The Machine in the Ghost: Augmenting Broadcasting with Biodata

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Abstract
This paper examines how 'biodata' – physiological information captured from the human body – might enhance television shows by giving viewers access to actors' physiological data. We broach this challenge through a prototype-show called *The Experiment Live,* in which four 'paranormal investigators' were outfitted with sensors as they explored a 'haunted' basement. This experience has enabled us to probe the challenges of using biodata as part of broadcasting and formulate an agenda for future research that includes: exploring whether/how biodata can be acted and/or simulated; and developing techniques that treat biodata visualisations in similar ways to existing camera-based production processes.

Keywords
Biodata; TV; performance; narrative; visualisation

ACM Classification Keywords
H.5.2 [User Interfaces]: Input devices and strategies

General Terms
Design

Introduction

'Biodata' – by which we mean physiological information that can be captured from the human body such as heart rate, galvanic skin response (GSR), and the movements of facial muscles – has the potential to yield powerful resources for interpreting people's physiological responses to a variety of experiences. In particular, such data might enhance a viewer's experience of watching them. This idea has previously been explored in the context of fairground rides through a performance called *Fairground: Thrill Laboratory* in which riders wore a personal telemetry system that captured various biodata and transmitted them live to an audience who saw visualisations of the data alongside views of the riders' faces and live audio streams of their talk and screams [8].

This paper expands on this idea to consider how biodata might enhance television broadcasting. Here, biodata captured from actors and participants in television shows might be transmitted to viewers as a complementary, or perhaps integral channel of information. One obvious use lies in sports broadcasting, where telemetry data from racing cars is routinely displayed to viewers. However, our interests here reside in the potential to enhance dramatic, narrative-oriented forms of television in which biodata might support or even challenge audience interpretation of protagonists' emotional responses to an unfolding story or to one another.

At this point, it is perhaps worth clarifying what we are *not* talking about. We are not interested here in using biodata to control a participant's experience as has previously been considered for both games [1,5,6,9] and rides [4]. Neither are we interested in detecting the viewers' responses to a show as a form of feedback. Instead, our focus in this paper rests on developing ways to support viewers' sense-making practices when watching actors and other TV show participants, and thus to potentially enhance the vicarious nature of viewing another's experience. In order to probe this idea, we have staged a drama, called *The Experiment Live (TEL)*, in which a selected team of members of the public (whom we call 'investigators') explored an underground basement in search of evidence of haunting and during which various (scripted) unusual events unfolded. *TEL* had two phases: 1) a live performance in which a real-time video feeds, enhanced with biodata visualisations from the investigators, was transmitted to a live audience in a local cinema (see Figure 5); and 2) the subsequent editing and enhancement of recorded material from the live show to create a final edited video showreel. It is a key point that *TEL* is *not* a "real" experiment, either in the sense it appears in the fiction, or as a scientific study. but simply an event from which we have made some observations. In the following, we describe the backstory that was scripted for *TEL*, the live show, and the creation of the edited version, before reflecting on key challenges that were uncovered that constitute an agenda for future research in this area.

The Experiment Live's backstory

The practice of staging paranormal events is an old one, dating back at least to Victorian times and the birth of the public séance. Recently, films and television have built on the genre, including several TV shows that have focused increasingly on the application of scientific procedures as an integral part of the format, gradually moving away from more obviously theatrical elements to prosaic, realist forms. The early 90s saw a

revival of more dramatic forms, albeit in a decidedly postmodern way. The BBC's 1992 drama *Ghostwatch*, written by Stephen Volk and starring Michael Parkinson alongside several other high profile names, triggered a controversy when screened as many viewers believed the show to be a real scientific investigation into paranormal activity. Ironically, *Ghostwatch* helped regenerate the realist genre, with shows such as *Ghosthunters* and *Most Haunted* where members of the public are asked to spend time in 'haunted' places, typically equipped with various cameras and sensing systems, and relay their experiences to the audience. Whether staged or purported to be real, the dramatic focus of these shows lies in relaying the experience of the investigators to the viewers, an approach that formed the basis of *TEL*.

Selecting Investigators

An online application process was used to assess applicants' psychological and parapsychological profiles in order to identify people who were low in risk taking behaviours but high in parapsychological beliefs. This profile was preferred as it was believed that such people would provide participants who would show excitement, fear and other responses ideal for a dramatic performance. Participants' susceptibility to belief in the paranormal was assessed using the sheep/goat scale [10]; they were also assessed for their thrill-seeking behaviour using the Sensation Seeking Scale [11].

One investigator was a 'ringer', an actor who helped coordinate a series of scripted events such as a plate falling to the floor and smashing (via a tripwire).

Figure 1. The four investigators ready to take part.

As the entertainment value of *TEL* relied on the strength of emotions being experienced by our amateur paranormal investigators being conveyed on screen, it was necessary to create a compelling narrative. Our fiction ran as follows:

> *A team of scientists are researching the relationship between paranormal belief and subjective experience of reportedly haunted sites. Their research methods involve biosensing to determine a subject's emotional state. The team of scientists have been invited to feature as a scientific curiosity and conduct a live experiment at a Halloween horror festival. They reluctantly agree (they are sceptics, but can't resist the PR opportunity!), and arrange to capture, transmit and screen at a local cinema, the live audio, video, and biodata of four amateur paranormal investigators as they explore the basement of Nottingham's most notoriously haunted building – Lee Rosy's Tea Shop. The four investigators are to use various devices to search for evidence of paranormal activity in the different underground rooms, and ultimately are to conduct a séance to try to communicate with the ghost. Surveillance cameras are deployed around the basement to record what transpires; the team includes handheld camera operators who capture close-up views of events. In addition, the investigators are outfitted with a suite of wearable biodata sensors which record their heart rate, stress level and respiration rate so that the scientists can also monitor how they respond. All of this data – the investigators' readings, the static and handheld video and audio feeds, and the biosensing data – are to be relayed over the road to a local cinema where an audience of over one hundred and twenty people would be able to watch the experiment unfold.*
>
> *However, the scientists' public experiment doesn't go to plan. To their surprise, the resident ghost – The Sobbing Boy – begins to manifest during the séance through*

possession of a biosensing unit which, while temporarily discarded due to an apparent technical failure, begins to spontaneously transmit unusual biodata...

The Live Performance

In this section we describe how the live show was designed and delivered, focusing on the production environment, how the 'ghost' and other special effects were created, the design of the visualisation seen by the cinema audience, and some aspects of the underlying technical infrastructure that was used.

The production setting

The live production was spread across three spaces. The basement of Lee Rosy's Tea Room where the team of investigators was located (see Figure 3); upstairs in the team room where the show's host (playing the role of a scientist) and the supporting production team were located (Figure 2); and the cinema across the road where the audience was located (Figure 5). The technical production team comprised of an overall director (who also provided the role of host), a vision mixer who used a bespoke mixing interface created for the event (see Figure 3), a biodata mixer, a sound mixer, a music producer who created an ambient soundtrack, a floor crew and several camera operators. The host/director instructed the investigators on how to proceed using a radio microphone. In order to encourage more discussion between the investigators and to improve the experience for the cinema audience, only one member of the team was able to hear the host's instructions while in the basement, and it was the investigators' discussion of the those instructions that was audible to the audience. While the host did occasionally talk to the audience directly, in most cases his words were relayed this way. He switched to a separate radio channel to talk to the production team and so managed the overall coordination of events.

The 'TV screen' and production interface

As noted above, we developed a dedicated interface for displaying and mixing the various video streams and the four biodata streams from the investigators. This interface, shown in Figure 3, was the same as seen by the cinema audience (Figure 5). In other words, it defined the final layout and appearance of the 'TV screen' as seen by the audience.

Figure 2. Mixing the live feed in the production space

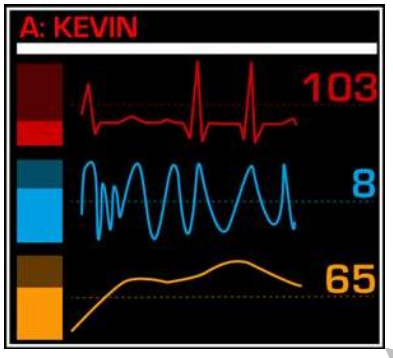

Figure 4. An individual's biodata visualisation. Each visualisation consists of three streams of data, presented either directly, or with some filtering. Heart data (top, red) is displayed as a direct electrocardiogram (ECG) trace, as well as a numerical heart rate. Respiration is displayed as a direct trace of chest expansion as well as a numerical respiration rate (middle, blue). 'Stress', which is actually galvanic skin response (GSR) in this case, is displayed as a graph of rate of change in GSR (ΔGSR) along with an immediate numerical value (bottom, yellow). GSR is presented in this way because it is difficult to make sense of a comparison between the direct value for GSR in two different people.

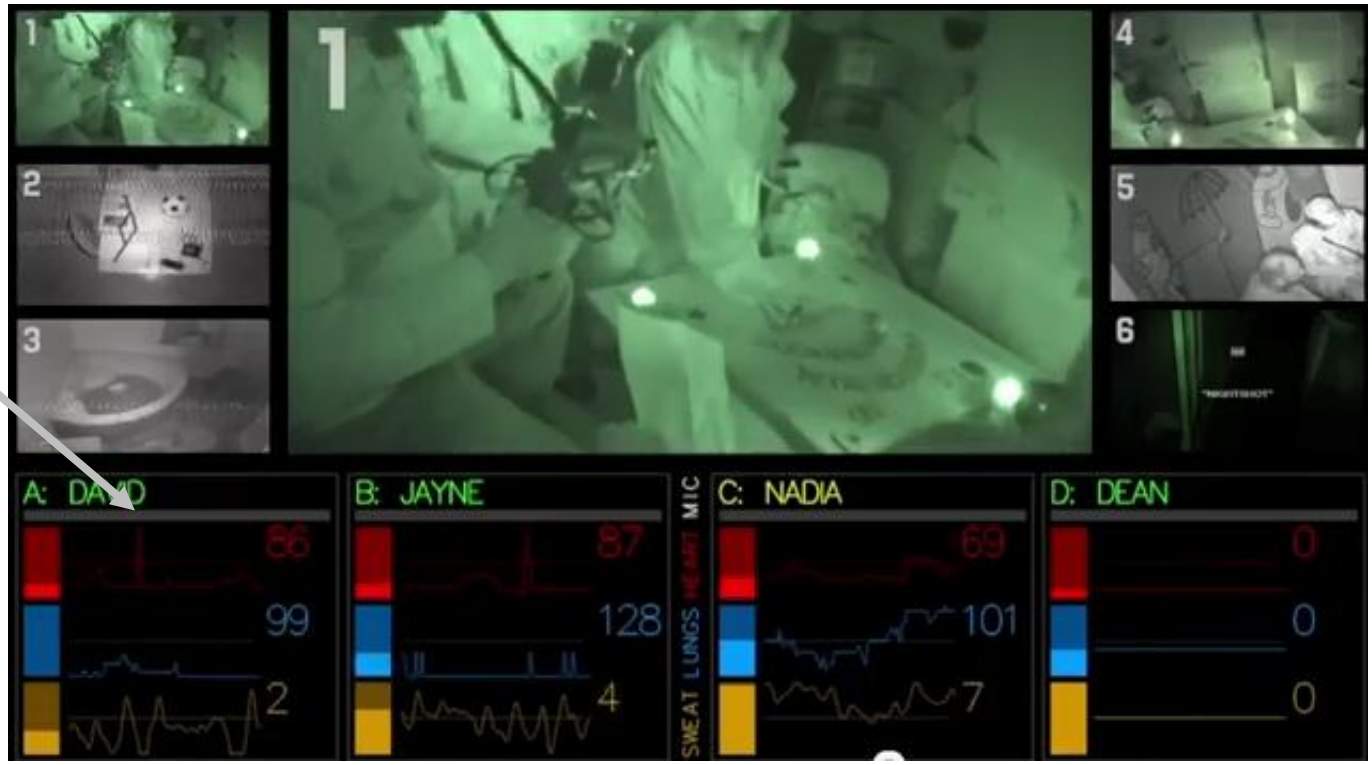

Figure 3: The 'TV screen', which formed both a display for the audience and an interface for the production team. The screen shows numbered thumbnail views from six cameras (four static and two roaming cameras, one operated by a production team member, and one operated by an investigator) with a central larger display a selected video stream. This active video could be controlled by the vision mixer. The vision mixer could also rescale any of the biodata visualisations during the show in order to deal with unpredictable variations in scale.

Along the bottom of this main screen are four visualisations of the biodata from each investigator. The bounding box surrounding each investigator's visualisation flashes when that particular investigator is speaking, drawing attention to the speaker's biodata. An additional presentation is made of a 'threat level' for each person based on a combinatorial filter of both heart rate and ΔGSR. The threat level is represented on a green-amber-red traffic light scale (colouring the participant's name in the above Figures 3 and 4, where green is 'calm' and red is 'threatened'). We note some more significant challenges in designing such an interfaces in the callout box on the following page.

Emotion and biodata

A key challenge for the development of interfaces for biodata is in the problematic links between physiological response and the representation and interpretation of emotion.

Accordingly for TEL's interface, little attempt was made to make explicit the idea that the investigators are displaying any particular emotion, or to create an environment in which interpretation is automated. Instead, we simply chose to make the physiological data visible, thus creating space for the audience to draw their own conclusions about what it might mean and how it may or may not be related to the action unfolding on-screen.

Further work is required to understand the ways in which such interfaces may support or perhaps challenge audience interpretation of the emotions or experience of the participants. Such work is currently part of our longer-term study.

Figure 5. Watching the show in the cinema [photo credit: Jo Longhurst]

Special effects: props, fake biodata and video static

The success of the story hinged on being able to stage several special effects at key moments during the show, including the introduction of the ghost. The four investigators explored a basement area of the building that consisted of several rooms that had been purpose-built as sets. These included recreations of an office space, kitchen, and bathroom that included a bath full of water. Props were rigged such that either the production team upstairs or the 'ringer' investigator could trigger them at appropriate moments (such as the smashing plate).

Special effects also generated the 'ghost'. A member of the production crew used a purpose built a biodata simulator tool (Figure 6) to generate the ghost's (fake) biodata at the appropriate moment during the scripted performance. The simulator provided sliders to control the generation of streams of biodata that mimicked real ones for both the ECG (heart rate) and GSR data streams. This presented itself to the system as a normal sensor, mirroring the protocol used by the real one and becoming an effective testing tool as well as a controllable simulator. While a similar approach was theoretically possible for respiration, in practice we found respiration traces hard to simulate convincingly, especially when people are speaking, so we decided to use a real sensor to capture just the respiration from an on-site live actor sitting in the production room.

The final special effect was to be able to simulate technical faults at various points by turning any or all of the videos to 'static' for dramatic purposes.

Figure 6. The person simulator

Enabling technologies

A full technical description of the implementation of *TEL* is not appropriate for this paper, but we do briefly touch upon some key details before passing on to consider what happened on the night.

Gathering live biodata from participants in a busy mobile wireless environment was surprisingly difficult,

as will be seen later. However, in principle a wireless medical monitoring device is required. We chose to use a Vilistus DSU[1], which allowed us to stream ECG, GSR and respiration data live over WiFi to a PC which ran custom made software to consume, filter and render the data into an OpenGL environment (which generated the interface / display, Figure 3). All six camera streams were captured by the same PC rendering, using industry standard Blackmagic capture cards[2], allowing live frames to be embedded into the same environment for mixing.

Audio in the cinema

The audio heard by the cinema audience was mixed from multiple sources using a dedicated hardware mixing desk. This combined talk picked up by the host and investigators' radio microphones, along with a musical soundtrack. This soundtrack used several streams of filtered biodata from each participant; the biodata was then fed, live, into a Max/MSP configuration which in turn enabled the musician to manipulate a predetermined musical track. The basis manipulated soundtrack itself was inspired by and developed from classic horror soundtracks.

What happened on the night

The Experiment was staged broadcast to a live cinema audience as part of Nottingham's *Mayhem Horror Film Festival* in October 2011. The show was broadcast only once – with no rehearsals – and so represented an initial experiment in mixing biodata and audiovisuals in order to support a horror-themed live dramatic performance. Much of the experience worked well and a 40 minute performance was delivered to the audience. However, there were some technical problems as might be expected, of which the most significant involved the biosensing hardware. It proved impossible to maintain a reliable connection to all but one of the Vilistus mobile biodata sensors over the wireless network on the night (for reasons that could not be clarified in spite of initial successful tests). Our backup was an alternative, professional grade biosensing platform (NeXus[3]). However, this proved similarly problematic when connecting through bluetooth. In the end we were only able to transmit momentary biodata into the cinema, although we were able to use our person simulator to improvise some additional 'fake' data for the one participant still using the Vilistus, as well as create the artificial biodata for the ghost. Fortunately, as the other technologies worked successfully, we were able to deliver audiovisual components as planned.

Due to the unusual – and live – nature of our event, the audience was forgiving, remained watching throughout, and expressed their appreciation afterwards. However, the live show had clearly not been the test of biodata that we would have wanted. Fortunately, we still had a second chance in the form of post-producing an edited version from material recorded at the event.

Post-producing *The Experiment Live*

The live performance was captured on the night by a number of audiovisual devices, which served live broadcast, post-production and documentation roles. As noted earlier, there were four static cameras set up in the basement which provided live views for the

[1] http://www.themindpeople.com

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

[3] http://www.mindmedia.nl

Acting Biodata

This was performed by first identifying 'key frames' in the script, then connecting an actor to the bio-sensing equipment and attempting to self-induce 'presumed appropriate' physiological responses (e.g., exerting oneself to gain a higher heart rate, or slapping oneself to gain a GSR spike at what would be considered an appropriate time). In order to assist with this task, the script of the event was followed, which contained detailed markup regarding the emotional trajectory of the performance, and directorial remarks regarding the desired experience of investigators.

Whilst it is the easiest signal to control directly, breathing was the most challenging signal to fake, as it needed to match visual cues of breathing in the video, such as points where all participants breathed in synchronisation, and also needed to look realistic when participants were speaking. As such we also added to the script as a transcription in order to have the acted respiration data affected by speech.

visualisation. One professional camera operator accompanied the investigators in the basement, providing a further live view, and one of the investigators themselves had a handheld camera that wirelessly broadcast another live stream. Additional cameras recorded events in the auditorium. Finally, the audio feed from the host's and investigators' microphones was also recorded, as was the biodata-generated musical soundtrack. Each video and audio stream was spooled to a hard disk as it was rendered, creating an accessible record of all the streams to be used in post production.

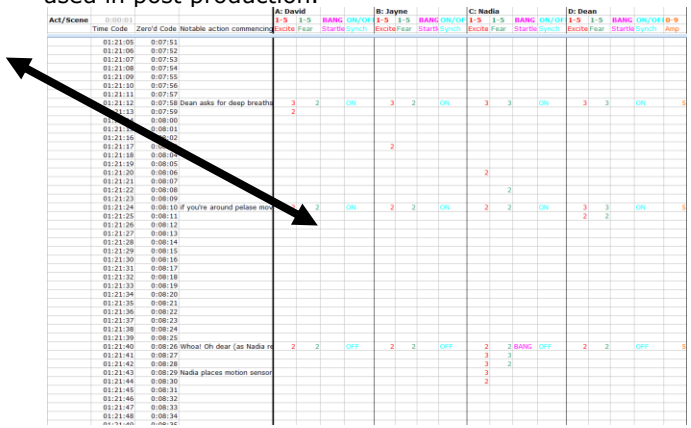

Figure 7. A script for acting biodata

However, in order to edit the show we had to address the challenge of the missing biodata which had not been transmitted from the investigators and was therefore not stored. This involved recreating sections of the biodata through human actors 'acting' the appropriate responses to the now correctly synchronised video streams of the event. This required the use of a special kind of script (see figure 7). The actual process of acting the data consisted of watching the performance live (once for each dataset), selecting an individual and attempting to mimic both their action and a presumed physiological response. It is unfortunate that the biodata connection to the ringer failed on the night, as it would have been an excellent test to see if he, as a professional actor, was able to act appropriate biodata in situ.

The newly generated data was combined with the video streams and some introductory material from the auditorium to create a 40 minute version of the show[4], much of it using the original visualisation seen by the cinema audience, but with new biodata added.

New research challenges

TEL was intended to demonstrate the potential of incorporating biodata into TV drama, but also to help us refine the challenges to be addressed by future research. Here we focus on two key challenges that have emerged from this initial experience, speculating on some new and novel (for HCI) research questions.

Is acting biodata feasible?

Our first challenge concerns the need to be able to 'act' biodata, that is for actors to be able to produce or react to it on demand as part of their professional practice. *TEL* demonstrated two requirements for this: as a narrative device in which fictional characters, events and hence biodata are introduced into the show (e.g., the ghost); and during post-production when it may be necessary to generate missing data or improve on data that was captured during live recordings. However, this

[4] http://www.youtube.com/watch?v=448i9vTkfps

need to act biodata raises some interesting questions that warrant further investigation:

- Can actors produce credible and useful biodata on demand? In other words, can they control their physiological responses to the extent that they already do their faces and bodies?
- A further interesting questions is whether actors who are acting a part will generate recognisably different biodata from non-actors (e.g., public contestants in gameshows or reality TV shows), for example, unconsciously giving away that they are not the genuine article?
- Building on our own experience of trying to generate biodata in post-production of *TEL*, what specific techniques might they be able to use to do this?
- Conversely, how can we support actors in acting to existing biodata (adapting their responses to recorded signals rather than producing new signals), for example by generating appropriate annotations to scripts or visualisations and cues that can easily be followed in real time?

A related challenge concerns the development of better tools for simulating biodata. Our current person simulator was clumsy and relatively unworkable, requiring the operator to use individual sliders to manipulate separate streams. A higher level interface that specified an intended emotional response or trajectory and generates multiple streams of biodata from this would have been more useful. Thus, as well as trying to recognise aspects of emotional response from biodata which is the focus of much current work in this area, there is also a need for the reverse – to author biodata in ways that may support interpretation of emotion.

Visualisations and cameras

Our second broad challenge concerns the nature of biodata visualisations. Further research is required into how these should appear so that viewers can read them appropriately. This is not just about the usability of a visualisation (although this is a factor), but is specifically about the visual language of their use on television. What existing conventions are already established for showing biodata (or indeed other data such as GPS positions) on TV, for example in medical dramas, spy stories or other genres? One important challenge here may be signalling the difference between actual and fictional data. Using fictional data will of course be fine in fictional shows, for example for a character with extraordinary physiological capabilities (Superman perhaps) or when introducing fictional characters (such as our ghost), but is it important that viewers can separate this from more factual attempts to show real data, for example as part of news, sports, or popular science programming. This may in large part be a matter of the wider framing of the programme, but perhaps might also involve a set of conventions about how the data themselves are presented. What aspects of a visualisation suggest truthfulness, rawness or liveness for example?

Turning to a second issue, our initial mixing interface in *TEL* treated cameras and visualisations quite differently. Although video could be selected for prominent display in the central part of the screen (Figure 3), biodata was fixed. Ideally we could have manipulated biodata visualisations in the same way as the camera feeds, for example moving them to the central area in order to draw attention to them (e.g., when we did mange to acquire live biodata or introduced the ghost character). In general, we need to

develop more powerful techniques and supporting tools for manipulating visualisations alongside and with equal power as existing video and audio feeds within TV production. As part of this, we need to consider the kinds of practical 'camera work' [2] that are appropriate for visualisations – what are the visualisation equivalents of zooming and panning, or of close-ups, wideshots and so forth? We also need to address the mixing of visualisations with other feeds in terms of operations for cutting, fading, compositing and otherwise mixing visualisations of biodata with images of participants so as to create visually engaging but also rapidly legible TV output. More broadly, we ask how biodata visualisation gets integrated generally into the interactional relationship between production room and camera operators [2, 7]? Developing this we may also ask in what way might participant camera operators be supported in providing footage that is integrated with their biodata [3]?

Conclusion

In this paper we have presented an initial exploration of the challenges in designing and running a live TV show format that integrates biodata and video footage. We have also explored the post-production of such an event, and identified two key aspects that support the development of the live and post-produced experience: issues surrounding the post-production of 'fake' and 'acted' biodata, and the need for tools to support the visual language of biodata and its integration with existing production practices.

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