Comparative Review Apps towards an 'in-between' performance app
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1. Introduction

Background

Questions regarding listening, performing and technology to approach 'in-between spaces' in the context of migration were explored in Ximena Alarcón's experience with telematic sonic performances in the project Networked Migrations (Alarcón, 2014).

By combining Deep Listening practice (Oliveros, 2005) and improvisation through telematics, the performance experience allowed the emergence of feelings that arise in migration, thus acting as a catalyst of the ongoing process of identity and sense of belonging. It opened the idea of territory and allowed participants to create mixed-reality narratives[1], within a supportive sound space free from geographical and cultural constraints.

Deep listening helped participants to expand the perception of time and space and reach a *sense of self* in the space. Performing in an improvisatory manner, participants were invited to listen to the other and responded creatively in a dynamic of game and interrogation, with spoken word, about multiple migrations in a shared space. Improvisation mediated by networking technologies defined and articulated the performances' perception of space, allowing also participants to move toward "resisting one's self-preoccupation in order to allow for the essential unselfing, a state of moving from oneself to the other" (Schroeder, 2013 - 223).

The use of technology for connectivity and performance in Networked Migrations was inspired by the technology used by musicians performing between distant locations: bi-directional streaming, which has been developed to overcome concerns with delay, multiple participants, audience, and quality of the sound. Thus, high quality bi-directional streaming audio software such as SoundJack and Tube Plug were used, adapted to the performances' needs. Jacktrip software, which offers the highest sound quality through uncompressed sound, was also explored without success, as it required broader bandwidth than the venues could provide.

Other technology challenges were to arrange equipment for the performers, such as microphones and laptop computers, which are not easily accessible when venues are not linked to academic institutions. Also, if participants needed to control a visual interface as part of the performance, their body could feel limited; for instance, in *Migratory Dreams* four performers used a single visual interface to facilitate the mix of sound resources. This could become limiting and confusing regarding the streaming computer and the mixing/performing devices.

[1] http://networkedmigrations.org

How can one facilitate this rich performative experience in a way that involves more participants, and improve technological access and performativity?

Envisioning the introduction of mobile technology in migration-based and dislocated telematic performances felt very relevant by the researcher for expanding and enrichening the initial proposal, enabling the exploration of relationships between local and distant locations and involving people in immersive experiences via headphones.

Using mobile technology for alternative music making has been explored by artists such as Atau Tanaka and Ge Wang. In their analysis of their experience with technology, listening, sounding and performativity, they look back at the process of conceptual and media convergence and explain how 'musicking' using mobile technology provides an open ground to explore and develop features in today's available mobile phones, particularly in the iPhone. Tanaka (2014) notices the listening experience via headphones as an intimate one, and also as connection with others. Being location-aware is an interesting aspect that he highlights, and proposes in his work Malleable Mobile Music system a hybrid model that supports the two social contexts, the personal and the community context. Wang, Essl and Penttinen (2014), when describing their experience with the Mobile Phone Orchestra (MoPhO), notice the portability of mobile phones as instruments, and the flexibility of the venue in comparison with traditional musical performances:

'[they] can easily be moved, performed on-the-go, and spontaneously organized. The typical power of the speakers of these devices allows for a chamber music quality of the performance: strong enough for adequately quiet spaces while preserving the intimate instrumental qualities of these devices. Portable speakers attached to gloves, neck, or belt can overcome even this limitation and allow for intimate yet potent performance in large concert venues and outdoors.' (465, 2014)

Even more, they believe that 'entrenched in mass adoption of this type of mobile personal technology lies potential for radically new paradigms of creative and social exchange' (idem).

Regarding the 'in-between space', mobile technologies are facing challenges that question our idea of space. Adriana de Souza e Silva (2013) introduces the term 'net locality' to refer to the state (not a space, not a place) where for the mobile user 'remote connections are still present, but become part of the space in which the mobile user is, instead of removing users from it' (118, 2013). In the sense of migration, this resonates as a metaphor of the negotiation that the person in exile makes between internal and external space (Ortega, 2008). In the practice of Deep Listening, a balance between space and time is proposed by Pauline Oliveros as a way to reach 'homeostasis', by practicing global and focal, inner and outer listening. Thus, this interweaving of practice and theory, makes more meaningful the choice of the mobile device as a performative device for a mediated sonic performance in the context of migration.

What are the functionalities and technologies needed to develop a mobile app that allows improvisatory telematic performance to explore the sonic 'in-between' space, allowing intimate and collaborative social experience?

This reflection led to the realisation of this comparative review of mobile apps that use streaming of sound, voice and other sources of sound for performative purposes, created within commercial, artistic and research contexts, currently available for iPhone, iPad and Android. The review has been made with the support of Donal O'Brien, an iOS developer with an expert knowledge of sound. This work is understood as a first step to understand in a practical manner the listening, performative, and technological possibilities that are being explored by mobile apps available for the general public.

2. Comparative review parameters for sound

A customised set of qualitative parameters were defined to analyse the experience with each app: *listening experience*, *expression and performativity*, *embodiment and gesture*, *social engagement* (collaboration - connection), and *perception of sonic space*. Eventually, and because of the connections made during our analysis, we structured our writing by linking *listening experience* with *perception of space* and *with social engagement*, and *expression and performativity* with *embodiment and gesture*. Thus the analysis of the apps includes two main sections: *Listening* (intimately and collectively) *to the acoustic environment,* and *Performing* (with the device, and with others). This division doesn't isolate the process of listening from the process of performing; it is rather a practical way to analyse how the functionality of the reviewed apps departure from one or another purpose.

Aesthetic appreciation of graphical Interfaces and technical description and evaluation were given to each application according to current technological possibilities. An appendix analyzing in depth the technologies complements the qualitative analysis.

A total of forty applications were reviewed. Some were chosen to exemplify the use of functionalities with sonic elements, such as: soundscape (live streaming or pre-recorded), live voice, and sampled sounds; others were audio production apps that exemplify the possibilities that lie in the mobile technology to aid the performative experience. Some generative sound apps were also included. The apps were found through search engines such as Apps Store (iTunes), and Googleplay, under the names of 'sound', 'sound art', 'soundscape', 'binaural', 'surround sound', 'recording', 'listening', 'deep listening', 'audio', 'music', and 'DAW (Digital Audio Workstation)'. Also some apps were found through the Sound Software repository[2], and through forums, email lists and web searches.

3. *Listening* (intimately and collectively) *to the acoustic environment*

[2] Sound Software Repository at Queen Mary University of London http://soundsoftware.ac.uk/

For the purposes of this review, *Listening* is understood as a complex and subjective experience that helps to expand people's perception of time and space regarding their inner and outer acoustic environments (Oliveros, 2005; Carlyle & Lane, 2013). Also, we were interested in how the apps invite one to collaborate and to connect with others by playing with others' sounds, or having the 'feeling' of social presence while immersed in the app. We also considered the audio quality experience according to current technological standards and possibilities, such as spatialisation and differentiation of sound sources.

Acoustic environments from all over the world are used by apps that use GPS to either stream sound to or from the Internet. For instance, the *LocusCast app* part of the Locustream project[3] streams sound in one direction in *real time* to a sound map on the Internet. Although coming from a mono microphone, the quality of sound using an iPad is good, and the delay, in our test, was calculated as being seven seconds. When used as a resource for an installation such as the recent REVEIL/SoundCamp[4] project led by Grant Smith, Locustream can present the user with 'the sound of daybreak streamed from microphone positions all over the world as a continually changing soundscape over a 24hr period' (Papadomanolaki, 2014). The perception of streaming in real-time strengthens the feeling of *connectedness* with others in different locations in the world. In an interview by Maria Papadomanolaki, Smith describes the experience:

> "… remote listening does seem to give a quite distinctive sense of location. Listeners commonly report that, as they are listening to what is going on under the ice, they often become much more closely aware of local sounds as well. The juxtaposition of two live audio fields seems to be brought into relief, curiosly, by the more or less conscious effects of latency, which creates a disjuncture of a few seconds if you listen to the same sound locally and via the network [18]…something like watching and hearing a woodcutter in the distance. Except that here both channels are audio. So the disjuncture works something like a conceptual stereophonic effect."(2014: 11)

REVEIL used *LocusCast app* in conjunction with *LiveShout App*[5], which is a mobile streaming app that allows for single or simultaneous multiple user broadcast and works with Icecast streaming technology[6].

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[3] This project has been developed since 2005 by the research group Locus Sonus in France. http://locusonus.org

[4] REVEIL is 'the first 24 hour radio broadcast of the sounds of daybreak around the world'. It was transmitted in Soundcamp, a listening event over the first weekend in May.

[5] Pearl Young, Liveshout. *App Store*. Available at: https://itunes.apple.com/us/app/liveshout/id469761290?mt=8 [Accessed July 13, 2014].

[6] Icecast is an opensource project written in the C programming language by Jack Moffitt and Barath Raghavan and now maintained by Xiph.org. The project started in 1998 and provides the capacity to create an audio server, which is software that is capable of creating connections with clients, i.e. an end user browsing a website or the user of an iPhone application, for example, and continually streaming audio to them. Icecast was initially developed to support the audio formats Ogg and MP3. However, the developers intentionally architected the Icecast programme so as to be easily adaptable for other audio formats. The programme typically runs in conjunction with a source programme, i.e. an application that provides the input which is then streamed to

An example of *pre-recorded* sound streamed from the web is the *43D App*, developed by 43D, which offers a virtual tour of planet earth via soundscape. The sounds, streamed from the Freesound project website[7], are mixed in and out. Alternatively the user can explore the soundscapes of particular areas by selecting locations on a map, and mixing them in two modes: random and simple. This app is interesting, however the visual interface is a bit confusing. Technically it does not require an additional server, as it is using Freesound.

Mixing *pre-recorded* and *live sound* can be experienced in the *Sound Hailuoto* app*,* developed by Juan Carlos Duarte Regino, from Hai Art[8], as part of a participatory project with children. The interface is a graphic piece of land representing the Finnish island Hailuoto. It is a fascinating concrete element that contrasts with traditional soundmaps. It mixes natural sounds from the island, with any environment where the user is. The application uses network feature via server and offers the possibility of recording the mix, and sending it to the project. Mixing these two spaces is an interesting contrast between nature and built/urban environment. Also the listener is invited to locate herself in a different space created by the mix and also to a different perception of time (as might occur in the migratory experience).

By contrast, we noticed how some apps such as *Ocarina* app, developed by Smule, can offer a radical difference from the perception of real time, and how it could be perceived as an illusion. The app physically models the acoustics of the ocarina to produce an impressively convincing ocarina sound out of the iPhone by utilising the microphone input as the mouthpiece. The user can see on a map how other users in the world are playing the ocarina. Given the fact that the product is commercial and closed-source, it is not clear how the real-time streaming is taking place or what types of streaming technologies are employed. In Ge Wang's article (2014) he explains the concept behind the *Ocarina* app and its success. As users, we probably need a reference to where the sound is coming from to 'believe' that the streaming is in real-time; this feeling is possibly linked to the perceivable texture of real-time sound, or as Smith was referring to, the excitement of real-time broadcast.

Other commercial apps offer the idea of taking the listener to an *imagined space*. The *Dimensions* app [9] created by RJDJ, Reality Jockey Ltd, offers of 'being' in dimensions with friends, and the user needs to connect with friends via Twitter and Facebook. The application has access (if the user allows) to the database of friends in Twitter and Facebook, and is supposed to localise them. The app's game consists of gaining 'quantum cells', which will offer more 'power' to unlock, amongst others the 'collective dimension'. Basically the user has to buy quantum cells if s/he wants to play with friends. The local space where the

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connected clients by Icecast. The developers provide a ready-made solution in the form of a programme called Ices, which supports Ogg. Icecast.org. Available at: http://www.icecast.org/docs.php [Accessed July 13, 2014].

[7] http://freesound.org

[8] http://www.haiart.net/

[9] https://itunes.apple.com/us/app/dimensions-game-new-experience/id473626010?mt=8

user is located is captured by the microphone, and modified in a radical way by the filters and effects used. There is not a subtle perception of sound, but probably a crude awareness of the busyness of the users' current sound environment. The experience becomes 'effects' driven. This app is closed source[10].

Other approaches to listening to space and specifically to *location* are the apps that allow the user to leave their sonic trace in a GPS locative point, such as *Shoudio and Woices.* These invite the user to record with the built-in microphone, leave a message, and then to search for others that are in the user's proximity. The performance is proposed by these apps in the sense that it geolocates the user on the map via GPS, inviting the user to leave traces of passing through that space. In *Shoudio* for iPhone, by RP Landegent, the sound is definitely enhanced by the association of location. Being able to view where the sound comes from on a map and in relation to the user's current location, it creates a sense of exploration. Furthermore, it uses information relating to the date and location of the recordings that creates a *dislocation* of time and space, which is at times somewhat unsettling - particularly for recordings made a long time ago. The app enhances an urge to create something worth listening to; by making a recording the user is putting herself on the map and making herself available to be heard by anyone anywhere. The whole idea of the Shoudio app revolves around sharing sound.

Aside from the sharing provided by the app, the user can also connect to social channels such as Facebook, Soundcloud, and Twitter. An interesting explore mode allows the user to browse sounds by proximity, popular sounds, recently added, or those that were recorded nearby. There is also an option to leave the app running in the background and allow it to play sounds that were recorded nearby as the user moves around.

Woices, by *Woices*, is intended more as an audio guide, where voice is used as primary resource. It attempts to use crowd sourcing, in which people record audio guides about their local areas and upload them for the benefit of visitors. All the guides are then played back according to the location where the listener is, locating and triggering the guides closest to the listener. The listening attitude is like overhearing your neighbours' sound traces, and perceiving perhaps a sense of surveying the community. The audio quality depends on the original recordings, and can be very low at times. There is a sense of engagement and community created by the ethos of the app, which aims to create a sort of Wikipedia-style encyclopedia of audio guides. However, in our experience, the app suffers from a lack of popularity as evidenced by the scarcity of source recordings in combination with, and further aggravated by, the fact that it is available globally. For example, the explore feature, intended to retrieve nearby guides, yielded no results for us. Proximity (global-local) is an interesting variable that stands as a very important one when using sound and geo-location.

Chirp app, by Animal Systems, allows interaction between two users in the same vicinity

[10] Is it possible that the programming behind is similar to Reality DJ RJDJ is a mobile interactive music playback engine based on Pure Data.

through sound. The fact that the sending user may or may not be visible to the receiver extends and contorts the traditional bounds of close quarters communication by making it possible to engage in communication with someone who may be at the other end of the house or somewhere else that is beyond the bounds of human visual and / or auditory perception. The app allows multiple participants to interact with each other simultaneously. The musician Matthew Herbert demonstrated the collaborative potential of the app by utilising it in the contemporary production of Charles Gounod's Opera Faust[11], in which the audience was encouraged to come with the app installed in order to interact with the production as it unfolded.

The app *Arrivals* created by the vocal artist Viv Corringham[12] brings into location performative and documentary elements about her exploration of feelings associated with location in conjunction with the residents in the city of Kingston, NY. The user can walk anywhere in the world and the app will track a path according to the route that the artist took with Kingston residents. An interesting sense of dislocation is generated by the description of a foreign city within another city. Furthermore, Viv Corringham's embodied experience expressed with her voice offers to the listener a very inspiring way to approach a path in any city. The themes of the interviews are about location, home and histories; these invite us to link these lives of a distant place with the local one. The artist is the guide through the path, and this makes the multilayered experience both beautiful and interesting in its documentary character.

In these examples we have highlighted the excitement produced by the idea of being heard in real time, the subtle differences in the perception of real time, the timeless feeling created by the combination of a pre-recorded, distant context (e.g. rural) and a real-time, present context (e.g. urban/enclosed); walking and its powerful forms of listening to territory, when embodied by a voice; and also the popularity offered by sharing sounds in social networks such as Soundcloud, Facebook, Twitter and others, which becomes a commercial pressure covered within the idea of socialization.

4. *Performing* (with a device, and with others)

In Networked Migrations performances, voice in its many creative manifestations plays a very important role in the listening of the 'self'. Identity is created and expressed through voice. By interacting with others in the distance (e.g. with a memory of language, a memory of a voice that has changed), voices reflect and cross cultural limitations. These approach a concept that Alarcón (2014) is keen to explore: 'nomadic voice' as developed by Janette El Haouli (2006), a voice without fixed territories, which "becomes a bridge for the overcoming of pre-established values and inherited questionings." (2006)

[11] http://www.roh.org.uk/productions/the-crackle-by-matthew-herbert
[12] With the technical production of Paul Cantrell https://itunes.apple.com/gb/app/arrivals-kingston/id534582158?mt=8 (most recent update 26/06/12)

Which parameters, if any, can be utilised or experimented with, for developing the concept of a nomadic voice, for a Networked Migrations app? What are the effects produced by sending a voice to a distant location and retrieving it later?

Regarding expression and performativity with voice and other means we focused on how the reviewed apps allow the user to express through sounding (alone and with others).

4.1 Interacting with voice bi-directionally

A central technological requirement for a telematic performance app is the need to create and connect live, bi-directional audio streams. Obvious examples of existing apps that provide such functionality are Voice over Internet Protocol (VoIP) apps. Several popular VoIP apps exist today for both the iOS and Android platforms. Skype, now owned by Microsoft, was originally developed by Janus Friis and Niklas Zennström. It was one of the first VoIP apps to gain widespread popularity, and the iOS and Android Apps boast many of the features of the desktop version. Put simply, Skype allows users to communicate via video, voice and message over the internet. Although it is available as a free download, it offers a premium service to customers in the form of 'Skype Out', which allows users to make calls from Skype to traditional landlines and mobile phones at a cost. The sound quality of calls over the Skype network, i.e. Skype-to-Skype, are in our experience very good over a typical broadband connection, far better than landline-to-landline, for example, and this typically holds even when crossing continents. However, Skype to landline typically suffers similar degradation in sound quality as does landline-to-landline and sometimes worse.

For performance purposes, artists have used Skype, and in fact, it has been useful for working with participants in the Networked Migrations performances (Alarcón, 2014). When performing, it is noticeable that Skype uses a sound compression that works for relatively normal conversation, but when the sound goes above the dynamic level understood as normal (e.g. shouting, or singing loud), the compressor or limiter reacts by muting one of the two sources of the conversation. Open source and free Internet applications used in telematic performance, mentioned above, have solved this issue by using high quality audio data compression[13] or uncompressed audio[14], in which levels are managed by connecting the streaming sound to audio software of the performer's choice and offering a desired sound quality for each performance. It can be argued that Skype and other commercial applications bring another aesthetic, and that performances can take place with it. In Hangouts app[15] from Google, a VoIP app[16] which acts as competition for Skype, it seems that the audio quality is higher[17] [18].

[13] Soundjack and TubePlug.
[14] Jacktrip.
[15] http://mobileoffice.about.com/od/conferencing-tools-reviews/fr/google-plus-hangouts.htm
[16] http://www.engadget.com/2014/08/14/google-hangouts-ultraviolet-chat-heads/
[17] http://gigaom.com/2011/06/30/google-hangouts-technology/
[18] http://thefutureofink.com/google-hangouts-technology/

However, in the envisioned app, sound quality is key to offering a listening experience that is mediated, and some degree of control is needed over the network, as well.

Viber[19] is another VoIP app and is developed by Viber Media. Likewise, Whistle Phone by Vail Systems. For all intents and purposes, Viber and Whistle Phone are very similar propositions to Skype, including their comparable level of audio quality. However, subtle differences do exist, such as the need to link one's mobile phone number to the service as a user name in the case of Viber, rather than the more traditional approach taken by Skype, where the user creates a handle / username and password at the point of registration, which they then use to access the service. Because of this, Viber first needs to be configured on one's phone before a desktop version can be used. Because VoIP-to-VoIP calls are typically free and the creators of VoIP apps don't typically charge for the initial app download, VoIP Apps have revolutionised the communications industry, as users flock to take advantage of what for most is a very useful and affordable service. See the Appendix for a discussion of the technologies behind VoIP.

4.2 Interacting with voice uni-directionally / transforming

Either for voicing, speaking, or singing, the reviewed apps promote performing with the voice with known strategies in the musical world, such as looping. *Looping Voice* app invites one to listen in anticipation for the sound that has been recorded and visualised on the interface. Performing takes place while looking at the interface. It is an engaging app that invites the user to improvise with up to six different loops. The interface suggests the possibility of creating visual, animated scores[20]. A similar application with a visual animated interface is the *Looping Body* app*,* which achieves some degree of playfulness by using a skeleton that moves extremities when a sound layer is being added to the loop. It is interesting, the connection that this visualization creates with the body, which could invite the user to experience a performative game with voice and body.

The *Overdub* app*,* by Kirill Edelman, allows the user to determine a loop of arbitrary length. The user can then overdub an unlimited number of times, each time specifying a new track for the recording. It is very expressive, since the user can build up a 'sound mesh' utilising multiple layers of her/his own voice.

Transformation of voice is another functionality offered by many commercial apps. For instance, the *Tabletop* app, by Retronyms Inc., creates sound textures that allow the acoustic voice to be heard outside traditional headphones. Many other Apps transform

[19] A similar new application is called We Chat http://community.giffgaff.com/t5/Blog/WeChat-Messaging-App-Review/ba-p/14153535?utm_source=giffgaff&utm_medium=email&utm_campaign=email-OBC085

[20] Examples of animated scores are the ones created by Ryan Ross Smith, http://www.youtube.com/user/ryanrosssmith/videos Accessed 21/06/14 Other scores have been created as apps themselves, such as Decibel ScorePlayer developed in Australia by Lindsay Vickery. These used networked possibilities too. https://itunes.apple.com/gb/app/decibel-scoreplayer/id622591851?mt=8

voice with simplistic effects: The *Voice Changer* app, by App DEV, allows the user to generate different voices with seven sound effects[21]. In *Talking Parrot*, by AppBasic, the user interacts with a virtual parrot that repeats all what the user says. *OttO – The Amazing Live Voice Reversal* app *and FX Gizmo* app, by Yonac Inc., behaves in a similar way. Another example of transformation is the *VIO* app*,* which allows hearing the user's voice at different pitches. It transforms also the space, in which the voice transforms with an effect of waving panning, aided by the visuals of particles that are being drawn into a void. We suggest that the visuals mimic the sound experience, and this creates an obstacle for the listening experience of people's own voice.

In a more articulate manner the *Voice Bubbles* app, by Yvon Bonenfant, an app designed for children*,* uses different parameters: echo, pitch variation, some granulation, filtering, inviting children to transform their voices, which leads to the creation of imaginary characters. The recording becomes active with touch. It allows exploring visually the effects of the voice by way of colourful bubbles. These invite the user to play with her/his voice, in a relationship of visual feedback. The sequence of bubbles plays like a composition made collectively by children.

The reviewed applications raise the question: at which point of an applied effect in real time does the person stop listening to her/his acoustic (recognisable) voice?

Perhaps looping approaches the idea of a voice frozen in time and acoustic space, and a reflection on the recorded voice which requires some delay; it could come back to the listener in the form of a non-artificial effect-driven transformation. Perhaps also the archives of a voice that has embodied a distant location can be heard together with a present voice. Looping with optional delay can offer an idea/ or a metaphor of the recent past of a voice. Bi-directionality of voice, as a reflection of its actual journey in a telematic performance, is an interesting feature that has been interrogated by the original Networked Migrations performance, and which requires technological options that are explored in the Appendix in the section on VoIP technology.

4.3. Interacting with the body and the device

We explored the possibilities used by apps to extend the expression of the user, e.g. multitouch (tapping and dragging), screen capture through video tracking; sensors that allow detection of movement, position and bearing, and gravity; the on-board accelerometer and gyroscope, and built-in microphone.[22] [23]

[21] Such as chipmunk, helium, deep, slow, echo, reverse and robot.

[22] The sensors available in Android phones are Motion sensors (including accelerometers, gravity sensors, gyroscopes, and rotational vector sensors), Environmental sensors (including barometers, photometers, and thermometers), position sensors (including orientation sensors and magnetometers) http://developer.android.com/guide/topics/sensors/sensors_overview.html (Accessed on 17/09/14)

The *Music Ball app*, by Acoustic World, uses a clever combination of the onboard sensors and a game engine that mimics gravity. Tilting the screen influences the direction in which the balls fall and bounce, producing sound. In the *Fourier Touch app (iP)*, by KonakaLab, in addition to its multi-touch interface, with the help of the embedded accelerometer, the user can control the pitch and volume by tilting the device about the x and y axis.

In the *Ocarina* app, by using the built-in microphone and physical modeling of sounds, the app transforms the mobile phone into an instrument, which in itself invites the user to perform. The reverb helps create pauses for listening and playing the mix of sounds (only four sounds), and it is possible to choose timbre and scale, which makes the experience enchanting. The immediate response to touch is rewarding. The handling of the iPad as an ocarina is demanding; it works better on the iPhone, compared also to the HTC Sensation XE, as it is a smaller object.

By using screen touch (and dragging) the *Sonic Zoom* app[24] creates precise sonic changes, and an immersion in the many layers of generative sound through the zoom feature, which is attractive and engaging. It can take the user into the exploration of areas of pure electronic sound, with an engaging interface that is far from typical music production knobs[25].

An engaging use of video tracking has been developed in the *AirVox* app, by Yonac Inc., which invites the user to wave their hands in the air. Taking inspiration from the Theremin, the app makes use of the front facing camera of the newer iPhone models to detect hand movement in space. The user can use either one or two hands to engage, mapping one to the pitch control and another to various parameters, including volume, vibrato and filtering. The gesture of the hand with the body in stillness offers awareness of each movement the body is making by changing the sound. Interacting in this way leads to a feeling of intense engagement when the sensors are working as intended.

The *AUMI* app, by Deep Listening Institute, was designed to provide full engagement with the body by camera tracking and motion. The wide variety of sounds and instruments allow the expansion of the listening experience. The software finds the 'intentional motion' of the user if all lighting settings and conditions are in place. The sounds are high quality and beautiful. Designed for people with physical impairments, this app opens the inner expressive self, locked due to the lack of mobility of the body. If the user wants to record activity, s/he can log in to AUMI. This allows collaborative learning between the creators of the app and the users, which are mainly in educational institutions that work with children

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[23] The sensors available in iOS devices are Proximity sensor (iPhone), motion sensor/accelerometer (iPhone, iPad), Ambient light sensor (iPhone, iPod, iPad), moisture sensor and gyroscope. http://ipod.about.com/od/ipodiphonehardwareterms/qt/iphone-sensors.htm (Accessed on 17/09/14)

[24] OS iPad App. PhD Project at Queen Mary University of London. By Robert Tubb. Created on 05/08/2013

[25] Currently there are knobs developed for iPad to control Touch OSC, http://www.wired.co.uk/news/archive/2014-07/09/tuna-knobs (Accessed on 14/08/14)

with impaired movement. The app has options to work via a local network, and has been created with improvisation in mind.

The reviewed apps suggest that the use of a device's technologies of movement can offer performativity and mobility to the users. A tracking of movement in space, which does not necessarily involve GPS, is a feature worth exploring for a future application where performers explore Deep Listening body, and the perception of physical space in local and distant locations. Awareness created by the precision that sensors offer to body motions can be explored when performing; particularly slow movements can be explored to achieve better awareness of sound in space/time.

4.4 Interacting with visually engaging interfaces

Dragging and tapping have been embraced by apps, in what Harmony Bench (2014) calls 'gestural choreographies', to explore forms of interaction helping the user to play with sound. The *Patatap* app[26], by Jono Brandel, offers an interactive audio-visual experience that the user can explore by typing keys on a traditional keyboard or the surface of a touch screen to trigger sound clips and short graphic animations. With this app the user can create musical pieces by learning and choosing the sounds and images triggered by the touch action (on the iPad) or typing on the keyboard (on the computer); the graphics enhance the sense of expression in what can be achieved by experimenting. For instance, an interesting experiment is to play with the app where a QWERTY keyboard[27] is available. If the user types away as though writing a letter or giving voice to a random train of thought, s/he can observe how it is expressed in sound and image, while playing the app unveils layers of sound in a sort of composition. The interface is relatively hidden, and spaces are discovered by repeated interaction. By tapping the user memorises the spaces on the screen where sounds are triggered.

Other apps that similarly engage the user with images and sounds are *Bloom*, by Mindbloom, *Dropophone*, by Hayashi Yosuke and *Soundrop, by Develoe LLC*. The *Soundrop* app is a beautiful and engaging app, which works with lines that, according to their position, influence both the pitch of the ball when touching and the rhythm given by the collision between surfaces that are positioned in a parallel or oblique manner. Both listening intuitively and the rational mind are focused on the game. Overall, simplicity of interface makes sounding and listening stand out.

These applications have invited us to think how image can leave sound its role without falling into a functional relationship, but establishing an interesting dialogue between sound

[26] We included the web-based app Pratatap, as when it works in iPhone or iPad it takes advantage of screen touch technology.
[27] QWERTY. *Wikipedia, the free encyclopedia*. Available at: http://en.wikipedia.org/w/index.php?title=QWERTY&oldid=615184753 [Accessed July 13, 2014].

and image, resulting in a rewarding experience for the user. Simplicity in the visuals, such as in Soundrop, is not only functional but helps to create sounding space. Imagining telematic performances, it is important to be mindful of the role that the screen plays as the separation in-between the two locations, almost the physical border, which can be richly explored aesthetically and technically.

4.5 Composing by sequencing and transforming sounds

Composing on a mobile device can be understood and developed as a form of performance, and also as a process that complements some types of performance. We selected audio production apps that are of high standard in the market. Their functionalities vary widely from simple sample-based sequencers (*Dropophone*), to keyboards and synthesizers (*Seline,* by Amidio Inc.), wave editors and multi-track recorders (*Overdub*) to fully featured Digital Audio Workstations, which mimic the complex internals of a digital studio, including instruments, devices, effects units and their interconnections (*Audio Evolution Mobile, Tabletop*).

For instance, the A*mbient sound lab* app allows the user to discover rhythms and create compositions, modifying the sound through features such as speed, mood, and the frequency of tones that are being generated.

In the same line, the *Audio Evolution* app allows users to record or import any kind of sounds and modify them in real time. In the app *Traktor DJ*, by Native Instruments GmbH, the sound can be enhanced in a number of ways, including the application of effects, equalisation and by mixing. The sound is greatly enhanced by the existence a graphical waveform representing each track. It allows the user to create new music with her/his music collection. On top of the standard mixing functionality, there are options that allow the user to cue beats by tapping at different time locations along the waveform.

The sound accuracy achieved by these apps shows how powerful can be the manipulation of audio parameters on a mobile phone. It is worth looking into possibilities of real time mixing that in the future might be attached to the streaming audio signal.

Conclusions

This review has offered a good degree of clarity into technical, sonic, visual and performative aspects that need to be considered to design a prototype for a mobile app for telematic sonic performance. Because of the medium, performances could be understood as mobile or locative.

There is lots of potential to explore creatively the in-between sonic space created in migratory/dislocation experiences with mobile phone apps. However the way of developing the app and the perfomance will be considerably different than a performance mediated through the Internet.

The social context where the application is going to be used is key, and location is an important feature to consider both socially and technologically. Intimacy and social engagement are attributes experienced through the medium, which are crucial when thinking of developing an app in any context. This invites one to consider how to engage a community of users, and the different layers of collaboration that might be established and learnt together with migrants.

Streaming sound via mobile phones offers a construction of real-time, which can be used in different ways for an app focused on migrations. Forms of listening to streaming, pre-recorded and live sound, or only pre-recorded, as exemplified in the reviewed apps, highlight their perceptual and aesthetic differences.

Mobile phones offer different options to think of bi-directional streaming (as happened in the Internet-based performances) and interaction. Other forms of dislocation can be created by the context and the technology.

LocusCast app, part of the Locustream project, proposes an interesting alternative, which needs more than one device in each location to approach the original feeling of bi-directionality. Together with LiveShout these apps can be used to experiment with streaming and listening through the web as pilot projects that support a work on dislocation.

The use of voice transformations needs to be carefully developed. The acoustic transformation is a key aspect to raise awareness in the listener of how voice is reflected in different spaces. Using either reverb, a pure reflection of the voice in space, or delay, the voice in space mediated by times of recording, listening and reflecting, is a first step to be explored.

Looping applications invite self-reflection, and it would be interesting to explore how this can be applied to improvisation in real time. For example, how by traveling to another space, the voice is bounced back to the listener, informed by the environment where the listener is, and also reflected on other people’s voices. Focusing on the 'nomadic voice' and its performative possibilities seems like a good way to start developing an app: first for individual users, and then for collective or networked use.

On the other hand, the integration of many possibilities of movement with the device invites us to think of performance with the body. Deep Listening practice, and within it the listening body practice, opens a creative ground for experimenting with this technology.

Visually, it might be interesting to think of animated scores, even if minimal, as a resource to explore the concept of anticipation.

On the device, engagement with touch is very relevant. Touching the screen as a 'limit' between the two locations can become a powerful feature that cannot be underestimated. For instance, exploring visually location, such as in the Sonic Zoom app, is interesting as a metaphor for exploring in-betweens in multiple layers, and is engaging. It is difficult to think of improvisational navigation that brings the unselfing, as navigation is a rather self immersive experience. However its simplicity, and the possibility of playing with the space, with borders and possibilities according to the encounter of limits, is an interesting

metaphor for migration and in-between-ness that can be applied to the making of sonically rewarding experiences in an improvisational manner, as a multiplayer space.

Technically an app development needs to focus on a number of functions, which need to be developed and tested step by step. According to the context and resources, the researchers can focus on one idea and build in a modular way an interface that supports different forms of interaction in the 'in-between' space.

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Technical Appendix

1. General technical aspects

iOS and Android are by far the biggest mobile operating systems on the market: Between them they enjoy over 95% market share[28]. Despite the fact that Android makes up the majority of this percentage, a common strategy amongst developers is to target iOS as a priority due to the complexity, time and financial cost of developing for Android due to device fragmentation[29] coupled with the fact that Apple enjoys a more buoyant App Store[30]. For this reason, we thought it pertinent to target iOS devices as a development priority with a view to developing for Android in the future. That said, we chose to review Android as well as iOS apps to give us the most representative view of the state of the art.

The most obvious point from the apps reviewed is that there is a massive range in the complexity of technical implementations. From the throw-away simplicity of some apps such as *Relax Lamp* Lantern, by Lifestlyle, to the much more highly accomplished and, one would think, valued *Audio Evolution Mobile*, by eXtream Software Development. Simplistic apps, whilst they may be fun in the short term, lend themselves to being disposable in the medium to long term as is the case with the aforementioned *Relax Lamp Lantern*. Another obvious point is that apps with the technical functionality desired by the *Migrations* app do not yet exist for mobile. Instead, many apps touch on relevant aspects while neglecting others. Together these apps give a good indication of the significance of the technical task that lies ahead. Similarly, apps that don't suit the aesthetic of the Migrations app but expose a technical architecture that may be of use—e.g. the unidirectional streaming capability of *Sing Like A Star* by Famous Blue Media LTD, at least for one of the preliminary iterations of the app—provide a certain value.

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[28] IDC: Smartphone OS Market Share. www.idc.com. Available at: http://www.idc.com/prodserv/smartphone-os-market-share.jsp [Accessed July 14, 2014].

[29] Dredge, S., 2013. If Android is so popular, why are many apps still released for iOS first? The Guardian. Available at: http://www.theguardian.com/technology/appsblog/2013/aug/15/android-v-ios-apps-apple-google [Accessed July 14, 2014].

[30] Why Developers Prefer Apple Over Google. The Street. Available at: http://www.thestreet.com/story/12759340/1/why-developers-prefer-apple-over-google.html [Accessed July 14, 2014].

That said, the importance of getting the complete package correct is also clear. A good app that lacks an expected feature—as in the case of *Overdub* with its lack of a 'bounce' feature, allowing the user to combine all tracks at any given moment onto a single track and continue from there—shows how a good app can still lead to bad user experiences. Likewise with *Voice Changer, which has* decent sound quality but at the same time lacks an option to store audio on the device. Conversely, the importance of a good technical implementation lies not just in providing for complex functionality but also in allowing for high quality audio. This is something that can be all too apparent when it is missing, e.g. *Talking Parrot,* and is a definite positive when present, e.g. *Ambient Sound Lab* by Outer Limits or *3D Sound* by TucuDroid. Furthermore, frustration arises from complex implementations that are buggy or do not work as well as one would like, i.e. *AirVox* or the *Talking Parrot* with its sometimes inaccurate phrase detection.

The latest iPhones and also the latest Android devices are basically computers of substantial power. This power is enhanced by their mobility and the inclusion of embedded sensors that allow for the detection of movement, position and bearing, not to mention audio and image capture. Apps such as *Dropophone* show how the correct use of these 'extra' features can become an endearing feature for users, and its important to remain aware of their presence. *Shoudio* or *Woices* are examples of apps that make good use of location services available on the iPhone. However, at the same time, these apps highlight a potential oversight of the developers in their decision to release the app globally. They simply don't have enough users to create the user experience that the developers most likely envisaged during the development stages. A better strategy might be to release to app to different territories on an incremental basis, which is something that developers do have control of via iTunesConnect[31].

Furthermore, it's important to be aware of the implications that technical decisions entail. For example, making gravity a feature for *Soundrop* may have meant excluding users on an earlier version than iOS 7. Whilst gravity may not be of immediate concern to the Migrations app, the point still holds. Certain features of Apple's telephony framework, for example, are only available to users on iOS 7 and above.

[31] iTunesConnect is a resource for iOS developers to manage the publication of Apps on the Apple AppStore.

Potentially, there is much reward to be had from heeding the technical needs and expectations of the user. Successful implementations can lead to joyful user experiences, which can lead to high ratings, which in turn lead to more downloads and the overall success of the app, as is the case with the excellent *Audio Evolution Mobile* or *Traktor DJ* apps.

In conclusion, in order for the migrations app to work bi-directionally, it will require a mixture of mobile and internet technologies, as is the case of the Locustream project, and other apps such as LiveShout based on the Icecast framework. The use of Pd (i.e. libpd) could help accelerate and expand the development process.

2. DEVELOPMENT OF VoIP FUNCTIONALITY FOR THE MIGRATIONS APP

We were intrigued by the Voice over Internet Protocol (VoIP) since it seems a prime candidate for a central technological requirement of the Migrations App, i.e. the need for live bi-directional audio streams. VoIP is the name given to a group of technologies that allow for multi-media communication over a network such as the Internet. It uses various encode / decode protocols that allow for the transportation of data such as audio and video. Communication can occur over wifi as well as cellular networks. Two key questions were developed, focusing on iOS. An initial focus was placed solely on iOS given that the initial implementation of the Migrations App is intended to be iOS only.

1. What are the technologies required to build a VoIP app for iOS?

2. Can VoIP be delivered in a way that allows for the integration with the technologies required to achieve the other technical goals of the project?

Examples of VoIP protocols include H.323, Media Gateway Control Protocol (MGCP) and Session Initiation Protocol (SIP). Lately, SIP has achieved widespread adoption partly because its security measures are seen in a favourable light.

2.1 Session Initiation Protocol (SIP)

The SIP protocol defines the messages that are sent between peers on a network for the

commencing, termination and other essential elements of calls such as 'hold' functionality and call forwarding. However, SIP is defined as an application layer protocol meaning that it 'sits on top' of other transport layer protocols, which are responsible for the transmission of the audio / video / text data itself. Of these, the Transmission Control Protocol (TCP) is often recommended for its connection-oriented approach, which guarantees the delivery of data packets and the order in which they were sent.

VoIP implementations using SIP often rely on server-side infrastructure. However, the protocol itself is defined as peer-to-peer, meaning that it is possible in theory to connect users if their addresses on the network are known beforehand. However, reliability of the connection may be one major concern in this scenario: although it is possible to connect to a user if their IP is known, the service provider could potentially change that IP address any given moment. Servers are able to keep track of all this and for this reason are the preferred option for device-to-device communication over the Internet.

2.2 Client-Side Technologies

There are several options available that will allow for iOS devices to communicate using SIP/ TCP:

Commercial / proprietary

Commercial services such as Twilio[32], tokbox[33] and quickblox[34] allow for the easiest technical setup allowing for audio/ visual communication to occur in just a few lines of code. However, drawbacks to using these services include the fact that they are paid and that they are opaque in terms of the underlying implementation. That is, it is unlikely to be possible to get at the underlying audio streams for the purpose of further routing, as in the case of spatialisation, or processing, as in the case of applying time delays, both of which are technological goals of the Migrations app.

[32] Twilio Cloud Communications - APIs for Voice, VoIP and Text Messaging. Available at: http://www.twilio.com/ [Accessed July 13, 2014].

[33] Add live, face-to-face video with the OpenTok platform | TokBox. Available at: http://tokbox.com/ [Accessed July 13, 2014].

[34] QuickBlox Backend: cloud communication backend API as a service for mobile and web apps. Available at: http://quickblox.com/ [Accessed July 13, 2014].

Open source

There are also open source solutions in use such as PJSIP[35], idoubs[36] and linphone[37], which use SIP. There are still other solutions that do not use the SIP protocol such as miumiu[38], which uses IAX[39]. These frameworks relieve the developer of the complexities of having to implement the SIP protocol itself. However, significant development time would still be required.

One of the main advantages of the PJSIP framework is that it uses native core audio technology meaning that audio streams should be available for further processing / routing and general manipulation. On the downside, it is written in the C programming language, meaning it will be low level, complex and require significant effort in terms of setup. This would also typically make it less accessible to iOS developers, who are more accustomed to developing in the Objective-C programming language. Still, some Objective-C wrappers, i.e. higher level abstractions built on top of C, do exist, such as gossip, which would relieve some of the effort required.

idoubs is an Objective-C wrapper built around the doubango[40] framework, which is developed in C. This promises better support for the Objective-C developer since it's maintained by the developers of idoubs, rather than a third party. Using idoubs, it should be possible to gain access to audio streams for further processing / routing etc. This framework is quite advanced [41] and is still under active development. In addition, the source comes with an example project which demonstrates audio / video calling capabilities.

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[35] PJSIP - Open Source SIP, Media, and NAT Traversal Library. Available at: http://www.pjsip.org/ [Accessed July 13, 2014].

[36] idoubs - SIP/IMS VideoPhone for iOS (iPhone, iPad and iPod Touch) and MAC OS X - Google Project Hosting. Available at: http://code.google.com/p/idoubs/ [Accessed July 13, 2014].

[37] Linphone, open-source voip software | Linphone, an open-source video sip phone. Available at: http://www.linphone.org/ [Accessed July 13, 2014].

[38] Home · pzion/miumiu Wiki · GitHub. Available at: https://github.com/pzion/miumiu/wiki [Accessed July 13, 2014].

[39] IAX - voip-info.org. Available at: http://www.voip-info.org/wiki/view/IAX [Accessed July 13, 2014].

[40] doubango - open source 3GPP IMS/LTE framework for embedded systems. Available at: http://doubango.org/ [Accessed July 13, 2014].

[41] As of July 2014 idoubs is on version 2.0.

Due to it being open source, linphone, like idoubs and PJSIP, should give the developer access to underlying audio streams. The developers even provide access to a free SIP server-side service which clients can register and interface with to allow, in theory, for the easy attainment of server-mediated communication between devices, which is the ideal means of establishing communication sessions.

Licensing considerations

In choosing a framework, it's important to consider the licenses with which those frameworks are released. For example, certain licenses, such as the GPL license, may be incompatible with the needs of the project and / or Apple's own terms and conditions resulting in rejection of the app from the App Store.

Apple Documentation

Apple provides some specific guidelines to developers of VoIP apps[42,43].

Development Time Considerations

It's estimated that there would be significant development time required for a developer new to VoIP apps. Much time would need to be spent understanding the underlying protocols and specifications. It is also anticipated that manipulating audio streams provided by the open source frameworks mentioned above, in a way considered useful to the end goals of the Migrations app, would represent a significant challenge due to the fact that these frameworks were not developed with such functionality in mind, and the complexity

[42] Anon, iOS App Programming Guide: Advanced App Tricks. Available at: https://developer.apple.com/library/ios/documentation/iPhone/Conceptual/iPhoneOSProgrammingGuide/AdvancedAppTricks/AdvancedAppTricks.html#//apple_ref/doc/uid/TP40007072-CH7-SW12 [Accessed July 13, 2014].

[43] Anon, Core Telephony Framework Reference. Available at: https://developer.apple.com/library/ios/documentation/NetworkingInternet/Reference/CoreTelephonyFrameworkReference/_index.html#//apple_ref/doc/uid/TP40009603 [Accessed July 13, 2014].

of the underlying implementations makes them brittle in the face of adaptation.

However, although a server side component is ideally required, it seems that such services are already in existence, though some may require a fee[44]. This should mean that development of the Migrations App would be possible with just iOS developers. At this preliminary stage of investigation, development time for the Migrations App would be estimated at 9 – 12 months.

[44] Anon, Hosted Phone Systems | Virtual PBX for your Business | RingCentral. Available at: http://www.ringcentral.ca/ [Accessed July 13, 2014].