Experimental Sound Mixing for *The Well*, a Short Film Made for Tablets

KAREN COLLINS AND **RUTH DOCKWRAY**

ABSTRACT

This article presents an overview of the use of binaural recording and experimental headphone mixing for a short film. Drawing loosely on theories of proxemics, the article illustrates how sound mixing can be used to create a unique subjective perspective. In particular, the authors sought to experiment with and to use the peculiarities of stereo headphone mixing and binaural sound to reinforce visual elements of a film designed for horizontal viewing on tablets.

Touch-based tablets have ushered in new ways of consuming media. Already in a 2013 survey by Motorola, more people watched TV and movies on tablets than on television sets [1]. However, the experience of consuming media on tablets is significantly different than on more traditional devices: The screen size is much smaller, and audio capabilities are very different from what the average home theater offers. Despite the changes in the ways in which people are consuming their media, that media itself has yet to really respond to the change (with the exception of touch-based games). Rather, in most media we continue to see ever-higher resolutions beyond what is (arguably) necessary for small screens (e.g. 4K and larger), increasing emphasis on surround sound (such as Dolby Atmos) and higher-fidelity music (such as the Pono format). While the media is moving in one direction, the devices of people consuming this media are not keeping up and, in some cases, have moved in the opposite direction. The built-in audio capabilities of the iPad and similar tablet devices are often mono (or at best, "stereo," where stereo usually means two side-by-side speakers along one edge of the device). Apple and other tablet manufacturers rarely even release the names of the manufacturers of such speakers, let alone specifications, but suffice it to say, these speakers are, at best, very limited in both amplitude and bass reproduction (most have little frequency response below about 700Hz).

Even with their poor built-in sound capabilities and smaller screen sizes, tablets also offer some potentially unique experiences over home theater/television sets. In particular, there are two significant distinctions between the hardware when it comes to comparing tablets with traditional experiences: Tablets are portable and taken to a variety of locations to use, so we can assume that most listeners are using headphones, and the screen can be configured at a variety of angles to suit the viewer. This latter fact means that the tablet can be laid flat on a table, lap or other surface. It was with these two unique aspects of tablets (headphone use and the ability to alter the viewing angle) in mind that we set out to design a short film specifically for tablet consumption.

The Well [2] is an experimental short film designed for tablet playback. The initial concept for the film was quite simple: create a film designed for a screen that would be placed on a horizontal, rather than vertical, plane, and mix the audio for headphones rather than loudspeakers. In other words, the tablet would be laid flat and the viewer would sit looking down onto the screen. In this paper, we describe the considerations in designing a film for tablets and the alterations that we made in order to take advantage of the unique affordances of tablets.

VISUAL CONSIDERATIONS FOR A HORIZONTAL SCREEN FILM

The film was conceived for a horizontal screen, meaning the viewer would sit and look down onto the film (Fig. 1). While it is possible to hold tablets at other angles, we wanted to explore a horizontal screen and envisaged that the film could similarly play, for instance on tabletop or floor screens. There were three initial concerns when it came to laying the screen flat and altering the viewing angle: glare, anamorphic distortion and camera angles. Although we experimented with high contrast levels and different color corrections, ultimately we found we could do little to ameliorate glare except

Karen Collins (associate professor), Department of Communication Arts, University of Waterloo, 200 University Avenue W., Waterloo, ON N2L 3G1, Canada. Email: <collinsk@uwaterloo.ca>.

Ruth Dockwray (associate professor), Department of Performing Arts, University of Chester, U.K. Email: <r.dockwray@chester.ac.uk>.

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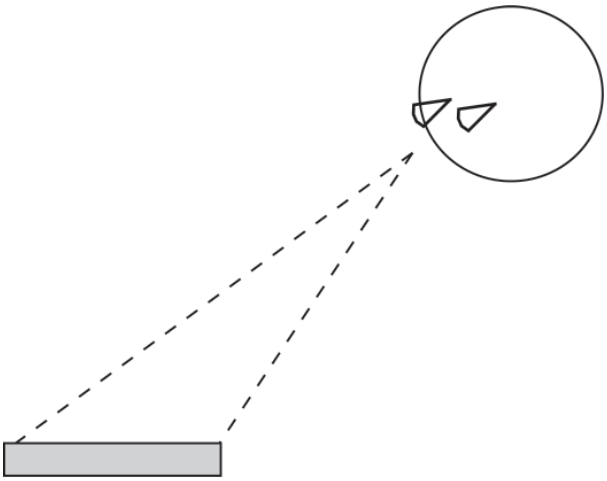

Fig. 1. Approximate viewing angle of a tablet-based horizontal film. (© Karen Collins)

to suggest that viewers look directly down onto tablets. The second consideration also relates to the viewing angle of the tablet, which is that objects can appear slightly distorted when viewed at an angle; this phenomenon is known as anamorphosis. Anamorphic distortion (also known as perspectival projection) can be seen, for example, in the stretching of painted words like "stop ahead" on a road, where the words when viewed from above will appear elongated but viewed from standing or driving on the road will be more readable. For the purposes of our film, we explored different types and amounts of anamorphic distortion on a horizontal screen. Eventually, however, we determined that, although anamorphic distortion made a difference on larger screens, when viewing images on a small screen like the tablet, the brain easily compensates for the distortion, and anamorphic distortion was unnecessary.

The one significant change we did make, however, was to adjust our camera angle to account for horizontal viewing. With regard to camera angles, if the viewer is looking *down onto* the scene instead of *across into* the scene, it makes the most sense to have the majority of shots from the top down or bottom up. With this idea in mind, we conceptualized a film in which the main character is constantly moving up or down toward or away from the camera. Most shots were top down (bird's-eye angle or high angle—Fig. 2) or bottom up (worm's-eye view—Fig. 3) throughout the film, although budget constraints meant that obtaining shots from very high locations down onto the scenes was not always possible and a few standard long shots were also used. It was not necessary to have *all* the scenes shot from a top-down or bottom-up angle. After all, we are regularly presented with high-angle/bird's-eye-view shots in film and television on a vertical screen, and so the opposite should not appear too unnatural. However, in the interests of the experiment, we wanted to explore what a film on a horizontal screen might want to present to a viewer.

The planned camera angles limited the scope of the narrative. Shooting from above or below makes common scenes such as, for example, dialogue between characters suddenly awkward. Fairly simple devices, such as the use of facial expressions to show the internal feelings of characters, were suddenly removed from our use, unless that character was looking up into (or down into) the camera. We found that shooting from a first-person perspective for many of the shots was one effective way to combat some of the difficulty of the angles. First-person POV shots of course have a long history in cinema and in particular in terms of the camera angle's relationship to audience involvement [3]; however, as our focus is on the auditory experience, we acknowledge but do not cover the camera POV in more detail here.

The narrative needed to give us a reason to use these somewhat uncommon angles. Our story was inspired by the H.P. Lovecraft short story "The Rats in the Walls" [4], in which a man discovers an opening in his basement that leads down into the remnants of a hidden slave village. In our film, the protagonist (the Scientist) finds an old well and descends downward, discovering another deeper well below that and another below that, until finally uncovering a creature at the bottom. Approximately halfway down, the Scientist discovers a fungus that blows spores into her face, leading to a hallucinatory sequence that leaves the entire rest of the film open to question as to what is reality and what is hallucination.

While struggling with designing the film's unique viewing angles was an interesting challenge, the bulk of our time was spent designing the audio for horizontal screen, which will be the focus of the rest of this paper.

Fig. 2. An example high-angle shot as the Scientist drops down *The Well*. (© Karen Collins. Photo: Neil Baker.)

Fig. 3. An example worm's-eye-view shot looking up *The Well*. (© Karen Collins. Photo: Neil Baker.)

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A GENERAL OVERVIEW OF FILM AUDIO MIXING

Mixing is often overlooked by scholars as a creative, rhetorical, semiotic or narrative device in film, music and games. It was only recently that music scholars turned their attention to what Dockwray and Moore describe as the "sound-box," the stereo positioning of sound in the mix of a musical track [5]. While some work has been done to explore the impact of surround sound in film [6], these efforts are usually historical or technologically focused and tend not to discuss the creative aspects of mixing nor explore the impact that the mix can have on the cinematic experience. Film mixing can be very technical (aiming for a highly realistic space) or very creative (for instance, in the films of Jacques Tati, in which ordinary sounds are exaggerated for comic effect) and is often a careful balance of both of these elements.

Mixing in film can often provide us with insight into a film's meanings: Sounds are emphasized to draw our attention to particular objects or characters or deemphasized to draw attention away from other objects or characters. Stereo positioning can help to create a sense of space and place and of emotional associations with those places—for instance, open spaces and loneliness or warm, reverberant, womb-like rooms. As with camera point of view, an auditory perspective can be created for the audience using recording and mixing techniques [7], which enhance audience identification with characters, describe mood or psychological states and create a realistic space. Auditory perspective (using microphone placement, positioning in the loudspeaker and digital signal processing effects) is a combination of both that sonic positioning and the resultant perceived social distance created (or *proxemic zones* [8]): In other words, it is both a spatial and a subjective sense of distance. Previously, we outlined an analytical framework for a sonic proxemics analogous to camera angles and point of view [9]. Here, we explore a practical implementation of this understanding of acoustic space in terms of social and psychological space.

The spatial positioning of sound effects using loudspeaker positioning helps to represent the sonic environment of the visualized space and can extend beyond the screen into the offscreen space. Sounds can appear to emanate from a physical place around us using the positioning of loudspeakers or panning techniques. The effect can be so significant as to have us physically turn our gaze toward a speaker, in what is commonly referred to as the "exit sign effect," where a discrete sound located in the rear loudspeakers will have us turn our eyes toward the exit signs in the theater. While considerable attention is paid by mixers to the placement of sounds in the loudspeaker positions, playback varies greatly and can be dependent on the listener's equipment and setup, the environment that setup is in and the decoding method used by the listener's device. What the listener hears may be very different from what the engineer or designer heard in the studio. One of the most difficult distinctions in sonic environments occurs between mixing for loudspeakers and for headphones.

It is generally accepted that most sounds in a musical or film mix will take place within a fairly narrow range of about 60 degrees, in an equilateral triangle from the listener to the two front loudspeakers (Figs 4A and 4B). When surround speakers are added, that same equilateral triangle remains for the frontal speakers, and the majority of important information (dialogue, discrete sound effects and often music) still remains in that 60-degree range, although the rear speakers (usually reserved for atmosphere/ambience) have a much wider field. In fact, stereo imaging and spatial expander plug-ins for film commonly have the 60-degree angle as a default "factory" setting. It is only through intentionally expanding or contracting that space that the standard mix is altered.

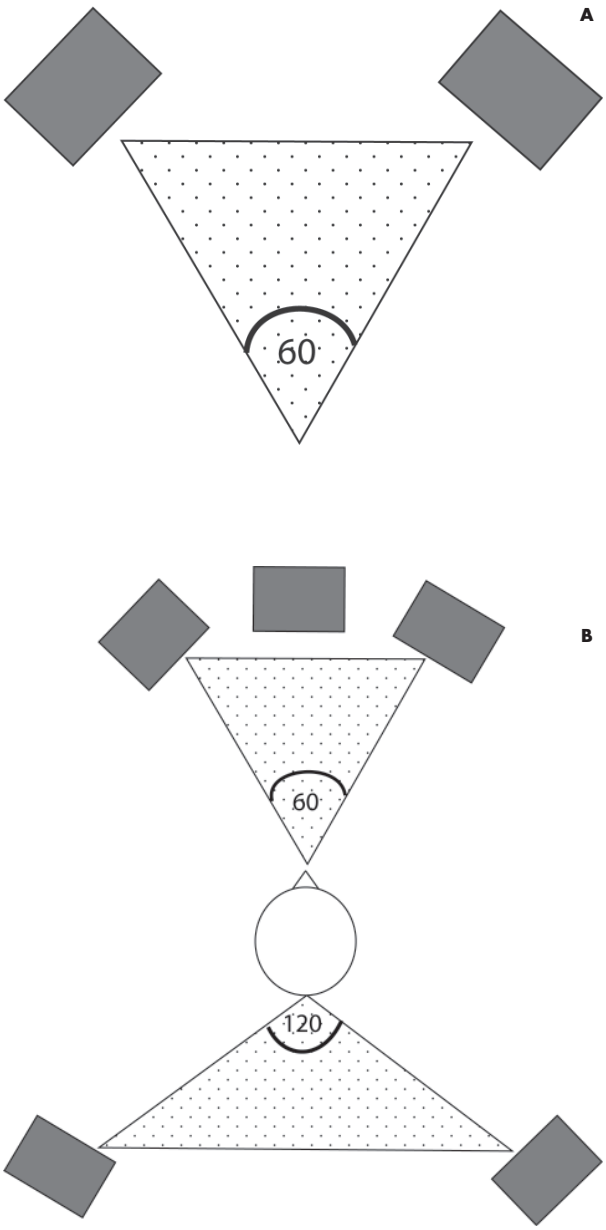

Fig. 4. The accepted "ideal" stereo setup (A) and one version of a surround sound setup (the placement of the rear speakers can vary) (B). (© Karen Collins)

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MIXING SOUND FOR HEADPHONES: IN-HEAD LOCALIZATION AND BINAURAL AUDIO

The 60-degree angle works well in media when the sound is played back over loudspeakers. However, when using (stereo) headphones, the mix presents a problem: in-head localization. Stereo sound recorded for loudspeaker playback is typically heard as being too narrowly spaced when listened to on headphones. In-head localization occurs when the sound sources are perceived not to be a part of the external space around the listener but rather to take place inside the head. In other words, the auditory cues that the listener receives fail to indicate a particular location in space, and the sound is heard as emanating from inside the listener's head rather than externally. In-head localization of sound is generally considered in sound reproduction to be a problem to be avoided. Headphone sound stereo imaging is usually therefore tripled when mixing specifically for headphones, to up to about 180 degrees.

To understand in-head localization with headphones, a basic understanding of crosstalk is necessary. With loudspeaker presentation, sounds emanating from the left and right front speakers are each heard by both of our ears when we listen. There is some "bleed" of sound from the right speaker into our left ear and vice versa. With headphones, there is no crosstalk: Almost all headphones are designed to transmit one of the stereo channels to one ear exclusively (i.e. the left channel transmits to the left earphone), so it is possible for one ear to hear an entirely different sound than the other ear. Sounds panned hard into one channel can therefore sound unnatural when translated to headphones, since in the natural world we do not normally hear a sound with just one ear. There are some crossfeed software plug-ins that simulate the loudspeaker experience on audio mixed for headphones, which mix some of the left and right channels together. However, these plug-ins can still result in a not entirely natural feel.

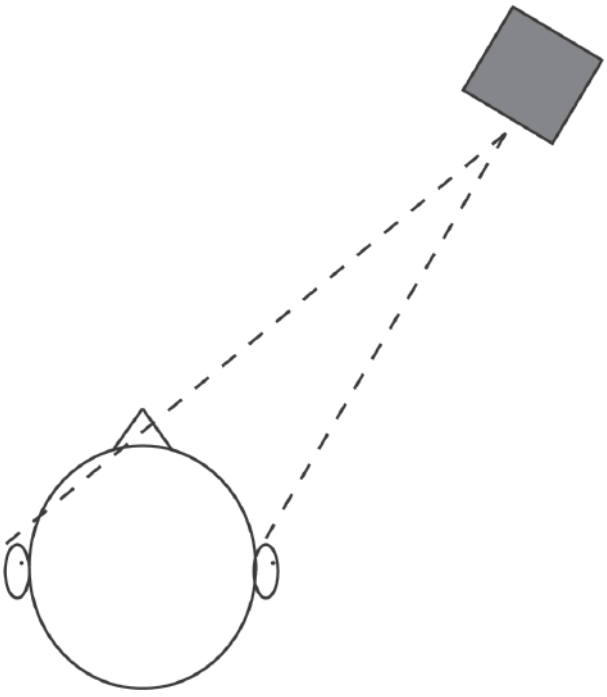

Fig. 5. Interaural differences from a source: The sound reaching the leftmost ear will be slightly delayed, slightly less intense and "colored" slightly differently by the shadow created by the listener's head. (© Karen Collins)

Another disadvantage of headphones is the lack of accurate low-frequency sound reproduction on most consumer headphones. Many consumer headphones have little to no response below about 500 Hz, an important range of sound for providing impact in film. The Apple iPod earphones, for instance, have no response below 50Hz and little response up to about 500Hz. Effectively, headphones remove low frequency effects (LFE, or subwoofer) channel sound nearly entirely. Even with extended boost of the bass frequencies using equalization techniques, the mix can sound weak in the bottom end.

Despite a few disadvantages, there are also some advantages to mixing sound for headphones. Unlike loudspeaker listening, headphones remove all room ambience from the listener's experience: there are no reflected sounds, allowing for the ability to recreate a space virtually over headphones. This lack of ambience can be an advantage in that the mixer can know that the media will sound approximately the same when heard outside, inside in a small room or in a large cathedral. The "problems" described above (in-head localization and lack of crosstalk) can also be intentionally used creatively. Moreover, we can take advantage of knowing that the listeners are using headphones to employ binaural sound.

Binaural Sound Recording and Mixing

When we hear sound externally in our environment, we can determine the location of that sound through a number of different input factors, including interaural time differences (it takes slightly longer for a sound signal to reach one ear than the other), interaural intensity differences (the level of the sound will be slightly quieter at the ear farthest from the sound) and spectral differences (the head will block, or create a "shadow" that filters some of the frequencies from reaching, the ear farthest from the sound) (Fig. 5). The interaural differences rely on the transfer of sound from each ear to the ear canal. We can simulate the effect of this transfer function by processing the sound, either by recording sound binaurally (using two microphones inserted into the ear canal) or by synthesizing the effect in post-production using a binaural processing algorithm. Binaural sound is normally only used with headphone listening, because to reproduce the effect over loudspeakers requires considerable crosstalk cancellation techniques to obstruct the path of the sound from each speaker to the opposite ear.

Binaural sound can create a much more realistic three-dimensional space. Tsakostas et al. outline a number of key advantages of binaural over stereo reproduction, including a reduction of in-head localization, a broader perceptual auditory image, a clearer positioning of sounds and the perception of a more "pleasant" experience [10]. As described by Francis Rumsey, "if binaural is done well, the sense of

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three-dimensional realism can be astonishing, because theoretically all of the information that enables one to perceive spatial features in sound will be present in the correct proportions" [11]. The only real disadvantage to using binaural sound is that, since stereo listening is still the norm when viewing movies/television on a tablet with headphones, the familiarity of stereo sound means that for some the change to binaurally recorded or mixed sound can take some time to adjust to.

Binaural sound has gone in and out of favor in the music industry over the last fifty or sixty years. However, until recently, most consumers still listened to their music over loudspeakers, which made binaural recording more a curiosity than a practical technique. Unlike in music, in film, binaural sound has never really been seen as a viable option due to the limitations of reproduction using loudspeakers and the typical design of movie theaters. Applications of binaural sound in shorts and experimental film have existed for several decades, but there is, to our knowledge, only a single use of binaural recording in a feature-length theatrical release film—*Bad Boy Bubby*, an Australian film made in 1993 [12]. A handful of video games have also toyed with binaural recording, particularly audio-based or audio-only games, in which the auditory experience takes precedence over the visual experience. Despite the occasional use of binaural sound in music and games, and the increasing amount of media played on mobile devices, it is surprising that more media is not being mixed for mobile, headphone-based experiences.

MIXING FOR MOBILE: *THE WELL*

As described above, *The Well* was designed to take advantage of the particular affordances of tablets, visually and sonically. There is no musical soundtrack (aside from a short clip at the start and end of the film), although elements of the ambience stand in for music in a sense, with a rhythmical, textural quality and occasionally with some violin flourishes. Our inspiration for this lack of music was Hitchcock's *The Birds* (1963) [13], in which sound effects create an emotional and heightened dramatic quality in place of music. Our first consideration for mixing was the fact that film and television mixing techniques up to now have been designed for sound combined with a vertical screen. Aspects such as the use of offscreen sound effects, stereo panning, placement of sounds in the mix, human localization ability and the location of potential external loudspeakers are all different when viewing a horizontal surface. Previously, we have explored localization with loudspeakers and a horizontal screen [14]. While loudspeaker position made a considerable difference to localization and perceptual experience, we had run no experiments on headphone listening. An informal testing process was therefore the first step in our mixing considerations. This listening test consisted of the authors altering stereo positioning of a number of files while viewing a moving image on a tablet. We found that, perhaps due to the ventriloquism effect (in which a sound will appear to be associated with a moving visual object), or due to the size of the screen and distance from the viewer, we could use most of the techniques that already exist for synchronizing sound with a visual image. In other words, despite many technical experiments, we found that our minds could perceptually compensate for the altered viewing angle.

The film was mixed using AKG K701 reference headphones and tested on the standard iPod earbuds. The mix uses a combination of stereo and binaural mixing and of stereo, mono and binaural microphone recording. In particular, in order to reinforce the visual elements of the film, we sought to experiment with and use to our advantage the peculiarities of stereo and binaural sound outlined above. The film was divided into three sections for mixing: from the beginning to the initial drop down to the lower level, the hallucinogenic sequence, and then the final portion in which the audience is not clear whether or not what the protagonist experiences is a continuation of the hallucination or of reality.

The first portion of the film consisted of the main character uncovering the well and descending to the first level. The Scientist descends using a climbing rope to the first stop, where she uncovers a series of small stone carvings. This portion of the film was mixed in a fairly straightforward and standard way, in that the ambience and bulk of discrete sounds were mixed in stereo but with a broader than normal auditory field. As described above, stereo mixing tends to place sounds in a fairly narrow range in the auditory field, and this form of mixing can potentially lead to in-head localization when heard with headphones. As such, where a standard stereo mix might place most sounds in a panned field of approximately 10:30 to 1:30 on a clockface, this field was widened to about 3:00 and 9:00 using widening and panning. While we could have used a narrower mix inside the well to create an illusion of being in a cramped space, we used stereo widening on the internal well sounds to show that the cave was much bigger than what we could see. Since there were no discrete (spot) effects that required distinct localization, it was not necessary to have binaural sound mixing in this portion of the film. A distinct exception to this stereo mixing is all the Foley sounds of the protagonist, which were recorded binaurally. Since the bulk of the actions of the main character are shot from a first-person point of view, binaurally recording the actions of the character meant a more realistic physical space could be obtained. An additional increased volume on the Foley sounds works effectively to place the listener in the first-person perspective.

Binaural recordings were made in post-production, due to the visually obstructive nature of wearing binaural microphones during filming. The recordings were made using Roland CS-10EM microphones (twin omni condenser microphones) with a Zoom H2n recording device. Despite the inexpensive nature of the equipment, we found that we could obtain high-quality recordings virtually indistinguishable from other sounds recorded in mono or stereo, many of which were recorded using a variety of microphones to a Sound Devices 702T recorder and supplemented with sounds from several different sound libraries.

A quick vocal whisper when the Scientist first picks up a stone carving was recorded in mono and mixed binaurally.

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Here the whisper is panned hard right and moves around the Scientist's head and then off to one side. This mixing has the effect of placing the voice close enough to the listener to make them immediately "sit up and notice" that it is there and then give them a sense of space with the sound moving around the listener's head.

The first-person perspective is further enhanced by the perceived interpersonal distance between the listener and main character. The close interpersonal distance can be described as the intimate proxemic zone, which is distinguishable by key aural identifiers such as whispers, low-volume voice and breath intakes that are (in comparison to the background sounds) perceived to be comparatively louder. Another aspect of suggesting an intimate proxemic zone is the potential discomfort experienced by anyone who has had their intimate zone invaded by others [15]. Close-miking effects lead to a sense of encroachment, of potential invasion of the listener's space, providing discomfort.

The second portion of the film consisted of the character touching a fungal spore-ball alongside the edge of the Well's interior wall. The large spore-ball initiates a hallucinatory sequence, opening up to reveal an eyeball, and hieroglyphs (influenced by Cthulhu mythos fan art) appear before the Scientist wakes up at what appears to be the bottom of the well. The hallucination sequence was mixed using all stereo or mono files with the in-built binaural panner in Logic Pro, aside from the ambient bed and musical flourish, which remained in stereo. To further confuse the aural field, a delay was placed on only the left channel of the whispering voices. For the ambient bed and musical flourish, the stereo field was narrowed in an attempt to place the sound intentionally into an in-head localization position. By placing the sounds "in-head," we were able to create the confusion of reality/unreality.

Using the binaural panner, we achieved the impression that whispers and laughter were circling around the listener in a wider space than the music and ambience, intentionally confusing the spatialization. According to Dockwray and Moore, such " 'switching of sides' through the use of pan pots is an attempt to enhance the overall psychedelic style" and otherworldliness [16]. This mental disorientation and confusion was also emphasized by flanging and pitch shifting on the musical flourish. Here we drew on Branigan's notions of "internal focalization": the use of visual and aural elements to allow an audience to "gain access to a character's deeper thoughts, memories, stream of consciousness, daydreams, hallucinations, fantasies or similar aspects of a character's personal inner world" [17]. Once again, in this sequence the Scientist's sounds are recorded using binaural microphones to maintain the impression of a first-person auditory perspective.

The third portion of the film confuses the stereo positioning of sounds even further. In this sequence, the Scientist wakes up at what appears to be the bottom of the well to a large rumbling sound. A space opens up below, and, after she has sent down two light sticks, it is quickly revealed that this is not the bottom of the well, but rather that there is even more below this stop, and what is worse, there is a very angry creature making its way up toward her. Grabbing her rope, the Scientist rapidly ascends the well to the top. Once again, the Scientist's Foley sounds were binaurally recorded, and the positioning of the other sounds in the stereo mix becomes narrower, resulting in an uncertain and unnatural mix whereby the environment sounds too close to the listener. The use of spatial imaging effects to convey the closed-in and, potentially, in-head location of the sounds contrasts with the earlier wider expansion and confuses the stereo field so that we do not know if this last sequence occurs in the Scientist's head.

CONCLUSIONS: CREATIVE MIXING AS COMMUNICATION AND MEANING IN FILM

We have sought to describe here an experimental approach to the design of a film that takes advantage of the unique affordances of tablets. To our knowledge, this is the first film designed specifically for a horizontal screen, and we believe that there has been no prior attempt at mixing film sound for horizontal presentation. We expect that as more and more media is consumed on tablets, media creators may shift their visual and auditory language to adapt. While this shift is unlikely to be as radical as what we have presented in this article, it is necessary to explore the potential impacts of this significant change in consumption habits. While at this time we have conducted no audience studies on the reception of media in this new, experimental form, anecdotally, audiences were excited by the possibility and enjoyed the experiment as a novelty. However, without considerable further testing and more media production in this manner, it is difficult to know if the novelty effect would wear off and whether audiences would prefer media explicitly designed for specific media formats.

Sound in film is usually designed to support the image: it functions to reinforce (and sometimes contradict) what we see. Sound's position in the mix is important to the audience's understanding and appreciation of the film. It evokes spatial location and internal focalization and provides a subjective perspective for the audience in ways that cannot be achieved using visuals alone. Nevertheless, mixing, as a communicative, rhetorical or narrative device, is often overlooked by academic studies. We do not have the space to delve into all of the aspects of film mixing in such a short paper, but we believe that much more work on mixing and its relationship to proxemics should be undertaken in order to understand how mixing adds to the cinematic experience.

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Acknowledgments

The authors note the generous support of the Social Sciences and Humanities Research Council of Canada.

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Manuscript received 2 July 2015.

KAREN COLLINS *is Canada research chair in Interactive Audio at the University of Waterloo. She is the author of* Game Sound *(MIT Press 2008) and* Playing with Sound *(MIT Press 2013).*

RUTH DOCKWRAY *is senior lecturer in Music at the University of Chester. Her recent work explores surround sound in Formula One racing television and games.*

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