Research report
Lua ja Koje -project

Proto experiment at Aalto University and
experiment at the Tampere Guitar Festival (TGF)

Report 6 Sept 2023

Table of Contents

Table of Contents

Introduction

Lua ja Koje is a Business Tampere Oy project, funded by the Council of Tampere Region (Pirkanmaan liitto) and the European Regional Development Fund (ERDF). It brings together different stakeholders in the area of new technologies for the virtual-digital space and the different possibilities within this space, ranging from virtual concerts or fairs to sport events and festivals. In cooperation with Aalto University, we are *researching the affective differences between a live concert and its reproduction in a digital space*. This was actualized by two research situations: the first ”proto experiment” in Aalto University’s premises in May-June 2023 and the second in the Tampere Guitar Festival (TGF) 2023 at the conservatory in Tampere in June 2023 and Aalto University in August 2023.

The purpose of the proto experiment was to test the research methods, operation and measuring apparatuses. We did the proto experiment in controlled conditions, with only the artist, researchers and test audience present, In the live concert in the Tampere Guitar Festival, our test audience is taking part in a public event, which means we had to ensure that our recording and measurement technologies work in the designed way. While the proto experiment was preparing for the research at the conservatory in Tampere, we also gathered actual data on the participants. The proto experiment took place in two occasions

1. Satu Lankinen, live concert with measurements of audience response and recording in the Odeion theater (Maarintie 8) on 26 May at 4:30 pm.
2. Playback with measurements of audience response in the Visualization Hub (Otakaari 7b) on 9 June at 4 pm.

Building for the recording took place in Odeion in the TUAS building on Thursday 25 May, and testing the measurement apparatuses in Otakaari 7 on Wednesday 24 May. Building for the playback experiment in the Visualization Hub took place on the day prior to the measurements. We made measurements with a small test audience of 4 participants: heart rate, facial expressions and gaze direction. In addition, the members of the test audience answered a short survey (see Appendices 1 and 2) immediately following the performance.

As for the concert in the TGF, the recording of the first half of a live concert took place in Pyynikkisali, Tampere conservatory F.E. Sillanpäänkatu 9

1. Isabel Martínez on Wednesday 7 June at 7 pm
2. Playback experiment in the Visualization Hub on Thursday 3 August at 3 pm

Building for both the recording and playback took place on the previous day. Again, we made measurements with a small test audience of 4 participants: heart rate, facial expressions and gaze direction.

From Aalto University, the project team comprised Rolando Camilo, Jari Manninen, Antti Ruotoistenmäki (project manager), Iván Pérez Torres and Alejandro Yllarramendy from Aalto Studios, Mikko Sams from the Department of Neuroscience and Biomedical Engineering, and Veli-Matti Saarinen from the Aalto Behavioral Laboratory (ABL). From Business Tampere, Tuomas Lammi worked in the project team. We collected audiovisual material and measurement data using equipment from Aalto Studios MAGICS (P.O.Box 13300, FI-00076 AALTO) and Aalto Behavioral Laboratory (Aalto Behavioral Laboratory, Aalto Neuroimaging, Aalto University, FI-00076 AALTO).

The study has been approved by the Research Ethics Committee in Aalto University (D/296/03.04/2022). All participants gave their informed consent in writing and received financial compensation.

Research problem and question

Our research problem concerns the transfer of human experience using technology. We are interested in how the affective responses differ in a live situation compared to a technologically reproduced situation (e.g. live streamed or recorded concert to a digital environment) and what is the immersive capacity in the virtual environment and how could it be supplemented. Our research question for the proto experiment was

- What are the main affective differences between a small live concert and its reproduction in a digital environment?

In an important sense the question about the affective differences in transferring the experience concerns both the receiving end of the content (e.g. the audience) and the performers' side of the interaction. The interactive component of transferring experience through technological means is an important and interesting aspect, but in these aforementioned research settings it will not be taken into account but left for further research.

Experiment setting

We studied the main affective differences on the part of the receiving audience. On both dates of the proto experiment and the TGF concert there was a group of four test participants: the first date consisted of a concert at a movie theatre / concert hall and the second contained the digital reproduction of the concert for the same test audience in the Visualization Hub (Igloo Vision). Both situations were research situations with accompanied measurements. It is to be noted that in the proto experiment and the TGF concert all four participants (test audience) were different. This reduces the possibility of directly comparing the results between the two experiments.

Research setting 1:

Live performance at Aalto University premises / Tampere conservatory.
Musician and 4 participants in the audience. In the conservatory, the participants were sitting among the public audience.
Participants to the proto experiment were asked to listen to the music to be performed in advance to the concert to eliminate the "newness" -effect. The music was rather dramatic, so as to rouse measurable emotions in the participants.
Three of the four participants to the TGF experiment were music students, and thus well oriented to the kind of music being performed (classical guitar).
The measuring devices were mounted beforehand to the environment and onto the participants to neutralise the experimental setting and pre-expose the participants to the environment and to wearing the instrumentation.
After the concert the participants answered a questionnaire (Appendices 1 EN and 2 FIN).

Research setting 2:

The recorded performance was digitally reproduced at the Visualisation Hub in Aalto Studios.
The same audience as in the live concert participated in the recorded concert with the same measurements.
After the concert the participants answered the same questionnaire as after the live concert (Appendices 1 EN and 2 FIN).

Measurements & Questionnaire

Research and experiment design

The initial phase involved an in-depth literature review to determine the project's objectives and experimental approach. The review yielded key insights into various methodologies for measuring user experience. Four measurements were identified for experimentation, described in more detail below:

- Wireless heart-beat recorder: Ultium EMG
- Cameras for facial recognition: Blackmagic studio cameras
- Glasses for attention recognition (eye tracking for gaze direction): Pupil Labs
- Questionnaire

Heart-beat recorder

Each participant wears a heart-beat recorder for the heart-rate monitoring. This measurement provides information about the participants' arousal and excitability during the performing in both conditions. We used a wireless measurement system (Ultium EMG, https://www.noraxon.com/our-products/ultium-emg/) where the sensor is attached to the chest of the participant using stickers and tape. The signal is gathered through a base station to the laptop that is used for controlling the measurements.

Cameras for facial recognition:

Two Blackmagic 4k pro studio cameras are placed in front of the participants, each recording the facial expressions of two participants while the performer is playing. The aperture and gain are adjustable so as to make the faces of the participants visible also in dark conditions typical to a concert. We use a video editing software (Adobe Premiere) to split the image so that only one face is shown in any individual video. Then we use a face recognition software (iMotions) to analyse the valence of the participants, based on their facial expressions.

Glasses for attention recognition

The participants wear special glasses (Pupil Labs invisible) for detecting the direction of their gaze. The glasses resemble regular eye glasses or sunglasses with thick frames. The glasses are connected using a USB-C cable to an Android phone that is used for controlling the measurements, separately for each participant. Data is saved directly to a cloud service. These measurements will provide information about the participants' attentional focus during the performance.

Recording the performance for playback in Igloo

We recorded the live concerts using a 360 camera (make and model Insta360 X3), took sound from the musician's sound system plus ambient sounds from microphones placed in the room. The TGF concert was acoustic, so instead of the musician's sound system, we used a microphone placed in front of the musician for streaming the concert.

Synchronisation

The heart rate measurement and the recordings using the studio cameras are synchronised automatically using a set of connected computers that use the same timestamp for different measurements. The measurements of gaze direction are synchronised with these using a clapperboard that the participants gaze at and that is visible in both the studio camera image and the 360 degree camera image. In addition, we attach one accelerometer to the clapperboard for backup.

For the playback experiment in Igloo, we use the code in Unity to send the trigger and a combination of black and white screen at the beginning and end of recording in the Visualisation Hub to synchronise the measurement of the gaze direction.

Questionnaire

The questionnaire was given to the participants as a paper-and-pen -type of packet. The questionnaire was somewhat ”light” so as to not take too much time to fill in. It consists of questions concerning the affective dimensions of the event (e.g. concert, sporting event) with a scale from 1-4. We prefer scale from 1-4 over scale from 1-5, to avoid the tendency to go to the medium score (3).

Proto experiment design

Following the selection of measurements, the team worked on designing a prototype experiment. Musical performance was chosen as the context for the experiment. Detailed plans were made for questionnaire development, measurement setup, camera arrangement, and experiment execution. Notably, a Unity project was created to show the performance in Igloo and facilitate measurement synchronisation, showcasing the team's ability to learn and utilise new software.

Proto Experiment and learning sessions

The team conducted test and learning sessions to familiarise themselves with the chosen measurements. This phase involved setting up heart-rate monitoring, eye tracking, and emotional face recognition equipment. In parallel, the participant recruitment process was initiated. Subsequently, the prototype experiment was carried out successfully in Odeion.

Adaptation to Tampere Guitar Festival

Building on the prototype experiment's success, the team adapted the experiment design for the Tampere Guitar Festival. Similar procedures were followed, but adjustments were made to account for the live festival environment. Test sessions were conducted to ensure seamless execution during the festival. Both the festival experiment and the proto experiment Igloo condition experiment were executed successfully.

Data visualisation and preprocessing

A learning phase was initiated to enable data visualisation and preprocessing. Software tools like iMotions and Ultium were employed for eye tracking, emotional face recognition, and heart-rate data analysis. Video editing using Adobe Premiere Pro was utilised for preparing videos from camera footage. The groundwork for data preprocessing and analysis was established, though the actual analysis awaited finalised data.

Preprocessing and analysis planning

The final month of the project focused on researching preprocessing, filtering, and data analysis techniques. Preliminary preprocessing efforts were made on heart-rate and eye tracking data. The report's preparation for data analysis underscores the intention to delve deeper into understanding the results once the data is ready.

Results

Heart rate is probably the most clear and straightforward indicator of arousal. As it turned out, we cannot detect basic emotions from video footage. This is so because the participants' facial expressions do not vary notably while listening to music in a concert setting. Instead, we plan to use positive valence detected from action units, using iMotions / Open Face analysis software.

Heart-rate monitoring

Measuring arousal during a musical performance is an essential aspect of understanding the emotional impact of music on both performers and audiences. Arousal refers to the level of physiological and psychological activation or stimulation a person experiences in response to stimuli, such as music. One effective way to measure arousal is by monitoring heart rate with a physiological monitoring technology.

Heart rate (heart beats per minute, bpm) is a direct reflection of the autonomic nervous system's activity. The autonomic nervous system has two branches: the sympathetic nervous system and the parasympathetic nervous system. These branches play a crucial role in regulating various bodily functions, including heart rate.

During a musical performance, a person's heart rate can provide insights into their arousal levels, which are closely tied to emotional responses. Here's how heart rate can be used to measure arousal:

Performance Start: As the musical performance begins, the emotional and sensory stimuli from the music can trigger the sympathetic nervous system, leading to an increase in heart rate. This increase is due to the release of stress hormones like adrenaline, which prepare the body for increased activity.

Arousal Peaks: The heart rate can fluctuate throughout the performance in response to different musical elements such as tempo changes, dynamic shifts, and emotional climaxes in the music. These changes can correspond to moments of heightened emotional arousal.

Physiological Responses: A higher heart rate indicates increased sympathetic nervous system activity, which is associated with the "fight or flight" response. This physiological reaction is linked to intense emotions, excitement, and even anxiety. Conversely, a sudden drop in heart rate could indicate moments of deep relaxation or emotional release.

Comparative Analysis: By comparing heart rate data from different performances or different parts of a single performance, researchers can identify which musical elements have the most significant impact on arousal. This can help composers, performers, and researchers understand how to evoke specific emotional responses in the audience.

Subjective Correlation: Heart rate data can be correlated with subjective reports from performers and audience members about their emotional experiences during the music. This helps validate the relationship between physiological responses and emotional states.

Intersubject correlation

It's important to note that while heart rate is a valuable tool for measuring arousal during a musical performance, it should be used in conjunction with other methods, such as self-reporting, facial expression analysis or gaze recognition to obtain a comprehensive understanding of the emotional impact of music.

Gaze recognition

Gaze recognition, also known as eye tracking, can be a powerful tool for measuring immersion during a musical performance. Immersion refers to the extent to which an individual becomes fully absorbed in an experience, to the point where they lose awareness of their surroundings and feel deeply engaged. Here's how gaze recognition can be used to measure immersion during a musical performance:

Visual Focus and Absorption: Gaze recognition technology tracks where a person is looking. In an immersive musical performance, individuals tend to focus their gaze on specific elements that captivate their attention, such as performers, instruments, stage effects, or visual projections. The more individuals fixate on these elements, the more immersed they are likely to be.

Extended Gaze Duration: Immersive experiences often lead to longer periods of fixation on points of interest. During a musical performance, extended gaze durations on performers or visual components suggest that the audience is deeply engaged and absorbed in the performance.

Neglect of Surroundings: As immersion increases, individuals may become less aware of their surroundings outside of the performance. Gaze recognition can show reduced attention to external factors, highlighting the focus on the musical elements that contribute to the immersive experience.

Gaze Path Analysis: Analysing the trajectory of gaze movements can provide insights into the flow of attention. Immersive experiences often involve smooth and coherent gaze transitions as attention seamlessly moves between various engaging aspects of the performance.

Emotionally Charged Moments: Immersion is closely linked to emotional engagement. Gaze recognition can identify moments of heightened emotional impact based on prolonged and intense fixations on emotionally expressive performers or segments of the performance.

Comparative Analysis: By comparing gaze data across different performances or sections of a single performance, researchers can identify patterns associated with varying levels of immersion. This can help understand which musical or visual elements consistently contribute to a more immersive experience.

Interaction with the Performance: Immersion often entails a sense of interaction with the content. Gaze recognition can show how individuals respond to dynamic changes in the performance, such as shifts in tempo, mood, or intensity, which contribute to a sense of engagement.

Combined Measure: Combining gaze recognition data with physiological measures like heart rate can offer a holistic understanding of immersion. Syncing moments of high gaze intensity with physiological changes can validate the connection between visual attention and immersion.

By leveraging gaze recognition technology to understand the patterns of visual attention and engagement, researchers, performers, and creators can design musical performances that effectively draw audiences into a state of deep immersion and emotional connection.

Emotional facial expression analysis

Emotional facial expression analysis can be a valuable tool for measuring the emotional experience of both performers and audience members during a musical performance. It involves the use of technology, such as facial recognition software and machine learning algorithms, to analyse and interpret the facial expressions displayed by individuals as they listen to or participate in a musical performance. Here's how this process can be utilised to measure the experience during a musical performance:

Data Collection: High-quality video footage of the performers and the audience is captured during the musical performance. This footage focuses on capturing facial expressions, which are known to reflect a wide range of emotions such as happiness, sadness, surprise, and more.

Facial Expression Recognition: Facial recognition software (Affectiva's Affdex from iMotions) is employed to detect and track facial features in the collected video footage. These software tools have the capability to identify key facial landmarks, such as the positioning of the eyebrows, eyes, nose, and mouth. Machine learning algorithms are applied to classify the detected facial expressions into different emotional categories. These algorithms have been trained on large datasets of labelled facial expressions, enabling them to associate certain facial configurations with specific emotions. Beyond classifying emotions, the technology can also assess the intensity of the displayed emotions. For example, it can differentiate between a slight smile indicating mild happiness and a broad smile indicating intense joy.

Comparative Studies: By analysing data from multiple performances, researchers can make comparisons to identify patterns in emotional responses. This could involve comparing the reactions of different audience segments, variations in emotional engagement between different musical genres, or how performer emotions align with audience reactions.

In essence, emotional facial expression analysis allows researchers, musicians, and other stakeholders to gain a deeper understanding of the emotional impact of musical performances. It bridges the gap between subjective emotional experiences and objective data, offering valuable insights that can contribute to the enhancement of musical experiences for both performers and audiences.

Analysis of Questionnaire Data

The Lua ja Koje project employed a questionnaire to delve into the subjective experiences of the test participants. The questionnaire comprised 14 questions utilising a 4-point Likert scale (strongly agree=4, agree=3, disagree=2, strongly disagree=1). It was designed to encompass affective, socio-spatial, temporal, and immersive aspects of the experience under scrutiny.

The collected questionnaire data encompassed two concert settings: the Odeion concert and the Tampere Guitar Festival. Each setting had both live and virtual versions. The Odeion concert was hosted in the Odeion hall in Otaniemi, while the Tampere Guitar Festival unfolded at the Tampere conservatory. The virtual reproductions of both concerts took place in the Visualization Hub (Igloo vision) in Aalto Studios' premises in Otaniemi. The first group of four participants attended both the live and virtual versions of the Odeion concert, while the other group of four engaged in both versions of the Tampere Guitar Festival.

While acknowledging the limited scope of the gathered data, it serves as a foundation for potential research hypotheses, future research and developmental issues, and questions. In the context of methodological research like this, the questionnaire acted as an instructive tool, showcasing its utility while also laying bare its constraints. The questionnaire's efficacy lies in its convenience and ease of applicability for gauging participants' experiences in quantitative form, yet a qualitative interview could unravel the qualitative intricacies and nuances of the experience more accurately. Thus, in addition to a quantitative questionnaire, a qualitative analysis would be needed in future research.

The analysis encompassed basic indicators derived from the questionnaire data, including total points received, mean, standard deviation, differences in means, and correlations between answers in live and virtual versions. Each of the 14 questions held a total of 16 points (from 4 participants), with the combined points for the questions in one concert totaling 224. Comparing the two concerts, the Tampere Guitar Festival garnered fewer points overall: 172 for the live version and 138 for the virtual counterpart. Conversely, the Odeion concert amassed 188 points for the live iteration and 146 for the virtual rendition. Here however one must note that each of the two concerts had different audiences.

Remarkably, the virtual version of both concerts received lower points compared to their live counterparts (**Odeion:** 188 for live, 146 for VR; **TGF:** 172 for live, 138 for VR). This outcome aligns with expectations, raising inquiries about the authenticity of the virtual concert experience. Can virtual concerts challenge "real live concerts," or should the aspirations of virtual concerts differ significantly from traditional concerts, embracing distinct metrics?

One plausible explanation for the virtual versions' lower overall scores could be the **visual quality** of the reproduction. A conspicuous contrast emerged in answers to the visual quality. For the Odeion concert, the mean difference between live and virtual stood at 1.75 points, while for TGF, it registered at 0.75 points. This divergence might also extend to answers regarding the ease of following on-stage occurrences (question 7); a mean difference of 0.75 was consistent in both concerts, with virtual versions yielding lower scores. Thus, enhancing and advancing the visual quality of the virtual version emerges as a focal point for future research aimed at bridging experiential gaps. This is also due to a compromise in the choice of camera, because the most advanced camera had a fan noise problem that made it unsuitable for a concert setting. In contrast, audio quality differences were less pronounced, with both TGF versions earning similar ratings.

Notably, the Odeion concert showcased a larger **standard deviation** within the answers in the virtual version. This divergence implies varying participant opinions or experiences, suggesting a lack of consensus in how the participants experienced the concert and also that some elements in the virtual concerts were favoured over others. On the other hand, the situation reversed in TGF, where the deviation was narrower in the virtual iteration, indicating a greater consensus among participants. Nevertheless, the deviations that came up from the data, indicate that the transferring of experience is a developing field of research and product development that succeeds in certain aspects, but needs to develop further in others.

During the examination of intersubject **correlations** between the live and virtual settings, responses from the Odeion concert yielded more intricate correlations concerning the relationship between the live and virtual experiences. Correlation values indicated differing degrees of linear relationships between responses in the live concert setting and the virtual reproduction for each participant. Correlations ranged from 0.1604 to 0.6892, reflecting the diverse degrees to which individuals engage with these novel technological avenues for transferring experiences: some found the two settings to be closely aligned and akin, while others perceived disparities.

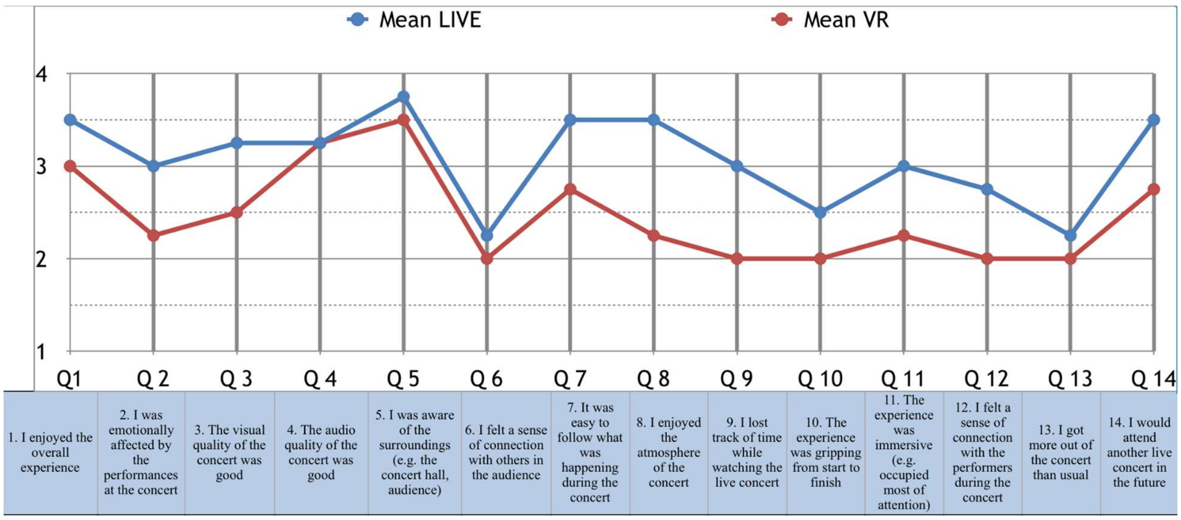
In our pursuit of understanding the relationships between the **means of participants' answers** across the concerts, we uncovered robust **correlations** within our dataset. Specifically, the correlation for the Tampere Guitar Festival (TGF) manifested as 0.77, while the Odeion concert yielded a correlation of 0.63. These values point to a significant and positive association between participants' responses in both live and virtual versions. Evidently, this alignment suggests that, *on average*, the perceptions and experiences of participants within these two settings share a considerable consensus. This inclination towards concordance hints at an interesting observation: the experiences and perceptions reported in the virtual rendition might well be harmonious with those encountered during the live event. This can be attributed to the virtual reproduction effectively encapsulating the quintessence of the live experience, at least on some basic, cumulative level.

However, it's important to acknowledge the interplay between the **correlation and the nuances of the responses**. While the correlation provides a snapshot of the linear connection between the mean responses, it might fall short when scrutinising instances where the disparity between "disagree" (answer 2 on the Likert scale) and "agree" (answer 3 on the Likert scale) is substantial. In essence, the correlation, while indicative of a **generalised alignment,** might not encapsulate the complete intricacies when certain aspects of agreement and disagreement are pronounced.

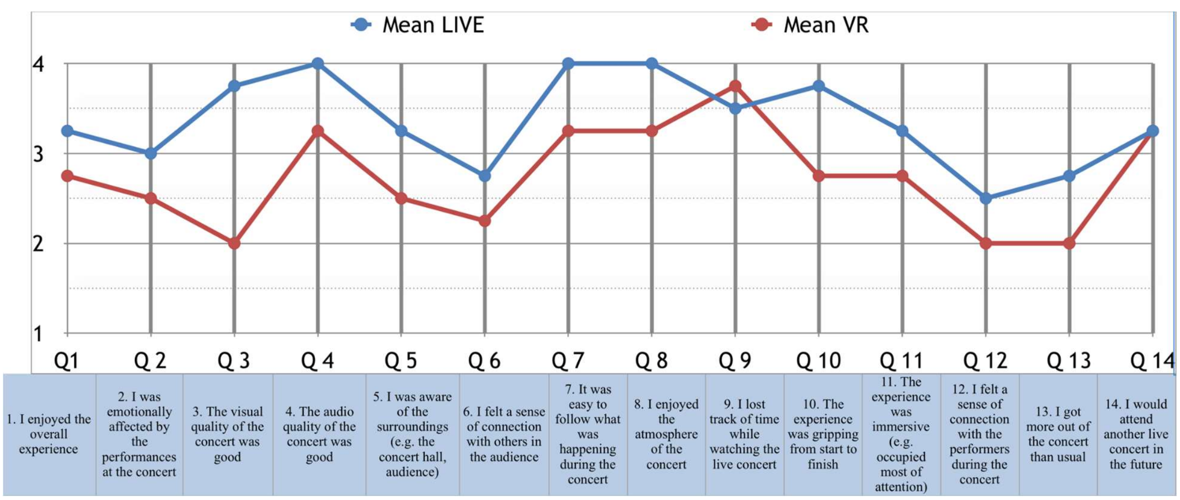
Recognizing this dynamic, it becomes evident that while the correlation underscores overall alignment, it also illuminates the disparities present within the distribution of responses across "disagree" and "agree." This dissonance reveals that while participants' perceptions exhibit a level of uniformity, they also hold distinct perspectives on specific facets. Consequently, this adds a layer of complexity to our interpretation, signalling that while the means converge, the richness of participants' experiences might not be fully captured by the correlation's lens.

To encapsulate, the correlations we've uncovered serves as an overarching metric of alignment, yet it may not fully unveil the intricate tapestry of responses, particularly in scenarios where significant differences within the Likert scale manifest. In essence, it beckons us to complement our analysis by exploring both the correlation and the granularity of responses to attain a holistic comprehension.

On the whole, the questionnaire data prompted intriguing preliminary observations. Despite its constraints, the data offered essential insights for future research directions and developmental objectives.



Mean answers (r = 0.772) for the proto experiment



Mean answers (r = 0.630) for Tampere Guitar Festival

Discussion

Achievements of the project

- Successful execution of both the proto experiment and the adapted experiment at Tampere Guitar Festival.
- Design and implementation of a Unity project for measurements synchronisation of measurements and Igloo presentation, showcasing adaptability to new software.
- Proficient utilisation of software tools like iMotions, Ultium, and Adobe Premiere Pro for data visualisation and preparation.
- Extensive groundwork for data preprocessing and analysis, indicating a strategic approach to post-experiment evaluation.

Challenges

- Learning curve associated with new software, particularly Unity and C#, was time-consuming.
- Navigating the intricacies of data preprocessing and analysis required significant research and exploration.
- The evolving nature of live events posed challenges during experiment adaptation but was successfully managed.

Work to be done

Data preprocessing and analysis

The eye tracking data from Pupil Labs is available in the project folder of Aalto University IT system (Triton). A pivotal phase of the Lua ja Koje project involves the preprocessing and subsequent analysis of the collected data. This stage is instrumental in uncovering valuable insights and drawing meaningful conclusions from the experiment. Below, we outline the data preprocessing procedures and the planned analysis methodologies for the different measurements.

Heart-rate Monitoring (Ultium EMG)

For Ultium heart-rate data, the initial preprocessing step involves the utilisation of a MATLAB script to trim the data. Although a slight time delay is introduced due to the second trigger, careful consideration of approximately 50 milliseconds should be considered during subsequent analysis. The beginning of the 50-millisecond trigger should be used for both the start and the end of measurements. (At the moment, the Matlab code takes the end of end trigger, and should be edited to be precise.) Additionally, for the live performance data, segmentation will be performed based on clapboard-related information. Three columns in the data corresponding to the clapboard's axes provide the necessary reference points. Peaks in these columns will identify the start and end points of the performance, enabling accurate segmentation.

Eye tracking (Pupil Labs invisible)

The next step involves importing this data into iMotions for analysis. A key component of this phase is the extraction of CSV files. Detailed instructions for this process can be found in the "Notes Pupil analysis.doc". Moreover, the exported data from Odeion is ready for analysis.

Emotional face recognition data

Emotional face recognition data has been captured through video recordings. However, some videos are yet to be split into two parts. The document "Adobe Premiere.doc" provides guidance on splitting these videos. Similar to heart-rate and eye tracking data, the videos will be aligned and cut based on the clapboard's temporal reference points. Following this, the processed videos will be imported into iMotions. The exported data types from iMotions will be explored to discern the most relevant data for further analysis.

Data alignment and Filtering

Once the data from Ultium, iMotions, and Pupil Labs are segmented, they will be brought to the same starting point, ensuring temporal alignment for accurate comparison. Subsequently, the data will undergo filtering procedures to eliminate noise and improve the signal-to-noise ratio if it is required. This step aims to enhance the quality of the data and the reliability of subsequent analyses.

Planned analysis

The planned analysis involves leveraging the aligned, filtered, and segmented data to gain insights into various aspects of the experiment. By focusing on heart-rate variations, emotional responses, and eye movement patterns, we aim to address the project's research questions and hypotheses. The analysis will involve both descriptive statistics and potentially advanced statistical methods, as referenced in the provided links (see section References). The idea is a model free analysis, provided we do not have any model prepared for the expected results. We should do an intersubject correlation (ISC) based on the different data. It must be done using the Intersubject Correlation toolbox for MATLAB. For each voxel in the matrix a t-value comparison should be computed (difference of the means scaled by the variance) between each participant for the different measurements.

References

https://www.sciencedirect.com/science/article/pii/S1053811921003876?via%3Dihub
https://github.com/eglerean/ISCstats/blob/master/iscstats_ttest2_np.m
https://aaltodoc.aalto.fi/bitstream/handle/123456789/18764/isbn9789526065427.pdf?sequence=1&isAllowed=y

Appendices

1. Questionnaire (EN)
2. Questionnaire (FIN)

Appendix 1: Questionnaire (EN)

Seat: A B C D

Media: LIVE STREAM VR

Age:
- ◻ <18-24
- ◻ 25-34
- ◻ 35-44
- ◻ 45-54
- ◻ 55-59
- ◻ 60 or older

Gender:
- ◻ Woman
- ◻ Man
- ◻ Other
- ◻ I don't want to say

1. I enjoyed the overall experience

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

2. I was emotionally affected by the performances at the concert

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

3. The visual quality of the concert was good

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

4. The audio quality of the concert was good

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

5. I was aware of the surroundings (e.g. the concert space, audience)

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

6. I felt a sense of connection with others in the audience

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

7. It was easy to follow what was happening during the concert

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

8. I enjoyed the atmosphere of the concert

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

9. I lost track of time while watching the concert

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

10. The experience was gripping from start to finish

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

11. The experience was immersive (e.g. occupied most of attention, engaged the senses)

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

12. I felt a sense of connection with the performers during the live concert

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

13. I got more out of the concert than usual

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

14. I would attend similar concert in the future

1 - Strongly disagree
2 - Disagree
3 - Agree
4 - Strongly agree

Appendix 2 Questionnaire FI (Kyselylomake)

Henkilö: A B C D

Media: LIVE STREAM VR

Ikä:
- ◻ <18-24
- ◻ 25-34
- ◻ 35-44
- ◻ 45-54
- ◻ 55-59
- ◻ 60 tai vanhempi

Sukupuoli:
- ◻ Nainen
- ◻ Mies
- ◻ Muu
- ◻ En halua kertoa

1. Kokemus kokonaisuudessaan oli nautinnollinen

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

2. Konsertti nosti tunteita pintaan

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

3. Konsertin visuaalinen laatu oli hyvä

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

4. Konsertin äänenlaatu oli hyvä

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

5. Huomioin ympäristöä konsertin aikana (esim. ympäröivää tilaa, muuta yleisöä)

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

6. Tunsin yhteenkuuluvuutta muun yleisön kanssa

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

7. Oli helppoa seurata, mitä konsertissa tapahtui (esim. lavalla soittajien kesken)

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

8. Konsertin yleinen tunnelma välittyi

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

9. Aika tuntui kulkevan nopeasti konsertin aikana

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

10. Kokemus piti otteessaan alusta loppuun

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

11. Uppouduin konsertin seuraamiseen ja tunsin olevani osa tapahtumaa

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

12. Tunsin yhteyttä ja samastumista esiintyjiin

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

13. Sain konsertista enemmän irti kuin yleensä konserteista

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä

14. Osallistuisin mielelläni samanlaiseen kokemukseen uudelleen

1 - Täysin eri mieltä
2 - Eri mieltä
3 - Samaa mieltä
4 - Täysin samaa mieltä