Airea: Arts and Interdisciplinary Research

DOI: https://doi.org/10.2218/airea.2764
www.journals.ed.ac.uk/airea

ARTICLE

Revealing the Invisible City: Comprehending the human-city bond through data visualisation and sonification

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"Exposing the Invisible: A Brain-driven Audiovisual Walk" is an audiovisual installation that we deveoped for a univeristy project entitled *Invisible Cities*. This paper analyses the research methodlogy, experimental process and compositional strategies that were devised for the installation. We explore the possibilities afforded from the creative combination of sounds, visuals, emotions and places, as well general aesthetic considerations relevant to data sonification and visualisation. Our approach conceptualised visualisation as a bridge to links emotions with various types of visual elements. Moreover, we identified sonification as a translation of the inaudible into the realm of the audible. Crucially, we use the combination of visualisation and sonification as an instrument for comprehending the bond between humans and cities, via the embodied sensory experience of place. Our artistic practice, inspired by interactions between the lived body and the urban environment, uses the EEG data in order to reflect upon and re-interpret this bond.

Keywords: EEG, emotions, affective data, video art installation, transmedia, ambisonics, data visualisation, data sonification, embodiment, lived body, urbanism.

Introduction

In Calvino's *Invisible Cities*, a fictionalised Marco Polo regales Emperor Kublai Khan with stories about his travels to a variety of cities. It is arguable that the cities turn out to be just one city seen from many angles, or even that this city may exist only in the mind. Marco Polo wants to uncover the hidden reasons that force people to live in cities. Based on *Invisible Cities*, this project was developed as part of the University of Edinburgh *Digital Media Studio Project* course. We aimed to understand the relationships between urban cities and the invisible elements that fulfil one's individual experience of living within them. The project brought together a variety of disciplines, culminating in the production of an installation work. Our team was comprised of digital media and sound design students. As Calvino states in the book "words were more useful than objects and gestures in listing the most important things of every province and city [...] and yet when Polo began to talk about how life must be in those places, [...], words failed him, and little by little, he went back to relying on gestures, grimaces, glances" (Calvino 1974, 39). Even though a city can be understood through "words" or concrete representations, it is not possible to fully experience it through these references, due to the range of information that constitutes human perception.

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Our audiovisual art installation "Exposing the Invisible City: A Brain-driven Audiovisual Walk" aimed to detect and reveal invisible aspects of urban life in order to create an artistic representation of the interaction between the lived body and the urban environment. To explore the relationship between emotions and the city, we decided to use an EEG headset to collect affective data from a group of participants as they explored a city. EEG, an abbreviation of Electroencephalography, is widely used to monitor brain activity from a human subject. It is capable of retrieving data regarding the emotional and cognitive state of the subject's brain (Ramirez and Vamvakousis 2012, 16). We measured the affective response of our participants whilst they walked along a predefined route in the city centre of Edinburgh. Four parameters – "valence"[1], "frustration", "focus"[2], and "excitement" - were recorded into a dataset, which was then mapped to a visualisation and sonification of the walk. This resulted in an audiovisual piece that maps the visual to the invisible and the audible to the inaudible, in a creative representation of the route.

Theoretical framework

We will give a short overview of the theoretical framework that we used to inform the design and analysis of our installation. The phenomenological approach[3] has been applied to a wide set of technologies and research topics in the study of human-computer/system interaction (HCI) design, including interactive art installations. In the development of our installation, we applied the phenomenological approach in order to examine relationships between our design, our tools, our installations and our audience. We specifically applied phenomenological concepts of *intentionality* (world-as-meant), *lifeworld* (a cultural and personal background), *perception* (a mediating link to the phenomenal world) and *the lived body* (the body as it experiences and is experienced). We used this conceptual focus in order to establish a theoretical ground that we could use to examine the experiences of ourselves and the audience.

Intentionality is, according to Bullington, the central structure of an experience. It characterises the way in which consciousness always points towards or "intends" the world-as-meant (Bullington 2013). Svenaes argues that the cultural and personal background of a user serves as a frame of reference and provides a context for every phenomenon and situation encountered by that person (Svanæs 2013). In order to understand how the interactivity of our installation could be meaningful for its users, we considered the lifeworld of our audience. To achieve this, we used an ambisonic microphone to record sound. Ambisonics is a sound reproduction format capable of encoding a spherical spatial image of a sound recording in a way that allows these spatial features reproduced via a loudspeaker system. We used this technology so that that we could surround our listener with a realistic soundscape, that they can hopefully use to produce an internalised mental map of their surroundings. We used an EEG headset to collect emotional data from participants as they walked through a city. We did this with the intention of exploring and uncovering some hidden features of urban life, i.e. the internal emotional states of citizens in public space. We explored the meanings of the Ambisonic microphone and EEG headset by applying phenomenological concepts to the data collection process. Moreover, as we considered our audience's typical lifeworld, we observed that they might have already walked through and experienced the street that was shown in the installation (the Royal Mile street in Edinburgh). In order to attract our audience into the installation, our work

[1] "Valence" means "the amount of positivity or negativity which a person feels towards something" (Harrison 2013, 8).
[2] "Focus" is associated with concentration and engagement (Emotiv 2014, 31).
[3] Phenomenology is the philosophical movement in Continental philosophy stemming from the works of Edmund Husserl. The term "Phenomenology" means literally the logos (or inherent meaning or order) of phenomena, that is to say, the meaning of that which appears or shows itself to man. How human beings perceive, understand and live the world is the subject matter of phenomenological study (Bullington 2013). In other words, it is "the study of structures of consciousness as experienced from the first-person point of view" (Merriam Webster Dictionary).

offered them a new experience based upon hidden qualities that they might not have noticed during their lived experience of Edinburgh's Old Town.

We also applied the phenomenological concepts of perception and the lived body to our design strategy. This was to show the essential involvement of human existence in the world through processes of perception and embodied interaction. The term "lived body", coined by Edmund Husserl (1990), refers to the body as it is experienced and experiences. This is interpreted by Bullington as "the lived unity of the mind–body-world system" (Bullington 2013, 25). Svanæs describes this notion as "subjects whose existence is in the world, and whose self-awareness arises from interaction with our physical environment or with other subjects" (Svanæs 2013, 8). As we collected data, participants were recorded walking the predefined route whilst wearing the EEG headset. While their body was engaging with the urban environment through the perceptual experience of moving, seeing, and listening, their lived body was experiencing its environment through conscious sensorial perception and the attribution of meaning. Consciousness and meaning emanated from the rhythm generated during the walk, in the way Labelle describes the body that is in "movement in continual negotiation within surrounding patterns" (Labelle 2010, 90). Merleau-Ponty (2013) anchored the concept of perception in the phenomenology of the lived body, in which, as Stienstra puts it, the perceiving subject is incarnated as the mediating link to the phenomenal world (Stienstra 2015). Given that "the body is the container holding emotions and body surface displays them" (Blesser and Salter 2009, 332), the EEG headset detected the emotions of the participants and enabled these materials to be recorded as scientific data. Our objective was to use digital technology to establish ways of experimenting with these couplings and processes.

Visualisation, sonification and space in the installation

We felt it was essential that our usage of emotional data could be understood by our audience, and to achieve this we deployed three different ways of showcasing the data. The use of data visualisation in transmedia artworks is a common practice in recent years. It is often used to provoke artistic impressions upon the user (Wu 2012). An example of this is the "Reefs on the Edge" project by Caitilin de Bérigny Wall and Erika Woolsey (2011), which used a transmedia technological process comprised of surround sound, paintings and visualisation. In this project, the researchers experimented with scientific data, underwater video and sound. The photographic images were edited and projected onto different sculptures. The data were displayed through artistic and abstract visualisations using Processing, an open-source programming language commonly used for new media art projects. The sound designer of the project, Michael Bates, recorded natural reef environments and processed them with the intent of producing an interaction with the images (ibid).

Given that our project aimed to display the feelings of a subject experiencing the city, we felt it was important that our audience was able to understand what they were perceiving as a creative interpretation of this experience. As it is written in *Invisible Cities*, "Marco enters a city: he sees someone in a square living a life or an instant that could be his; he could now be in that man's place" (Calvino 1974, 29). Through our use of screens, our audience were able to perceive another life, which was different form the life that they were used to. We used screens because we felt that they could allow the user to be more engaged to the project, as compared to other methods of presenting information. This is due to the illumination and the constant changing images, which, as Mondloch oberves, "insistently solicits the observer's gaze" (Mondloch 2010, 21). When developing our work, we understood sonification as a form of sonic art and used the EEG data as a type of 'score'[4], which provided the basic temporal structure behind our use of sound. We considered sonification as both a method of representing sound with non-

[4] The audio structure, automation, composition and transformation are directly influenced by the data we collected.

speech data and as an artistic tool. By combining the definition of sonification as both a way to use non-speech sound to represent data and also a source of aesthetic material for an art installation, we opened its meaning to identify the use of scientific data as a way of creating art, rather than just as a method of efficiently representing data values. Although Vickers argues that this approach can subvert the goal of communicating in pursuit of artistic interest (Vickers 2017), we decided to deploy the original EEG readings in our artwork. That way, the role of sonification in this installation was to transport the listener to places that the experiment subjects had visited during the data collection/soundwalk stage, and also to artistically represent the variation of affective data procured from the route.

To capture the soundscape of the route we used an Ambisonic microphone. This technique, which has been used successfully in the past in transmedia art installations such as “ambiStar” by Nikolas Grigoriou and Andreas Floros (2010), allowed us to record a 360-degree sonic image of the walk. As Bull and Back point out, sound is a key element when creating a mental map of a certain place. Sound can relate to memory and perception, giving a sense of “where, how and how long” (Bull and Back 2015, 69). In our case, the use of the Ambisonics recordings taken from distinctive spots along the route enabled us to communicate the omnidirectional nature of the soundscape. We did this with the aim of immersing the user in order to facilitate the creation of the mental map. These recordings were made during parts of the route where the soundscape changed sensibly from one set of sounds to another. For the sonification of the different parameters that we collected using EEG (excitement, frustration, valence and focus) we used psychoacoustic bonds (sounds and audio effects that could influence or represent the parameters) to link the affective data with the sound played. We considered the way Synder catalogues music into two main categories: music that attempts to exploit the listener’s long-term memory, creating hierarchical and associative structures, and music that sabotages the listener's expectations (Synder 2001). We aimed to associate the different EEG parameters with different and distinctive sound codes. We built these codes by using pattern repetition to exploit the listener's memory. The data values were then supported by sound throughout the route, which we hope resulted creating recognisable patterns which were specifically mapped to the variances of emotion data.

During the video, the soundscape spins around the listener to create the illusion of rotational movement. The speed of rotation is directly mapped to our excitement parameter. The higher the value, the faster the soundscape would spin. The frustration parameter was mapped to sound only when it peaked higher than a certain level, otherwise we felt it would disrupt the overall experience. We mapped this parameter to a distortion effect, as these sounds can produce alert and agitated responses from listeners (Bhoria and Gupta 2013). As valence is linked with moods of happiness or sadness, we used a musical cue to represent it. We chose a major mode to represent it harmonically (C Ionian in our case). We then used a relatively fast tempo and a percussive synthesiser patch to compose a melody that represented the happiness parameter. The combination of these three elements (major harmony, fast tempo and percussive timbre) are usually perceived as happy sounding by Western listeners (van der Zwaag et al. 2011). However, we recognise that this might not be the case for those from other cultural backgrounds (Juslin and Sloboda 2010, 769-773). Our focus parameter was mapped to the width of the projected sound. Higher values resulted in a narrower soundscape.

As the duration of the work is determined by its complexity as well as by its purpose (Mondloch 2010), we wanted to create an artwork that could make the spectator feel immersed and engaged throughout. We felt that a duration of five minutes was long enough for our audience to comprehend our project to a good enough level. Moreover, we chose this duration as a response to the idea that long video installations can lead to a distracted audience. As Walter Benjamin argues, traditional art demands concentration, but new media is “received in a state of distraction and through the collective” (Benjamin, Eiland and Jennings 2003, 268). Considering the time parameter, this

installation work aimed to be changing constantly in order to keep the audience focused. The audience took an active role the completion of the work, which we felt was a key component in regards to producing a connection between the user and the installation.

Helen Westgeest points out that video art installations are not only related to visual art but are also related to the spatial context of exhibition (Westgeest 2016). In fact, Mondloch defines spectatorial doubleness as a concept in which the spectator is part of the space and the screen being used to present a narrative (Mondloch 2010). To present a cinematic impression of immersion, by letting the viewer forget about the space and keeping them focused on the receipt of emotional data, our project was displayed in a small, completely dark space. The maximum number of people in the artwork simultaneously was limited to two, and we felt that this helped cement a sense of personality and uniqueness. Inside the spaces, our audiovisual technologies were deployed in such a manner that they would surround our audiences. Taking this into account, our art installation consisted of three screens and a surround loudspeaker system. The screens were located close to each other, so that the user could see each one simultaneously. The screen in the centre was guiding the user through the route, showing the manipulated video. Two additional screens were placed on each side, and showed the visualisations created through Processing. The speakers were surrounding the user. Our audience became the centre of the installation and could receive all audiovisual information without needing to move around the space.

Discussion

The creative use of scientific data is becoming more and more popular in contemporary art practice. This art-making condition benefits from the increasing number of open online datasets, as well as the commercialisation of lab equipment, such as fitness bands and portable EEG headsets. However, as Edmonds et al. point, and as we encountered in our own practice, there is a level of complexity in data interpretation and a lack of reliability in data analysis (Edmonds et al. 2004). In addition, the use of complicated devices designed for scientific experimentation requires a certain degree of expertise on the side of the artist.

According to Leslie and Mullen, the EEG headset device is a technology that can pose such difficulties. These problems can manifest even when applying the simplest models of EEG analysis (Leslie and Mullen 2011, 297). Understanding the physical principles of the equipment was certainly a challenge, especially in regard to the processing of raw data. In the commercial sphere, EEG models are typically accompanied with well-designed interface tools so that users can avoid processing raw data. However, in such cases the accessibility of the data is controlled by the company. For example, the Emotiv Company offers an interface for its EPOC+ model. The application contains an algorithm, *Performance Metrics*, to calculate six parameters (i.e. valence, focus, engagement, excitement, meditation, and frustration) from the raw data. Still, this tool has its limitations. For example, it is not possible to export the data from this algorithm without asking for permission from the company.

Since EEG was developed for professional psychological research, the price of the headset system is not low. After obtaining a device, the conductors of the experiment and the participants need to be trained to properly handle it. The electrodes should be placed in very specific positions, and participants may feel discomfort whilst wearing the system. Various practical issues may also occur during experiments, such as poor communication with the electrodes and noise interference. In our case, we found it challenging to differentiate between stable outputs and errors in the data, which potentially impaired the strategies designed for data mapping. As Filimowicz argues, “much biometric sonification indeed has little to distinguish it from other sensor data, such as seismographs or solar flares” (Filimowicz 2014, 96). However, our conceptualisation and usage of the data helped us to avoid considering it as a sequence of meaningless signal inputs.

The practices of data visualisation and data sonification are normally positioned in two domains: science or art. However, as Supper explains, there are no strict boundaries between these two disciplines (Supper 2012). Scientific applications largely aim to assist in explaining scientific principles, such as diagrams showing correlations or trends in datasets, illustrations of the brain based on sensor data (Figure 1), or the sonication of natural phenomena[5]. Accuracy is a high priority in such cases. In comparison, since our approach falls within the art domain, our focus was primarily based on concepts and aesthetics; we developed design strategies that served our artistic goals. For the purpose of our audiovisual installation, our objective was to attract attention, deliver thoughts, and evoke emotions.

As stated above, this paper has mainly discussed practices that fall into the art domain. We feel that a creative response to the sources of data allows more freedom to interpret the scientific datasets in meaningful ways. However, there are still some grounding principals that we feel should be applied to this method of art practice. Once an artist plans to use scientific data sources, we feel that they should apply rigorous and considered methods to the collection, analysis and interpretation the data. Otherwise, one may as well replace the dataset with random sequences of digits. In the context of our installation, we wanted to reflect the impression of a city by communicating the emotions of our subjects through visual and sonic interpretations. To assess the effectiveness of our installation and the methods that applied whilst realising it, we needed to find out how the audience responded to our work. We conducted interviews with our audience members in order to collect feedback from those who had recently experienced it. Moreover, after we published our work on the Internet, we conducted a survey[6] for additional evaluation. So far, we have received 23 responses, from 15 real installation viewers and 8 online video viewers. Most of questions in the interviews and the questionnaire were asking participants about their subjective feelings and opinions. We admit that people might not describe their emotions accurately enough in words or ratings, but the feedback and survey results still provided us with many insights and suggestions for future development. On average, viewers rated 3.609 on a 1-5 scale (Figure 1) for how much they agreed with the statement that the whole artwork was a good way to display emotion data. The manipulated video, the abstract animation and the manipulated audio received 3.522, 3.565, 3.739 respectively (Figure 1). This finding echoes the responses that we received on the day of our installation. Many viewers found the sound was surrounding them, and that this helped them to produce a range of bodily sensations. This, to some extent, emphasises the importance of the environment in shaping the viewer to become a lived body.

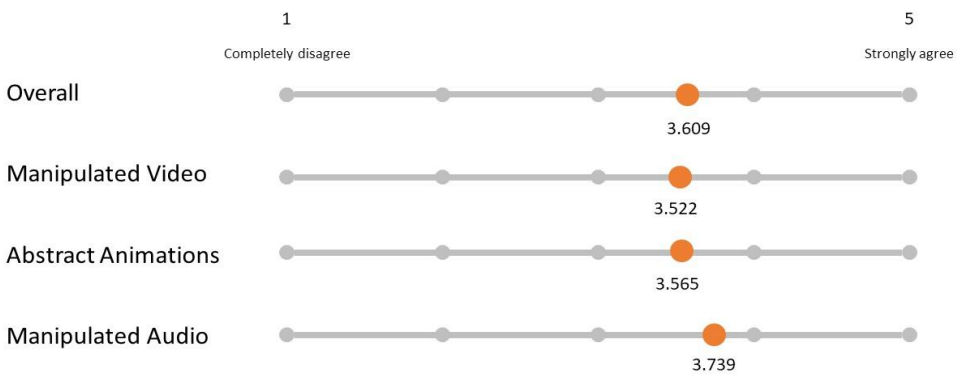

Figure 1: Average scores of the statement “It is a good way to display emotion data” in the online survey
Source: generated by the authors

[5] An example can be found at https://www.youtube.com/watch?v=JKqaqndHu04.
[6] The questionnaire is available online: https://goo.gl/forms/BWbyaPP0yW1rrGz12 . Also see: Appendix A - Questionnaire and the Brief Summary of Responses.

A common critique that we received is that our installation gave the user too much to focus on:

> Basically, you gave me everything. The thing I get from that is possibly what you say the city is like. […]. You physically do that. It actually makes it quite hard to see multiple things at the same time. (Martin Parker in DMSP Invisible Cities 2017, 1:00-1:17)

A comment from the questionnaire held a similar view:

> There was so much to bear in mind visually that honestly, I didn't pay much attention to the audio.

Taking this feedback into consideration, we felt that we needed to more carefully organise the multiple strategies that we applied. This could have resulted in a more integrated experience, which conveyed simple, easy to understand concepts rather than complex and incomprehensible perceptual experiences.

Within reference to our manipulated video, the abstract animation and the manipulated audio, we observed that each strategy had a different degree of reception. We partitioned the perception of user into three stages: noticing the objects, understanding the mapping between the objects and emotions, and feeling the emotions. To assess the mapping rules which were followed throughout the whole installation (contrast for excitement, speed for frustration, saturation for valence, and blurring for focus in the manipulated video, alongside spinning speed for excitement, distortion for frustration, musical cue for valence, and soundscape width for focus in the manipulated audio), we asked viewers to rate how often they noticed such methods of manipulation, how strongly they could relate the method to specific emotion, and how intensively they felt such emotion. It is shown from the results (Figure 2)[7] that higher percentage of noticing often leads to higher percentage of understanding (applying to 5 out of 8 sections), and similarly, a higher percentage of understanding often leads to higher percentage of feeling (also applying to 5 out of 8 sections). 3 out of 8 sections indicate a consistent trend in these three questions. In other words, in most occasions, we observed that noticing the manipulation and then understanding the relationship between the manipulation and the emotion would raise the possibility of the user feeling that emotion. Since the user's experience is affected by the context of their perception, it seems that their reality will more likely be mediated by the intention as well as the perception of the artist. Within the context of our installation, the goal has been to communicate the emotions to the audience. We attempted to invoke this by inviting them to understand our design strategies for the manipulation of the affective data in terms of both sonic and visual outcomes.

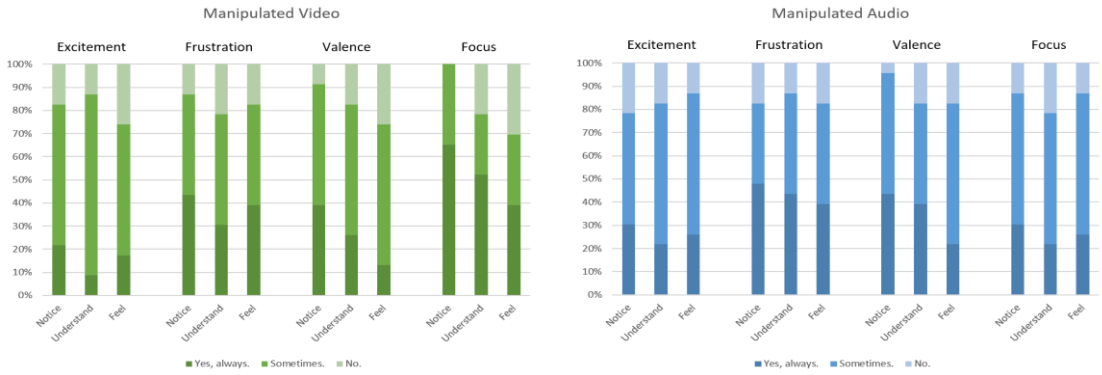

Figure 2: *Survey results on the perceived relation between the video and audio manipulation and the emotions. Source: generated by the authors*

[7] Sorted results of how intensively the viewers noticed the methods of manipulation, understood the mapping between the manipulation and the emotions, and felt the emotions within the fields of the manipulated video and the manipulated part.

Conclusion and future steps

The practice of mapping aesthetic form to scientific data is developing in popularity. As the feedback from our installation seems to demonstrate, it is welcomed as an opportunity to increase the connections between science and the public. There is room to improve the design of such artistic processes. We feel that this can be achieved by establishing collaborative relationships with scientists. This will strengthen the scientific base of our creative applications of data. When we consider the user-system relationships (i.e. the relationship between artist and audience) by applying phenomenological concepts of intentionality, perception and the lived body, we can have the following insights:

Firstly, the relationship between user and system is characterised by the user's exploration of the installation, which reveals itself to the user through interaction. This implies that we cannot control what the installation means to the user but can only influence the context of interaction and construction of meaning by embracing the uniqueness of every individual. In other words, we have to understand how an interaction can be meaningful for a specific user of a specific cultural and personal background. By exploring and uncovering the hidden aspects of urban life in our installation, the emotions, which to a great extent are influenced by the unique background every individual, provide a new context for interaction and the construction of meaning. In practice, we collected the emotion data with EEG, transformed it into an audiovisual work and expressed these materials as an immersive art installation. As the user has little control over the installation itself, we used psychoacoustic bonds to influence what the affective data could convey to the listener. Moreover, we used colours, filters and geometrical abstract forms to show how the emotion data can be represented to the viewer. The use of colours, as well as the distortion of images, tried to lead the user into a specific perception, though they were not being forced to feel in a certain way, as we understand that the experience of the user is highly individualistic. So, by representing different emotional parameters with our sound and visuals, our installation created a new audio-visual environment within which our audience could explore new meanings.

Second, during the design process, we needed to take the lived or the embodied nature of the body into consideration. The self-awareness or consciousness of this lived body arises from its interaction with the installation. Stienstra posits that the concept of perception in the phenomenology of a lived body, in which the perceiving subject is incarnated as the mediating link to the phenomenal world, (Stienstra 2015), affords the possibility to construct meaning during perceptual experience. At the same time Svanæs, argues that, in the context of an immersive an art installation, the lived body is able to extend its sensory apparatus through the mediation of digital technology (Svanæs 2013). Our installation has enabled the perception of our audience to construct meaning through the audiovisual display. Although the immersive representation of emotion data contributes to a mental mapping of the route through the visual and listening experience, the body is not yet lived or embodied, thus not conscious by itself. This can be achieved through further development of the user– system relationship to the stage of physical interaction between human body and the system.

To further develop our installation, we plan to add interactive design elements which will enable our audience to customise their own virtual route by rearranging the individual parts of the entire Royal Mile in their own preferred order. This will give more autonomy for our audience to explore the space and construct the meaning of their experience. Additionally, we plan to link Kinect with Processing to create visuals that can be controlled by human bodily movement. To interactively link the body to the sound of the installation, we plan to use real-time audio programming languages, such as Pure Data or Max/MSP, and head-tracking techniques to trigger audio and modify the sonification of the route, depending on the listeners' position in the soundscape. With these additions, the sensory apparatus of the audience is also extended to the degree that the bodies movement can influence

their experience. The lived body can realise its consciousness from this embodied interaction, and consequently it can construct meanings from the interactive experience.

Acknowledgments

The installation in this paper was originally designed as part of the course Digital Media Studio Project of Edinburgh College of Art, University of Edinburgh, with Liangtian Chen, Fengshi Qin, Bing Sun in addition to the four authors as designers, and Katerina Talianni as project supervisor. More information was documented on their project blog[8]. We would also like to thank Owen Green, Louis McHugh, Roderick Buchanan-Dunlop and Dorothea Kalogianni for their great advice and support. And we sincerely appreciate everyone who tested, viewed or commented on our installation as well as this paper.

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Appendix – Questionnaire and summary of responses

Notes:

(1) The questionnaire is still accepting responses online: https://goo.gl/forms/BWbyaPP0yW1rrGz12;

(2) By 15 May 2017 we have received 23 responses;

(3) The number next to each option means how many participants chose this option; there are no multiple-choice questions.

Part 1 - Basic information

Q1: Did you experience the installation on 6 April, or just watch the online video?

Real installation experience	15
Just online video	8

Q2: Did you read the Guide Map before watching the video?

Yes, very carefully. I memorised all the rules in three fields (Processing, video and audio).	5
Yes, but just at a glance.	14
Completely not.	4

Part 2 - For the video in the middle

Q1: Did you notice these manipulations?

	Yes, always.	Sometimes.	No.
Contrast	5	14	4
Speed	10	10	3
Saturation	9	12	2

Blurring	15	8	0

Q2: Can you relate these methods to specific emotions?

	Yes, always.	Sometimes.	No.
Contrast for Excitement	2	18	3
Speed for Frustration	7	11	5
Saturation for Valence	6	13	4
Blurring for Focus	12	6	5

Q3: Did you feel the specific emotion when such manipulation occurs?

	Yes, always.	Sometimes.	No.
Contrast for Excitement	4	13	6
Speed for Frustration	9	10	4
Saturation for Valence	3	14	6
Blurring for Focus	9	7	7

Q4: Statement: "It is a good way to display emotion data."

	1	2	3	4	5	

Completely disagree	0	4	5	12	2	Strongly agree

Q5: Free comments on the middle video. (optional)

Part 3 - For the abstract animations on two sides

Q1: Can you relate these colors to specific emotions?

	Yes, always.	Sometimes.	No.
Orange for Excitement	14	7	2
Purple for Frustration	3	8	12
Green for Valence	7	9	7
Blue for Focus	3	10	10

Q2: Can you understand the amount of these emotions from the animations (for example, through the size, the area of occupation, the number of small pieces, etc.)?

	Yes, always.	Sometimes.	No.
Excitement	3	16	4
Frustration	5	15	3
Valence	4	15	4

Focus	6	13	4

Q3: Did you feel the specific emotion through watching these animations?

	Yes, always.	Sometimes.	No.
Excitement	4	13	6
Frustration	6	13	4
Valence	3	14	6
Focus	7	11	5

Q4: Statement: "It is a good way to display emotion data."

	1	2	3	4	5	
Completely disagree	0	2	8	11	2	Strongly agree

Q5: Free comments on the animations. (optional)

Part 4 - For the audio

Q1: Did you notice these manipulations?

	Yes, always.	Sometimes.	No.
Spinning speed	7	11	5
Distortion (like screams)	11	8	4

Musical cue (or rhythm)	10	12	1
Soundscape width	7	13	3

Q2: Can you relate these methods to specific emotions?

	Yes, always.	Sometimes.	No.
Spinning speed for Excitement	5	14	4
Distortion (like screams) for Frustration	10	10	3
Musical cue (happiness) for Valence	9	10	4
Soundscape width for Focus	5	13	5

Q3: Did you feel the specific emotion when such manipulation occurs?

	Yes, always.	Sometimes.	No.
Spinning speed for Excitement	6	14	3
Distortion (like screams) for Frustration	9	10	4
Musical cue (happiness) for Valence	5	14	4
Soundscape width for Focus	6	14	3

Q4: Statement: "It is a good way to display emotion data."

	1	2	3	4	5	
Completely disagree	0	2	6	11	4	Strongly agree

Q5: Free comments on the audio. (optional)

Part 5 - General questions

Q1: Which field do you like best?

Manipulated video	9
Abstract animations	11
Audio	3

Q2: Statement: "Overall, the whole artwork is a good way to display emotion data."

	1	2	3	4	5	
Completely disagree	0	4	4	12	3	Strongly agree

Q3: Statement: "Overall, my emotion had been manipulated during the experience."

	1	2	3	4	5	
Completely disagree	2	4	9	6	2	Strongly agree

Q4: Which way to display scientific data attracts you the most (just in your personal taste)?

Charts or graphs with exact numbers	6

Charts or graphs without numbers	1
Designed graphs or animations that are not absolutely accurate but could let you know the trend	9
More aesthetic ways (like the manipulated video and audio in the installation)	7

Q5: In your opinion, is it meaningful to transform scientific data to aesthetic presentation?

	1	2	3	4	5	
Completely disagree	1	0	7	7	8	Strongly agree

Q6: Free comments. (optional)