TellTale: Adding a Polygraph to Everyday Life

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p://dx.doi.org/10.1145/2702613.2732878

Abstract
TellTale is a wearable device that seeks to augment communication with subconscious emotion information. By sensing a user's heart rate and galvanic response, two major biological indicators of physiological state, *TellTale* can provide insight into true physiological and emotional response. In this way, TellTale acts as a playful, wearable polygraph or lie-detector. Through abstracted visualisations of the physiological data, we aim to position TellTale in-line with the learned skills of communication. In this paper, we motivate the design of TellTale, detail a prototype device and pilot study and present future areas for TellTale's exploration.

Author Keywords
Wearable Polygraph; Affective Computing; Ludic Design; Communication; Wearable

Introduction
Communication occurs in a myriad of different ways, across varied settings, between near and distant participants and through different technologies. Regardless of the setting, we develop methods for enhancing the richness of these interactions; techniques for conferring our meaning, our opinions and our mood. For example, a speaker may use gestures [12], facial expressions [11] and timing [5], whereas a writer may use punctuation, carefully picked vocabulary [16] and, for better or worse, emoticons [6,17]. Similarly, a

Figure 1. **TellTale**. A wearable polygraph for augmenting communication with subconscious emotional data. (Chest mounted output screen displaying abstracted visualisations. Red color on fingers indicates sensor placement.)

listener must develop methods for interpreting this contextual information. For example, *was that gesture for me or just part of thought* [7]? W*as that laugh genuine? Was that a joke?* This interpretation and ability to 'read someone' undoubtedly forms part of the skill of communication [11].

There are a variety of factors that affect our ability to successfully 'read' someone, including how well we know them, our communication medium (face-to-face vs. email) and even our clothing choices (e.g. sunglasses hiding eyes). But this is further complicated by the communicator's ability to provide false or misleading information, such as through lies, false smiles and so forth [3]. For this reason, when attempting to verify the truth of communication, law enforcement agencies will look to other physiological information through polygraphs. This information includes galvanic skin response (GSR), blood pressure, respiration and heart rate (HR); all subconscious markers of our emotional state [1,15].

In this paper we explore the playful application of this information within everyday settings. We present *TellTale*, a non-invasive wearable polygraph capable of augmenting communication with physiological changes that are normally invisible. *TellTale* portrays both the wearer's galvanic skin response and heart rate through a small chest-mounted display. In this way, the device becomes a telltale of the wearer's current emotional state.

Through *TellTale*, we seek to add emotional state to the vast dimensionality of communication, providing a subconscious, unfalsifiable insight into a communicator's thoughts. In-line with the skill of communication, we do not seek to classify emotions, instead present a playful device using abstract visualisations that requires a learned interpretation.

Related Work

Emotional Response

TellTale uses physiological sensors as a means of conveying emotional data. Lissetti and Nasoz [9] have shown that it is possible to infer a high level of emotional information through physiological sensors, while galvanic skin response itself portrays changes in arousal. More recent evidence demonstrate that galvanic response is part of the autonomic nervous system [15], which is controlled subconsciously, suggesting that people are not able to change it at will. Heart rate is also affected by the emotional content of stimulus, with evidence that people's heart rate decreases while watching negative stimuli (low valence) [1]. These signals could be thought of as the *TellTale* signs of emotions which can be easily hidden or masked.

Current emotion-related research focuses on a very prescriptive approach, classifying the wearer's emotions with very little room for interpretation. We wanted to allow the user to assimilate the new information into their understanding themselves. Gaver et al. [4] investigated how a ludic approach might improve environmental HCI design, with simple *Indoor Weather Stations*, by encouraging "environmental awareness while eschewing utilitarian or persuasive agendas". The *Indoor Weather Stations* simply displayed the sensory data and allowed the home owners to react as they saw fit; instead of altering the environment autonomously. The use of a ludic approach by Gaver et al., enabled participants to display a higher level of trust in their devices; opposed to so-called 'black boxes'. The participants also became attached to the Indoor

Key Components
Analogue Sensing
GSR Sensor
Pulse Sensor
Small Form Factor
Screen

Table 1: Key components for the prototype.

Figure 1: Abstract graphical visualisation of *TellTale*. Colour represents GSR with a white pulsating ring indicating heart rate.

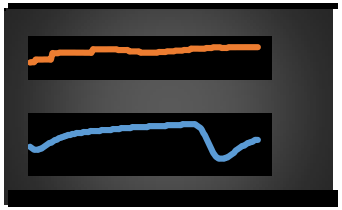

Figure 2: Numerical data visualisation. The top line represents heart rate and the lower line represents GSR.

Weather Stations over long periods of time, with one participant describing a "'eureka' moment [when the device] impelled him to perceive the home as an ecology and not a hermetically sealed box". This eureka moment, level of trust and attachment to the device is what we aimed for in the design of *TellTale*.

Wearable Communication Aides

The majority of the research on wearable devices focuses on providing additional information for the wearer; for example, Google Glass, McAtamney's head mounted device [10] and the SmartWig [14]. As a wearable display device, our work is more closely related to that of Takano et al. [13] and Reach [8]. Reach uses smart fabrics to display contextual information. In one scenario, Reach 'bleeds' patterns between devices to display proximity information between collocated wearers. More similarly to our work, Takano et al. also explored the use of physiological data to enhance communication. They utilise electromyography (through multiple on-head sensors) to communicate 'smiles' between autistic children and their parents. We continue this style of communication enhancement, while expanding the potential audience and reducing the invasiveness of the on-body sensing.

TellTale: Adding physiological emotion to communication

TellTale is a playful, wearable device that portrays subconscious physiological information during interaction and communication. It is designed as an additional communication channel, specifically one that the wearer has no control over. The device itself displays physiological data through abstract visualisations, requiring careful interpretation. Through this abstraction and required interpretation, we intend for the device to be playful for both the wearer and the observer.

We aim to explore the device's effect on everyday interaction, from public encounters whilst shopping where the device may allude to impatience or frustration, to more personal encounters, where the device may allude to impatience or frustration(!).

Prototype Device

To enable further exploration of our concept we built a prototype *TellTale* device. We chose to use a Raspberry Pi (RPi) as it supported our goal of making a small, lightweight wearable device. Table 1 lists the other key components of the prototype.

We have designed the device to be worn over the shoulder with an elasticated strap. The sensors are worn on the hand; the GSR contacts attached via a pair of soft fabric finger cradles and the pulse sensor strapped around the tip of a finger. We added an additional TFT display to the RPi to display representations of the wearer's physiological data.

Display Designs

We designed two different visualisations for displaying the data collected from our sensors. The first visualisation (Figure 1) abstracts the numerical data collected from the devices; displaying the GSR as a range of colours, and the heart rate as a pulsating ring. We selected a traffic light colour scheme to portray changing emotional states (based upon valence-arousal). While this visualisation inherently encodes some positive-negative classification, the precise interpretation of the signals is left to the observer. The second visualisation (Figure 2) is a continuously updating graph, with heart rate above and galvanic

Group	Visualisations displayed
1	Sensor visualisation
2	Graphical visualisation
3	Facial Expressions
4	Facial expressions and sensor visualisations
5	Facial expressions and graphical visualisations

Table 2: Classification of group numbers and visualisation shown in study 2.

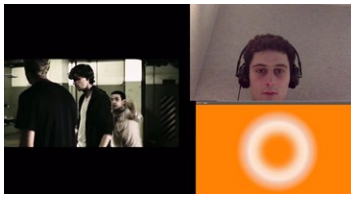

Figure 3: Example from *Group 4,* showing the abstracted sensor data and the participant's facial expression.

response below. We also abstracted this visualisation by removing the numerical information.

Prototype Pilot Studies

To confirm the design and accuracy of our device configuration we conducted a verification study and a pilot study. The aim of our verification study was to ensure that our device successfully detected changes in emotional state. We used four groups of videos from the LIRIS-ACCEDE database [2] as a stimulus for four participants. The LIRIS-ACCEDE database contains 9,800 clips from publically available videos, each annotated with an arousal, valence rating.

Videos were chosen that represented the extremes of the valence-arousal space. The participants watched the videos whilst their GSR and HR readings were recorded. The participant's faces were also recorded with a webcam, for our second study. To prevent distraction and reduce error in our results, the participants wore noise-cancelling headphones, the *TellTale* display was disabled and the room was air conditioned to a constant temperature.

Through an observation of the sensor data alongside the videos, we found that the participant's change in emotional state between the videos could be easily observed in their GSR readings alone. As emotion changes were detectable, we were keen to explore the understanding of our visualisations.

In our second study we examined whether our participants integrated the *TellTale* information into their empathetic responses when identifying other's emotional states. Twenty participants were shown some of our collected data from our verification study alongside one of two videos from the LIRIS-ACCEDE database (example shown in Figure 3). The participants were assigned randomly to one of five conditions, each relating to what additional information they were provided with. The details of these groups can be seen in Table 2. Each participant completed eight trials.

After witnessing the data alongside the database videos, participants chose which of the two videos the person from the previous study was watching. The participants were allowed to watch each video twice. After completing the task, the participants completed a questionaire regarding the task, their performance and the cues that they used.

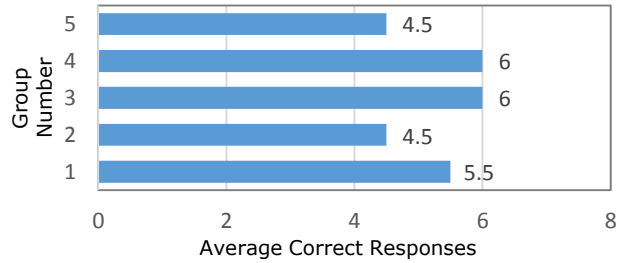

Figure 4: Study results showing the average number of correct responses (out of 8 total questions) per participant group.

The results of the study show that the groups with footage of facial expressions available to them performed best on average (Figure 4). We are encouraged by the similar performance of the group with only sensor visualisations available to them. Although the visualisation is abstract, the participants were able to identify the correct video with almost the same accuracy as with facial expressions. The results of the questionnaire showed that of the participants with *TellTale* visualisations available to them, one third of respondents used the graphical or sensor visualisations

as their primary source, with only a third of the remaining stated that they did not use the visualisations at all.

Future Work

Having developed a prototype device and conducted pilot studies to verify its design, we are keen to explore and study the wider use of *TellTale*.

Effect on Wearer and Observer

Firstly, we envisage *TellTale* as being a disruptive device for both wearers and observers. An interesting feature of *TellTale* is the effect it has on the wearer and how these effects vary by setting and interaction. Although abstracted, *TellTale* provides an insight into the wearer's emotional state and emotional responses to a situation. As a result of this, *TellTale* could serve to highlight discrepancies between emotions the wearer is trying to convey and those they are feeling. The device will also show the emotional responses to any questions that are asked. The device itself could be 'exposing' in that way. As a result of this, we envisage that *TellTale* may encourage more truthful behaviour in the wearer as they cannot hide behind the 'cloaks' typically available within communication. *TellTale* may also have an interesting impact on an observer, allowing them to change their approach to communication on specific topics given observed emotional responses.

Fictitious Physiological Data

As *TellTale* can impact both the wearer's and observer's approach to communication, we are interested in the effects of unknowingly displaying random, fictitious physiological data. As the visualisations will not correspond to current interactions, it may serve to introduce noise or lead to miscommunication. In turn, over time, this may lead to a more careful focusing of other emotional cues, such as gestures and vocabulary.

Displaying the observer's data

Looking forwards to a ubiquity of *TellTale* devices, another area for exploration is the display of the observer's physiological information. In this way, only the observer is able to see their own data. The aim of this use case is to encourage reflection on communication and a private understanding of emotional response to different situations.

TellTale beyond face-to-face interaction

Finally, as interaction increasingly moves beyond face-to-face encounters, we are keen to explore the augmentation of non-verbal communication with *TellTale* data. For example, is it possible to convey physiological data within telephone calls, in emails or through messaging applications? While certainly a design challenge, we believe that there exist opportunities to enhance constrained communication types with additional emotion data.

Conclusion

We present *TellTale*, a playful wearable device that augments everyday communication with polygraph information. While many different cues are available to us during conversation, we can learn to manipulate these cues to convey only the information that we want. *TellTale* adds physiological data through galvanic skin response and heart rate to these cues, as a subconscious display of our current emotional state. In this paper, we present a prototype device, two pilot studies to verify its design and a range of interesting areas for future work.

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