Robert Schenkenfelder / Stephan Selinger

A Comparison of Multiple Wearable Devices Regarding their User Experience During Running

125 - Sportforschung in Österreich

Abstract

In this paper, we compare three recently booming types of wearable devices—a fitness wristband, a smartwatch, and smart glasses—with each other in terms of their user experience during running. The comparison relies on a counterbalanced, within-subject study where 18 participants were asked to use each device during a short running session and fill out a questionnaire afterward. The achieved System Usability Scale (SUS) scores show that smartwatch and fitness wristband got better ratings in terms of usability than the smart glasses. However, there is no significant difference between the wrist-mounted devices. Emocards and PAD Semantic Differential Scale indicate that participants were emotionally more positive when using one of the wrist-mounted devices in comparison to the head-mounted device. Direct personal feedback suggests that the reason why smart glasses performed badly is associated with the actual product (Google Glass) and its limitations and weaknesses, but not related to the concept of a head-mounted device in general.

Keywords:

User experience, sports watches, smart glasses, running

1. Introduction

With an estimated 250 million wearable devices worldwide in use by 2018 (Leggatt 2014), it can be expected that—partly due to their decreasing dimensions and weight—a substantial part of those devices will be used during sports activities. While existing research (Nurkka 2013, Klock / Gasparini 2014, Pfannenstiel / Chaparro 2015, Lucero / Vetek 2014, Mustonen et al. 2013, Mueller et al. 2007, O'Brien and Mueller 2007) has sought to assess the usability and user experience for specific devices and apps, this paper focuses on a cross-device comparison.

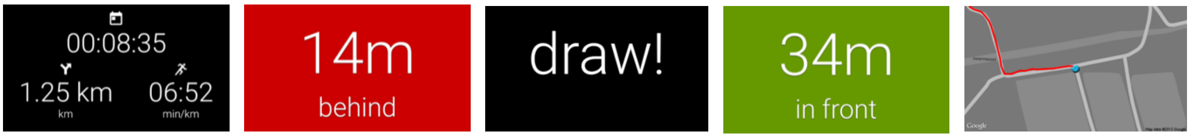
Lucero and Vetek evaluated the usage of interactive glasses during walking in a crowded area and concluded that minimalistic notifications do not interfere with the user's navigation task, but social acceptance is currently an issue with big, uncomfortable or peculiar glasses (Lucero / Vetek 2014). Mustonen et al. came to the conclusion that motion makes people's interaction with head-mounted displays worse and interaction with a head-mounted display also impacts the pace and gait of the movement (Mustonen et al. 2013). Mueller et al. proposed a system where users can connect between each other to transmit each other's speech during a run. Through 2D spatial sound over headphones, they indicate whether the partner/opponent is running faster, slower or at the same pace

(Mueller et al. 2007). O'Brien and Mueller found out that connecting users auditorily increased their enjoyment level significantly (O'Brien and Mueller 2007).

To find out which type of wearable device offers the best user experience during running, we compared three recently booming types of wearable devices—a fitness wristband, a smart watch, and smart glasses. We conducted a field test where participants had to run for a short amount of time with each of the three devices and fill in a questionnaire afterward. In addition, we collected verbatim feedback from every participant.

2. Methods

The comparison is based on prototypes we have built for Google Glass, an LG G Watch R smart watch, and an Android application communicating with the fitness wristband (Runtastic Orbit). The applications permanently track the user's location in order to compute the covered distance as well as average pace. To make this more engaging, we introduced the concept of an opponent, which can either be a remote user running at the same time at a different location, or a virtual user created from the trace of any previously completed session. The applications regularly informed users about the current distance to their opponent. The applications' user interfaces take the form factor and capabilities of the actual wearable device into account which includes color coding and auditive feedback for the smart glasses, color coding and vibration for the smartwatch, as well as vibration for the fitness wristband (figures 1, 2, and 3).



(a) (b) (c) (d) (e)

Figure 1. User interface for the head-mounted device application (Google Glass). Swipe gestures on the glasses frame allow navigation between screens. In addition to using different colors, runners are notified by audio whether they are ahead or behind. (a) Personal metrics user interface, (b) interface while the user is behind the opponent, (c) head-to-head with the opponent, (d) and in front of the opponent, (e) map user interface.

Usability was determined with the system usability scale (SUS) (Brooke 1996); for measuring emotions, PAD Semantic Differential Scale (PAD scale) (Mehrabian / Russell 1974, Agarwal / Meyer 2009) and Emocards (Desmet et al. 2001) were used. We used a counterbalanced within-subject design for the study with 18 participants (nine males, nine females). Participants ranged in age from 17 to 53 years (M = 28). All participants had experience in using mobile devices, but none of them with wearable smart devices. One participant used wrist-mounted sports trackers regularly. All except one were right-handed. Half of them sometimes wore a watch or a similar wrist-mounted device, five participants were habitually wearing glasses.

(a) (b) (c) (d)

Figure 2. User interface for the fitness wristband application (Runtastic Orbit). Navigation is performed by pressing a button. Additionally, the distance to the opponent is shown as a scrolling text every ten seconds instead of duration, distance, or pace. Runners are notified by distinct vibration patterns whether they are ahead or behind. (a) Interface showing session duration, (b) covered distance, (c) and average pace. (d) Opponent user interface. The arrow indicates the scrolling direction of the text and is not part of the user interface.

(a) (b) (c) (d) (e)

Figure 3. User interface for the smartwatch application (LG G Watch R). Similar to the Glass, navigation happens by swiping. Vibrations are used to inform runners whether they are ahead or behind. (a) Personal metrics user interface, (b) interface while the user is behind the opponent, (c) head-to-head with the opponent, (d) and in front of the opponent, (e) map user interface.

The task was to run with each device, one at a time. Since the participants' speed should not influence the amount of time they used the device during the test, we did not define a required distance to be covered, but instead defined 15 minutes for each device to be tested by each participant. When time ran out and the participant returned to the starting point, we video-recorded their first impressions directly after the test. Then, they had to fill in an online questionnaire consisting of personal questions (gender, age), which device they had just used (Glass, Watch, Orbit), which Emocard they would select right now, the opposite adjective pairs of the PAD scale and the SUS questions, in that exact order. We did not supervise the participants as this could have had an impact on their choices in the questionnaire (Tullis / Albert 2009). Additionally, after having tested all devices, participants were asked to sort the devices in their order of preference in a forced-choice comparison.

3. Results

The boxplot in figure 4 shows the achieved SUS scores for Google Glass (M = 50.56, SD = 20.03), LG G Watch R (M = 80.28, SD = 20.76) and Runtastic Orbit (M = 84.31, SD = 8.86). An ANOVA revealed a highly significant difference ($F_{2,51} = 20.152$, $p < 0.00001$) between the devices. T-tests between the Glass and watch and between Glass and Orbit ($p = 0.00009$ and $p = 0.00005$) confirmed the high significance, whereas the t-test between watch and Orbit (p = 0.364) stated no significant difference between the two wrist-mounted devices.

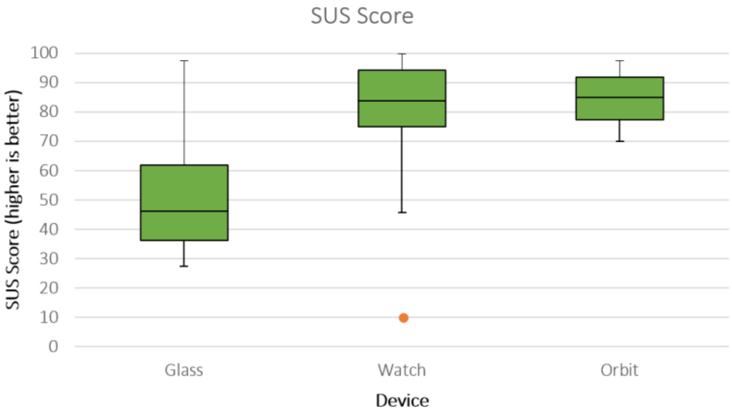


Figure 4. SUS score for the three devices.

For the Emocards (figure 5) we converted the received emotional responses into angles (as proposed by Kollee et al. 2014), where each emotional expression represents a unique angle between 0° and 360°, each with a distance of 45° (e.g. excited- neutral = 0°, excited-pleasant = 45°, etc.). With φ = 145°, the angle of the average emotional response of Google Glass can be classified into the calm-pleasant sector, with a slight tendency to calm-neutral. The average emotional responses of the LG G Watch R (φ = 80°) and Runtastic Orbit (φ = 77.5°) were both located in the average-pleasant sector, with a slight tendency to excited-pleasant. An ANOVA conducted on the Emocard angles showed a significant difference ($F_{2,51}$ = 4.491, p = 0.016) between the devices. Not surprisingly, the t-test between Glass and watch (p = 0.045) and between Glass and Orbit (p = 0.031) showed a significant difference, whereas the t-test between watch and Orbit (p = 0.889) showed no significant difference.

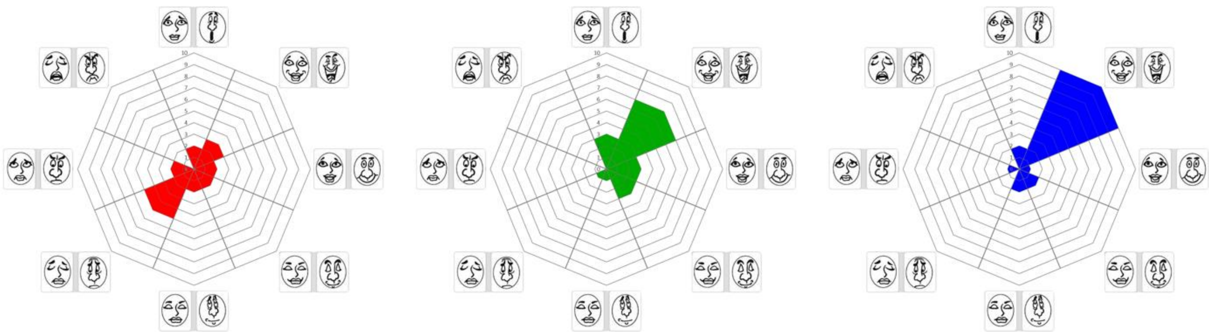


Figure 5. Visualization of the collected Emocard data, taking the number of responses for each emotional expression into account. (a) Results for Google Glass, (b) Runtastic Orbit, (c) and LG G Watch R.

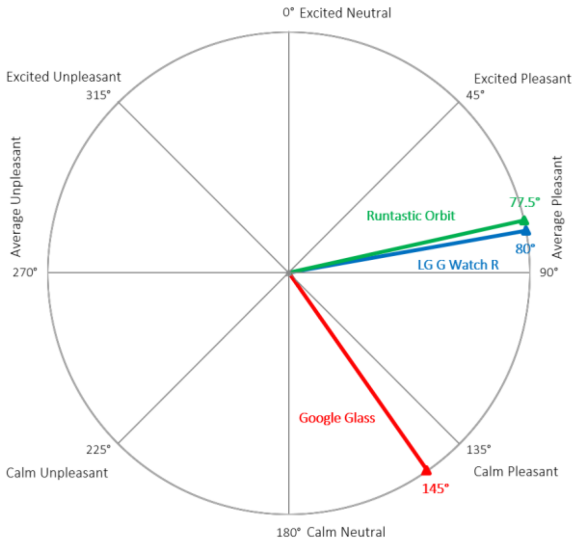


Figure 6. Emocard data converted into angles.

Regarding the PAD scale, out of the eleven pairs, five revealed a statistically significant difference between the three devices, each indicating the same result: participants were emotionally more positive when using one of the wrist-mounted devices in comparison to the head-mounted device.

Verbatim feedback indicates that although the Glass did not perform as well as the other devices, the participants were not negatively biased in general. The readability of the display has clearly been an issue for the majority (*N*=11) of the participants, but at the same time a noticeable amount of participants (*N*=7) stated that the concept of having a display in direct line of sight is promising. Problems with readability due to rain drops on the Glass display were reported by three participants. Seven participants said that Google Glass is convenient to wear; however, five participants stated that the Glass is eye-catching and they could not think of using them in public. Lastly, six participants liked audio feedback. While the watch's user interface was clearly understood by the majority (N=9) and half of them (N=9) felt more motivated with the green and red colors, four participants complained that the watch display was not so easy to read, either because there were three values which were simultaneously displayed or because the letters were too small. Eight participants noted that on the watch swiping is more intuitive than pressing buttons. Five participants complained that the display of the Orbit is too small and that it displays too little information. Those were clearly better off with the watch with its bigger display offering more information at a glance. Only four participants preferred pressing a button instead of swiping. Eight participants pointed out that the Orbit was more convenient to wear than the watch. The results of the questionnaire may indicate a clear difference between Glass and the two wrist-mounted devices, but the personal feedback gives a more multifaceted point of view, where participants pointed out good aspects and criticized things to be improved for each device and each implementation.

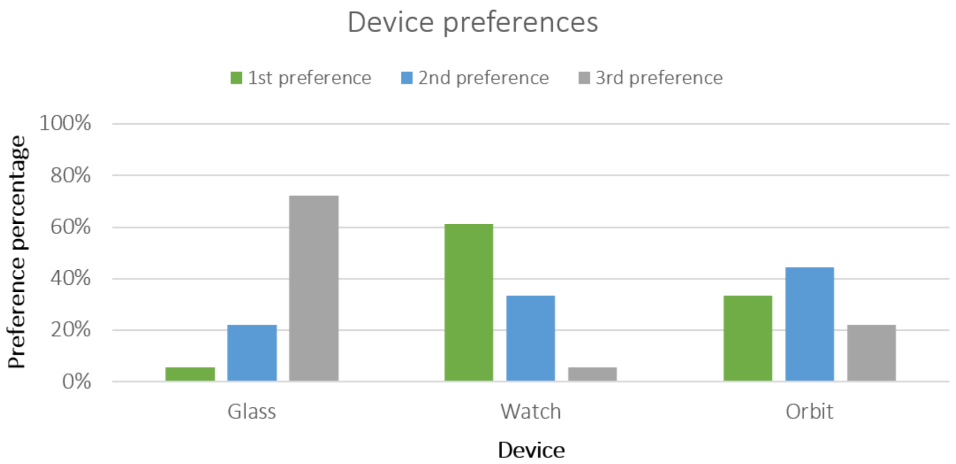


Figure 7. Preferences of the participants regarding which device they personally would use most likely during a running session.

Figure 7 shows the device preferences of the participants. In compliance with the results of the previous measurements in terms of usability and emotions, Google Glass was ranked as the least popular device most often (6%, 22%, and 72%). The diagram suggests that the watch is the most preferred device (61%, 33%, and 6%), followed by the Orbit (33%, 44%, and 22%).

4. Discussion and conclusions

While the results do not reveal a clear winner between the LG G Watch R and Runtastic Orbit, participants clearly attested Google Glass worse grades in every examined area. The reason why Google Glass performed badly might derive from two aspects: Firstly, since the concept of head-mounted devices is new for most people, they are not used to wearing a head-mounted device. They might not like wearing such a device in general, they find it uncomfortable to wear, or they feel ashamed or embarrassed when people stare at them while wearing such a device. Secondly, the display of the current Google Glass is placed in the top-right corner of the right eye. In order to read the display, users have to refocus their eyes from their original sight to the display, turning them partially unaware of the happenings in front of them. This might not be an issue when standing still, but it turns into one when losing the focus of the surroundings while running. Mann 2013 has already mentioned the negative effects of this issue.

Since wearables are currently subject to quite some change, we assume that user experience will even increase and thus this study could be repeated in the future with different, more sophisticated devices.

Literaturliste/Quellenverzeichnis:

Agarwal, A., Meyer, A. (2009): Beyond Usability: Evaluating Emotional Response As an Integral Part of the User Experience. In CHI '09 Extended Abstracts on Human Factors in Computing Systems (CHI EA '09). ACM, New York, NY, USA, 2919–2930.

Brooke, J. (1996): SUS-A quick and dirty usability scale. Usability evaluation in industry 189, 194 (6 1996), 4–7.

Desmet, P., Overbeeke,K., Tax, S. (2001): Designing products with added emotional value: Development and application of an approach for research through design. The Design Journal 4, 1 (2001), 32–47.

Klock, A., Gasparini, I. (2015): A Usability Evaluation of Fitness-Tracking Apps for Initial Users. In HCI International 2015 - Posters' Extended Abstracts, Constantine Stephanidis (Ed.). Communications in Computer and Information Science, Vol. 529. Springer International Publishing, 457–462.

Kollee, B., Kratz, S., Dunnigan, A. (2014): Exploring Gestural Interaction in Smart Spaces Using Head Mounted Devices with Ego-centric Sensing. In Proceedings of the 2Nd ACM Symposium on Spatial User Interaction (SUI '14). ACM, New York, NY, USA, 40–49.

Leggatt, H. (2014). Forecast: 250 million smart wearables in use by 2018. http://www.bizreport.com/2014/08/ forecast- 250- million- smart- wearables- in- use- by- 2018. html. (20 8 2014).

Lucero, A., Vetek, A. (2014): NotifEye: Using Interactive Glasses to Deal with Notifications While Walking in Public. In Proceedings of the 11th Conference on Advances in Computer Entertainment Technology (ACE '14). ACM, New York, NY, USA, Article 17, 10 pages.

Mann, S. (2013): My "Augmediated" Life. http://spectrum.ieee.org/geek- life/profiles/ steve-mann-my-augmediated-life. (1 March 2013).

Mehrabian, A., Russell, J. A. (1974). An approach to environmental psychology. MIT Press, Cambridge, MA, US. xii 266 pp. pages.

Mueller, F., O'Brien, S., Thorogood, A. (2007): Jogging over a Distance: Supporting a "Jogging Together" Experience Although Being Apart. In CHI '07 Extended Abstracts on Human Factors in Computing Systems (CHI EA '07). ACM, New York, NY, USA, 1989–1994.

Mustonen, T., Berg, M., Kaistinen, J., Kawai, T., Häkkinen, J. (2013): Visual task performance using a monocular see-through head-mounted display (HMD) while walking. Journal of Experimental Psychology: Applied 19, 4 (12 2013), 333–344.

Nurkka, P. (2013): "Nobody Other Than Me Knows What I Want": Customizing a Sports Watch. In Human-Computer Interaction – INTERACT 2013, Paula Kotzé, Gary Marsden, Gitte Lindgaard, Janet Wesson, and Marco Winckler (Eds.). Lecture Notes in Computer Science, Vol. 8120. Springer Berlin Heidelberg, 384–402.

O'Brien, S., Muelle, F. (2007): Jogging the Distance. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07). ACM, New York, NY, USA, 523–526.

Pfannenstiel, A., Chaparro, B. (2015): An Investigation of the Usability and Desirability of Health and Fitness-Tracking Devices. In HCI International 2015 - Posters' Extended Abstracts, Constantine Stephanidis (Ed.). Communications in Computer and Information Science, Vol. 529. Springer International Publishing, 473–477.

Tullis, T., Albert, W. (2013): Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics (second edition). Morgan Kaufmann Publishers Inc., San Francisco, CA, USA.