Performing Audiences: Composition Strategies for Network Music using Mobile Phones

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ABSTRACT

With the development of web audio standards, it has quickly become technically easy to develop and deploy software for inviting audiences to participate in musical performances using their mobile phones. Thus, a new audience-centric musical genre has emerged, which aligns with artistic manifestations where there is an explicit inclusion of the public (e.g. participatory art, cinema or theatre). Previous research has focused on analysing this new genre from historical, social organisation and technical perspectives. This follow-up paper contributes with reflections on technical and aesthetic aspects of composing within this audience-centric approach. We propose a set of 13 composition dimensions that deal with the role of the performer, the role of the audience, the location of sound and the type of feedback, among others. From a reflective approach, four participatory pieces developed by the authors are analysed using the proposed dimensions. Finally, we discuss a set of recommendations and challenges for the composers-developers of this new and promising musical genre. This paper concludes discussing the implications of this research for the NIME community.

Author Keywords

Audience participation performances, mobile music, network music, web audio

CCS Concepts

•**Applied computing** → **Sound and music computing;** Performing arts; •**Human-centered computing** → *Collaborative and social computing;*

1. INTRODUCTION

Participatory experiences in art and particularly in music involving the audience are not new (e.g. participatory art, cinema or theatre; collaborative musical experiences [2]; computer-supported collaborative music [1]; and so on). Although typically the experience is designed for novice musicians so that it is easy to plug and play [2], it is common that developing these experiences involves building complex systems that incorporate different technologies, which can become obsolete quite quickly [23].

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With the development of the Web Audio API,[1] it has become easier to develop and also for the audience to participate in these experiences with their own mobile phones. The benefits of using this technology include that these applications are fast to develop and easy to access by a broad audience. The drawback is that the technology can still become obsolete in a quick turn, a factor that cannot be avoided as it is inherent to any technological computer-based related project.

Turning the limelight to the audience has brought a new approach to collaborative music making, framed by active authors in the field as the emergence of a new musical genre [5, 14, 23]. This paper contributes with reflections on technical and aesthetic aspects of composing for audience-centric music making using web audio technologies. Again, we can find previous instances in the art history of audience-centric musical systems and processes (as opposed to musical products) with seminal work by John Cage and the Fluxus movement [7, 10, 15].

This paper focuses on composition strategies for music where the audience dictates the evolution of the musical piece. The analysis reflects on four audience-centric mobile music pieces developed by the authors. The approach aligns with Perry Cook's principle of *"Make a piece, not an instrument or controller"* [3, p.3]. Making these four pieces has helped to explore the characteristics of this new medium and identify future next steps. We propose a set of composition dimensions including the role of the performer, the role of the audience, the location of sound and the type of feedback, among others. Previous research has focused on the composer's perspective (treating the audience as a *"speaker array"* [23]) or from a socio-technical standpoint (treating the audience as different types of connected constellations or *"interaction topologies"* [14]). This paper builds on this prior research, focusing on technical and aesthetic aspects that inform about different composition strategies. This approach can be useful to analyse existing pieces as well as to compose new ones. We conclude with some reflections and future work.

2. RELATED WORK

The technologically-mediated audience participation in music making can be located within the field of *network music*. It is however out of the scope of this paper to provide a complete survey of this field. The interested reader is directed to [25]. In this paper, we focus on previous work on the use of web audio technologies on smartphones, which we contextualise with some influential references on collaborative music systems and mobile music.

The ideas behind participatory mobile pieces can be traced back to early works on network music and on collaborative

[1] `https://www.w3.org/TR/webaudio`

music systems, framed as collaborative musical experiences by Blaine and Fels [2]; computer-supported cooperative work (CSCW) for music applications by Barbosa [1]; institutional laptop ensembles such as SLOrk [24]; collaborative musical creations performed in mobile and remote conditions [22]; or institutional mobile phone ensembles such as the Michigan Mobile Phone Ensemble [4]; among others.

The development of the Web Audio API and other web standards during the late 2010s, and their quick availability in smartphone browsers, has produced an accessible platform for sound and music applications. This has brought the development of a range of co-located participatory musical pieces, as illustrated by the program of the Web Audio Conference since its inception in 2015 until present.[2] Matuszewski et al. [14] have investigated this new musical genre from the perspective of network systems in terms of the nature of the social organisation and interaction promoted by this medium. Following this tradition, our research focuses more specifically on composition decisions along with technical and aesthetic implications involved in composing network music using mobile phones.

An historical view on the use of the audience's phones as speakers was presented at NIME by Taylor [23]. In this review, the musical genre is termed *distributed music* and is rooted in the long tradition of network music since 1950s. A number of descriptions have been proposed, such as Golan Levin's: *"music that performs an audience's electronic devices as a unified instrument or invites their participation as an impromptu electronic ensemble."* [23, p.481] Three important new characteristics are highlighted: (1) how the sound location moves to the audience space; (2) how the location of the sound source changes to sound events coming from multiple scattered small phone speakers; and (3) how the timbre changes to sound textures *à la musique concrète*.

A technological survey review is provided by Essl and Lee [5]. Here, the genre is mapped from a technological perspective, and future directions point to explore further: (1) the built-in sensors and actuators found in mobile devices; (2) the bandwidth offered by the wireless networking capabilities of the mobile phones; and (3) the cross-pollination of machine learning as well as crowd and cloud computing when designing mobile music systems.

In most cases, these works consider the composer as a figure with a leading role in the piece who 'drives' or controls the audience. In this paper, we focus on the opportunities for the audience to become an active performer who controls the performance under predefined rules specified by the composer. This space can be characterised by the notion of *shared collective control* as described by Jordà [9]. In this paper we propose a set of composition dimensions involved in audience-centric participatory music.

3. COMPOSITION DIMENSIONS

Many different approaches exist for audience-centric participatory mobile pieces. Here we focus on a particular subset of pieces where the audience is expected to be active (as opposed to passive as *"speaker arrays"* [23]). Although common, a fixed, controlled location of the audience is not a requirement, as it happens in pieces that critically depend on the spatial location of the phones and their speakers. From this perspective, a set of composition dimensions is proposed. The composition dimensions are framed as 5-point Likert items (from 5, strongly agree, to 1, strongly disagree) related to the presence or absence of each component and its importance in the piece. This approach aims to outline the nature of the piece from an audience-centric perspective, useful as both an analytical and compositional tool. The composition dimensions can be seen as a range of possibilities in a continuum that involve certain trade-offs. Although similar rules apply to other setups, such as installations or public space interventions, we focus on traditional concert venues, where a stage and a PA system are usually available. The proposed dimensions are grouped according to the main elements potentially participating in the performance: (1) humans; (2) phones; (3) the sound system; (4) the projection system; and (5) the computer music system.

- **Human configuration**. Different human configurations are possible between the traditional and the audience-centric performance, where the latter promotes less traditional social dynamics because the audience becomes the performer.
  - **Stage performers**: Are there any performers taking a central role on stage? This role can be fulfilled by the composer or other performers, leading to more traditional social dynamics. In most cases, some sort of facilitator is needed at least at the beginning.
  - **Mutual interaction between the audience's actions**: Are the audience's actions *multiplicative* (the product of individual contributions, or a series of highly interdependent processes) as opposed to *summative* (sum of individual contributions, or independent processes, where there is little mutual interaction)? [9]
  - **Mutual interaction between stage performers' actions and audience performers' actions**: Are the audience's and stage performers' actions multiplicative (highly mutual interdependent processes) as opposed to summative (little mutual interaction)? This ranges from the use of mobiles to control the performers on stage (e.g. [6]), to performers on stage controlling the audience's mobiles (e.g. [23]), to mutual interaction between both groups.
- **Mobile technologies**. Modern phones are typically armed with a screen and a number of sensors and actuators [5], which can be used to create multi-sensory immersive experiences, more inclusive by nature for audience-centric performances.
  - **Use of sensors**: Does the system make use of many sensors in the phone? Most modern smartphones are equipped with accelerometers accessible through web browsers (e.g. via the Device Motion API), are there more sensors used?
  - **Visual feedback**: Does the piece provide a detailed visual feedback about the performance, potentially including a graphical interface, or does it supply a basic phone interface more based on sensor interaction?
  - **Haptic feedback**: Does the system provide haptic feedback (e.g. via the Vibration API) to the audience during all the piece and for different events?
- **Sound system**. A stage-based or surround sound system can be used as the main sound source or as a complement to the audience's phones, which can also create more immersive and engaging experiences.
  - **Acoustic mirroring**: Does the PA system mirror the sounds produced in the audience's phones?
  - **Complementary acoustic information**: Does the PA system provide complementary acoustic information to the sounds produced from the audience's phones?

[2] `https://webaudioconf.com`

- **Projection system**. A projector can be used for aesthetic reasons or for improving the audience awareness and engagement.
  - **Visual mirroring**: Does the projection mirror the information in the audience's screens?
  - **Complementary visual information**: Does the projection provide complementary visual information to the information in the audience's screens?
- **Computer music system**. The performance is typically mediated by a pre-programmed web application, which can interact with the audience in different ways. Aiming for a structured composition, either open or fixed, that can evolve over time, seems to align well with audience-centric performance because it provides narrative and a *raison d'être* to the improvisational performance.
  - **Pre-scored elements**: Does the composition include high to low pre-determined elements independent from the audience's actions? This can include structured timed parts up to fixed or algorithmic scores.
  - **System memory**: Does the composition use memory from past events as opposed to purely reacting to current events?
  - **Use of samples (high bandwidth)**: Is any number of samples used? Given computer music traditions and specific technical affordances of web audio, this choice can have an important impact. At the moment, the Web Audio API offers only a limited set of oscillators. Avoiding samples allows systems to minimise the exchange of information and the audience's phones to rely on their cellular data services, whereas the use of samples may require sophisticated Wi-Fi setups. Aesthetically speaking, the related attribute of *"musical range"* was found in collaborative experiences for novices [2].

4. CASE STUDIES

A number of audience-centric pieces have been presented in various specialised conferences during the last few years, notably [11, 12, 13, 19, 21]. Here we took a reflective approach inspired by Schön's ideas on reflective practice [20] and a qualitative analytical approach inspired by group consensus [18, p.35]. The authors reflected on their four web-based pieces and assigned a value for each dimension for each piece. The score generally reflects the importance assigned to each dimension in each of the compositions, and the corresponding use of the available technologies. The score for each dimension is summarised in a radar chart for each piece. Prior to that, we contextualise the main technical and aesthetic commonalities between the pieces.

4.1 Technical and Aesthetic Characteristics

Perhaps the main unifying aspect from a technical point of view is the use of the Web Audio API. This API allows developing sophisticated music systems that can be run both in a desktop browser (e.g. feeding a central PA system) and in a smartphone browser. Three of the four pieces described also make use of the *Handwaving* Javascript library [17], which can be used to detect different accelerometer gestures using a neural network. Other commonly used libraries include socket.io,[3] ToneJS[4] and Flocking.[5]

Building pieces based on web standards assures that, in general, the audience will be able to participate using their smartphones, in theory irrespective of their phone's model, phone's operating system and browser. However, composing pieces with cutting-edge technologies may leave some users behind. Using a web page that tests for the presence of the needed capabilities in a given phone/browser is generally necessary.

It is worth mentioning other similarities across the four participatory musical pieces, which align with a particular aesthetic of creating as-inclusive-as-possible pieces for an active performing audience: (1) the pieces are based on a structure with synchronised parts provided by a central server; (2) in the tradition of participatory mobile pieces [23] and algorithmic processes in music creation such as the influential *"event" scores* by John Cage [10] and Fluxus [7] among others, instructions are provided to the audience prior to start, typically shown on each of the mobile phones, sometimes combined with a projected slide; (3) as part of providing algorithmic music experiences, each piece becomes a system or a 'program' [8], where each performance becomes a new instance of the system; (4) the pieces are designed under design principles for collaborative musical systems [2], in particular the pieces are designed to be scalable in terms of supporting from two to multiple performers, as long as possible; (5) position sensing is not relevant here, partly because mobile sound spatialisation is not required as explained earlier, and partly because it still remains a technical challenge in indoor performances [5]; (6) the music composition systems tend to have feedback in terms of the audience's actions influencing present and future actions.

4.2 Do the Buzzer Shake

Do the Buzzer Shake [16] explores a setting where the music is entirely created by the audience using their mobile phones, although a facilitator role might need to be on stage (*stage performers*=2, *mutual interaction A-S*=2), and there are no predefined hierarchies beyond the proposed interface (see Figure 1). An example of a performance can be found here: `https://youtu.be/jp48n3a3vfw`. The piece is specified as a number of mobile accelerometer gestures (*use of sensors*=3) that are recognised in a web application. Each gesture triggers a recognisable sound, which allows exploring social learning of gestures in a musical context. A visual feedback is provided with colours and text used to indicate the different gestures and parts of the piece (*visual feedback phones*=4).

During the development of the piece, a structure of three parts was devised. In the first part, participants explore the use of the accelerometer and synchronisation with others by trying to achieve consonance (identical phone orientations) or dissonance (different orientations). In the second part, participants explore the different gestures and their musical mappings and learn them from each other (*mutual interaction A-A*=4). In the final part, synchronisation is 'mandatory': the server counts the number of participants performing each gesture, and participants performing minority gestures (*system's memory*=3) are 'punished' with a short vibration (*haptic feedback phones*=4) and a short period of silence (*mutual interaction A-A*=4). The duration of the silence increases progressively in order to induce a sparse ending unless a total synchronisation is achieved (*pre-scored elements*=2). Square wave oscillators (*high bandwidth*=1) are used to maximise the volume when using mobile phone speakers. Although the music is made out of drones with varying degrees of frequency stability, creating both harmonic and chaotic patterns, the resulting atmosphere of participation has some parallels with group behaviour in electronic dance music clubs. Figure 2 illustrates the main characteristics of the piece based on the composition dimensions introduced in the previous section.

[3] `https://socket.io`
[4] `https://tonejs.github.io`
[5] `https://flockingjs.org`

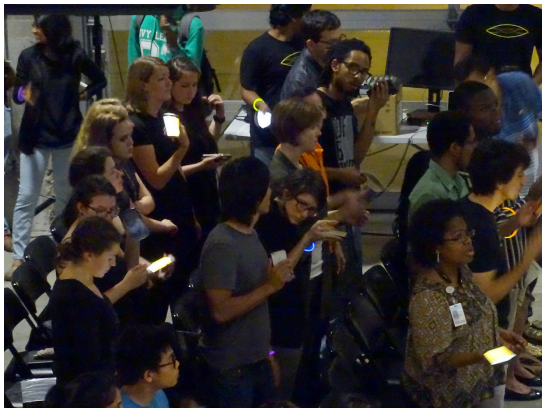

Figure 1: Do The Buzzer Shake presented at the Women Music Tech Concert 2016. Photo by Valentin Baillard.

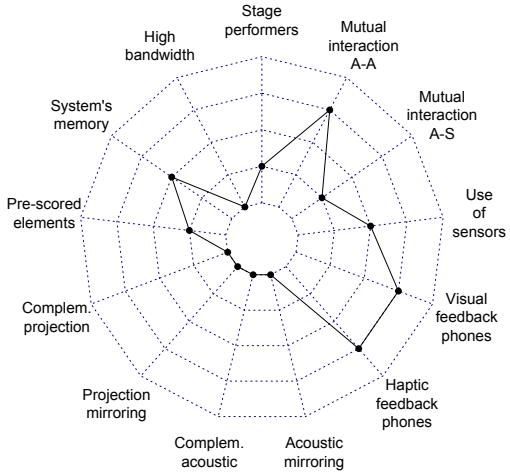

Figure 2: Radar chart of Do The Buzzer Shake.

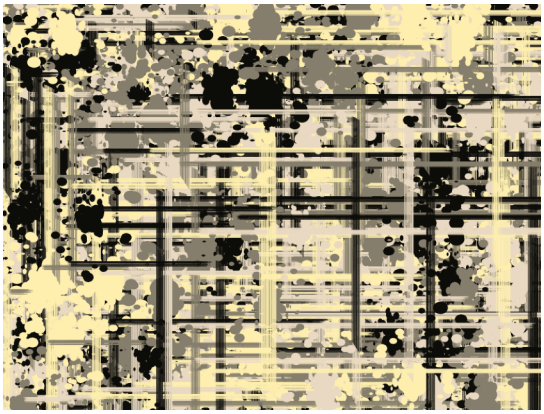

Figure 3: Digital canvas produced by the audience from the performance HAP at Audio Mostly 2017.

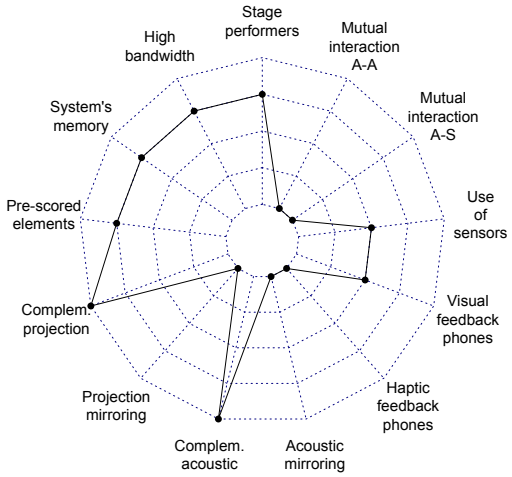

Figure 4: Radar chart of HAP.

4.3 Hyperconnected Action Painting

Hyperconnected Action Painting (HAP) [26] invites the audience to participate in an immersive experience, inspired by Jackson Pollock's action painting technique, using their mobile devices (see Figure 3). An example of a performance can be found here: `https://vimeo.com/241486914`. The audience is connected through a web application that recognises a number of gestures via the mobile accelerometer (*use of sensors*=3). The actions of the audience trigger a selection of audio samples (*high bandwidth*=4) influenced by post-jazz aesthetics and are captured on a digital painting (*complementary projection*=5). A performer is onstage to control the system (*stage performers*=4, *mutual interaction A-S*=1). Visual feedback on the mobile phones is also provided that indicates each identified gesture with a different solid colour (*visual feedback phones*=3). A PA system delivers a general sound stream that is complemented with the audience's actions (*complementary acoustic*=5). The spatial distribution of sound, combined with the digital painting, provides an immersive audiovisual experience. The final digital canvas is made available online after the performance (*system's memory*=4).

The piece is divided into four sections distinguished by timbre, density and rhythm (*pre-scored elements*= 4) using field recordings of street music in New Orleans, combined with sounds from the Freesound online database.[6] In each part there is a pre-defined background sound played by the PA system. The background music is combined with the sounds from the mobile phones that have short extracts from the background sounds or complementary sounds. Over the course of the piece, the samples played in the phones get more mangled and modulated by the accelerometer (*use of sensors*=3). The transitions between parts are marked with gong sounds (*pre-scored elements*= 4). Throughout the piece, the three gestures, left-right, top-down and front-back, are mapped respectively to horizontal brush, vertical brush and splashing on a digital canvas which is projected on the screen's stage (*complementary projection*=5). This collective digital painting is used as a graphical footprint and memory of the performance (*system's memory*=4). Figure 4 outlines the piece's main characteristics based on the composition dimensions.

[6] `https://freesound.org`

4.4 Imaginary Berlin

Imaginary Berlin is an anonymous celebration of participatory music in Berlin in the form of a collective soundscape. Inspired by John Cage's Imaginary Landscape No. 4 (1951), audio streams and sound samples from the Berlin area are sonically distributed, repeated, delayed, amplified, reverberated, distorted and finally vanished (see Figure 5). An example of a performance can be found here: `https://youtu.be/v7FwOEy0jK4`.

The structure of the piece consists of 2 parts (*pre-scored elements*= 3). Twelve sound samples related to the tag

Figure 5: Anna Xambó performing Imaginary Berlin at the Web Audio Conference 2018.

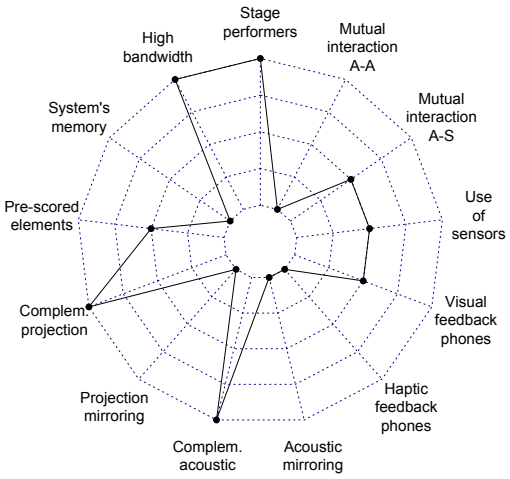

Figure 6: Radar chart of Imaginary Berlin.

Figure 7: No Merge Conflicts presented at the Web Audio Conference 2018.

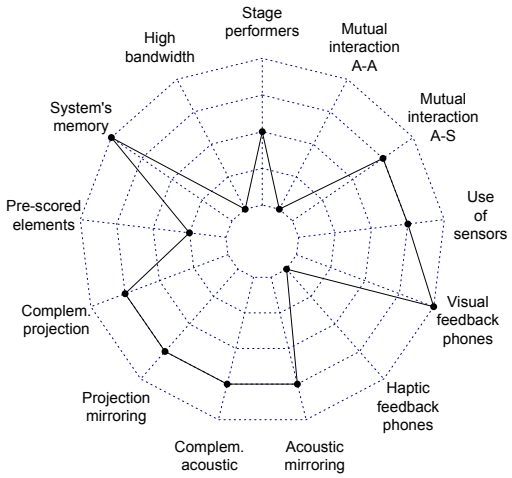

Figure 8: Radar chart of No Merge Conflicts.

"Berlin" from the Freesound online database are used as the sound material for the mobile phones (e.g. ambience sounds, street conversations, public transport sounds, and so on). In the first part, the sound samples are sequentially selected with left-right movement as if it was a playlist, and volume and playback speed are defined by top-down and tilt gestures, respectively. In the second part, the parameters of a low-pass filter applied with large values can be used to add effects to the sound samples, which turn into distorted sound textures, where it is harder to identify the original source. The accelerometer is used to identify the gestures (*use of sensors*=3). Visual feedback on the mobile phones is provided to indicate each identified gesture with a different solid colour, as well as the name of the current loaded sound (*visual feedback phones*=3). Sounds from twelve local online radio stations are mixed by the performer on stage and sent to the PA system (*complementary acoustic*=5), which combine with the sound from the mobile phones (*high bandwidth*=5). The performer on stage (*stage performer*=5) controls the online radio stations with a projected web-based application (*complementary projection*=5) where the location of the sound source (stereo panning) and the cutoff frequency of a low-pass filter can be controlled in real time (*mutual interaction A-S*=3). Figure 6 showcases the piece's key characteristics based on the composition dimensions.

4.5 No Merge Conflicts

The performance *No Merge Conflicts* explores the use of a central algorithmic performer (*stage performer*=3) that receives input from the audience (*mutual interaction A-S*=4). The interface in the audience's phones provides a basic synthesiser which uses touchscreen and accelerometer inputs (*use of sensors*=4). Audience members use the interface to create audiovisual patterns (*visual feedback phones*=5), which are periodically sent to the server and collected by the agent (*mutual interaction A-S*=4). The algorithmic agent creates new audiovisual patterns by evolving and mixing the audience patterns through random permutations (*system's memory*=5). The selected patterns are projected and played by the PA system (*acoustic mirroring*=4, *complementary acoustic*=4, *projection mirroring*=4, *complementary projection*=4). The strategy evolves in complexity and number of voices through ten different sections (*pre-scored elements*=2). An example of a performance can be found here: `https://youtu.be/n1T5dw71KQI`. The synthesis is inspired by the characteristic harsh sounds in the TB-303 bassline synthesiser (*high bandwidth*=1), as often heard in early club music. Figure 8 summarises the core characteristics of the piece based on the composition dimensions.

5. DISCUSSION

We have presented 13 dimensions or tradeoffs for composing audience-centric mobile music pieces and used them to analyse four compositions. It is our hope that these dimensions can be used to understand other composers' pieces as well as to imagine new pieces. From our experience, concerts are more engaging when there are performers on stage (including virtual) and there is mutual interaction of interdependent processes with the audience and between the audience for a high collaborative piece. At the same time, there is an unexplored territory when the social dynamics change from the expected stage performer to the audience, which is interesting to explore as part of the new genre. Bringing multi-sensory immersive experiences seem to be

more inclusive, entertaining, and a mechanism to keep the flow of the improvisational act. The combination of the PA system along with the phone sounds makes it easier to cope with diverse numbers in the audience and different venue sizes. The use of the PA system also offers many creative possibilities in terms of interaction with the audience, with or without a central performer, and can be used to maintain engagement. There is room for further investigation of the available sensors and actuators in the mobile phones to customise and augment the experience [5].

Regarding challenges, a recurrent question is how to keep the audience convinced that they are the performers, moving from a traditional passive attitude to an active attitude. It is necessary to include in the composition the mechanisms to keep or recover the engagement over time. It is also often the case that not all the audience members are equally active. One of the inherent characteristics of this genre is the intimacy provided by the mobile phone speakers. In this sense, balancing the levels of the phones and the sound system, depending the size of the room, is a complex matter that could benefit from a systematic study. Another important challenge is how to rehearse a piece of these characteristics using reliable methods: while it is useful to use software simulations, collect small numbers of mobile devices or organize gatherings with colleagues, it is only in the real situations that the piece encounters its potentials and limits.

6. CONCLUSIONS

In this paper, we presented reflections on technical and aesthetic aspects of audience-centric approaches to mobile music making. We introduced a set of composition dimensions and analysed four participatory mobile pieces, to finally discuss recommendations and challenges from this approach. Future work includes the analysis of other composers' pieces and the composition of new pieces to consolidate the dimensions. The implications for the NIME community are threefold: (1) a new approach to designing collaborative musical interfaces; (2) a new approach to collaborative music making; and (3) a new opportunity for designing more inclusive musical interfaces. As with any new musical genre, there is need of, and room for, exploration. Hopefully the above reflections can help on this respect to move the field forward.

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