HeartBeat Demonstrator: Tactile Support for Keeping a Target Heart Rate

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ABSTRACT
Physical activity should be performed within certain intensity limits. In this paper, we present a demonstrator which encodes different heart rate zones with continuous vibrotactile feedback. The demonstrator uses a tactile design created in a participatory design study and has shown to raise the awareness of the heart rate in a user study.

Keywords
Tactile feedback; Heart rate; Physical activity

Categories and Subject Descriptors
H.5.2. [**User Interfaces**]: Haptic I/O

General Terms
Human Factors; Design; Measurement.

1. INTRODUCTION
The heart rate is an important indicator for the training intensity. Depending on the goal of the activity, certain limits for the heart rate can be determined using the maximum heart rate. The optimal intensity is then defined by an upper and lower limit for the heart rate during physical activity.

Nowadays, users who want to observe or learn about their heart rate often do this by using a heart rate wristwatch. Unfortunately, these watches require to look at them to obtain the current heart rate. This is not only uncomfortable if a constant observation is wanted, but also distracting since users need to pay attention to the display instead to their activity. Some variants can also inform the wearer with tactile or audible alarms if previously entered limits are reached, but there are problems with these variants too: These alarms are commonly the same for the upper and lower limit. Thus, to classify the alarm, again a look on the display is needed. Further, according to experts, these limits are often used wrongly to avoid alarms, so the actual limits are lowered or raised. These wrong limits may then be learned by a user who did not look on the watch to read the concrete values.

To address these issues, in this paper we present a method to not only encode hard limits with tactile feedback, but use a user-designed more detailed tactile feedback to display multiple borders of different heart rate zones. This feedback allows the assessment of the heart rate without a distracting visual display. Further, due to a tactile-only display which not just shows the outer limits, we avoid the alarm character of the tactile signals and keep a constant awareness of the heart rate.

2. RELATED WORK
The encoding of abstract messages using tactile feedback was described by Brewster et al. (2004)[1]. These abstract messages are called *Tactons*. Tactons can be used to display information without demanding other senses like sight and hearing. Tactile abstract messages like Tactons have been proven to be able to encode several types of information[3], e.g. progress information[2] and navigational tasks[5]. Lee et al. (2010) evaluated the perception of tactile display worn on the wrist[4]. They showed a high discrimination rate of patterns up to 99 percent and found out that intensity is the most difficult parameter to distinguish and temporal patterns are the easiest. Thus, we decided to focus on temporal patterns in this work. These papers showed us that vibrotactile feedback at the wrist is a good way to communicate information to the user without distracting her or him.

The direct encoding of the heart rate was the approach of HapticPulse by Timmermann et al. (2012)[6]. Every heart beat measured by a chest belt was represented by a vibration impulse of a connected smartphone. Users were able to feel their heart rate with an accuracy of 10 beats per minute and reported a raised awareness about their heart. One Problem revealed was the distraction. The heart beat and therefore the tactile feedback interfered with the walking

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rhythm which disturbed the users. This approach showed us that the tactile representation the heart rate is effective and liked by users but has to be designed to not interfere with their running rhythm.

There are also commercial products which support the user in measuring the heart rate and in keeping it in defined borders for training purposes. One example is the *Garmin Forerunner 610* [1]. In addition to acoustic signals when the heart rate exceeds certain limits, it can also give tactile feedback in form of a vibration impulse. While it is able to provide information about certain limits, it e.g. can not distinguish between the upper and lower load limit. Thus, its vibrotactile feedback is not designed to be used without additional looks on its display.

3. SYSTEM

Our demonstrator allows users to create their own tactile encoding for displaying their heart rate. For demonstration purposes, we also include a tactile design, which we created with the help of an expert interview and a participatory design study with 16 users. This design was already tested in a user study with 20 participants against a common heart rate monitor and proven to significantly raise the awareness of the heart rate and increase the accuracy of users when keeping a certain heart rate corridor while not increasing the cognitive workload. Using this pattern, users can experience an already positively tested tactile heart rate feedback, and modify it among their wishes if they like. Our design uses five zones (optimal, higher, lower, too high, too low) to abstract the heart rate and keep the vibration pattern simple. Because 250 milliseconds were often described as a short impulse and 500 milliseconds as short pause in our participatory design study, we used these values for impulse and pause length in our design. For the optimal zone, the desired feedback was described as minimal by users, so we used one short vibration impulse recurring every minute. For the upper warning zone, most users wanted to use three short impulses with short pauses in between repeating every few seconds. For the lower warning zone, most users used a different count of impulses but generally the same rhythm. We used three short impulses with short pauses in between repeating every five seconds for the higher warning zone. For the lower warning zones, only two short impulses were used and the pause between repetitions was raised to ten seconds. For the critical zones, users explained the feedback for the higher critical zone should have very much vibration and only short pauses, while the lower critical zone should also use long vibration impulses but longer pauses. Thus, we used a two seconds long vibration impulse in the higher critical zone, followed by a 500 milliseconds long pause repeating continuously. For the lower critical zone, the vibration impulse length was lowered to one and the pause length raised to two seconds. The demonstrator consists of a heart rate monitor, a SmartWatch and a smartphone. *Figure 1* shows these devices. The depicted heart rate monitor can be replaced by a pulse oximeter, which can be worn on the finger, if necessary. The heart rate is received and processed with an Android app running on a smartphone. The app translates the heart rate into a vibration pattern according to the design we described before or a custom one. The vibration feedback is played back using a SmartWatch, which we already used in our studies.

Figure 1: The apparatus: Zephyr BioHarness 3 (top), Sony SmartWatch (left) and LG Nexus 4 (right).

[1] `http://sites.garmin.com/forerunner610/?lang=en`

4. CONCLUSION

Heart rate monitors are an important utility for observing the training intensity, especially when e.g. rehabilitating from cardiovascular diseases. Existing heart rate monitors show certain problems. Visual systems can be distracting, especially if users use them frequently during the training. Alarms can help to reduce but not to avoid this distraction. Further, these systems can not give a constant feedback about the heart rate without the user paying attention to them continuously.

In this paper, we presented a demonstrator which uses a tactile design to display the heart rate of the user. The tactile design was created by users in a participatory design study. Further, it was already tested in a field study and proven to raise the awareness of the users heart rate.

The demonstrator allows users to test the tactile feedback during physical activity and allows to adjust the vibration pattern. Thus, users can not only test the given vibration pattern, but also test their own ideas how information about the heart rate can be displayed.

5. REFERENCES

[1] S. Brewster and L. Brown. Tactons: structured tactile messages for non-visual information display. In *Proc. Conf. on Australasian user interface-Volume 28*, pages 15–23. Australian Computer Society, Inc., 2004.

[2] S. Brewster and A. King. An investigation into the use of tactons to present progress information. *INTERACT*, pages 6–17, 2005.

[3] L. Brown, S. Brewster, and H. Purchase. A first investigation into the effectiveness of tactons. In *Eurohaptics Conference*, pages 167–176. IEEE, 2005.

[4] S. Lee and T. Starner. Buzzwear: alert perception in wearable tactile displays on the wrist. In *CHI Proc.*, pages 433–442. ACM, 2010.

[5] M. Pielot, O. Krull, and S. Boll. Where is my team: supporting situation awareness with tactile displays. In *CHI Proc.*, pages 1705–1714. ACM, 2010.

[6] J. Timmermann, B. Poppinga, S. Boll, and W. Heuten. Hapticpulse–reveal your heart rate in physical activities. *Haptic and Audio Interaction Design*, pages 51–60, 2012.