Guidelines for the design of location-based audio for mobile learning

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Abstract

In this paper, we discuss the value of location-based and movement-sensitive audio for learning. We distinguish three types of audio learning experience: audio vignettes, movement-based guides and mobile narratives. An analysis of projects in these three areas has resulted in the formulation of guidelines for the design of audio experiences. We offer a case study of a novel audio experience, called 'A Chaotic Encounter', that delivers an adaptive story based on the pattern of movements of the user.

Keywords

Audio narratives; mobile learning; audio guides; location-based experiences.

1. INTRODUCTION

A consistent finding of research into mobile learning guides and outdoor learning games has been the value of audio as a medium of communication (see e.g. Bhaskar and Govindarajulu, 2010; Naismith *et al.*, 2005; Schwabe and Goth, 2005). This complements earlier findings from studies of distance learning which showed that students like being informed by the voice of their educator, listening to interviews or debates, hearing from experts and being encouraged with a reassuring audio message (Durbridge, 1984). The difficulty with audio as an instructional medium is that it can be hard to concentrate on a voice for long periods, it is difficult to retain de-contextualised audio information for later reflection (Laurillard, 2002) and some topics can be explained more effectively through pictures or graphics (McConnell and Sharples, 1983; Minocha and Booth, 2008).

This indicates two, diverging, opportunities to exploit audio as a medium for mobile learning: in podcasts, where the audio is de-contextualised and may need to be supplemented by graphics, images or video to explain or illustrate a topic; and in location-based guides, where the physical surroundings complement the audio commentary.

This paper has a focus on audio experiences, including guides, games and stories, that are either matched to location by position-sensing technology such as GPS, or that respond to the physical movement of the user.

The initial challenges for designers of location-based mobile learning are to:

- ensure that the learner is at the right place and looking in the right direction, so that the sound and the view are matched,

- minimise the need for learners interacting with the device so that that they have a 'heads up' continual flow of visual information rather than frequently shifting gaze between the scenery and the screen.

Physical movement around the environment can provide an effective method of interaction (Bristow *et al.*, 2002). Contextualised information can be adapted to the user's preferences and profile, their route, their current position and orientation, whether they are standing or sitting, and how long they have been at the current position. Thus a person's movement and posture can provide means of interacting with a combination of the physical surroundings and audio educational material, without the need to gaze at a screen or press buttons.

This paper provides an overview of the use of audio for location-based encounters. It provides a classification of types of verbal audio and examples of their implementation in mobile learning systems, followed by guidelines for the effective use of audio, drawn from the examples. We then present a case study called 'A Chaotic Encounter', an example of a novel approach that combines movement-based guides with mobile narratives (an adaptive narrative). We report an initial evaluation with ten users along with suggestions for future work.

2. TYPES OF AUDIO EXPERIENCE

Audio has been used effectively in many location-based experiences, including mobile gaming (Drewes *et al.*, 2000; Lyons *et al.*, 2000); tourism (Aoki *et al.*, 2002; Naismith *et al.*, 2005); educational visits (O'Hara *et al.*, 2007; Vavoula *et al.*, 2009) and theatrical events (e.g. Hotter than Hell[1]), or a combination of these activities (Rowland *et al.*, 2009; Schnädelbach *et al.*, 2008).

Audio can be used for directional purposes, for example to tell the user to follow a path until a particular landmark is reached, or to orientate them so they are facing a specific feature of the landscape or museum exhibit. It can be designed to engage the user in a task-based activity, particularly in educational scenarios, where the student is asked to make notes or take measurements/observations relating to their immediate environment. It can also be used to provide information about an object or scene, as a story-telling device, or to create ambient sounds relevant to the environment such as birdsong or machinery. These instil a more authentic atmosphere and make the experience more realistic, as demonstrated in Ambient Wood (Rogers *et al.*, 2004).

In this paper, we concentrate on the use of spoken audio rather than non-verbal audio. We propose three broad classes of movement-based audio experiences:

- *Audio vignettes*, where the user's movement into a location triggers audio, but there is no adaptivity based on previous movement;

- *Movement-based guides*, where the aim is to adapt information to objects or surroundings, and the interaction and adaptivity is based on user movement;

- *Mobile narratives*, where an audio narrative is performed based on a sequence of user movements.

These three forms of audio guide have some common properties and requirements (e.g. audio as the main means of delivery), some differences (e.g. whether the audio should be independent of previous location, adaptive to it, or cumulative), and some dependencies on the particular design goal (e.g. whether, and how, the users should be explicitly informed of the relation between their movement and the audio).

3. AUDIO VIGNETTES

We classify audio vignettes as short pieces of audio triggered by movement from the user. However, there is no history of where the user has been, and hence no adaptivity based on previous movement. Thus, users are able to engage with chunks of audio that are independent of each other and of their relative locations. Depending on the design, it could be possible to interact with some, all, or none of the audio segments in a particular place or sub-

area, with either the computer or the user choosing which aspects of the place to engage with. Missing out some vignettes should not necessarily disadvantage the user since the information in each should be self-contained, although there might be added value if related vignettes are played within a short space of time (e.g. audio descriptions of information relating to archaeological exhibits found at the same geographical location or with a common theme).

Examples include work by Bederson (1995), who created non-linear browsing for museum exhibits: a piece of audio would be attached to each artwork and this would be activated based on the proximity of the user. Since this was a non-linear system, users could approach any exhibit in any order; they could re-visit them or choose to skip over any that they were not interested in.

Rozier *et al.* attempted to take this further, by allowing users to overlay their own audio recordings onto existing 'audio imprints' that were already present in their immediate environment (Rozier *et al.*, 2000).

The 'Riot! 1831' project (Reid *et al.*, 2005) provides an excellent example of audio vignettes. This was an interactive play created using mScape[2], based around the riots which engulfed the Queens Square area of Bristol in 1831. Participants were given PDAs running the mScape client; they were then free to explore Queens Square on their own. GPS positioning on the device monitored the user's position and the area was divided into regions. When the GPS reported that the user had entered one of these regions, it triggered a short audio vignette depicting events of the riot which occurred in that place. These were not sequenced in any way, so users could freely wander between regions (and vignettes) in any way they chose.

Evaluations of 'Riot! 1831' report a positive experience for most users, however some feedback indicated that there seemed to be no overarching narrative and it could be difficult at times to get a more holistic overview (Reid *et al.*, 2005). The authors also encountered problems with the GPS signal often being adversely affected by buildings or weather conditions. When this occurred, they intervened to stop participants from using the system and encouraged them to return later.

Issues relating to the effectiveness of audio vignettes in outdoor locations have been explored through the 'Augmenting the Visitor Experience' project (Priestnall *et al.*, 2009). Here, groups of students were asked to develop their own mediascape for an area of the English Lake District, which would act as a free roaming visitor guide to some of the hidden cultural and geographical aspects of the landscape around them.

Pre-recorded audio vignettes describing vistas from specific locations were made available, along with audio descriptions of points of interest and miscellany relating to

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[1] http://www.aerial.fm/docs/projects.php?id=101:0:0:0

[2] http://www.mscapers.com/

areas with more indeterminate boundaries. An important aspect of the most recent occurrence of the field project was to encourage students to record their own audio using mp3 voice recorders. The effectiveness of audio was then tested in the field, using video diaries created by the students as one mechanism for gathering evidence.

Findings revealed difficulties experienced by the users in associating standalone audio vignettes with the corresponding landscape features. As with 'Riot! 1831' there were issues with GPS reliability, but also more subtle influences on the user experience, resulting from audio not being delivered at the locations intended.

Nevertheless this is an important category of audio guide and one that has proved popular at many tourist attractions and museums. Its popularity is due in part to the relative ease of authoring and delivering the vignettes, where each audio segment can be offered on its own, with no need to predict or respond to the route taken by the visitor. It also allows freedom of movement by the user, with no compulsion to follow a prescribed path.

4. MOVEMENT-BASED GUIDES

In a movement-based guide, the user's movement within and between locations, as well as changes to physical posture, orientation and gaze can all provide means of interaction and opportunities for adapting the content and delivery of educational material. In a museum or gallery, the layout of rooms and exhibits is designed as a structured information space, so any physical movement around the rooms is also a traversal between concepts. This can be used to advantage in a mobile guide. Consider a person standing in front of a painting in a gallery. A context-aware guide could adapt its content and presentation to take account of the person's route to that location ("you seem to be interested in pre-Raphaelite paintings"), their current location ("the portrait here is also by Rossetti"), their orientation and gaze ("if you turn further to your right you can see a similar painting by Burne-Jones"), and the time they have been at the current location ("now look more closely at the folds of the dress").

An outdoor setting may not be designed deliberately for an educational purpose, but it will have structure, coherence and continuity that can be exploited by a movement-based guide. For example, a rural landscape can reveal contrasts in agricultural use, or changing rock formations along a pathway.

The CAGE system was a prototype movement-based guide designed for a city art gallery (Rudman *et al.*, 2008). The location of the user was determined by an ultrasonic positioning system that was accurate to about 10cm. The user received audio through headphones, that continually adapted to: the nearest painting (as determined by the ultrasound positioning system); the length of time at a painting (the system assumed that the longer a person stayed at one place, the more they were interested in that painting); and the previous time at the position (the content was only repeated on request).

CAGE was evaluated through a comparison with a traditional printed guide. In general, the location-based delivery of content worked well and people liked using the technology. The adaptivity matched users' expectations, and feedback indicated that they found the presentations appropriate and useful. The evaluation found no significant differences between the handheld guide and printed sheet as sources of information, which is not surprising since they contained similar content. A particular success was one painting where the users were given increasing level of information the longer they stayed, encouraging them to look more closely into details of the imagery. This also worked with groups, who shared the headphones. One group of participants spent over three minutes pointing out details to each other and discussing what they were hearing. Other pairs of visitors talked about what they were seeing, prompted by the information from the guide.

Although the CAGE evaluation indicates success in customising the delivery of content based on the route, position and time at the current location, it was less successful in enabling users to make links between exhibits in different locations or in encouraging them to break their linear movement around the perimeter of the gallery. Further research is needed into how people's physical movement can be used as the basis for a coherent sequence of instruction or guidance.

A difficulty of movement-based guides lies in authoring the content so that it adapts to the user's activity. This is a well-recognised problem for intelligent tutoring systems and partial solutions range from the labour-intensive task of creating different content for typical routes, to implementing a computational model of the learner's interest and activity linked to automated generation of audio content (Gustafsson *et al.*, 2006) Adaptive tutoring systems based on computational models of learner activity and inferences as to the learner's cognitive state is an active area of research, with recent work exploring how such models can be presented to the learner to promote reflection (see e.g. Bull and McEvoy, 2003).

5. MOBILE NARRATIVES

In a mobile narrative, an audio narrative is performed that is based on the sequence of movements carried out by the user. Hence, the audio heard by a user will depend upon where the user goes to (and has come from). For example, you would expect a mobile narrative to integrate aspects of location that the user has already visited, but not those that they have not.

It differs from a movement-based guide in having a strong story-telling component and a level of dependency upon the previous audio segment. It may present different perspectives, so that an event or a place is told by different characters, presenting multiple interpretations that can

prove fascinating to a user (Lim and Aylett, 2007; Tozzi, 2000). These different perspectives can also provide a deeper learning experience than having a single narrative, since users can critically analyse the viewpoints and make their own conclusions, compared to having a single stream of information provided to them. It could also be more engaging than individual audio vignettes, since different aspects of the mobile narratives form part of a larger story, thus creating a broader background upon which these narratives are set (Roden *et al.*, 2007).

An example of how this has been created is the 'Mobile Narrative' framework, developed to facilitate the delivery of context-sensitive stories on the iPhone platform (Wiesner *et al.*, 2009). The framework allows an author to create a textual story, divided into multiple chapters. Certain chapters can then be restricted so that the end user can only read that chapter at a specific time or location, as monitored by the phone's internal clock and GPS receiver. Those reading the stories were often irritated by this imposed inaccessibility, regarding it as arbitrary and resenting their loss of control while writers were concerned that these limitations reduced accessibility. This project has only so far been developed in textual format and not in spoken audio, however it highlights the potential pitfalls of forcing users to access content only at specific times or that meet certain criteria, thus reducing and limiting their interactivity with the narrative.

In contrast, "History Unwired" was a freely-usable mobile narrative (in terms of cost to the user and lack of time restrictions) created as a walking tour around part of the lesser-visited yet culturally-rich areas of Venice. It was delivered over location-aware PDAs and mobile phones, to over 200 users, as an alternative to the mass tourism offerings provided elsewhere (Epstein and Vergani, 2006). It followed the personal stories of five local Venetians, who had been interviewed to provide folkloric commentaries on the area in which they lived. Location sensing was provided via Bluetooth due to intermittent GPS coverage in the streets of Venice. Initial user evaluations suggest that the authenticity of the storytellers was very well-received, with some users even meeting one or two of the characters in person. The narrative also provided opportunities to "open up" parts of the city whilst also respecting the privacy of the residents ("closed" areas). Further work is now being carried out by the project developers to investigate the possibility of developing mobile media for sustainable tourism, in co-operation with the local tourism offices.

6. GUIDELINES FOR EFFECTIVE AUDIO EXPERIENCES

Based on the above examples and the design experience of the authors, the following design guidelines are proposed for the creation of effective audio experiences. These are offered as initial suggestions to the mobile learning community and further work is needed to test and refine the guidelines. The guidelines are categorised under several headings: interactivity; narration; trails/navigation; technical issues; and sensitivity to the local environment.

Interactivity:

- An audio experience should be interactive: in the examples given above, the ability of the user to interact with and potentially influence the story (or at least have some control over it) appears to add significant value to the experience.

- This interaction should be dependent on the user's movements. A history or trail of where the user has been can enable the delivery of an enhanced experience and can avoid repetition.

- Under some circumstances, the precise dynamic by which movement affects the narrative should be obscured from the user. This allows the narrative to provide 'ambient informatics' (Greenfield, 2006) regarding the user's movements – the experience is enhanced by allowing the user to gain this information subtly. This is exemplified by 'I Seek The Nerves Under Your Skin', an adaptive poem in which the user had to constantly accelerate in order to continue hearing the poem. The ongoing narrative provided subtle information about the speed of the runner (Marshall, 2009). Gaver *et al.* (2003) also note that such ambiguity allows the designer to raise questions about a user's behaviour without having to necessarily answer them and can additionally compensate for the inaccuracies of sensors.

Narration:

- It is preferable for the narrative at all times to remain coherent and flowing, so that the user does not get 'lost' in the different audio offerings.

- Reducing the reliance on visual material can make an audio experience more engaging and promote curiosity in the user (Sprake, 2006). To that end, the delivery should employ audio alone whenever it can tell a compelling story or complement the visual surroundings. There is an established precedent for this in the examples of audiobooks and audio guides, which allow people to listen without impeding their routine patterns of movement. The content should therefore be able to respond to these patterns without necessarily affecting them. However, users can also be encouraged to experiment with new and unusual styles of movement in order to gain a different narrative experience, as shown by Marshall (2009).

Trails/navigation

- It cannot be assumed that users will follow the path proposed by the guide. The trials of the CAGE system indicated that it is difficult to persuade people to

deviate from a typical route, so it may be better to adapt rather than persuade.

Technical issues

- The audio should adapt to the failings of sensor technology in order to avoid having to abandon the experience when sensors stop functioning, as was the case for 'Riot! 1831' but was overcome by using Bluetooth in 'History Unwired'.

- Where the precise location of the audio in relation to features in the landscape is important, then the shape and extent of the 'trigger' regions should be designed to allow for fluctuations in calculated position caused by inaccuracies and 'wander' in the GPS data.

Sensitivity to the local environment

- Even when GPS positioning can be assumed to be accurate, there remains the issue of the 'geographic relevance' of audio, particularly when it is important that the user associates that audio with specific features in the landscape. Evidence from field exercises (Priestnall *et al.*, 2009) is that users commonly fail to associate the audio description with the landscape, by looking in the wrong direction. This suggests that designers should understand the geographical reference points and landmarks that may be important in a particular environment.

- Sensitivity to local surroundings is especially important when the audio experience takes place in an outdoor location. In History Unwired, sensitivity to local humour, privacy, art and culture was instilled from an early stage in the design of the experience. At the same time, there was a delicate balance to be maintained, so that the tour was not sensationalistic or voyeuristic (Epstein and Vergani, 2006).

7. CASE STUDY: A CHAOTIC ENCOUNTER

In this section, we present an example of a relatively unexplored category, that combines movement-based guides with mobile narratives (an adaptive narrative). Users of *A Chaotic Encounter* are provided with a small PocketPC featuring a GPS sensor, touchscreen and a headphone jack. This system, created using mScape (Stenton *et al.*, 2007), delivers an entertaining audio story, based on Nottingham folktales, which adapts its content to reflect the listener's movement patterns. Its concept was inspired by the Situationist movement, which proposes that peoples' everyday movements can be considered as objects for artistic study (McDonough, 1994). Ordinarily, a person might listen to a regular audiobook or podcast to distract them from the experience of a regular journey (such as the walk to work). This system is intended to be used in the same situation but to opposite effect: it focuses the user's attention on the routine of movement, encouraging them to

reflect on how interesting these movements are (and how interesting they could potentially become). Its design was informed by the guidelines described above, with particular reference to narrative structure and movement-based interaction. Specifically, it aimed to investigate whether users preferred to explicitly steer the story's development manually, or have the plot automatically adapt itself according to their movements.

The narrative is structured around the tree-branch model outlined in Phelps (1998), as this provides the linearity necessary for an enjoyable story (Paay *et al.*, 2008). The story is divided into three levels, each of which corresponds to the classic story structure of Exposition-Climax-Denouement defined by Freytag (1895).

At each level, there are one or more 'acts': short audio segments which perform the function of that level – for example, all of the acts at the Climax level depict the characters encountering a problem that must be solved, while those at the Denouement level present the solution of that problem and the story's conclusion. Each act can branch to one of three acts on the next level: these three all fulfil the same story-advancing function necessary for their level but differ in their content. Each has a 'Chaos Rating' representing the predictability of their content: a Low Chaos act features few characters and is relatively mundane, while a High Chaos act has many characters and is more surreal. A Medium Chaos act sits between these two extremes of the bland and fantastic. Thus, as the listener progresses from one level to the next, they have a range of Chaos Levels to choose from but will always experience a traditionally linear story.

The mechanism which determines this choice is hidden from the user. The system constantly records the user's speed and direction of movement during each act and then, at the end of the act, draws on this record to determine the appropriate Chaos Level to progress to. This calculation is based on the number and extent of the recorded changes: if these values are low (that is, if the user maintains a constant speed and direction) then a Low Chaos act is selected whereas if they are high (if the user often changes speed and direction, moving erratically) then a High Chaos act is delivered instead. Once this decision has been made and enacted, the movement records are erased so that the process can begin anew during the next act. The whole decision-making process takes place quickly enough so as to appear seamless to the user: one act instantly segues into the next so that the listener is left with the impression that they are hearing one continuous audio narrative when, in fact, it is composed of several segments corresponding to specific branches in the narrative tree (see Figure 1). It is only with multiple uses that they might come to realise that it is interactive at all, or that their movements have an effect.

The system is designed such that, after initial activation, the screen is unused and the device can be left in a pocket

throughout playback. However, should GPS reception become unavailable for a prolonged time while the story is playing, the system provides brief audio and visual messages warning them that this has occurred and to move away from potential sources of interference. The user can also avoid GPS altogether: when the system is activated, it allows them to choose between 'automatic' and 'manual' settings. Automatic mode uses the GPS system described above, while manual mode does not rely on sensors at all: rather than measuring the listener's movements, at the end of each act it pauses playback and presents, via the touchscreen, an interface for manually choosing the Chaos Level of the next act, which begins playing once the choice is made. This method sacrifices ambient reflection, but provides much greater reliability.

Time

L = Low Chaos

M = Medium Chaos

H = High Chaos
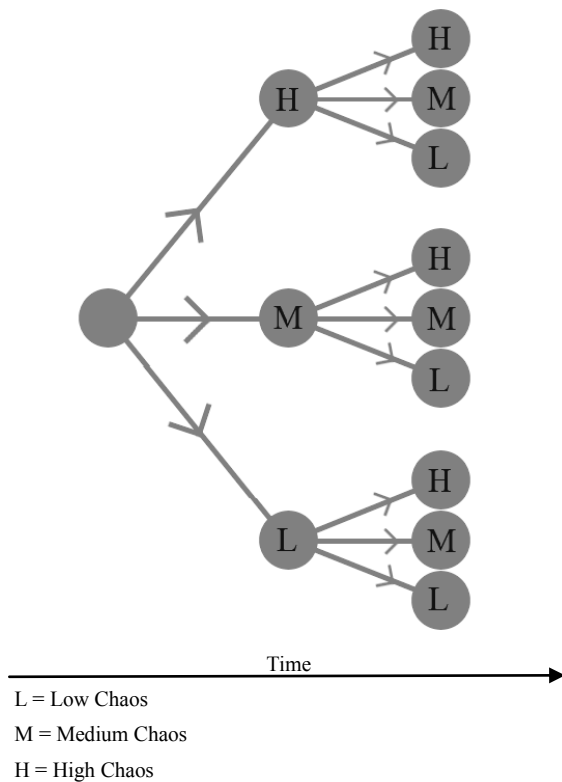
Figure 1: Narrative structure in *A Chaotic Encounter*

User trials were conducted with a group of ten participants, three of whom agreed to be interviewed and complete a questionnaire about their experience. Users were selected on the criterion that they regularly listen to a portable audio device while making routine journeys. They each tested the system individually, and were initially informed that the system relied on GPS technology to measure movement but were not told how or why this was this case. Instead, they were briefed to initially listen to the story in automatic mode at least twice, while walking through the city. Following this, they were encouraged to try manual mode. Finally, they were debriefed and given the questionnaire assessing the extent to which they felt their movements had

an effect on the narrative, whether they became more conscious of their movements, how much they engaged with the story and their opinions on the two modes of operation. User responses to the design were mixed: all agreed that they had enjoyed hearing the story, demonstrating the value of adhering to classic dramatic story structure. However, on their second listen, some reported feeling confused and unable to understand what they were meant to be doing differently, while others responded positively and quickly began experimenting with different movement styles. One user reported that although they enjoyed exploring the relationship between movement and story, they ultimately chose to use manual mode to provide precise control and prevent repetition. This suggests that ambiguity can be a potential resource in effective design, but can risk alienating users and must be carefully managed.

Nevertheless, the participants generally agreed that the manual mode, driven by explicit choice, was less enjoyable as it regularly interrupted the story to demand that they interact with the screen. This demonstrates Ryan's claim that explicit interactivity threatens immersion by forcing the user to step out of the fictional world (Ryan, 2001). However, in some cases the intermittent availability of GPS caused incorrect recording of movement, leaving the user being presented with the same story multiple times. This demonstrates the need to find an alternative to GPS that provides more reliable movement sensing, as well as a method that does not rely on movement sensing but also does not require constant user input. The former could be solved by the use of accelerometers, which are more reliable and sensitive than GPS (Slyper and Hodgins, 2008). The latter could use a randomiser to determine story progression when movement data is unavailable – this would strip the experience of its ambient reflectivity, but would not break immersion. This method could also store details of the previous story path taken and avoid it in future, to prevent accidental repetition.

8. CONCLUSIONS AND FUTURE WORK

We have presented an overview of how verbal audio can be used effectively by users as they physically move around their environment. We described 3 categories of how this can be achieved: through *audio vignettes*; *movement-based guides*; and *mobile narratives*. From case studies from these categories, we distilled some guidelines for the design of audio for engaging location-based experiences. These guidelines have yet to be tested fully but they are offered here as a starting point for future work and for discussion by the mobile learning community.

We have also presented *A Chaotic Encounter*, an example of an adaptive narrative, that provided users with differing narratives depending on their movements (described here as the amount of user 'chaos' that the system reacts to). Preliminary user trials, although not extensive, have indicated a mixed reaction by users. However it has

highlighted an important aspect of the work, namely the immersive experience of the story based upon the location of the user. Despite the limitations of using GPS technology to track movement patterns, users of *A Chaotic Encounter* reported that it was a mostly entertaining experience. All users found the concept of movement-based narratives novel and enjoyable, and agreed that a branching narrative structure was exciting and inspired curiosity. This demonstrates that it is possible to introduce interactivity to a narrative without rendering it incoherent, that such interactivity is seen as highly valuable when it provides subtle information on user behaviours, and that audio is a very good medium through which to deliver such narratives as it requires minimum interruption.

Future work will explore how audio guides can be used to augment a sense of place through a combination of guidance and narrative storytelling and also building on previous work carried out by Walker into cinematic narratives (Walker, 2004). Further research is needed into the cognitive and social aspects of audio guiding, including how words and phrases are interpreted in relation to location, how people gain a 'sense of place' from spoken commentary, and ways to engage groups of visitors in a shared narrative. By drawing on literary-linguistic theories, we aim to investigate how the story content of an audio narrative can be structured and composed in order to achieve its desired effect – be this entertainment or education.

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