Towards Increasing Bodily Awareness During Sports with Wearable Displays

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Abstract
Past studies have shown that commercial sports tracking technologies do not often provide the desired level of awareness of one's own body, and they are often abandoned after intermittent usage. In this position paper, we explore design possibilities for wearable displays for increasing bodily awareness while the users are engaged in sports. This builds our vision of future sports displays, and provides a framework and inspiration for developing interactive sport technologies utilizing wearable displays. Our work contributes new directions in developing wearable devices for enhancing the experience of physical activity.

Author Keywords
Sports; Wearables; Wearable Displays; Activity Tracking; Bodily Awareness.

ACM Classification Keywords
H.5.m [Information interfaces and presentation (e.g., HCI)]: Miscellaneous.

Introduction
As an increased fraction of the population engages in physical activity, technologies for sports are gaining increased attention commercially and in the Human-Computer Interaction (HCI) field [5]. Increasing numbers of wellness technologies are being introduced,

and activity trackers allowing users to follow their habits and performance have emerged, ranging from tracking sports to sleep and other aspects of life. Commercial activity trackers employ different form factors from bracelets to smart watches and rings, and very often use a smart phone as stand-alone wellness application or in conjunction with another tracking gadget [3].

In addition to the expanding selection of different products, research is also actively experimenting with new technologies and design solutions for wellness tracking. Yet, recent research has shown that technology support has limited positive impact on fitness [4]. Further, many sport technologies, primarily fitness trackers [6], are only used over a short period of time and then abandoned. To counter this, Baumer [1] postulated that technologies should support reflection that will in turn lead to increased engagement. Here, we focus on framing different design aspects that contribute to creating body awareness while doing sport. We explore the topic from the wearable displays point of view, and outline how the design of interactive technologies can support different design requirements.

Scope and Related Work

Several works have presented design spaces for wearables in general, for example Wang et al. [11] structure around the location of the wearable on the body, Schneegass et al. [8] focus on the input space and Rantakari et al. [7] on wellness applications. In contrast, we focus on the output channel of wearables targeted for use by those engaging in sporting activities. Perhaps the most relevant work in this area is that by Jensen and Mueller [5], who present a design space for technology interventions in the running domain, describing the range of possible feedback as representative-to-assistive. Here, the lack of research on providing assistive feedback to runners is highlighted, with a call to action *"There is a need to investigate how we can provide complex technique-related feedback to the runner in an assistive and expedient way"*[5].

Whilst a wide variety of output modalities to communicate various aspects of sports performance to athletes have been presented in prior work, we focus on the visual channel - in the form of displays worn by the participant. To position our work, we shortly review other modalities that have been applied to provide bodily awareness to sportsmen and women. Here we note that the vast majority of works have considered running, with other areas of sports such as athletics, swimming and ball sports being relatively less covered.

Haptic and Electrical Muscle Stimulation (EMS) technologies have been demonstrated a method to create bodily awareness as simultaneously guiding the user to make correct movements. For example, Wiehr et al. [12] have presented FootStriker, where EMS is used to activate the runner's muscles to forefeet running instead of landing to ground heel first. This helps a beginner find the correct running style, and lowers the risk for knee injuries. Other approaches to guiding running form have used audio [9] and vibration based haptic feedback [10].

Wearable Displays for Engaging Interactions During Sports

Informed by the prior work, and aiming for a structured approach to the area, we created a design space for wearable displays worn during sporting activities (Figure 1). Through this framework, we aim to identify opportunities on how exploring the usage of wearable displays may answer user needs connected to physical activity, and contribute to augmenting the overall experience of participating in sports. In the following we discuss the contribution of each of the

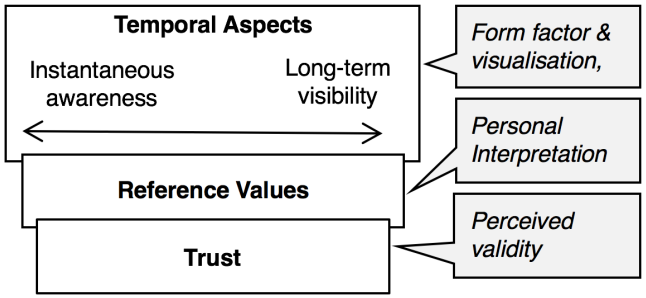

Figure 1: Factors affecting the bodily awareness provided by wearable displays during sports

factors within our defined space.

Supporting Instantaneous Awareness
Past work has shown that runners and their social environment often desire an implicit and constant awareness of some running parameters, such as pace or remaining distance [13]. This requirement has been largely addressed by glanceable wearable displays, which have the potential to offer ambient display properties during physical activity. The most common form of wearable display currently used in sports activities, smart watches and bracelets, typically offer some support for momentary awareness.

Noticing Long-Term Change
Another aspect often highlighted by sportsmen and women is the need to notice long-term change and values that change slowly [6]. When wearable displays are embedded into multiple garments, they can offer possibilities for reflecting on data during opportune moments. It remains a challenge to design subtle displays that can be integrated in different kinds of garments.

Aiding in Goal Setting and Providing Reference
Recent work indicated that users found it difficult to track how their wellbeing is related to fitness goals they set, and desired more reference values to better understand their fitness [6]. Here, users need to understand the values presented to them compared to e.g. group averages or their personal history. Wearable displays can empower users to effectively set reference values and continuously see their status with regard to a reference value, as demonstrated by Colley et al.[2].

Building Trust in Sensing
Finally, studies have shown that users feel a need to understand how fitness devices sense their activity in order to build trust that the values presented by the devices are accurate [6]. This, in turn, may lead to increased engagement. Wearable displays can be effectively used to indicate when sensors are gathering data and processing thus contributing to the transparency of the fitness tracking process.

Conclusion
In this position paper, we identified opportunities for new wearable displays to answer user needs connected with physical activity. We proposed a design space for wearable displays for sports that includes the temporal aspects of the displays, comparison against reference values and trust in the device's accuracy. We hope that our ideas can inspire further design explorations.

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