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Biometric data sharing in the wild: Investigating the effects on online sports spectators

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ABSTRACT

There has been a market surge in both provision of and demand for fitness applications and sport wearables. These wearables often come equipped with highly sophisticated biometric data (e.g. heart rate) functionalities that make the capture and sharing of such biometric data increasingly common practice. A few research studies have considered the effect that sharing biometric data has on those individuals sharing this data. However, little is known regarding the social impact of sharing this data in real-time and online. In this study, we investigate whether there is value in sharing heart rate data within social applications and whether sharing this data influences the behavior of those seeing this data.

We do so by conducting a study where the heart rate data of runners competing in a 5-km road race is shared in real-time with 140 online spectators. We collect rich quantitative data of user interaction though server logs, and a qualitative data set through interviews and online users' comments.

We then compare and contrast the behavior of online spectators who are presented with heart rate data together with contextual data, and those who are only presented with contextual data, for example, location. We also examine whether this difference is dependent on the social relation between the athletes and the spectators. Results indicate that spectators who are presented with the runners' heart rate data support the athletes more and rate the presented system more positively. These effects are dependent on the social tie between the athletes and spectators. This is one of the first studies to carry out an empirical investigation in the wild on the effects of sharing heart rate data in an online social context. In this light, in addition to supporting earlier literature, the outcomes present new insights and research directions within the sporting context.

1. Introduction

The use of biometric data such as heart rate data is becoming increasingly popular outside the medical practice. As the number of communication channels has increased throughout the digital era, so too has the diffusion of biometric data. Some socio-technical systems provide embedded features that allow users to share their biometric data. For example, freely available sports applications such as RunKeeper, Runtastic and Azumio, allow users to share their heart rate data over social networks in real-time. Similarly, a prevalence of fitness devices, such as the Apple Watch, Fitbit, and MI Band, capture and share heart rate data to social networks. Additionally, the decreasing price point and diversity of these applications is increasing the capacity for users to share this data (Chung et al., 2016).

This data is also sporadically used in live public broadcasts. For example, the Red Bull Stratos event superimposed the heart rate data of an athlete over live video streams. This event was followed live by over 8 million online viewers (Caulfield, 2012). However, while this data type is increasing in use, its effect on viewers and the added value of broadcasting this data, if any, are still largely unclear. In other words, is it worth broadcasting this data? In this study, we are interested in understanding whether presenting athlete heart rates to remote spectators adds value and influences spectator behavior. Additionally, the work of Janssen et al. (2010) and Kurvinen et al. (2007) hints that the effect that heart rate data has on others might depend on the social relationship between the athlete whose data is being shared and those viewing that data. Thus, in this work we also investigate whether the influence on behavior when seeing another's heart rate is subjective, depending on the social tie.

We use the sport of running as this provides conditions for repeatability and research observation that fit our requirements. This affords a realistic context for a data sharing setting whose duration is neither too short (in which case the researcher does not have enough time to capture the necessary data) nor too long (in which case managing the setting may become too complex). Additionally, we have explored, in the last four years, how to design and develop systems that

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facilitate real-time remote crowd support during challenging sporting events such as marathon running, thus, this provided a familiar setting. By remote crowd support we intend that spectators who are not physically at the event can cheer the athletes remotely during the event. In this process, we iteratively developed and tested HeartLink (heartlink.co.uk), a system that allows athletes to broadcast location and biometric data to online spectators as the event unfolds. With HeartLink, online spectators can support their favorite athletes by clicking a 'Cheer' button while following their performance live. This creates a small vibration and a sound on the athlete's device (e.g. mobile phone), thus creating a physical connection between the athlete and the remote supporters. In this way, the athletes become aware that a crowd is following their performance. We are then able to utilize the cheering as one of the indicators for user engagement.

The outcomes of an earlier pilot study that considered the effect of cheering athletes, suggested that displaying the users' heart rates to remote others influences spectators' behavior (Curmi et al., 2013). For example, spectators became anxious when the biometric data of athletes was interrupted during the sporting event. In this pilot study, we also identified that the use of heart-rate data during the sport broadcast presented logistical challenges that were not clearly justified by the increase in value for the spectators. These challenges included a limit in the number of heart-rate sensors that were available for the study at the lab where the investigation took place (N=8) and the increase in the complexity of the setup from the necessity of explaining-to and wiring-up participants. This scenario prompted us to empirically investigate whether the use of heart rate data justifies the expense of the additional hardware sensors and the effort of wiring participants. In other words, is sharing additional heart rate data in this context worth the trouble? It is in this light that we now further investigate the effect that the sharing of heart rate data has on those seeing this data in a sporting context.

Thus, through an in-the-wild study, we investigate the difference in behavior between those spectators seeing and not seeing heat rate data and why such a difference, if any, occurs. By recruiting two groups of spectators and randomly assigned each spectator either to a condition where the interface included the heart rate data of the athletes, or to a condition where the interface excluded the athletes' data, we compare and contrast behavioral difference between those presented with the heart rate and those who are not presented with the heart rate. Additionally, we investigate whether any difference is equally reflected among those who know the athletes and those who do not. The first group, recruited from the athletes' social networks, comprises the athletes' friends; we refer to this group as 'friendsourced' (Bernstein, 2010). The second group, recruited from a crowdsourcing platform and with no social connection to the athletes, we refer to as 'crowdsourced.'.

In this light, this paper's contributions are as follows:

1. It reports on the online behavioral differences between spectators who are presented only with context data and spectators who are presented with both biometric and context data.
2. It reports on the online behavioral differences between friend-sourced and crowdsourced spectators.
3. We then compare disparities between the four groups in conditions 1 and 2 above, the results of which indicate that the most engaged spectators are friendsourced spectators who are presented with the additional heart rate data.
4. Finally, we draw upon these results with support from the collected qualitative data from this study and its relation to the existing literature.

Section 1.1 reviews how technology-mediated heart rate data sharing evolved, from its emergence in the early 1900s up until the widespread diffusion through digital communication channels and seminal academic work in this area over a century later. We then describe the study's approach, methodology and emerging findings.

We reflect on the results from sharing biometric data in real-time through three theoretical concepts. 1) The sharing of personal informatics (Epstein et al., 2015), 2) subjective versus objective information sharing (Bae et al., 2013) and 3) boundary negotiated artifects (Lee, 2007). Boundary objects were first proposed by Star and Griesemer in 1989 to investigate the interaction of actors in a museum curating setting and the bridging of ideas across these actors. More recently, Lee et al. built upon this to differentiate between routine and non-routine collaborative work by injecting 'boundary negotiating artefacts' into the design discussion. It is the latter that we are most interested in for the non-routine use of heart rate sharing as a boundary object for the athletes, researchers and the spectators.

The next section reviews how technology-mediated heart rate data sharing evolved from its emergence in early 1900 up until the widespread diffusion through digital communication channels and seminal academic work in this area. We then describe the study approach, methodology and emerging findings.

1.1. The state of the art in heart rate sharing

Traditionally, medicine has been the driving force for advances in biometric data capture, processing and communication. The history of biometric data in health dates to the early 1900s, and the communication of biometric data, biotelemetry, was subject to rapid evolution through a series of disruptive technologies. Fig. 1 highlights key milestones in this regard. These advances were initially driven by demands in health care (Grundy et al., 1977); however, more recently, the rise of ubiquitous computing, particularly smart phone technology, facilitated a rapid dissemination of biotelemetry-based applications outside the medical domain.

The first reference to biotelemetry dates to 1903, when Nobel prize winner Willem Einthoven transmitted electrocardiogram signals from hospital to his laboratory over telephone lines (Nihal and Elif, 2002). The next change occurred 18 years later with the first transmission of heartbeats over radio. Subsequently semiconductors opened up multiple possibilities for biotelemetry as equipment became more stable, smaller and more accurate. Today, the availability of off-the-shelf biometric sensors and mobile devices lets individuals who are not necessarily medical savvy, to capture, log and share this data. Smartphone applications like RunKeeper, Runtastic and Azumio, among many others, are freely available and allow users to capture and share their heart rate data over social networks in real-time with great simplicity. For example, Azumio, reads the user's heart rate through a finger placed in front of the phone's camera without necessitating any additional sensors. More recently, Poh et al. (2010) developed a non-contact heart rate measurement application; through a webcam, they analyze minute changes in facial skin colors and determine the cardiac pulse.

In this scenario, while devices and applications that allow the sharing of heart rate data are on the increase, little is known regarding

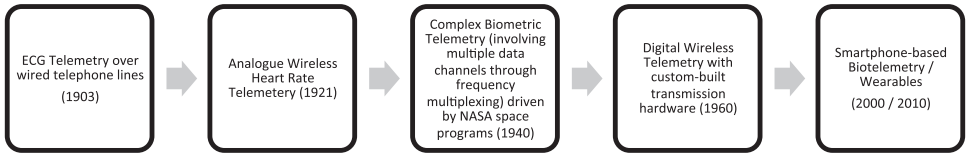

Fig. 1. The evolution of biometric telemetry.