SIEMPRE

Social Interaction and Entrainment using Music PeRformancE

SIEMPRE

Second series of experiments

Version	*Edited by*	*Changes*
1.0	UNIGE	First draft and contribution (quartet, orchestra)
1.1	UPF	Added UPF contribution (quartet)
1.2	QUB	Added QUB contribution (audience)
1.3	IIT	Added IIT contribution (orchestra)
1.4	UNIGE-CH	Added UNIGE-CH contribution (audience, quartet, audience eval.)
1.5	UNIGE	Revision (orchestra, quartet)
1.6	UNIGE-CH	Added studies 1.6, 1.7, 1.11 and 1.12
1.7	UNIGE	Final Revision

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INTRODUCTION

This deliverable describes the second series of experiments performed in the second year of the SIEMPRE Project.
Each experiment or group of experiments are listed and described according to the template table produced at the SIEMPRE Geneva Workshop, as described in deliverable D1.1 "Research Requirements".
The results of this second series of experiments will be described in D4.3 "Results from the 2nd series of experiments, final assessment and evaluation".

Neurophysiological experiments will be described in D4.2 ("Neurophysiological experiments in controlled environment for evaluation and theoretical assessment").

The SIEMPRE Project was recently extended by the INCO Project "SIEMPRE INCO Extension", started in March 2012.
SIEMPRE INCO Extension focuses on non-verbal remote social interaction, the INCO project kick-off workshop was held at Virginia Tech (April 2012).
The research scenario proposed by the SIEMPRE-INCO Extension project addresses empathic processes between performers and listeners in remote locations. It aims at understanding how emotional contagion and co-creation can and do occur when the individuals or crowds that are involved do not share the same physical environment.
Instances of the research challenges explored in the SIEMPRE-INCO extension scenario include:

- how emotional contagion and co-creation can and do occur when the individuals or crowds that are involved do not share the same physical environment?
- how autonomic physiological signal used to assess emotional contagion can be efficiently recorded in real-time in mobile environment?

The SIEMPRE-INCO experiments are planned in the third year, and will be described in D2.3 ("SIEMPRE-INCO extension experiments").

Scientific papers - some already published, others ready for submission or in preparation - provide further details.

Scientific papers, data of multimodal recordings from experiments, and results in general, once consolidated, are uploaded on the new SIEMPRE web site (www.siempre.infomus.org), and a subset is available on the online repository, currently available in the private part of the web site.

1. ANALYSIS AND FINE-TUNING FEATURES FROM AUDIO AND INSTRUMENTAL GESTURES

1.1 Analysis of intonation adjustments among violinists

Title	**String quartet interdependence - <u>Intonation</u>**
Question of interest	1. How to combine low-level audio and instrumental gesture features in order to extract meaningful information about the intonation of a string quartet 2. Which mathematical methods of quantifying interdependence can be applied to the above signals in order to reveal interpersonal influences in a string quartet ensemble 3. Which computational methods of analysing the musical score are capable of predicting interdependence from the score structure
Leaders	UPF
Other SIEMPRE groups involved	UNIGE, UNIGE-CH
Referent scenario	Scenario1: String quartet
Research objectives	1. To obtain a 'ground truth' dataset of recorded musical exercises that demonstrate clear cases of musical interdependence in a string quartet 2. To obtain an 'evaluation' dataset of musical pieces on which the accuracy of our methods can be tested
Theoretical hypotheses	**In a string ensemble, good intonation is achieved through adjusting one's pitch to that of another musician. Studying these adjustments can reveal the interdependence among the members of the quartet.**
Operational hypotheses	1. A clear difference between musicians performing solo and musicians performing in an ensemble can be seen by studying the musicians' intonation adjustments. 2. Through an efficient analysis, this difference can be attributed to (and partially predicted from) the structure of the score.
Relationship with the objectives of the project	Studying **interpersonal synchronization** in a musical ensemble and **musical leadership**.
Time schedule	Second half of 2012
Methods	
Participants	Four advanced-level students from the ESMUC (Escola de Musica Superior de Catalunya), Barcelona.
Materials	Two exercises from Mogens Heimann's 'Exercises for the string quartet': • I1, Violin 1 Solo • I1, Violin 2 Solo • I1, Viola Solo • I1, Cello Solo

	• I1, Ensemble rehearsal • I1, Ensemble final • I2, Violin 1 Solo • I2, Violin 2 Solo • I2, Viola Solo • I2, Cello Solo • I2, Ensemble rehearsal • I2, Ensemble final Two classical music pieces: • BEETHOVEN OP.18 N.4 in Cmin - 4th movement (Allegretto) • HAYDN OP.71 N.3 in Ebmaj - 4th movement (Vivace)
Data format	WAVE
Experimental protocol/procedure	Each recording will be aligned to its corresponding score using the motion capture data. Pitch (fundamental frequency) will be extracted from each recording, and its deviation from the expected pitch of each note will be extracted and compared to that of the other musicians.
Measures	**Audio.** A piezoelectric pickup will be attached to each musician's instrument in order to obtain individual audio. A large diaphragm cardioid microphone will be capturing the overall ensemble sound. **Video.** The quartet will be captured with a video camera for reference and to aid in post-processing the captured data. **Motion capture.** Wired electromagnetic field sensors will be attached to each instrument and bow, in order to extract low-level instrumental gesture features (such as *bow force, bow transversal velocity, bow-bridge distance* et cetera.) **Questionnaires.** A questionnaire will be filled out by every musician after each recording, regarding: • The difficulty of the exercise as a personal task • The difficulty of the exercise as an ensemble task • The degree of success with which the musician performed his personal task • The degree of success with which the ensemble performed the task • The existence of a leader for the particular exercise
Results	
Descriptive results	To be developed.
Inference statistics	linear and rank correlation, mutual information, Granger causality, nonlinear coupling.
Additional results	Indications about musical leadership can be extracted through this procedure.
Discussion	To be developed.

1.2 Analysis of Unity of execution in the string quartet

Title	**String quartet interdependence – Unity of execution**
Question of interest	1. How to combine low-level audio and instrumental gesture features in order to quantify the unity of execution in a string quartet 2. Which mathematical methods of quantifying interdependence can be applied to the above signals in order to reveal interpersonal influences in a string quartet ensemble 3. Which computational methods of analysing the musical score are capable of predicting interdependence from the score structure
Leaders	UPF
Other SIEMPRE groups involved	UNIGE, UNIGE-CH
Referent scenario	Scenario 1: String quartet
Research objectives	See '**Intonation**'.
Theoretical hypotheses	**In a string ensemble, unity of execution is achieved through temporal synchronization of note onsets and synchronized fluctuations of the intensity of musical dynamics (piano, forte, etc). Studying the two phenomena can provide information about ensemble interdependence and musical leadership.**
Operational hypotheses	1. Through interpersonal synchronization, a musical ensemble can achieve the goal of 'sounding as one instrument' – which is otherwise impossible in a solo performance setting. 2. Through an efficient analysis, -this effect can be attributed to (and partially predicted from) the structure of the score
Relationship with the objectives of the project	Studying **interpersonal synchronization** in a musical ensemble and **musical leadership**.
Time schedule	Second half of 2012
Methods	
Participants	Four advanced-level students from the ESMUC (Escola de Musica Superior de Catalunya), Barcelona.
Materials	Three exercises from Mogens Heimann's 'Exercises for the string quartet': • UOE1, Violin 1 Solo • UOE1, Violin 2 Solo • UOE1, Viola Solo • UOE1, Cello Solo • UOE1, Ensemble rehearsal • UOE1, Ensemble final • UOE2, Violin 1 Solo • UOE2, Violin 2 Solo • UOE2, Viola Solo

	• UOE2, Cello Solo • UOE2, Ensemble rehearsal • UOE2, Ensemble final • UOE3, Violin 1 Solo • UOE3, Violin 2 Solo • UOE3, Viola Solo • UOE3, Cello Solo • UOE3, Ensemble rehearsal • UOE3, Ensemble final Two classical music pieces: • BEETHOVEN OP.18 N.4 in Cmin - 4th movement (Allegretto) • BEETHOVEN OP.18 N.4 in Cmin – 1st movement (Allegro ma non tanto)
Data format	WAVE
Experimental protocol/procedure	Each recording will be aligned to its corresponding score using the motion capture data, in order to obtain the precise moments in which each musician's note onsets and offsets occur. In parallel, an estimation of dynamics intensity will be obtained by combining bow velocity, bow force, and audio loudness. Mathematical methods for quantifying interdependence will be applied to the above data in order to quantify synchronization and detect leadership.
Measures	See '**Intonation**'.
Results	
Descriptive results	To be developed.
Inference statistics	linear and rank correlation, mutual information, Granger causality, nonlinear coupling, phase and period correction, point process synchronization
Additional results	To be developed.
Discussion	To be developed.

1.3 Analysis of dynamics adjustments among violinists

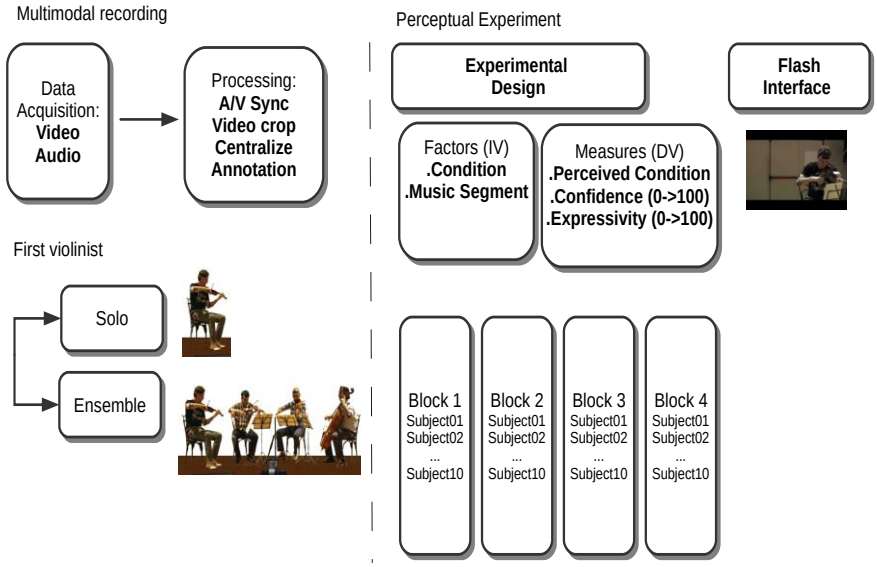
Title	**String quartet interdependence - Dynamics**
Question of interest	1. How to combine low-level audio and instrumental gesture features in order to extract an estimation of the intensity of musical dynamics in a string quartet 2. Which mathematical methods of quantifying interdependence can be applied to the above signals in order to reveal interpersonal influences in a string quartet ensemble 3. Which computational methods of analysing the musical score are capable of predicting interdependence from the score structure
Leaders	UPF
Other SIEMPRE groups involved	UNIGE, UNIGE-CH
Referent scenario	Scenario 1: String quartet
Research objectives	See '**Intonation**'.
Theoretical hypotheses	**In a string ensemble, the musicians strive for synchronization in the fluctuations of their dynamics' intensity. Moreover, the ensemble collectively shapes the overall dynamics level of the performance.**
Operational hypotheses	1. A clear difference between musicians performing solo and musicians performing in an ensemble can be seen by studying the musicians' fluctuations of their dynamics' intensity. 2. The overall intensity of the ensemble's dynamics is different between the 'solo' and the 'ensemble' case, as a result of interdependence among the musicians during joint performance. 3. Through an efficient analysis, –these differences can be attributed to (and partially predicted from) the structure of the score
Relationship with the objectives of the project	Studying **interpersonal synchronization** in a musical ensemble and **musical leadership**.
Time schedule	Second half of 2012
Methods	
Participants	Four advanced-level students from the ESMUC (Escola de Musica Superior de Catalunya), Barcelona.
Materials	Three exercises from Mogens Heimann's 'Exercises for the string quartet': • D1, Violin 1 Solo • D1, Violin 2 Solo • D1, Viola Solo • D1, Cello Solo • D1, Ensemble rehearsal • D1, Ensemble final

	• D2, Violin 1 Solo • D2, Violin 2 Solo • D2, Viola Solo • D2, Cello Solo • D2, Ensemble rehearsal • D2, Ensemble final • D3, Violin 1 Solo • D3, Violin 2 Solo • D3, Viola Solo • D3, Cello Solo • D3, Ensemble rehearsal • D3, Ensemble final Three classical music pieces: • HAYDN OP.71 N.3 in Ebmaj - 4th movement (Vivace) • BORODIN n.2 in Dmaj - 1st movement (Allegro moderato) • BEETHOVEN OP.18 N.4 in Cmin – 1st movement (Allegro ma non tanto)
Data format	WAVE
Experimental protocol/procedure	Each recording will be aligned to its corresponding score using the motion capture data. An estimation of dynamics intensity will be obtained by combining bow velocity, bow force, and audio loudness. Mathematical methods for quantifying interdependence will be applied to the above data in order to quantify synchronization and detect leadership.
Measures	See '**Intonation**'.
Results	
Descriptive results	To be developed.
Inference statistics	linear and rank correlation, mutual information, Granger causality, nonlinear coupling.
Additional results	To be developed.
Discussion	To be developed.

2. STRING QUARTET: STUDYING THE DIFFERENCES BETWEEN SOLO AND ENSEMBLE PERFORMANCE

Title	Solo Vs Ensemble performance
Question of interest	Are there specific non-verbal behavioral variables that may be automatically measured and that enable to distinguish between performing an action alone or jointly in a group?
Leaders	UNIGE

Other SIEMPRE groups involved	QUB, UNIGE-CH
Referent scenario	Scenario 1: String Quartet
Research objectives	1. Develop techniques for automated analysis of multimodal recordings of a musician's performance in two conditions: solo Vs ensemble performance. 2. Design a perceptual experiment to evaluate the difference between Solo Vs Ensemble performance conditions, using audiovisual recordings. 3. Identify a set of non-verbal cues that characterize the social behaviour of the musician: communicative gestures to regulate the ensemble performance, and continuous movement features enabling to distinguish between the two modalities. 3. Correlate the results of the perceptual experiments (participants' ratings) with the results from the automated behavioral analysis of musicians.
Theoretical hypotheses	Playing jointly with others may affect individual behavior. Joint performance requires strategies to cope with others' intentions and to adapt one's behavior accordingly. The success of the interaction may depend upon one's ability to anticipate and manage others' actions and ensure efficient group coordination. Techniques for automated analysis can be developed and assessed with perceptual ratings: external observers may be able to identify through a set of non-verbal cues the social behavior of the performer.
Operational hypotheses	There are non-verbal visible behavioural cues in music performance that may help an external observer to distinguish between a performance interpreted alone (solo) or within an ensemble. Two types of non-verbal cues can been distinguished: key gestures using upper-body parts (e.g., head gestures) to capture others' attention and to coordinate the ensemble (Davidson et al. 2006); non-verbal behavioral variations, which are continuous perturbation of movement. These behavioral cues may refer to implicit adaptation and co-ordination process of musicians during the performance (Glowinski et al. 2011).
Relationship with the objectives of the project	Investigate social behavior in music performance and identify the set of non-verbal cues explaining the phenomenon.
Time schedule	Multimodal recordings at UNIGE in Spring 2011 (student quartet Music Conservatory, See D2.1); Multimodal Recordings in July and September 2011 with Quartetto di Cremona (UNIGE); data analysis and perceptual experiment (results expected in the second half of 2012 and first half of 2013). Perceptual ratings of the videos of Quartetto di Cremona (Solo Vs Ensemble conditions, blind rating), Spring – Summer 2012; subjects ratings performed at UNIGE-CH and UNIGE. Comparison of subjects ratings with results from automated analysis.
Methods	Automated analysis techniques described in D1.3.
Participants	Data recordings: - String Quartet of Music Conservatory; Quartetto di Cremona.

	Subjects ratings: - Students from UNIGE-CH (spring 2012) - Students from UNIGE (summer-fall 2012)
Materials	Material: -Synchronized Audio/Video/MoCap recordings of the Schubert The Death and The Maiden piece interpreted by the first violinist of the Quartetto di Cremona (see also D2.1 First series of experiment).
Data format	SIEMPRE multimodal data. Excel files and Matlab matrices of subjects ratings.
Experimental protocol/procedure	Subjects ratings: Selection of the stimuli. From all the video recordings and according to the satisfaction, expressivity and cohesion (only for the "ensemble" condition) z-scores from the questionnaire filled by the musician(s), we first proceed to a selection of the sequences, in order to have an equal number of "solo" and "ensemble" excerpts. After this selection, we created 4 lists (with the objective of 10 participants per list). Each of these lists is composed by 12 takes -one take consisting of 5 segments; each list consists of 60 segments (pseudo-randomization). Among the 4 lists, 4 takes (2 "solo" and 2 "ensemble") are always rate through the participants. The first part of the experiment consisted of a musical questionnaire. The second part of the experiment was the evaluation task with 5 questions: -Do you think the violinist was playing alone or with other musicians ?; - What is your degree of confidence in your evaluation alone vs. other musicians? ; - How do you assess the expressiveness of the musical performance? ; - How much the musician one or several emotion(s) during the performance); - How did you enjoy the performance? Rating of the 9 GEMS dimensions expressed by music after each video sequence was done. The third and last part of the subjects ratings consists of the filling of the Interpersonal Reactivity Index (Davidson, 1983) 
Measures	Automated multimodal analysis; Participants' ratings

Results	A journal paper submission on automated analysis; A journal paper submission on participants ratings in preparation.
Descriptive results	
Inference statistics	The analyses are in progress.
Additional results	-
Discussion	To be developed.

3. ORCHESTRA SECTION MOVEMENT ANALYSIS

3.1 Orchestra violin sections and conductor

Title	Orchestra violin sections and conductor
Question of interest	Role of visual communication in shaping network dynamics across musicians and conductors
Leaders	IIT
Other SIEMPRE groups involved	UNIGE
Referent scenario	Scenario 2: Orchestra
Research objectives	The main objective is to study non-verbal communication among experts in sensori-motor synchronization such as orchestra musicians. Measures of synchronization and leadership.
Theoretical hypotheses	Movement kinematics can be used to extract the dynamical pattern of communication among orchestra players and conductors
Operational hypotheses	Acceleration profiles of body parts movements can be used to compute causal influences (Granger analysis), information flow (information transfer) and synchrony among musicians and from conductor to musicians. Electromyography of violinists will be used to establish the amount of co-contraction strategies used by musicians associated to the amount of coordination across them and the conductors. Questionnaires will associate the perceived and objective measures of sensori-motor non-verbal communication among the participants.
Relationship with the objectives of the project	This experiment on the orchestra scenario is central to the objectives of SIEMPRE. This will be the final recording for this scenario.
Time schedule	Multimodal data recordings with orchestra of Music Conservatory of Genoa and 3 different conductors was done in March 2012 at UNIGE premises of Casa Paganini. Data analysis is in progress with different techniques.
Methods	
Participants	3 conductors, 8 violinists and 10 instrumentist
Materials	Music materials: Ouverture of "Signor Bruschino", Rossini Vivaldiana, terzo movimento, Malipiero
Data format	SIEMPRE multimodal platform data
Experimental protocol/procedure	The three conductors and the orchestra executed the two pieces in a standard and two additional experimental conditions. The standard condition consisted in a normal

	orchestra scenario with musicians placed in a conventional spatial position. The two other conditions consisted in playing the pieces with the first violin (first row) section facing the second section (second row) thus avoiding eye contact with the conductor. The second experimental condition consisted in the inclusion of dynamic changes to the pieces (accelerando, diminuendo, etc.). The conductors alone knew what and when the dynamic alteration was going to be applied.
Measures	1) Questionnaires: - BFI questionnaire before the experiment - Post-performance questionnaires to evaluate their ability to play and follow the conductor 2) Kinematic recording: - violinists' bow and head position - conductors's head, left hand and baton 3) Electromyography: - violinists' right biceps and triceps
Results	Successful multimodal recordings of the orchestra of the Music Conservatory of Genoa have been done in March 2012. Significant multimodal data have been identified, segmented, and prepared for data analysis. Data analysis is in progress.
Descriptive results	
Inference statistics	
Additional results	
Discussion	

4. AUDIENCE

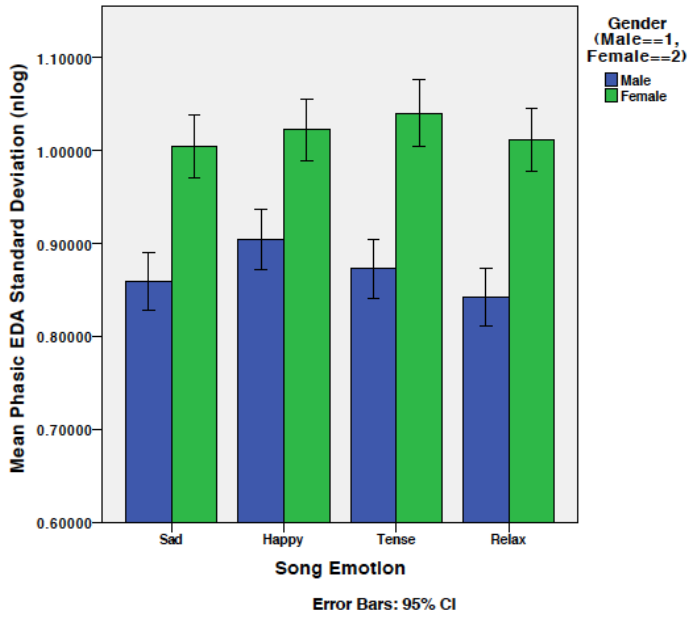
4.1 Autonomic Response to Randomly Chosen Songs

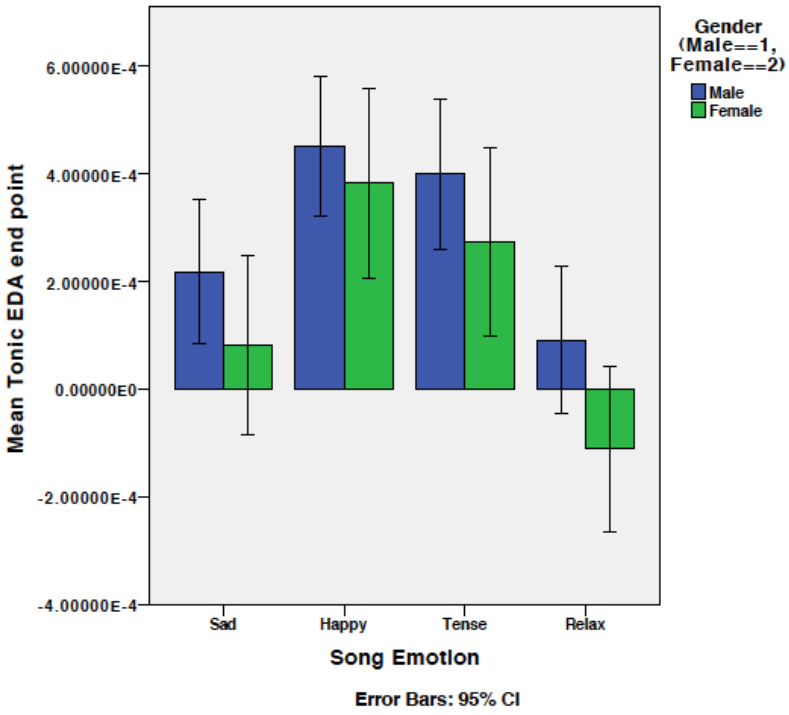
Title	Autonomic Response to Randomly Chosen Songs
Question of interest	What are the relationships between the properties of a song (dynamics, rhythm, emotional intent, etc), the self-reported emotional response, and Electrodermal and Heart Rate response?
Leaders	QUB
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	This study is a large-scale, cross-sectional study that collects data of an individual's response to music excerpts from multiple genres, with the objective to understand their emotional reaction to music.
Theoretical hypotheses	The hypothesis of this study is that, when an individual listens to music, there are quantifiable relationships between: 1) Self-report measures including affect, demographics, familiarity, and aesthetic judgments 2) Physiological measurements of EDA and HR 3) Structural and sonic properties of the music
Operational hypotheses	This study proposes that there are specific ecological measures that can assess an individual's response to listening to music.
Relationship with the objectives of the project	This study directly informs all of the objectives targeted at understanding the cognitive and emotional response to music. Without understanding whether there are specific measures of relationships between and among individual listening experiences, it will be difficult to explore measures of audiences.
Time schedule	First experiment in Dublin June-August 2010, Refinement and testing in Genoa October 2010, revised version presented New York June-July 2011.

	Revised version is running in Bergen since December 2011 and will be installed in Singapore June-August 2012. Analysis started October 2010. First publication May 2012.
Methods	A computer terminal is equipped with a sensor package (Electrodermal Activity + Pulse Oximeter), data capture device (Arduino), mouse and headphones along with custom software developed in Max/MSP. An isolation transformer is used to ensure electrical isolation for participants ensuring their safety. Following completion of a consent form, participants are instructed on the fitting of sensors to the fingers and are asked some demographic questions and general questions regarding their musical experience (all questions are on-screen as part of the experimental software). Participants are played 3 short (approx. 1'30'') randomly selected musical excerpts, during which physiological signals are recorded via on-body sensors, and are then asked to answer several short questions after each excerpt. The songs were chosen randomly from a pool of 53 songs, which were selected to elicit positive emotions (high valence), negative emotions (low valence), high arousal and low arousal. In addition to this, special effort was made in order to include songs from different genres, styles and eras. At the conclusion of the experiment session, participants are shown an image of their physiological signals plotted against the audio waveform for each of the audio excerpts. The experiment takes no longer than 10 minutes to complete. The experiment/workstation is self-contained but there is an assistant/mediator on hand to help with consent forms, sensor fitting and answering any questions as well as basic troubleshooting. Recorded signals are indexed against time for later analysis.
Participants	Currently over 5000 people have participated in the experiment. They represent a broad spectrum of ages and demography.
Materials	- 1 x PC workstation + Screen (minimum 2 available USB ports, excluding Mouse/Keyboard) - Full frequency response headphones with a high degree of acoustic isolation - 1 x MediAid POX-OEM M15HP sensor - 1 x EDA sensor - 1 x circuit box with two Arduinos and USB isolator to capture signals

	- Internet connection
Data format	Ascii data files
Experimental protocol/procedure	See methods
Measures	Overall self-reported measures of Engagement, Likeness, Familiarity, Activation, Valence, Tension, and Chills/Shivers/Thrills/Goosebumps. One implementation of the experiment included the 9 point version of the GEMS scale, with Wonder, Transcendence, Tenderness, Nostalgia, Peacefulness, Energy, Joyful Activation, Tension, and Sadness. Physiological features extracted from Phasic and Tonic Electrodermal Activity (EDAP - EDAT) and Heart Rate Variability (HRV) include: Standard deviation of phasic EDA (*STD_EDAP*), mean of Phasic EDA (*mean_EDAP*), Tonic EDA final value divided by duration (*End_EDAT*), Tonic EDA trapezoidal numerical integration divided by duration (*Area_EDAT*), standard deviation of tonic EDA (STD_EDAT), difference between tonic EDA vector and linear regression of tonic start and end values (*Lin_EDAT*), EDA raw start value (*Init_EDA*), mean HR (*HR*), mean heart rate variability (*mean_HRV*), HRV end value divided by duration (*End_HRV*), standard deviation of HRV (*STD_HRV*), square root of the mean squared difference of successive pulses (*RMSSD*), HRV low frequency (0.04-0.15Hz) component (*LF_HRV*), HRV high frequency (0.15-0.4Hz) component (*HF_HRV*) and ratio between *HF_HRV* and *LF_HRV* (*HtoL_HRV*). Demographic and Background measures include: Age, Gender, Musical Expertise, Music Styles, Nationality, and Hearing Impairments.
Results	
Descriptive results	Results presented in this section are specific to the Dublin Study. For this implementation, the participant's age ranged between 10 and 80, and the majority (67.3%) were under 30 years old. Gender was divided in 53% female, 47% male. When asked about their nationality, 62% stated to be Irish versus the remaining 38% who declared themselves as nationals from a different country. 61% stated not having a musical background. Regarding the musical genres the participants declared to listen regularly, the results were the following: Rock 23%, Pop 20%, Classical 12%, Dance 12%, World 9%, Hip-Hop 9%, Jazz 8%, Traditional Irish 6%, None 1%.
Inference statistics	*Correlation between physiological features and demographics.* As expected, correlation between age and features extracted from HR showed a negative relationship ($p < 0.01$ level, two-tailed) for several

features (*STD_HRV*, *RMSSD*, *LF_HRV*, *HF_HRV*, *HtoL_HRV*), being the features that specify frequency components the ones with maximum correlation ($r < -0.4$). EDA showed a significant difference between gender for most features (see figures below for 2 examples).





These two figures also show the differences between the four categories of songs selected by the researchers and the means of two EDA features.

Factor analysis of physiological features. Principal Component Analysis (PCA) was performed on a selection of features, excluding features with high degrees of correlation. Principal Component Analysis shows three salient factors after rotation. These indicate a clear

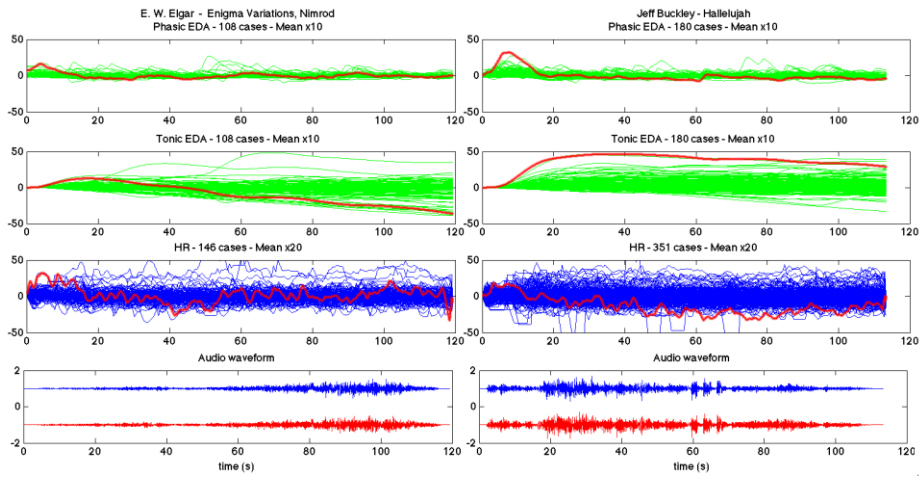
distinction between frequency-related features from HRV (Component 1: *STD_HRV*, *HF_HRV*, *LF_HRV*, *Age* and *RMSSD*), features from EDA (Component 2: *Area_GSRT*, *End_EDAT* and *STD_EDAP*) and secondary features from HRV (Component 3: *mean_HRV* and *End_HRV*).

Correlation between factors and questionnaire. The three salient components from PCA were correlated against a selection of the self-report questionnaire: Song Engagement, Song Positivity, Song Activity, Song Tension, Song Chills/Shivers/Thrills/Goosebumps (CSTG), Song Likeness and Song Familiarity. Results show a relationship between components 1 and 2 with the self-report questionnaire (see Table below).
It is important to point out that the correlation coefficients presented below explain only a small portion of the variation in the questionnaire results. Furthermore, it is interesting that there was no significant correlation between CSTG and the 2nd component, taking into account that 10% of the participants reported to experience CSTG. Nevertheless, it is fascinating to see a relationship between physiological features and self-reports such as song likeness, positivity, activity and tension.

Table. Correlation between components from physiology and questionnaire

Question	Correlation by component (p<.001)		
	1	2	3
Song Engagement	-.081	.075	-
Song Positivity	-	.097	-
Song Activity	-	.110	-
Song Tension	-	.044	-
Song Chills/Shivers/Thrills/Goosebumps	-	-	-
Song Likeness	-.052	.061	-
Song Familiarity	-.060	.083	-

Music Dynamics vs. Physiology. Analysis of temporal changes in correlation with the excerpt's dynamic has been explored. Preliminary results show a relationship between the three physiological vectors; phasic EDA, tonic EDA and HRV, with changes in the music content, such as dynamics and structure. The Figure below shows two examples of pieces that present temporal correlation between physiology and music dynamic (a clear example is shown (b) between the phasic EDA and the audio waveform after the 60 second mark).

	 (a) (b)
Additional results	A more detailed description of this experiment and results will be available in: Jaimovich, J., Ortiz, M., et al., 2012. The Emotion in Motion Experiment: Using an Interactive Installation as a Means for Understanding Emotional Response to Music. In Proceedings of the 2012 Conference on New Interfaces for Musical Expression (NIME 2012), Ann Arbor, Michigan. New Interfaces for Musical Expression. Ann Arbor, Michigan, p. (In Press). Jaimovich, J., Coghlan, N. & Knapp, R.B., 2012. Emotion in Motion: A Study of Music and Affective Response. In Proceedings of the 9th International Symposium on Computer Music Modeling and Retrieval (CMMR) Music and Emotions. Symposium on Computer Music Modeling and Retrieval. London, England, p. (In Press).
Discussion	Due to the public gallery nature of this study, work has mainly been focused in improving the acquisition of signals, and the algorithms that correctly identify and remove noise and artefacts. Any unaccounted variation at this stage can impact the validity of the statistical tests that use physiological measurements. It is important to point out that with the current sensor design, which requires no assistance and can be used by participants briefed with short instructions; we are obtaining approximately 65% valid signals (with a confidence threshold of 90%). This has to be taken into account when calculating group sizes for experiments that require physiological sensing of audiences. The analysis of the physiological measures shows high levels of dispersion between participants for the same feature, which seems to indicate that large sample sizes need to be maintained for future experiments. Nonetheless, the preliminary results show small but significant relationships between physiology and self-report questionnaire. We are yet to further define the precise musical cues and variables that influence changes. Next steps in the analysis will be focusing on additional physiological descriptors, multimodal analysis of the dataset, looking at temporal

	changes (versus the current whole song approach) and measures of correlation and entrainment with musical features.

4.2 Testing audience subjective responses across contrasting live performances

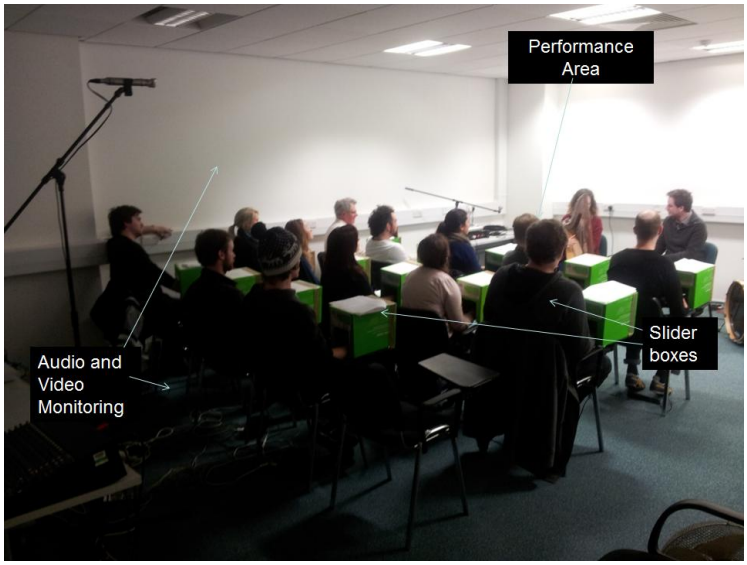
Title	Testing audience subjective responses across contrasting live performances
Question of interest	To investigate different types of subjective response from an audience across contrasting live performances
Leaders	QUB
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	To (i) test whether measures of audience subjective response distinguish between contrasting performances, (ii) whether a continuous subjective response is viable and effective and (iii) whether a shortened version of the Quality of Experience (QoE) questionnaire is an acceptable alternative for the longer version.
Theoretical hypotheses	Engagement, as measured by our subjective measures, will vary across contrasting performances and vary within performances on continuous responses.
Operational hypotheses	There will be significant differences on scores on the QoE questionnaire between different performances. Each factor on the QoE questionnaire will display moderate independence. Positive scores will be correlated with liking and engagement as measured by continuous response. The continuous response measures will show differences between, and within performances. There will be no significant effect of using the continuous response interface on overall audience enjoyment.
Relationship with the objectives of the project	Confirming the validity of these measures will allow effective testing of large audiences in future experiments. This will be used to gauge the audience's participation in a live musical scenario, one of the 3 key areas of study.
Time schedule	Decemeber 2011
Methods	
Participants	An audience of 12-15 participants, taken mostly from a student population
Materials	The shortened QoE questionnaire (12 items) and a continuous response response mechanism both devised at QUB will be used to measures audience engagement. Performers will vary musical genre and composition (traditional Irish duo, solo classical, popular acoustic duo, experimental trio)
Data format	Data from the experiment will be analysed primarily in Matlab and SPSS.
Experimental protocol/procedure	The entire experiment consists of 4 performances, each 10-15 minutes long, lasting an hour in total. In between each performance participants answer the QoE questionnaire. Throughout the performance participants will adjust the

	continuous response mechanism. Two participants will also be wired to sensors measuring GSR and pulse for testing implementation in future experiments. Video data of the experiment will be taken for future use.
Measures	Continuous Qualitative Response: The interface itself is a slider device with a spring mechanism which requires increased force to move to higher values (negatively scaled). The concept it will ask participant's to rate will be engagement. Retrospective Questionnaire: The version employed in this experiment will be a shortened version of that tested earlier, comprising the most promising factors from the pilot study. Physiological Measures: Some participants will be fitted with a number of sensors placed on the fingers which measure their heart rate, heart rate variability and galvanic skin response.
Results	
Descriptive results	Results show that there was a significant effect of performance ranking on most of the QoE factors, showing that it can discriminate between performances of varied enjoyment. Some items displayed full independence from each other however others were closely correlated. Continuous data showed that participants did use the slider to represent their engagement across performances.
Inference statistics	
Additional results	
Discussion	The shortened QoE questionnaire was effective in distinguishing between different performances based on audience engagement but clearly by shortening it there is a trade-off in subtlety, with a lesser range of variance between the factors than in the long item version. The continuous response mechanism was effective and therefore will be tested further in follow up experiments.

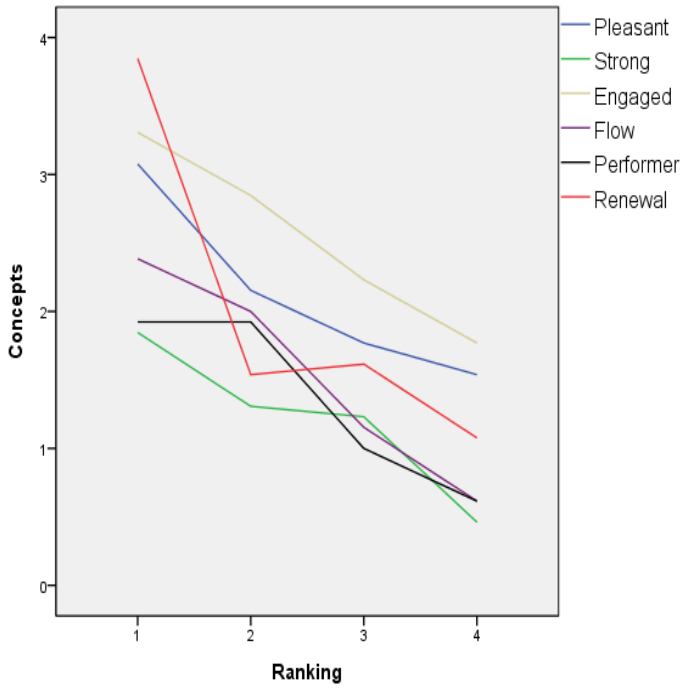
4.3 Multimodal investigation of audience responses to live musical performance

Title	Multimodal investigation of audience responses to live musical performance
Question of interest	Using different techniques to assess the dimensions of audience engagement in live performance and the eMAP features relevant to them.
Leaders	QUB
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	This series of experiments implemented a full multimodal experiment schedule to investigate audience responses to different live music scenarios. The aim was to give us an indication of which measures are most informative and influential in

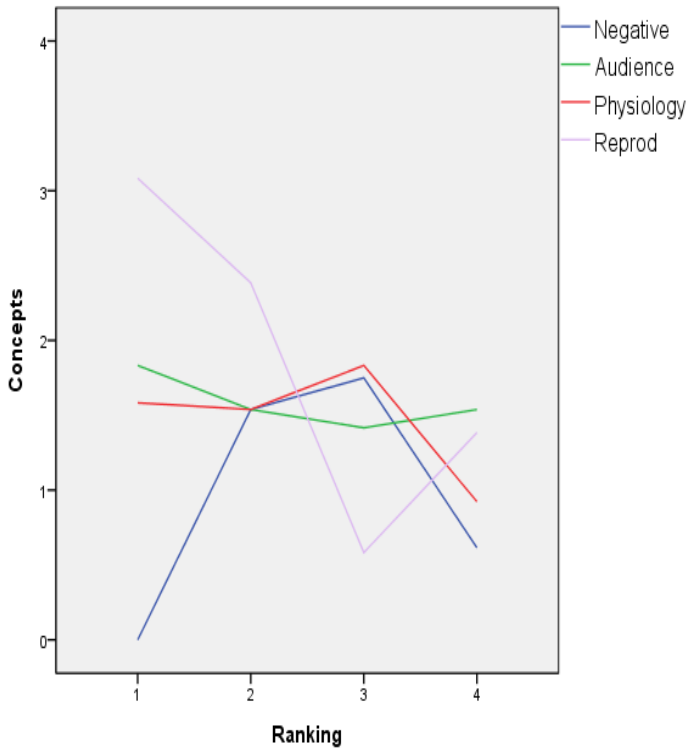
	determining audience enjoyment of live music performance, and if there are are inter-relationships between measures at different levels (psychological, kinetic, physiological, etc.). Because some of the measures are time-varying, relationships may include synchronies between measures and their relationship to the performance. The measures were subjective response (Quality of Experience questionnaire and continuous mechanism), physiology (GSR and pulse), motion capture and post recording video rating.
Theoretical hypotheses	Measures will be able to discriminate between different performances within and between concerts, and synchronies between different measures will be visible at certain points throughout the performances. Hence ideally, measures will be able to discriminate between differing levels of an audience's engagement, and will show congruence whilst doing so.
Operational hypotheses	There will be a significant effect of liking/engagement on all measures in the experiment. There will be correlations and synchronies visible between the continuous measures employed in the experiments (physiology, subjective response, motion capture and post recording video rating)
Relationship with the objectives of the project	The series of experiments aimed to establish the framework for large multimodal experimentation in a live music performance environment, a key aim for SIEMPRE.
Time schedule	Pilot experiments Experiment 1: May 2011 (reported previously) Experiment 2: Dec 2011 Main experiments Experiment 3: Jan 2012 Experiment 4: Mar 2012 (at *Sonorities*) Experiment 5: Mar 2012 (at *Sonorities*) Experiment 6: Mar 2012 (at *Sonorities*)
Methods	
Participants	The pilot studies had small numbers of participants (15-20) 55 participated in the main experiments, 18 with sensors and all with questionnaires. The pilot experiments featured a largely student population; the others were genuine concert-goers with a range of ages and backgrounds.
Materials (music)	The pilot and January experiments presented contrasting musical genres (Irish traditional and experimental electronic music), chosen to ensure that audiences gave contrasting responses. The Sonorities experiments presented three concerts, giving a wide variety of styles within the electro-acoustic genre.
Data format	Data is in a variety of formats. Video: avi Audio: wav Physiological & continuous self report: text files Motion capture: Qualysis QTM files.

	Questionnaire: SPSS
Experimental protocol/procedure	The second pilot experiment followed the same format as the first (reported previously), but adapted the design of the faders) and used the shorter questionnaire derived from analysis of the first pilot. It is shown below.  The first main experiment was entirely experimentally controlled (participants and performers recruited by researchers) and set in a concert hall. Audience members completed the full length QoE questionnaire. 12 of them used faders, and 12 had physiological instrumentation. 30 members of the audience were also fitted with silver balls on hairclips for the motion capture system. Both of these used the design developed in the first pilot study, with an extreme contrast of musical styles designed to ensure contrasting responses. The last 3 concerts were part of the Sonorities contemporary music festival in Belfast. For each of these there was a large audience (50-100), about half of whom completed shortened QoE questionnaires. A subset of 18 participants were fitted with physiological devices (GSR and ECG). Concerts were about an hour in length and of varying format (having 1, 2, 3 or 4 different groups playing). Video data of the concert was taken throughout.
Measures	*Continuous Qualitative Response:* The interface for this is a slider device with a spring mechanism which requires increased force to move to higher values (negatively scaled). The participants were asked to rate their engagement. Following the first pilot experiment, the slider was concealed so that responses were not visible to onlookers. *Retrospective Questionnaire:* We employed two versions of the questionnaire, a long version in the first pilot and the first main

	experiment and a shortened version (based on analysis of data from the longer version) in other concerts. *Physiological Measures:* For the second pilot experiment two participants were fitted with Galvanic Skin Response and ECG sensors to test the correlation between continuous qualitative response and physiological data. For the subsequent three experiments we increased the number of participants with physiological sensors to twelve on the January concert and 18 in the Sonorities concerts. *Motion Capture:* In the January concert participants were fitted with a silver ball on a hairclip to track their head movements via a motion captures system (Qualysis). This was done to assess group synchronization. *Post-Recording Rating:* After the experiment external judges will study the video and audio of the experiment and rate the participants on levels of engagement using the continuous qualitative response mechanism. This remains to be done.
Results	
Descriptive results	The questionnaire data have been analysed and show that a modest number of dimensions capture most of the variability in the data. Logistic regression indicated that over 90% participants can be categorised on the basis of the responses. The motion capture data suggest that there was very little movement during any part of the concert, and we do not expect to find differences in that respect. Analysis of the physiological and slider data is under way. Results from the December experiment illustrate the issues that are revealed by the questionnaires. Most of the factors measured correlate with participants' overall ranking of enjoyment, as shown below.



However, not all of the factors behave in this way. For example, as the graph below shows, there is an inverted U relationship between negative emption and overall enjoyment. When audience members were really negative about a performance, they did not feel negative emotion about it: they lacked emotion of any kind. Analysis of the other measures needs to be guided by this kind of information.



Inference statistics

We show here the contrasts between responses to the two parts of the concerts in December and January respectively. They show that the questionnaire effectively captures the differences in response.

December (shortened questionnaire, experimental setting)

Concept	df	F	sig (p)
Emotion (pleasant)	4,51	4.355	.004*
Emotion (negative)	4,51	1.139	0.35
Strength	4,51	3.554	.013*
Engagement	4,51	3.529	.019*
Attention (audience)	4,51	2.542	0.052
Physiology	4,51	0.444	0.776
Presence	4,51	4.271	.005*
Reproduction	4,51	5.812	.001**
Performer	4,51	3.831	.009*
Renewal	4,51	2.308	.037*

January (full questionnaire, concert setting)

Concept	t	df	Sig.
Emotion	11.18	45	<.001
Social	4.239	46	<.001
Performer	9.086	45	<.001
Attention	5.687	45	<.001
Renewal	5.194	46	<.001
Physiology	-2.096	45	0.042
Presence	3.137	45	0.003
Reproduction	8.026	42	<.001
Aesthetics	6.665	44	<.001

Additional results

To be developed.

Discussion

After problems in the first pilot experiment, the subsequent studies were carried out without complications and all data was recorded successfully. Analysis is ongoing.

4.4 Dynamic judgments during live performance vs. laboratory condition

Title	**Comparison of dynamic judgments during live performance context vs. laboratory condition**
Question of interest	Is there a difference between the dynamic judgments made during a context of live performance vs. in a laboratory condition? Is the emotional attribution to music more intense during a live performance context?
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3, audience evaluation.
Research objectives	Compare the dynamic judgments made during the concert of the Quartetto di Cremona in July 2010 with the dynamic judgments performed during laboratory condition.
Theoretical hypotheses	Both the subjective feeling and the perception/attribution of an emotion to the music can be influenced by numerous parameters. According to Scherer & Zentner (2001), contextual characteristics are among the most important.
Operational hypotheses	The dynamic judgments made during a context of live performance will be more intense than those made during a laboratory condition.
Relationship with the objectives of the project	Investigate the audience reaction in different contexts.
Time schedule	Second half of 2012
Methods	
Participants	37 Students from UNIGE-CH
Materials	Material: -Musical pieces played by Quartetto di Cremona during the concert at Saint-Germain Church in July 2010 (D2.1 First series of experiment), i.e. : - movements from Robert Schumann, String quartet n3, op.41 - movements from Béla Bartók, String quartet n4 in C major, Sz 91
Data format	Excel files
Experimental protocol/procedure	The experimentations took place in a room at University of Geneva and each participant was paid in course credits for their participation. We used our Flash interface (D2.1 First series of experiment) for the dynamic judgments task and the main instruction was: "*Please rate the intensity with which the music expresses*…" followed by the emotional GEMS dimensions of interest.
Measures	Participants' ratings (dynamic judgments).
Results	
Descriptive results	The analyses are in progress.
Inference statistics	The analyses are in progress.
Additional results	-
Discussion	To be developed.

4.5 Dynamic judgments expressive and non expressive musical stimuli

<table>
<tr><td>Title</td><td>Dynamic judgments of expressive and non expressive musical excerpts</td></tr>
<tr><td>Question of interest</td><td>Is there a difference in participants' dynamic judgments when evaluating different types of musical expression?</td></tr>
<tr><td>Leaders</td><td>UNIGE-CH</td></tr>
<tr><td>Other SIEMPRE groups involved</td><td></td></tr>
<tr><td>Referent scenario</td><td>Scenario 3: Audience</td></tr>
<tr><td>Research objectives</td><td>1. Design a perceptual experiment to evaluate the difference between expressive Vs non expressive musical excerpts
2. Correlate the results of the perceptual experiments (participants' dynamic judgments) with the results from the study on the thermographic reactions of a small audience (cf. D2.1 First Series of Experiments).</td></tr>
<tr><td>Theoretical hypotheses</td><td>Strategies used by performers to modulate the musical expressiveness are numerous. Drawing on the proposition of the Lens model (Brunswik, 1955), it is interesting to investigate if the different cues and strategies used by performers help people to attribute more or less musical expression to the music.</td></tr>
<tr><td>Operational hypotheses</td><td>Given the preliminary results for the thermographic study with a small audience (cf. D4.1 Results from the first series of experiments and first evaluation report), the "academic" musical excerpts should be rated as less expressive than the "emphatic" musical excerpts in dynamic judgments during laboratory conditions.</td></tr>
<tr><td>Relationship with the objectives of the project</td><td>Investigate audience perceptions of musical expressiveness in laboratory condition</td></tr>
<tr><td>Time schedule</td><td>Second half of 2012</td></tr>
<tr><td>Methods</td><td></td></tr>
<tr><td>Participants</td><td>-20 Students from UNIGE-CH</td></tr>
<tr><td>Materials</td><td>Material:
-Musical excerpts used in the thermographic study during the workshop with the Quartetto di Cremona (D2.1 First series of experiment) i.e. :
<table>
<tr><th>Order</th><th>Movement</th><th>Musical style</th></tr>
<tr><td>1</td><td>Schumann, IV: Allegro molto vivace</td><td>emphatic</td></tr>
<tr><td>2</td><td>Bartok, III: Non troppo lento</td><td>academic</td></tr>
<tr><td>3</td><td>Beethoven, IV: Finale</td><td>emphatic</td></tr>
<tr><td>4</td><td>Bartok, III: Non troppo lento</td><td>emphatic</td></tr>
<tr><td>5</td><td>Schumann, IV: Allegro molto vivace</td><td>academic</td></tr>
<tr><td>6</td><td>Beethoven, IV: Finale</td><td>academic</td></tr>
</table></td></tr>
<tr><td>Data format</td><td>Excel files</td></tr>
<tr><td>Experimental protocol/procedure</td><td>The experimentations took place in a room at University of Geneva and each participant was paid in course credits for their participation. We</td></tr>
</table>

	used our Flash interface (D2.1 First series of experiment) for the dynamic judgments task and the main instruction was: "*Please rate the intensity the music's expressiveness*".
Measures	Participants' dynamic judgments
Results	
Descriptive results	The analyses are in progress.
Inference statistics	The analyses are in progress.
Additional results	-
Discussion	To be developed.

4.6 Dynamic judgments of self-reported subjective feeling to classical music depending on expressive style

Title	**Dynamic judgment of self-reported subjective feeling to classical music depending on expressive style (Capuçon II)**
Question of interest	To investigate how different versions of the same piece affect the listener in terms of his/her subjective feeling of emotion and entrainment.
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	To compare dynamic judgments of subjective feelings and self-reported explicit entrainment to 9 pieces between 3 different versions (academic, emphatic, natural) and compare the rhythmic/acoustic variability between the versions.
Theoretical hypotheses	Different versions of the same piece will lead to differences in terms of subjective feeling of emotion; Different versions of the same pieces will lead to differences in terms of entrainment; Differences in terms of rhythmic variability between the versions could act as a mediating variable for both entrainment and subjective feeling of emotion.
Operational hypotheses	Different versions of the same piece will lead to different intensities of felt emotion in the listener; Different versions of the same pieces will lead to different intensities of self-reported explicit entrainment; Differences in terms of rhythmic variability between the versions could act as a mediating variable for both explicit entrainment and self-reported subjective feeling.
Relationship with the objectives of the project	Entrainment.
Time schedule	This experiment had to be reopened due to insufficient data. End: may 2012.
Methods	
Participants	Total expected = 120.
Materials	27 music tracks = 9 pieces for solo violin * 3 versions (emphatic, academic, natural); Dynamic judgments Flash platform; Empathy Questionnaire (EQ), Baron-Cohen & Wheelwright (2004); 12-item explicit entrainment questionnaire (not published); Geneva Emotional Music Scale (Zentner, Grandjean & Scherer, 2008)
Data format	Excel.
Experimental protocol/procedure	
Measures	Self-reported subjective feeling of emotion; Self-reported explicit entrainment; Self-reported empathy.
Results	

Descriptive results	
Inference statistics	
Additional results	
Discussion	

4.7 Comparison of dynamic judgments of self-reported felt vs expressed feeling

Title	**Comparison of dynamic judgments of self-reported felt vs expressed feeling**
Question of interest	To investigate the differences between continuously rated felt and expressed emotion during music listening.
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	To compare dynamic judgments of subjective feeling of emotion and perceived expressed emotion to the same pieces to test whether music truly induces musical emotions or if it simply represents them. In addition, 3 levels of emotional expression (academic, emphatic, natural) will be used to investigate to what extent expression impacts the intensity of ratings of perceived expression and felt emotion. This study combines the results of experiment two separate experiments.
Theoretical hypotheses	Different versions of the same piece will lead to differences in terms of subjective feeling of emotion and perceived emotion; Dynamic ratings of felt emotion will be more heterogeneous than dynamic ratings of perceived emotion; Dynamic ratings of felt emotion will not always match with dynamic ratings of perceived emotion.
Operational hypotheses	Different versions of the same piece will lead to different intensities of felt emotion in the listener; Different versions of the same piece will lead to different intensities of perceived emotion in the music; The correlation coefficients for dynamic ratings of felt emotion will be lower than the coefficients of dynamic ratings of perceived emotion; Correlation coefficients between dynamic ratings of felt and perceived emotion will vary within sections of the pieces.
Relationship with the objectives of the project	Entrainment.
Time schedule	End: second half of 2012.
Methods	
Participants	To be determined.
Materials	27 music tracks = 9 pieces for solo violin * 3 versions (emphatic, academic, natural); Dynamic judgments Flash platform; Empathy Questionnaire (EQ), Baron-Cohen & Wheelwright (2004); 12-item explicit entrainment questionnaire (not published);

	Geneva Emotional Music Scale (Zentner, Grandjean & Scherer, 2008)
Data format	Excel.
Experimental protocol/procedure	
Measures	Self-reported subjective feeling of emotion; Self-reported explicit entrainment; Self-reported empathy.
Results	
Descriptive results	
Inference statistics	
Additional results	
Discussion	

4.8 Musical expertise, social impact and listening context

Title	**Musical expertise, social impact and listening context**
Question of interest	Is there a difference in the attribution of the intensity of emotions expressed by music between participant's judgments during a live performance and during laboratory conditions?
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	1. Investigate the impact of musical expertise by comparing the dynamic judgments of professional musicians and music lovers. 2. Compare the dynamic judgments made during a live performance vs. laboratory conditions and with headphones vs. free listening. 3. Investigate the impact of the presence of others in the dynamic judgments task.
Theoretical hypotheses	Some studies show differences in how people listen to music between musicians and non musicians (Besson et al., 2007) and others not (Bigand et al., 2005). The listening context is one of the most important features in the emotional process related to music (Scherer & Zentner, 2001), that's why we propose to compare different listening contexts. The presence of others in the process of emotion attribution to music has never, to our knowledge, been studied before and is therefore exploratory.
Operational hypotheses	Professional musicians, due to the long hours of practice, develop another way of listening and understanding the music (Sloboda, 2000). In this context, it's relevant to investigate the potential differences in the dynamic judgments of musicians and non musicians in the emotional attribution to music. Listening to music with headphones or not, or listening to music during a concert or in a laboratory context are very important factors which can help us to understand the relationship between music and emotion.
Relationship with the objectives of the project	Investigate the audience evaluation/reaction in terms of the listening context, the social context and the expertise factor.
Time schedule	Second half of 2012
Methods	
Participants	30 Students from UNIGE-CH 15 Students from the Geneva University of Music
Materials	Material: -Musical pieces played by the Quatuor Terpsycordes during their concert at the Geneva University of Music in November 2010 (D2.1 First series of experiment), i.e., based on their Cronbach alphas : - W.A. Mozart, String Quartet n14, KV 387 - 3rd movement (rated on the Wonder dimension) - F. Schubert, The Death and The Maiden – 1st, 3rd , and 4th movements (rated on the Power dimension)
Data format	Excel files
Experimental protocol/procedure	This study consists of three parts: 1. Laboratory condition with headphones: the experimentations took

	place in a room at the University of Geneva and each participant (N=15) was paid in course credit for their participation. We used our Flash interface (D2.1 First series of experiment) for the task of dynamic judgments and the main instruction was: "*Please rate how strongly the music expresses…*" followed by the emotional GEMS dimension of interest, the same GEMS dimension as the one judged during the concert at the Geneva University of Music – comparison of dynamic judgments during live performance vs. laboratory context and with headphones or in "free listening". 2. Experiment in group with non musicians: the experimentation will take place in a room at the University of Geneva with 15 non musicians (students from UNIGE-CH). The musical stimuli will be broadcast with speakers while participants continuously rate the music on laptops with the main instruction: "*Please rate how strongly the music expresses…*" followed by the emotional GEMS dimension of interest. 3. Experiment in group with musicians: the experimentation will take place in a room at the University of Geneva with 15 musicians from the Geneva University of Music. The procedure will be the same as the one with non musicians.
Measures	Participants' continuous ratings (dynamic judgments)
Results	
Descriptive results	The analyses are in progress.
Inference statistics	The analyses are in progress.
Additional results	-
Discussion	To be developed.

4.9 Thermographic measure: "online" /"offline" contexts and musical expressiveness

Title	**Thermographic measures of a small audience in "online" and "offline" contexts and with different types of musical expression performed by a String quartet (Ensemble Nachtigall)**
Question of interest	
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	Replication of the study with Quartetto di Cremona (D2.1 First series of experiment) and investigation of the thermographic reactions in "online" – i.e. during the direct musical performance- vs. "offline" contexts – i.e. during the visualization of the same musical performance on a screen.
Theoretical	Musical expression can be represented by various cues in a musical

<table>
<tr><td>hypotheses</td><td>performance and might have an impact on audiences' emotional reactions (Juslin, 2000). Three types of musical expression will be investigated: academic, natural (as the musicians play in a concert) and emphatic, with thermographic recordings of listeners' faces. Attending directly or not to live musical performances can also impact the thermographic reactions of the audience.</td></tr>
<tr><td>Operational hypotheses</td><td>Higher thermographic measure correlations between listeners during the listening of emphatic style compared to academic style. Increase of thermographic measures for emphatic compared to academic musical styles. Similarly, higher thermographic measure correlations between listeners during the "online" performance compared to the "offline" performance and an increase of thermographic measures for "online" performance compared to "offline" performance.</td></tr>
<tr><td>Relationship with the objectives of the project</td><td>Understand the impact of musical expression and context on the reactions of the audience using peripheral reactions (one of the component of the emotion processes).</td></tr>
<tr><td>Time schedule</td><td>Second half of 2012</td></tr>
<tr><td>Methods</td><td></td></tr>
<tr><td>Participants</td><td>15 Students from UNIGE-CH</td></tr>
<tr><td>Materials</td><td>Material:
-Musical pieces played by the Quartetto di Cremona during the workshop at the University of Geneva in July 2010 (D2.1 First series of experiment), i.e. :
<table>
<tr><th>Order</th><th>Movement</th><th>Musical style</th></tr>
<tr><td>1</td><td>Schumann, IV: Allegro molto vivace</td><td>emphatic</td></tr>
<tr><td>2</td><td>Bartok, III: Non troppo lento</td><td>academic</td></tr>
<tr><td>3</td><td>Beethoven, IV: Finale</td><td>emphatic</td></tr>
<tr><td>4</td><td>Bartok, III: Non troppo lento</td><td>emphatic</td></tr>
<tr><td>5</td><td>Schumann, IV: Allegro molto vivace</td><td>academic</td></tr>
<tr><td>6</td><td>Beethoven, IV: Finale</td><td>academic</td></tr>
</table>
- And also movements (1, 3 and 4) from the Death and the Maiden by F. Schubert.</td></tr>
<tr><td>Data format</td><td>Images / matrices, Matlab</td></tr>
<tr><td>Experimental protocol/procedure</td><td>The experiments will take place in a room at the Jacques Dalcroze Institut (Geneva) with a group of 15 music lovers. Participants will be placed in front of the thermographic camera and the musicians.</td></tr>
<tr><td>Measures</td><td>Thermographic measures (in kelvins) on continuous scales</td></tr>
<tr><td>Results</td><td></td></tr>
<tr><td>Descriptive results</td><td>The analyses are in progress.</td></tr>
<tr><td>Inference statistics</td><td>The analyses are in progress.</td></tr>
<tr><td>Additional results</td><td>-</td></tr>
</table>

Discussion	To be developed.

4.10 fMRI study : selection of stimuli with dynamic judgments

Title	**Selection of musical stimuli for fMRI study (behavioural pilot)**
Question of interest	Select the most relevant musical stimuli to investigate the process of attribution of an emotion to the music at brain level.
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	Dynamically evaluate musical stimuli for the study of attribution of emotional characteristics to the music at the brain level. The next step will be rating the selected stimuli in the scanner with a transducer.
Theoretical hypotheses	In order to investigate the attribution of emotional characteristics to the music at the brain level, it is necessary to choose two opposite GEMS dimensions and also select musical stimuli presenting at least one fluctuation in the dynamic judgment.
Operational hypotheses	Tenderness and Power are two dimensions which are relevant emotions related to music. The differences in their musical expressions make them very interesting. This behavioral pilot will allow us to select the most relevant musical stimuli from the analyses of the dynamic judgments and to prepare the fMRI study (model-based approach).
Relationship with the objectives of the project	To investigate the attribution of emotion at the behavioral level with dynamic judgments in order to better understand this attribution at the brain level.
Time schedule	Second half of 2012
Methods	
Participants	50 Students from UNIGE-CH
Materials	Material: - 25 musical excerpts expressing Power - 25 musical excerpts expressing Tenderness
Data format	Excel files
Experimental protocol/procedure	The experimentations took place in a room at the University of Geneva and each participant was paid 15 chf for 40 minutes of participation. We used our Flash interface (D2.1 First series of experiment) for the task of dynamic judgments and the main instruction was: "*Please rate how strongly the music expresses…*(*Tenderness / Power*)".
Measures	Participants' ratings (dynamic judgments)
Results	
Descriptive results	The analyses are in progress.
Inference statistics	The analyses are in progress.

Additional results	-
Discussion	To be developed.

4.11 Human Intracranial Local Field potential recordings during percussion listening paradigm (Intracranial II)

Title	Intracranial EEG recording of brain activity during a percussion listening paradigm (Intracranial II)
Question of interest	To investigate how different metrics and different tempi entrain brain areas during passive listening.
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	To compare how different brain areas are entrained by percussion beats that vary in terms of tempo (fast/slow) and metrical structure (simple/complex) in a pharmacoresistant epileptic patient with intracranial electrodes. This study replicates and improves the paradigm used in Intracranial II.
Theoretical hypotheses	Tempo and rhythm are represented in (internal) brainwave rhythms which will entrain to the (external) rhythm of music; Therefore, subjecting the patient to pseudo-pieces with different tempos and meters should result in the alteration and eventual entrainment of brainwave components to the corresponding tempo, frequency or phase of the music; The observed response will be dependent on the perceived tempo of the piece rather than just the objective tempo.
Operational hypotheses	Keeping tempo constant, different metrics will lead to different brainwave entrainment responses; Different tempi for the same piece (i.e. metric) will lead to different brainwave entrainment responses; Should the perceived tempo (as determined by a tapping paradigm) be different to the objective tempo, the latter rather than the former will be related to the brainwave entrainment response should one be observed.
Relationship with the objectives of the project	Entrainment.
Time schedule	Data analysis in progress.
Methods	
Participants	N=1, female, non-musician, pharmacoresistant epileptic patient. Intracranial electrodes in: the left supplementary motor area, left amygdala, and right cingulate cortex.
Materials	16 beat tracks = 4 metrics * 2 tempi (100 vs 130bpm)

	12-item explicit entrainment questionnaire (not published); Geneva Emotional Music Scale (Zentner, Grandjean & Scherer, 2008); Tempo tapping programmed with E-Prime 2 (Psychology Software Tools Inc., Pittsburgh, PA).
Data format	To be determined.
Experimental protocol/procedure	
Measures	Overall self-reported explicit entrainment for all trials; Overall self-reported subjective feeling of emotion; Intracranial EEG recordings; Heart rate.
Results	
Descriptive results	
Inference statistics	
Additional results	
Discussion	

4.12 Electroencephalographic (EEG) study on brainwave entrainment

Title	Electroencephalographic (EEG) study on brainwave entrainment
Question of interest	To investigate how different metrics and different tempi entrain brain areas during passive listening.
Leaders	UNIGE-CH
Other SIEMPRE groups involved	
Referent scenario	Scenario 3: Audience
Research objectives	To compare how different brain frequencies are entrained by percussion beats that vary in terms of tempo (fast/slow) and metrical structure (simple/complex) in normal subjects and the links between the strength of entrainment and self reported feelings of entrainment and emotion.
Theoretical hypotheses	Tempo and rhythm are represented in (internal) brainwave rhythms which will entrain to the (external) rhythm of music; Therefore, subjecting the participants to pseudo-pieces with different tempos and meters should result in the alteration and eventual entrainment of brainwave components to the corresponding tempo, frequency or phase of the music; The observed response will be dependent on the perceived tempo of the piece rather than just the objective tempo.
Operational hypotheses	Keeping tempo constant, different metrics will lead to different brainwave entrainment responses; Different tempi for the same piece (i.e. metric) will lead to different brainwave entrainment responses; Should the perceived tempo (as determined by a tapping paradigm) be different to the objective tempo, the latter rather than the former will be related to the brainwave entrainment response should one be observed.
Relationship with the objectives of the project	Entrainment.
Time schedule	Data collection in progress.
Methods	
Participants	In progress. Francophone right handed men and women between the ages of 18 and 35 in good health.
Materials	16 beat tracks = 4 metrics * 2 tempi (100 vs 130bpm) * 2 modes (major vs minor) 4 explicit entrainment questions; 3 GEMS supra ordinate factors; Tempo tapping programmed with E-Prime 2 (Psychology Software Tools Inc., Pittsburgh, PA).

Data format	
Experimental protocol/procedure	Participants passively listen to a rhythm track while their heart rate, right forearm EMG activity and EEG activity are recorded. After listening they are instructed to reproduce what they heard using their right index finger and are then asked to what extent they felt: "their own body rhythms change"; "their own bodies resonate with the music"; "like dancing"; "like moving"; and the GEMS second-order level factors: "sublimity", "vitality" and "unease" (Zentner, Grandjean, & Scherer, 2008) on 5 point Likert scales.
Measures	Overall self-reported explicit entrainment for all trials; Overall self-reported subjective feeling of emotion; Intracranial EEG recordings; Heart rate.
Results	
Descriptive results	
Inference statistics	
Additional results	
Discussion	