Seeing what the audience feels: Live visualization of audience engagement during a music event

SUBMITTED IN PARTIAL FULLFILLMENT FOR THE DEGREE OF MASTER OF SCIENCE

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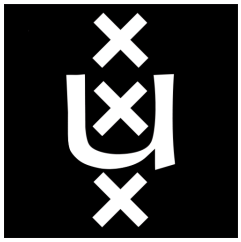
June 29th, 2016



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ABSTRACT

This thesis evaluates the influence of audience engagement as an aesthetic element for providing visual enhancement to a music concert. The audience engagement is gathered using Galvanic Skin Response (GSR) sensors, which the audience wears on their hands during the concert. In a small experimental setting two visualizations are compared: the first visualization is driven only by the music of the concert, while the second visualization takes into account also the engagement of the audience. The hypothesis of this experiment is validated, the visualization enriched with the audience engagement adds value to the experience: the concert is enhanced with an additional visual layer, which causes a higher level of immersion and feeling of togetherness among the audience. This could be an approach of a new multi-layered concept of cultural events, merging visual interactive arts with live music, creating a deeper shared experience. In the future it is planned to test the visualizations in a live setting, to confirm and extend the results that were gathered in this experiment.

Categories and Subject Descriptors

H.1.2 [**User/Machine Systems**]: Human information processing; H.5.0 [**Information interfaces and presentation**]: General

General Terms

Design, Human Factors

Keywords

Galvanic Skin Response, Data Visualization, Human Centered Multimedia, Immersion, Togetherness, Shared Experience

1. INTRODUCTION

Enriching a music event with visual content is an art field itself, which began in the late 1980s and has since then further developed worldwide by video artists, or so called 'VJs'. Experiments reach from combining visuals with music, but also light and even smell, in order to give the audience an enhanced experience [5]. New technology developments in the field of human computer interaction open new pathways which can enrich the experience of musical events. User generated content plays an important role in this development [8]. One example that incorporates user generated content in visual art at music events, is shown by Engström et al. (2008), where users can directly upload videos to the VJ through an app [6]. In this experiment, we want attempt to include user generated content in form of biofeedback into visual art. Several studies confirm that GSR correlates with human arousal [15] [21] [16]. But does the integration of GSR in visualizations enrich the experience of concert attendees? In section 2 the research question is elaborated, defining the measurable relevant variables 'togetherness' and 'immersion'. Section 3 examines previous research in the fields of visual enrichment of music events, measurement approaches of audience engagement, immersion and togetherness. Section 4 describes the mixed methodology approach of this research, section 5 lists the gathered requirements for the visualization, section 6 describes the design steps of the different visualizations, section 7 explains the evaluation outcomes. Section 8 presents a discussion and section 9 concludes this article.

2. RESEARCH QUESTION

Our hypothesis is that the combination of 'traditional' music visualization with measurement results of the GSR sensors from the audience, can add a new layer to the show and therefore add a value to it. The visualization we hypothesize about is then triggered by two parameters:

- music
- arousal of the audience

Therefore, the visualization extends existing approaches based only on music, taking into consideration the atmosphere of the event. The perception is more captivating, the audience experiences a multi-layered event. In addition, the emotional state of the audience gives the visualization a new dimension: knowing that their arousal is shown on the screen, may increase their attention and the feeling of being part of the event.

So we can define our research question as: *Does the additional visualization of the user engagement add value to the experience of the event in form of:*

- *Increase of immersion*
- *Increase of togetherness*

3. RELATED WORK

Literature review has been made in the fields of visual enrichment of music, measurement procedures of gathering audience engagement, as well as measurement of immersion and togetherness.

3.1 Visual enrichment of a concert

Music visualization has a big role in the artistic scene, dating back to the late 1980s. So called 'video jockeys' or 'VJs' are similar to 'video artists', but usually work in live performances, complementing music with visuals [5]. While the working field for VJs expands also towards museums, art galliers, live shows and concerts, the main field still remains the nightclub scene [7]. Still, the development of user centered media reveals new opportunities in visual enrichment of music events. Engström et al (2007) state that the importance of user generated content is increasing when it comes to the production of hybrid media [8]. Therefore they ran a research study (2008) of new ways for the audience to contribute to these visuals, using a mobile app to upload directly videos to the VJ. This shall approach a new collective experience [6].

3.2 Audience Engagement

Previous works identify different ways for gathering the level of engagement from people. Gathering data during a live concert puts practical constraints on the measurement, since it should not affect the users' experience of the concert. Lang (1995) found a linear correlation between GSR and human arousal [15]. Since the sensors are attached to the users' skin, and therefore do not harm the user, GSR was found as a practical way to measure arousal. There have been several research experiments which build on this approach: Wang et al. (2014) measured the GSR of a group of test users during a live performance. The performance was recorded in video. Later, the video recording was compared with the data gathered from the sensors. Enriched with results from questionnaires and interviews, the researchers validated that GSR sensors are an accurate proxy for measuring audience engagement. There are further opportunities of providing visual, auditory, or haptic live-feedback, based on the measurements of the sensors [21].

Latulipe (2011) supports the approach of interpreting GSR as audience engagement, after running an empirical study with 49 participants. A video of a dance performance was presented to the participants, who were equipped with GSR sensors and scales that allowed them to self-report their current state of emotional reaction [16].

Several sources state the difference between arousal and valence, describing the emotional state. Mandryk et al. (2007) put arousal and valence into an emotional grid in order to distinguish five stages of a user when playing a video game [17]. This distinction refers to the 'Model of affect' introduced by Russel (1994) [18]. Since the GSR sensors can only measure arousal, and not valence, it is not possible to state if the experienced emotion is positive or negative. Latulipe (2011) ran an exploratory study, in which she showed audience engagement data of performances to performance arts experts. These experts stated that without a causal explanation, the valence factor would not be interesting anyway, since valence is a very subjective variable [16].

3.3 Immersion

Immersion is an aspect which occurs in gaming, as well as virtual environments, but also in visiting art exhibitions or watching movies. Several measurement questionnaires have been developed and tested. Witmer et al. (1994) define immersion and involvement as two important aspects for experiencing presence. They introduced a 'presence questionnaire' to measure presence in virtual environments [22]. Jennett et al. (2008) developed a questionnaire to measure immersion in games [13]. They base their definition of immersion on two descriptive studies of Brown and Cairns (2004) and Haywood and Cairns (2005). In the first study, 'gamers' were interviewed about their experience in playing computer games [4], the second study dealt with children in an interactive exhibition [10]. Jennett et al. state in their research that immersion consists of three features [13]:

- Lack of awareness of time
- Loss of awareness of the real world
- Involvement and sense of being in the task environment

3.4 Togetherness

The aspect of 'togetherness' is equated in this research as the degree of 'feeling part of a group'. In a music show, the audience member can feel as part of the audience, but also - when included with GSR data in the visualization - part of the concert/show. Previous works describe different approaches to measure the feeling of being part of a group. The 'group attitude scale' (GAS) is a measurement tool with 20-items, which was developed to measure attraction to a group. The selected items were tested in several studies and provide a valid measure of attraction to group [9].

Besides text based measurement tools, there are also graphical measurement options to get an insight on to what degree a person feels part of a group. Schubert et al. (2002) developed a pictorial scale of 'Ingroup - Outgroup Overlap' and 'Self-Group Overlap' (OSIO) [20], building up on the 'inclusion of others in self' (IOS) scale of Aron et al. (1992) [1]. The tested and proven OSIO measure scales are easy to use and well comprehended.

4. EXPERIMENTS AND EVALUATION

The Goethe-Institut e.V. is a German language and culture institution with institutes around the world. Besides German classes, there regularly are cultural events, including lectures, discussions, exhibitions and concerts. The Goethe-Institut in Amsterdam launched a new monthly Jazz-series. The first concert of these series was taken as an example of a real live scenario. The concert organizer, the musicians performing at this concert and the audience were involved in this research. The milestones of this research included the following steps (see figure 1).

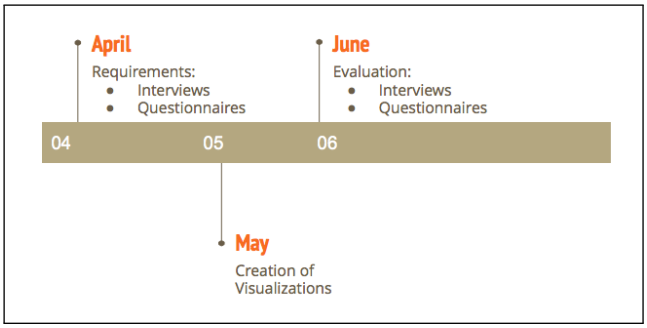

Figure 1: Milestones of the research

This research followed a mixed methodology approach: Both requirement gathering and evaluation were done using qualitatively and quantitatively mechanisms. First, requirements were gathered through interviews with the musicians and the concert organizer. The interviews were followed by the first experiment, where GSR data was gathered from the concert audience. Requirements from the audience were gathered through questionnaires. According to these requirements, visualizations were created, which were evaluated quantitatively in a second experiment with potential audience members. Additionally, a qualitative evaluation was conducted with the musicians and the concert organizer.

4.1 Setup: Requirement gathering

Initial interviews gave first impressions and information about the requirements and expectations of the visualization. The expert and the musician were interviewed in a semi-structured way in order to gain more insights about what the persons in different roles would expect from a visualization that shows the audience's engagement. The interviews with the concert organizer and the musicians were held in person or on the phone, recorded and transcribed.

The quantitative requirement gathering was set up with the audience of the concert. The concert (see figure 2) was acoustically and visually recorded; the recordings were temporally aligned. During the concert, the engagement of 40 users was gathered with GSR sensors and stored (see figure 3).

Figure 2: Jazz concert with audience

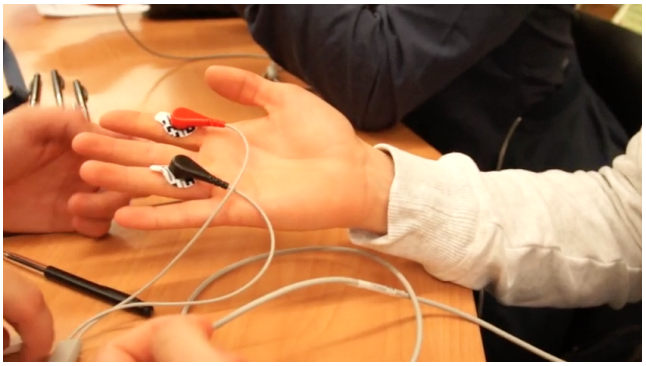

Figure 3: Audience member with GSR sensor

The 40 concert attendees were handed out questionnaires before and after the concert. The concert attendees were a mixed crowd of students and culturally interested persons between 19 and 70 years, mixed in gender (15 male, 25 female) and mainly based in Amsterdam.

With the questionnaire before the concert (Appendix A), general information was gathered, how often attendees visit cultural events, weather they know the bands performing on this evening. Since alcohol consumption could affect the GSR, the attendees were asked, how much alcohol they drank and how their current state of emotion is. The current state of emotion was identified with the 'self assessment manikin', introduced by Bradley and Lang (1994) [3]. After the concert, the questionnaire (Appendix B) asked the same questions about the current emotional state, alcohol consumption, but also about the attendee's expectations for future audience engagement visualizations. Expectations were gathered with Likert scales from 1 to 5, (1 = 'I fully disagree', 5 = 'I fully agree').

4.2 Setup: Evaluation

The evaluation was also conducted with a mixed methodology approach. A qualitative evaluation was performed through semi-structured interviews with the concert organizer in person and one of the musicians on the phone. The interview with the concert organizer was recorded and transcribed. Due to technical issues, the recording of the musician failed, therefore the key concepts extracted from the interview, were summed up and confirmed with the musician via Email.

A full-factor quantitative evaluation with 16 potential concert visitors was conducted. Participants were mainly students, researchers and young professionals. The setup was as follows: Participants were seated in front of a screen. The experiment was held with either two or three participants at the same time. Prior steps of the research were explained to the participants. Participants were asked to imagine themselves in the audience of the concert, wearing the GSR sensors, while seeing the visualizations projected behind the band. Participants were shown two excerpts (1:15 min) of the recorded concert, enriched with the two visualizations. Each excerpt was tested in a full-factor procedure, meaning under four conditions, see figure 4. One excerpt was chosen out of a calm play, the other one out of a rhythmic, energetic part of the concert.

In total, each participant watched eight video clips. The

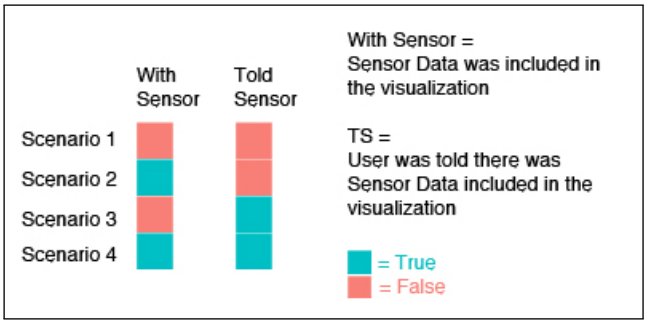

Figure 4: Full-Factor experiment setup

Aspect	Nr. questions	Based on	Measure scale
Immersion	3	[23], [19]	5-point Lickert
Togetherness	2	[9]	5-point Lickert
Togetherness	2	[20]	OSIO
Identification	1	-	5-point Lickert

Table 1: Questionnaire for the evaluation of the visualization

clips were randomized to prevent an influence of fatigue effect on the results. After each video clip, participants had to fill out a one page questionnaire (Appendix C/D). 3 questions to measure immersion were taken from previous research from Zhu et al.(2015) [23], which is based on the work of Schubert et al. (2001) [19]. 4 questions to measure togetherness were adapted from previous research of the 'group attitude scale' [9] and 'assessment of Self-Group Overlap' [20] (see table 1). For Scenario 3 and 4 the questionnaire had one additional question, which asked if the user could identify herself/himself in the visualization (Appendix C).

5. REQUIREMENTS FOR THE VISUALIZATION

Insights gained from the interviews showed that sensing and feeling the audience is very important for the musicians interviewed.

"Otherwise I would only record CDs. If you enter the stage, you already feel the atmosphere, so you know what the vibe is a little bit." [12]

Both musicians pointed out that a live visualization during the concert would not be valuable for them. Either because their eyes are closed during playing, but rather more - if the visualization would show that the audience engagement is low - they would feel insecure about their play and get influenced by the visualization. Still, both musicians mentioned, if the visualization would show a very highly engaged audience, the visualization would influence them in a positive way and strengthen them in their play. All in all, the musicians see the potential of a live visualization more for the audience than themselves [12] [11].

"Maybe for the audience it would be better. Maybe it should be projected behind you and then the audience can see. Because I think this is really interesting. Maybe it even creates a feeling of collective." [12]

The perspective of the concert organizer follows this direction. A live visualization of the audience engagement would not be used for evaluations of the event.

"You cannot evaluate art, put it into numbers" [14].

Rather more, the concert organizer sees this experiment as a new way to form a collective artwork, giving the concert an added artistic visual value. Hearing of the concerns of the artists, that the visualization might insecure them, the concert organizer points out clearly, that the most important part of an event is, that the artists are happy and get their space to perform their art, without being disturbed. A live visualization of the audience engagement has to be coordinated very closely to the choreography of the performing artist, the artistic aspect is very important [14].

Results from the questionnaires showed that the users were very interested in the gathered data (mean of 4.55) and also very interested in a live-visualization during a concert: mean of 4.075 (see figure 5). The users were interested in the general mood of the audience (mean of 3.8), but still wanted to be able to identify themselves in the visualization (mean of 3.7). Privacy concerns were voted as not very high (2.1). 77 percent of the attendees stated, a live visualization would influence their concert experience, while 23 percent did not see an influence, if the sensor data would be visualized live during the concert. In comparison, weather the visualization would enrich the experience or distract from the music, the users were quite indecisive. Both mean values are found in the middle of the scale, while the users tend to say that the visualization would rather distract from the music (mean: 3,2), than enrich the experience (mean: 2,85).

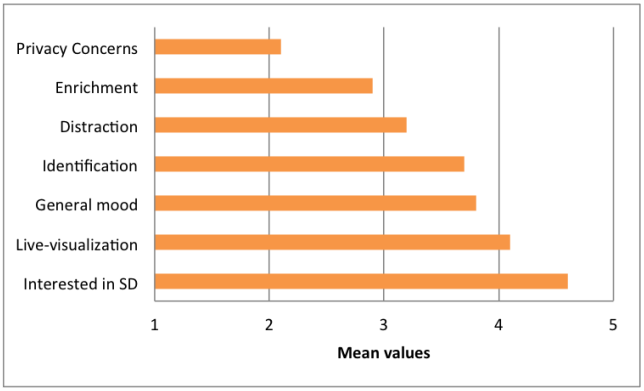

Figure 5: Mean values of questionnaire results

Regarding the influence of this visualization depending on the mood reaches into the same direction as the estimation of the musicians [2]:
"If everyone seemed to be enjoying themselves it might make me feel better. If everyone seemed bored, however, it may make me feel bored too"

"I might get carried away with the general vibe even if it's not my own personal experience"

"Probably I would be influenced by the opinion/feeling of the

other people so I would be distracted"

An unexpected feature appeared while scanning the questionnaire results: Some audience members saw the potential of 'gamification' in the visualized data, wanting to try to influence their engagement values:

"It would be great sideshow for those not engaged by the main show. Also a lot of people would probably try to see if they could influence the visualization/compete for who could set the highest GSR"

Most important findings

- Visualization more interesting for the audience than musicians
- Audience is interested in GSR data and its visualization
- Low privacy concerns
- Visualization could enrich/distract

Requirements gathered for the visualization

- Visualization as **'collective artwork'**
- **Identification**: Audience members should be able to identify themselves in the visualization
- Visualization should show the **general mood** of the audience
- Visualization not meant for **evaluation**

6. CREATION OF THE VISUALIZATIONS

Based on the requirements gathered from the cultural expert, the musicians and the audience, two visualizations were created using Processing, a programming language that allows visualizations based on different input types. While one visualization just takes the music as an input, the second visualization takes two parameters as input: the music and the data gathered from the sensors. First, the visualization which is triggered by the sensor data and music was created. By taking the sensor data input away, the second visualization was created which is only triggered by music. In this way the two visualizations only differed in one parameter and were therefore comparable. The gathered data from the concert was pre-processed and stored in a CSV file, which returns for each sensor each second a normalized value between 0 and 1000. The concert recording and the visualization was presented throughout the process in a split-screen, showing on the left side the concert recordings, on the right side the visualization (see figure 6). A timeline in the bottom left side of the screen allowed to jump to different parts of the show.

6.1 Design Step 1: Absolute values, Absolute average mood

With regard to being a 'collective artwork', the concept of the visualization was kept abstract. It was decided to highlight the changes of the GSR data in order to show that

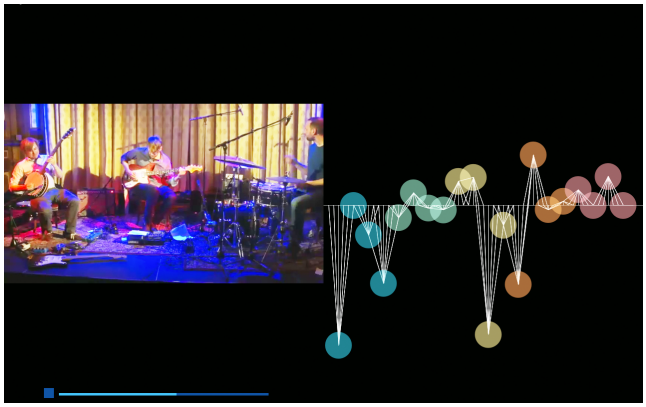

Figure 6: left side: video recording; right side: visualization with absolute values

the audience is triggering and influencing the visualization. Therefore an abstract construct with moving elements was the key feature in the visualization. Meeting the requirement of the audience members to identify themselves in the visualization, each sensor (audience member) was shown individually as a circle, that moved along the y axis according to the value of engagement. The radius of the circle responded to the amplitude of the music (see figure 6).

Additionally, the circles were plotted in different colors, to make the identification more evident. In this example, five colors were used, so each four balls were plotted in the same color. The audience member with the sensor 'blue2' could identify herself/himself as the second blue circle on the screen.

With regard to showing the 'general mood' of the room, the average value of engagement was plotted as a horizontal line. Since the average is pulled and pushed by each audience member, additional lines were plotted between the circles and the average line, in order to create an abstract visualization. The concept behind this visualization was, that the 'general mood' of the room is driven by each audience member's mood.

The requirement to 'not evaluate' was only partly covered with this visualization approach. Showing the average and each audience member above/under the average strives towards elements of evaluation. Although no graphs and numbers are shown, a slight touch of evaluation could be interpreted in this visualization approach.

Additionally, a restriction was realized with this first visualization: the values of the GSR changed gradually, but very slowly. During a concert of one hour duration, there was movement visible, but it was hardly recognizable for the viewer.

6.2 Design Step 2: Mapped relative values, Relative average mood

One approach to intensify the movement of the visualization, was to map each person's individual values across the whole screen. Therefore, for each person, the personal minimum and maximum values were stored, then mapped from the bottom of the screen to the height of the screen (see figure 7). Every person's circle floated in its own range of minimum and maximum values, presenting each person's individual/relative experience and reaction to the music. The

relative average mood was plotted as a horizontal line across the screen (see figure 8).

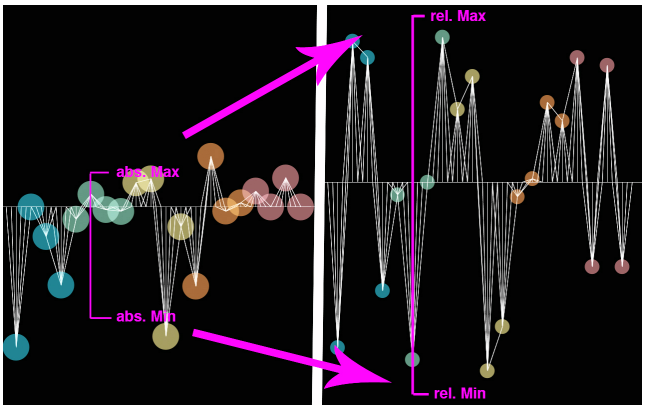

Figure 7: Example of mapping absolute values to relative values: second green circle

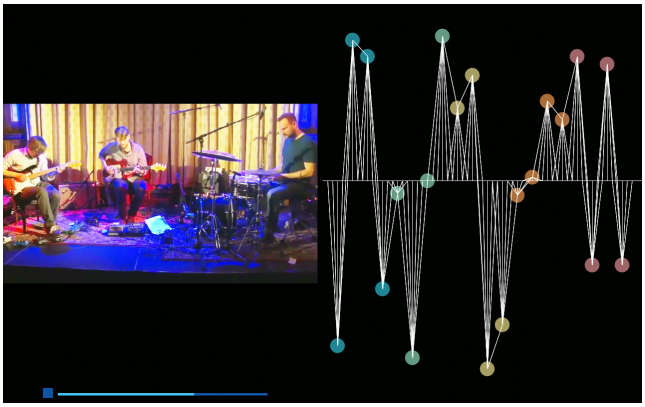

Figure 8: Left side: video recording; Right side: visualization with relative values

To increase the visual focus on movement, the new position of the circle was updated every 5 seconds. With these two adjustments, the visualization was perceived more smoothly and dynamically. Still, the relative average required explanation in order to be understood correctly. Additionally, the implicit indication of 'evaluation' was not solved either. Different approaches to visualize the relative/absolute average in other ways, e.g. changing the background color by the value of the relative/absolute average mood, showed that the relative/absolute average was was not changing much during the whole concert. Therefore the relative average, as well as the absolute average did not contribute a valuable information to the visualization.

6.3 Design Step 3: No Average, Audience in a context

Even though the audience was interested in the 'average mood' in a live visualization, the decision was made not to show the relative/absolute average explicitly as a line, based on the observations described above. Therefore, the final visualization showed only the audience members as circles, floating over the screen, driven by their GSR-data, changing size by the amplitude of the music (see figure 9). Still, the connection of the audience was important for the concept of the visualization. Therefore, the audience members were connected to each other with lines. The movement of the audience member pulled the lines with them. An abstract, constantly changing, collective artwork was created, triggered by the feelings of the audience and the music. Even though the 'general mood' of the audience was not explicitly shown with a line anymore, the constant movement and re-formation of the abstract visualization could be understood as the 'general mood' of the room. By scanning the QR codes in figure 10, the two video excerpts will be shown, with the final visualizations including the sensor data.

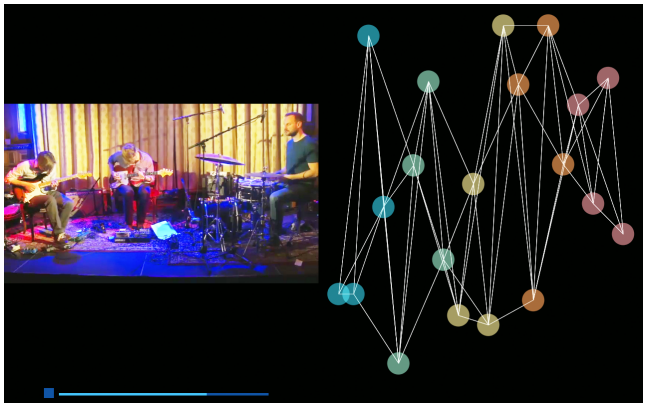

Figure 9: Left side: video recording; Right side: visualization with no relative/absolute average

Figure 10: Please scan the QR-codes to see videos of the shown excerpts. Left: Excerpt calm play, right: excerpt energetic play; Both visualizations with sensor data

7. EVALUATION OF THE VISUALIZATIONS

7.1 Results: Quantitative analysis

The results of the questionnaires were analyzed statistically. Both the questions concerning immersion and togetherness showed an internal consistency of Cronbach's Alpha, immersion with an alpha of 0.8, togetherness with an alpha of 0.85. These high values state an internal consistency and therefore confirm that the 4 questions regarding togetherness measure the same construct, as well as the 3 questions regarding immersion measure the same construct. Therefore, the questions could be summed up for further analysis

into one variable for 'togetherness' and one variable for 'immersion'.

Both the correlation between liking the music of the video clip and immersion/togetherness were moderate, immersion with 0.47 and togetherness with 0.45.

The Friedman test was conducted to find significant differences between the four testing scenarios. A p-value below 0.05 confirms a significant difference between two testing scenarios. Surprisingly, the two video clips showed different results regarding immersion and togetherness.

With respect to immersion, the calm video clip showed a significant difference between the testing scenarios 1 and 4 , with a p-value of 0.022. The comparison of scenario 3 and 4 was slightly over the acceptance level (p-value: 0.061) (see figure 11). The results suggest that regarding immersion of the calm video, there was a difference perceived, when the sensor data was included in the visualization. The difference was even higher, when the participants were conscious of the sensor data included. With respect to immersion, in the energetic video clip there was no significant difference found between the four testing scenarios (see figure 12). Still, not being statistically significantly proven, the figure shows a small difference when the sensor data was shown, compared to the scenarios where it was not shown. An evaluation in more realistic settings could possibly prove this difference also statistically.

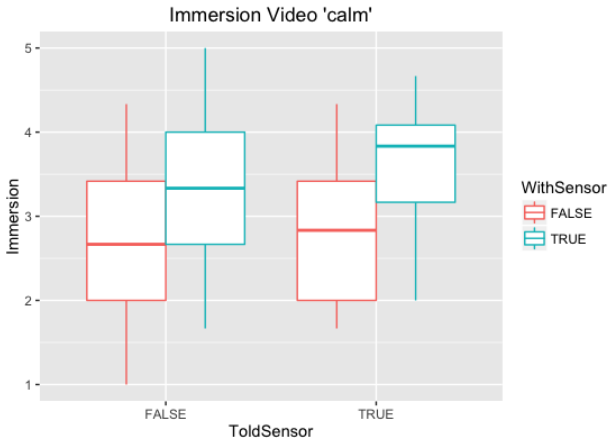

Figure 11: Level of immersion: Video calm; Scenarios 1-4 from left to right

Reasoning for this outcome in this research could be, since the visualization is also triggered by the amplitude of the music, the visualization of the calm concert excerpt shows more variance in the size of the circles, which leads to more obvious transformations in the visualization. The movement of the circles according to sensor data in continuously and evenly spread over the circles. The visualization is perceived as a flowing movement, which raises immersion. The visualization for the energetic part of the concert is triggered by a constant high level of the music amplitude, which leads the focus more on the colorful bright circles, that only show show a small variance of size. While the calm visualization shows more a general flow of the circles, in the energetic part, single circles change at certain times their position quickly, which could minder the aspect of immersion.

Regarding togetherness, the results show for both video

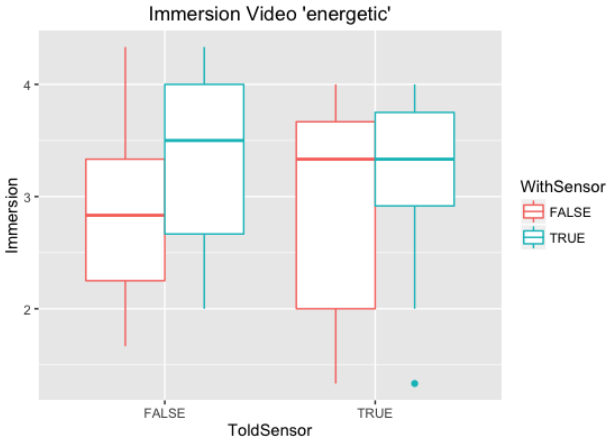

Figure 12: Level of immersion: video energetic; Scenarios 1-4 from left to right

clips more similar outcomes (see figure 13 and 14). In both clips the highest significant difference (p-value calm video: 0.025, energetic video: 0.018) was perceived between scenario 1 and 4, stating that including the sensor data in the visualization, while participants are aware of that, increases the feeling of togetherness. A different perception towards togetherness also occurred, when participants were told that sensor data was included, but in truth it was not included: The comparison of scenario 3 and 4 revealed a p-value of 0.033 for the energetic video and a p-value of 0.055 for the calm video. The slightly too high value could be still accepted because of the small test-set and has to be confirmed through further tests.

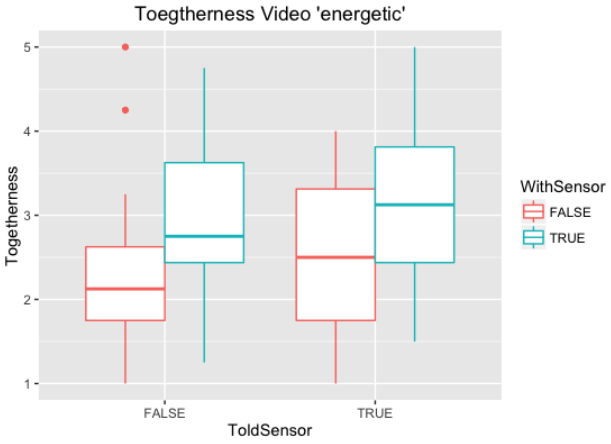

Figure 13: Level of togetherness: video energetic; Scenarios 1-4 from left to right

In respect to togetherness, still the two video clips have a different outcome in the comparison of scenario 1 and 2. In both scenarios, the test persons were told that the visualization was only triggered by music, while in scenario 2, the sensor data was in fact included. In the energetic video clip, this comparison was perceived with a significant difference (p-value = 0.049), while in the calm video there was no significant difference perceived between these two

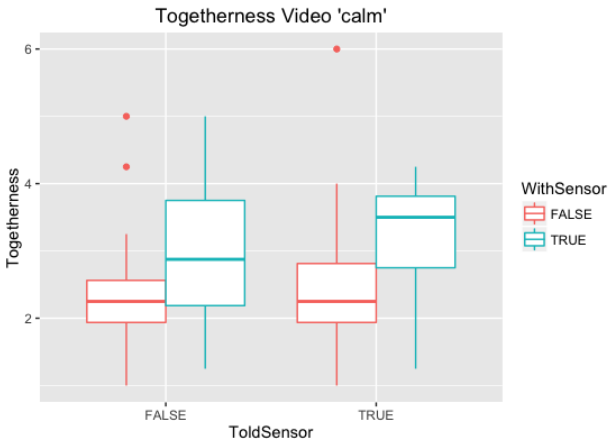

Figure 14: Level of togetherness: video calm; Scenarios 1-4 from left to right

scenarios (p-value = 0.11). Explanation for this different perception could be here as well the difference in the visualization caused by the amplitude of the music. Since the calm video clip shows variation and modification of the visualization through the changes of amplitude, the missing movement triggered by the sensor data is not that obvious. Additionally, the movement caused by sensor data in the energetic video clip is more abrupt and punctual, which pulls attention to it. Under the aspect of 'togetherness' this feeling could increase, when seeing the aprupt change of the visualization.

In summary these results show that there is a difference in perception regarding togetherness and immersion, when sensor data is included in the visualization. This effect also occurs when participants think their sensor data is visualized, but in fact it is not. This difference could not be proven statistically in all scenarios, but shows a trend towards it in the visualized graphs. Further tests have to be conducted to prove the difference statistically in all scenarios.

In the questionnaires of scenario 3 and 4 (The users were told there is sensor data included in the visualization), one additional question was included. The participants were asked, weather they could identify themselves, if their sensor ID would be 'blue2'. This identification was rated as not very high, with a mean of 1.02 on a scale from 1 to 5 (1 = 'I fully disagree', 5 = 'I fully agree'). This question in the questionnaire raised a lot of questions in the experiment, which could be interpreted that the participants did not completely understand what was meant with this question. This issue in the experiment could have raised out of the fact that the experiment was conducted in an experimental room and not in a live scenario of an actual concert. Further testing during a live concert could give more insight, if the attendees would identify themselves in a visualization, when actually wearing a sensor, labeled 'blue2' and seeing the visualization live on the screen.

7.2 Results: Qualitative analysis

The qualitative evaluation confirmed that the created visualization was perceived as a 'collective artwork', that enriches the concert. The concert organizer sees a potential added value in respect to the experience of the event, where the audience is included.

"It would increase the live-experience when the audience is included in the uniqueness. Emotions are always unique - what you feel in this moment, you will never feel in this way again. This is why people go to concerts - to feel this uniqueness of the moment. And seeing this uniqueness of the moment visualized for the audience, this is an incredible added value"

Furthermore, she states, *"It is not about only the listening. When you go nowadays to a cultural event, you want to feel and experience."*

As the different design steps are discussed, she agrees with the decision to eliminate the 'average' in the visualization, since a concert experience is *"highly individual."*

"The average is not relevant, we don't need the average. [...] We live in a society where we become more and more individualized and in a 'narcissist' kind of way we want to be mirrored [in the visualization]. We all want to know more about us... And it also looks nicer!"

Finally, she highlights the collaborative aspect of an concert, which is represented in the visualization by the connecting lines between the circles (audience members).

"The atmosphere of the evening is created by the cooperation of all involved participants, also the audience, of course." [14]

When presented the final visualization, the musician remained at the opinion, that a live-visualization of the audience engagement would not be of a great value for themselves. This procedure would not be established in an everyday routine of concerts. Still, he pointed out that he could imagine this visualization as a 'happening', experiment, on a special night, in order "*to bring two art forms together*" [11] .

7.3 Summary of evaluation

Summarizing the quantitative and qualitative evaluation, the requirements of the visualization were met. The quantitative results suggest that there is an association between the notion of the sensor data and the visualization of it. Still, in some cases this difference could not be proven significantly by statistics, but the plotted graphs show a difference (see figure 11-14). Further test have to be conducted, in order to prove this difference statistically. Both criteria of the collective artwork and the requirement of 'no evaluation' were confirmed. The 'general mood' is only shown implicitly through the re-formation of the visualization; the decision to not show the average mood through a plotted line was supported by the expert, regarding the trade-off with the requirement not using the visualization for evaluation. Only the identification of the audience members did not score as expected. This has to be tested in a live scenario and improved.

Evaluation of the visualization

- **'collective artwork'** (achieved ✓)
- **Identification**: needs to be improved, or tested in live scenario
- **(Implicit) general mood** (achieved ✓)
- **No evaluation** (achieved ✓)

8. DISCUSSION AND FUTURE RESEARCH

The quantitative findings showed that the increase of immersion and togetherness were dependent on the visualization, but also on the music event. This aspect should be evaluated in a setting of more realistic conditions in further research.

Out of several reasons a live-scenario testing is indispensable: the evaluation of the visualization was conducted in an experimental room, which required a high degree of imagination from the participants. Therefore a further experiment is proposed, where the visualization is tested live during a concert. This would help the participants to understand better the context. In this way, it is presumed for example, that the identification of the audience members in the visualization will be understood better. Furthermore, user testings with different kind of identifications within the visualization are needed, in order to make it easy and understandable for the concert attendee to identify herself/himself in the visualization. Additionally, the concept of 'togetherness' is hard to measure, when test persons have to imagine themselves, being in a group, while in fact not being physically there.

The created visualization is based on a basic concept and developed out of requirements from the three different roles participating in a music event. In order to bring the visualization closer together with the music act, it would be advisable to define and adjust the visual elements beforehand with the musicians and concert organizer into an integral and complete audio-visual concept for a deeper experience. This was also supported by the concert organizer.

Human arousal is a very sensitive variable, which can be triggered by various elements. Further research should be conducted to learn more about the confounders. In a live setting at a concert or a nightclub, the emotions of the audience are not only triggered by the music, also by social interaction, conversations, personal thoughts; but also factors like alcohol or drugs could influence the human arousal. Further research in this field should examine, how different factors influence the GSR data and therefore would also influence the visualization. Some of the variables are measurable, like the amount of alcohol, as it was conducted in the questionnaire of the concert. Other variables, like personal thoughts are much more difficult to measure objectively. This field opens a wide range of further research areas.

Since the audience is an included part in the visualization, the chance of distraction increases as well. The visualization itself could also be a trigger which influences the arousal and therefore the GSR - which would also influence the visualization again. This could lead to a spiral of perceived experience through the visualization and the created emotions through the visualization. It could possibly intensify, but maybe also distort the visualized emotion.

Additionally, in this experiment, the data was gathered, stored and pre-processed, before it was used as an input for the visualization. These steps have to be implemented in a live-algorithm, before the visualization can be tested in a live scenario, a concert or a nightclub.

The main goal of the current study was to determine weather a live visualization would add value to the experience of a concert. This question can be confirmed. Still, the study revealed that there are various further research areas which occur in this field of human arousal during live events. For the cultural scene the outcomes are valuable and serve as inspiration for which purposes such visualizations could be useful and how they could be integrated into events in order to create multi-layered shared experience.

9. CONCLUSION

This study has shown that in general a visualization of audience engagement increases the experience of the concert audience, increasing togetherness and immersion. The effect is higher, when the audience is aware that the sensor data is shown. Still, it was found that the measurable increase of togetherness and immersion is dependent on the visualization itself. In this specific research it was dependent on the amplitude of the music, which was a trigger for the visualization. Further research in a live setting and a bigger sample size will bring better insights.

For musicians and concert organizer, this approach of visualization is not (yet) seen as a feature in the daily concert business, rather it is seen as a 'happening', an experimental way towards new collaborative artworks and concert experiences. The aspect of evaluation of the event through the sensor data is not welcomed and was stressed throughout the project by the musicians and the concert organizer. Rather, it is the emotional, artistic, collaborative aspect, that appeals the interviewed experts. Sensor data could be used to highlight the already existing important features of a live event: experiencing the 'live-moment', which is unique. A visualization of the uniqueness of a moment including the live emotions in the room could deepen and enrich the experience of the audience.

10. ACKNOWLEDGMENTS

The author wants to thank her supervisor Dr. Pablo Cesar for the guidance and freedom to experiment throughout the project, all members of the research group DIS of CWI for support during the experiments and valuable reflection, Hans-Georg Thönges, the director of the Goethe-Institut Amsterdam and Sophia Karimi, responsible for the Jazz series, for the cooperation in this project and the trust in it, the musicians Maarten Hogenhuis and Tobias Hoffmann, for the interviews and openness towards this experiment, all participants for their interest and time, Kevin Mayo for encouraging reflections and discussions about the visualization as well as the processing lessons, last but not least family and friends for support throughout this project.

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APPENDIX

A. PRE-QUESTIONNAIRE CONCERT

B. POST-QUESTIONNAIRE CONCERT

C. QUESTIONNAIRE EVALUATION (WITH SENSORS)

D. QUESTIONNAIRE EVALUATION (WITHOUT SENSORS)

Jazz Concert Experiment (pre-questionnaire)

Please fill in the questions below

SENSOR Nr. ……

(EVALUATION CODE)

1. **Do you know the bands performing today?**
   - ☐ I know both bands (1)
   - ☐ I know only Maarten Hogenhuis Trio (2)
   - ☐ I know only Tobias Hoffmann Trio (3)
   - ☐ I don't know any of the bands (4)

2. **Are you interested in the concert today?**

	1	2	3	4	5	
I have no interest at all	☐	☐	☐	☐	☐	I have extreme interest

3. **Do you like Jazz music?**

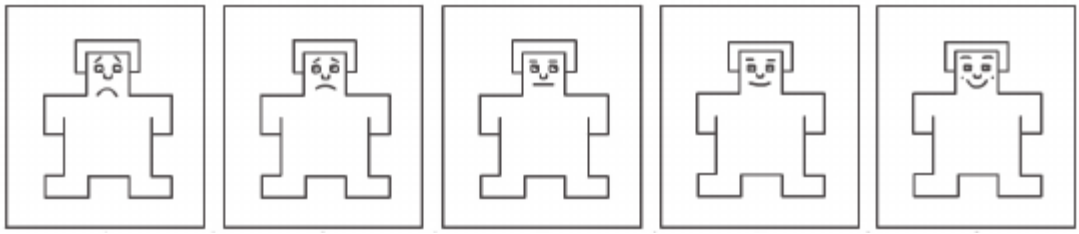
	1	2	3	4	5	
I don't like jazz at all	☐	☐	☐	☐	☐	I love jazz music

4. **Background**

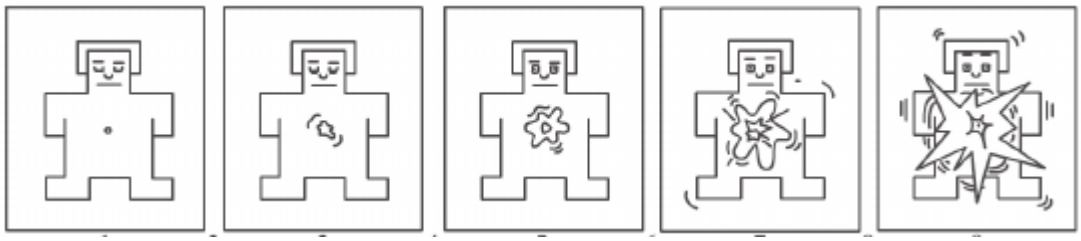
In the past year, how many times did you attend a live concert?

- ☐ 0 (1)
- ☐ 1 – 6(2)
- ☐ 7 – 12 (3)
- ☐ 12 + (4)

5. **What is your mood at the moment?** (1-5)



6. **How calm/excited do you feel at the moment?** (1-5)



7. **How much alcohol did you consume in the last 2 hours?** (1-3)

☐ 0

☐ 1 or 2 glasses of wine/beer

☐ more than 2 glasses of wine/beer

8. **Gender** (1-3)

☐ Male

☐ Female

☐ Prefer not to disclose

9. **Age**

……

Jazz Concert Experiment (post-questionnaire)

Please fill in the questions below.

SENSOR Nr. …….

(EVALUATION CODE)

1. How was your experience with the sensor?

	1	2	3	4	5	
The sensor disturbed my experience	☐	☐	☐	☐	☐	My experience was not disturbed by the sensor

2. Are you interested in the gathered data from the sensors?

	1	2	3	4	5	
No, I'm not interested In the gathered data	☐	☐	☐	☐	☐	Yes, I'm very interested in the gathered data

3. Would you like to see the data live during a concert?

	1	2	3	4	5	
No, I'm not interested in a live visualization	☐	☐	☐	☐	☐	Yes, I'm very interested in a live visualization

4. **Live visualization of the data: Please let us know, if you agree or not agree with the following statements:**

A "If this data would be visualized during a concert, I would like to see the general mood of the audience in the room."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

B "If this data would be visualized during a concert, I would like to see each audience member separately, but anonymous, visualized."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

C "If this data would be visualized during a concert, I would like to identify myself in the visualization."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

D "If this data would be visualized during a concert, I see no problem if other people are able to identify myself in the visualization."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

E "A live visualization of the audience engagement during a concert would enrich my experience at the concert."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

F "A live visualization of the audience engagement during a concert would distract me from the music."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

G "I have privacy concerns, if this data would be visualized live during a concert."

	1	2	3	4	5	
I fully disagree	☐	☐	☐	☐	☐	I fully agree

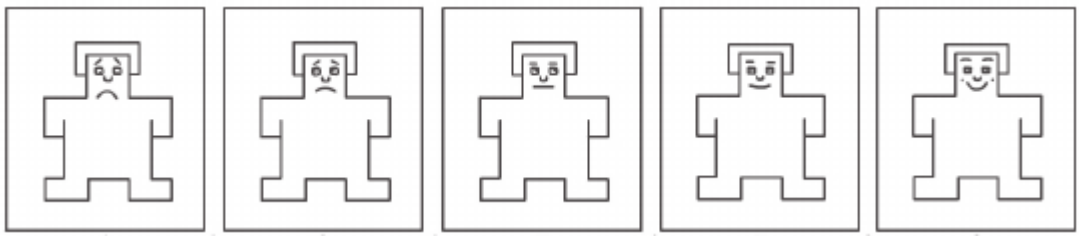
5. **Would a live visualization during a concert influence your experience? (1/2)**

☐ yes

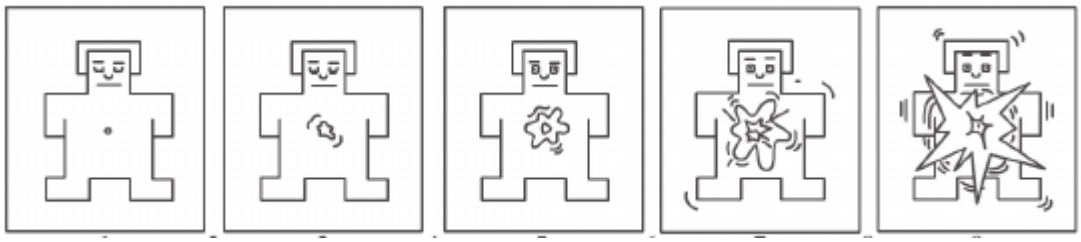
☐ no

6. **In what way would it influence you/not influence your experience?**

7. **What is your mood at the moment? (1-5)**



8. **How calm/excited do you feel at the moment? (1-5)**



9. How much alcohol did you consume during the concert? (1-3)

☐ 0

☐ 1 or 2 glasses of wine/beer

☐ more than 2 glasses of wine/beer

10. How many times did you leave the concert hall during the show? (1-3)

☐ never

☐ 1 or 2 times

☐ more than 2 times

11. Anything else you want to share with us?

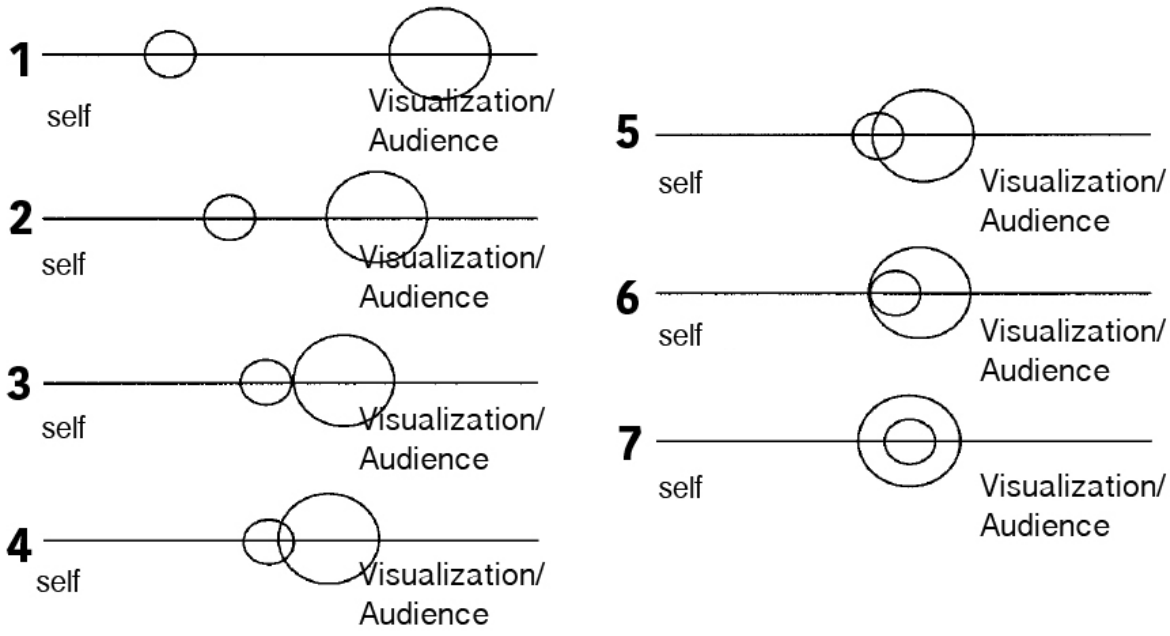
Questionnaire Evaluation Visualization: Q13 - Q14 - Q23 - Q24

Please answer the questions, imagining yourself in this situation:

You are in the audience of the concert and are **wearing a sensor** on your hand that measures your Galvanic Skin Response (which could be understood as a human's arousal).
The visualization is shown live on a screen behind the band.
The visualization is **driven by the music and sensor data** of the audience members, **including yourself**.

I fully disagree *1 2 3 4 5* **I fully agree**	**1**	**2**	**3**	**4**	**5**
1. *" When I was watching the visualization, I lost track of the world around me"*	☐	☐	☐	☐	☐
2. *" When I was watching the visualization, I still paid attention to the world around me."*	☐	☐	☐	☐	☐
3. *" I was completely captivated by the visualization."*	☐	☐	☐	☐	☐
4. *"I felt involved in what is happening with the visualization."*	☐	☐	☐	☐	☐
5. *"I felt involved in what is happening with the audience."*	☐	☐	☐	☐	☐
6. *"I liked the music of the clip"*	☐	☐	☐	☐	☐
7. *Your sensor Id is 'Blue2'. "I can identify myself in the visualization"*	☐	☐	☐	☐	☐

(See graph below)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
8. *To what extend did you feel part of the visualization?*	☐	☐	☐	☐	☐	☐	☐
9. *To what extend did you feel part of the audience?*	☐	☐	☐	☐	☐	☐	☐



Questionnaire Evaluation Visualization: Q11 - Q12 - Q21 - Q22

Please answer the questions, imagining yourself in this situation:

You are in the audience of the concert.
The visualization is shown live on a screen behind the band.
The visualization is driven by the music.

I fully disagree *1 2 3 4 5* **I fully agree**	**1**	**2**	**3**	**4**	**5**
1. *" When I was watching the visualization, I lost track of the world around me"*	☐	☐	☐	☐	☐
2. *" When I was watching the visualization, I still paid attention to the world around me."*	☐	☐	☐	☐	☐
3. *" I was completely captivated by the visualization."*	☐	☐	☐	☐	☐
4. *"I felt involved in what is happening with the visualization."*	☐	☐	☐	☐	☐
5. *"I felt involved in what is happening with the audience."*	☐	☐	☐	☐	☐
6. *"I liked the music of the clip"*	☐	☐	☐	☐	☐

(See graph below)	**1**	**2**	**3**	**4**	**5**	**6**	**7**
7. *To what extend did you feel part of the visualization?*	☐	☐	☐	☐	☐	☐	☐
8. *To what extend did you feel part of the audience?*	☐	☐	☐	☐	☐	☐	☐