degree would be experienced as contributing to the musical expression.

Also, in work within the field of audio quality, two identical sounds with differences in sound level only have shown to evoke sensations not immediately associated with the level [10]. This suggests that a subject unaware of an existing difference in sound level perceive this as differences in some other attribute, e.g. clarity or sharpness. However, in the current experiment, volume was considered as the parameter of least importance by the subjects. One explanation might be that sound level, when identified as such, is not considered as a part of the music itself.

On some counts regarding the relative importance of the parameters, differences between musicians and musically untrained people have been observed. This is especially prominent for the Instrumentation parameter, which is perceived as more influential to non-musicians. However, the second experiment indicates, which also is pointed out by Sloboda and Juslin [11], the actual ability to experience emotional meaning in music does not seem to require specific musical training – non-musicians access "musical emotions" just as easily as do musicians. In the field of computer entertainment, this is a significant conclusion to bear in mind when developing multimedia-based environments and interfaces including sound and music as expressive and narrative elements. On the other hand, the cases where a difference between musicians and non-musicians have been observed are important to consider when creating music aimed at a general population. In such cases, artistic and narrative intentions realised as changes in certain nuances of the music's structure may be differently perceived by non-musicians compared to musicians.

The Musician category assigned higher significance to the parameters of *mode*, *articulation* and *register*, in expressing the given emotions than did the Non-musician category. One explanation for this might be that musicians, due to their training, are able to identify these parameters also on a cognitive level and thus are more prone to apply musical conventions in their choices. For example, the idea of the major mode signifying happiness and the minor mode signifying sadness is a well-known convention in the western music tradition – which a trained musician would be more likely to recognize and acknowledge than a non-musician. Articulation, being a distinctly performance-related parameter, might offer a stimulus for an experienced musician to relate to and identify with in a stronger manner than a non-musician might.

One parameter that was perceived as being of more expressive significance to the Non-musician category than to the Musician category is *instrumentation*. In the present test, this parameter was designed to primarily represent timbre-related properties of the musical sound. The timbre parameter has in previous research not been perceived as requiring different properties when expressing happiness versus sadness. "Few harmonics" has been perceived as contributing to expressing both these emotions, while "many harmonics" has been attributed to expressing emotions like potency, anger, disgust or fear [6]. In the present study though, both Musicians and Non-musicians preferred a brighter timbre for happiness, relative to a darker timbre for sadness – even if the Non-musician category emphasized the brighter properties even more for the emotion of happiness than did the Musician category. These results then seem to contradict the results from previous research. However, the detailed review of previous research made by Gabrielsson and Lindström indicates that timbre is not a widely researched parameter - in fact they refer to only one study on timbre that includes both the emotions of 'sadness' and 'happiness'. More research is called for in this area. The difference between the Musician and Non-musician categories of the present study, might be explained by a greater ability of a trained musician to single out structural musical elements (as indicated by the results on the mode, articulation and register parameters) – and thus listen "past" the timbral surface of the musical sound. A non-musician might be expected to react more to the musical sound as a whole, thus assigning greater significance to timbre as being a parameter which envelopes all other parameter properties.

It seems that careful consideration on the topic of timbre in designing multimedia interfaces for computer entertainment – especially when intended for general audiences – holds great potential. It is not possible to imagine music without timbre or instrumentation in a broader sense, including any electronically or acoustically produced sounds. In this respect, instrumentation can be said to be an even more fundamental ingredient of music than the traditional trinity of melody, harmony and rhythm.

The musical context, i.e. the two different music examples provided in the second test, did significantly influence the perceived expression of parameters – especially in the case of mode and instrumentation. This influence can most likely be attributed to the differing conditions for interaction between parameters that each musical example provides. This is consistent with previous research - e.g. loud and fast music might be perceived as 'happy' even if in minor mode [6]. So far, not much research has been done on parameter interaction. We believe however, that this is an important area to explore – and that the REMUPP interface provides an interesting tool for future research of interaction mechanisms between musical parameters as well as between music and other forms of media.

The results from these experiments utilising REMUPP generally support the results from earlier studies [7]. This indicates the REMUPP interface to be a valid tool for exploring the relationship between musical parameters as well as between parameters and emotions.

Music has a strong history as a powerful communicator with innumerable and unique functions in our lives. With the emerging new conditions and possibilities offered by current and future user interfaces in interactive systems, music is posed to take on new functions and challenges. The representation and real time manipulation of music in parameterised form – with its emphasis on providing adaptability, variety and expressional control along with a strong sense of continuity – seems to be a concept with great capabilities and potential for use and integration with the new media.

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