Self monitoring – an age-related comparison

Peter Rasche, Matthias Wille, Sabine Theis, Katharina Schäfer, Christopher M. Schlick, & Alexander Mertens
Chair and Institute of Industrial Engineering and Ergonomics of RWTH Aachen, Germany

Abstract

Wearable devices like activity trackers, measuring motion and steps, enable users to monitor their behaviour and might support a healthier lifestyle. These wearables might also motivate elderly to be active and age healthy. Unfortunately these wearables are mostly designed for younger users and it is unclear if they are suitable for older adults, too. In order to answer this research question we conducted a four weeks lasting empirical study about individual motivation and the activity trackers’ usability dependent on age groups. During the first session, participants put the activity tracker into operation without further training while a think-aloud-method was applied and mental effort was measured. During the whole study participants used the activity tracker according their personal needs. Usability was measured by PSSUQ at the introduction session, at the middle session after two weeks and at the final session after four weeks. Aspects concerning customer requirements identified during interviews were weighted by a pairwise comparison at the final meeting. Results show a comparison of younger and elder users regarding usability, requirements, motivation, mental effort and technical affinity.

Introduction

One main aspect in terms of healthy aging is daily physical activity and exercise. Performing sports regularly has been proven to reduce the risk of mortality and age-related morbidity and have a common positive effect on older adults’ (+65 years) physical and mental wellbeing (Vankipuram, McMahon, & Fleury, 2012). Although all these advantages are well known and promoted by the World Health Organization (2010), more than 70% of older adults are inadequately active (Vankipuram et al., 2012). Thereby industrial societies have to investigate solutions for this problem. Main barrier for elder people to perform physical activity is their lack of information about their individual capabilities and limitations (Hirsch et al., 2000). A solution might be activity trackers which are proven to motivate young user to be more physical active (Clemes, Matchett & Wane, 2008; Steinert, Wegel & Steinhagen-Thiessen, 2015).

Scope of this paper

This paper presents results of a study about an age-related usability investigation of an activity tracker and corresponding daily activity. To identify age-related differences, two age groups (x < 30 years; x > 60 years) were compared. Aspects explored within this study are users’ motivation and intention of use depending on
age and whether activity trackers are emphasized to stigmatize a user. Further preferred wearing position is evaluated in relation to age. Positive and negative feedback about the use of the activity tracker within the first four weeks of contact were collected. Finally a pairwise comparison was performed to identify basic requirements for an activity tracker.

Method

This section provides a detailed overview about the method of this four week study under field conditions.

Experimental design

The general task of participants in this study was to use the provided activity tracker and as much as possible integrate it into their daily life. For a most realistic setting all participants were asked to put the activity tracker in operation by themselves without any special training or certain instruction in advance. They were just provided with the standard manual which is sold with the activity tracker. Participants were divided into two equally sized groups by age.

The usability was evaluated according to DIN ISO 20282-2. Therefore, usability tasks were defined which participants should accomplish while “thinking-aloud”. Besides this qualitative observation each usability task was evaluated by the Rating Scale of Mental Effort (RSME) to evaluate the mental effort necessary to accomplish the tasks (Zijlstra, 1993). All participants were familiarized with the RSME scale by appropriate daily live examples. For a more detailed insight into the usability participants fulfilled several Post Study System Usability Questionnaires (PSSUQ) (Sauro & Lewis, 2012) at different points in time: at the beginning, after two weeks and at the end of the study after four weeks. These three moments were chosen to investigate whether the perceived usability improves or at least changes during the first four weeks of contact with the product. The PSSUQ Questionnaire consists of 11 questions rated by 5-likert-Scale.

Furthermore, participants’ individual technical affinity was evaluated by a questionnaire containing 15 questions (Jay & Willis, 1992). This questionnaire was completed before initial contact with the activity tracker. People with a high technical affinity are supposed to accept and use technical products more frequently and easier than people without (Lee & Coughlin, 2014). The questionnaire was collected a second time at the end of this study after four weeks of activity tracker usage. Aim of this approach was to investigate whether the use of such an innovative product which is worn day and night influences a users’ attitude towards modern information and communication technology (ICT) in general. It might be possible that the users’ attitude changes due to the intensive contact with this product and certain feelings like stigmatization or surveillance.

To evaluate the perceived aesthetics of the activity tracker, stigmatization, wearing position and intention of usage, the MeCue questionnaire was used (Thüring & Mahlke, 2007). As a supplement, a self-developed questionnaire was used which
was specially designed for evaluating activity trackers based on the work of Vooijs et al. (2014).

Finally, a pairwise comparison between relevant aspects of an activity tracker was performed in the final session (Pfeifer & Schmitt, 2014). The evaluated aspects were obtained from a market research about sold activity trackers. Aim of this method was to evaluate basic requirements for an activity tracker in the context of the investigated age groups.

Participants

In total 30 participants (14 female, 16 male) with no experience with activity trackers took part in this study. The group of younger users contained 15 participants (6 female, 9 male) recruited at RWTH Aachen University. The 15 older participants (8 female, 7 male) were recruited in a special technical lecture for elderly at RWTH Aachen University.

The age of the older participants reached from 60 years up to 78 years (mean age 68 years, SD = 5.29). All were retired for at least one year and up to 35 years (mean time 12.33 years, SD = 12.64) and used a smartphone in their daily life. 11 out of 15 elder participants described themselves as sporty. Each of these participant performed on average 5.2 h sport (SD = 2.957) per week. For no one sport was a medical requirement. All were interested in measuring their daily activity (measured by a seven point Likert scale (1 = I totally agree; 7 = I totally disagree)) the average answer was 1.71 (SD = 1.139).

The age within the younger group of participants reached from 19 years up to 30 years (mean age 25 years, SD = 2.59). All younger participants were users of a smartphone and 10 out of 15 described themselves as sporty. Within this group the average time of sport was 4.80 h (SD = 4.758) per week. Six out of 15 participants reported sport as a medical requirement in sense of staying healthy and feeling well. The interest in measuring daily activity was lower than in the group of older participants. It was in average 2.53 (SD = 1.356) on the seven point Likert scale.

Experimental apparatus

Prior to this study, different activity trackers were evaluated and compared. As technical features were mostly the same, finally the “ViFit connect Activity Tracker” by Medisana AG was chosen due to higher privacy policy standards. Furthermore, a german-speaking support would have been available to participants, although none of our participants made use of it. The “ViFit connect Activity Tracker” consists of two components: the tracker itself measuring steps and a silicon wristband necessary to position the tracker on the wrist (see Figure 1).
Figure 1. ViFit connect Activity Tracker and Vitadock+ app.

The tracker containing an accelerometer linked with an algorithm is able to measure and count steps as well as to classify user movements during their sleep. A daily activity overview can be displayed on a small liquid crystal display integrated in the activity tracker itself. A more detailed visualization of all recorded data could be viewed within the “Vitadock+” app after the activity tracker is synchronized with the user’s smartphone via Bluetooth 4.0. All trackers were used with anonymous online accounts to provide the highest possible level of privacy.

Experimental procedure

The Ethics Committee at the RWTH Aachen Faculty of Medicine authorized this study and its ethical and legal implications by their statement EK038/15 in February 2015. Afterwards participants were recruited for this study.

Each participant started the four week study individually and had his/her own initial meeting. During the initial meeting a semi structured interview was performed to evaluate the participant’s demographics and their experience with medical products in general. Then participants were asked to fill in the questionnaire to measure their technical affinity, as described in the experimental design. Afterwards, the usability tasks were performed. Therefore, the RSME Scala was introduced to the participant with five examples to familiarize them with this instrument. Then the participants performed certain usability tasks while “think-aloud” method was applied and an interview was executed at the end (see Table 1). The tasks were separated by the evaluation of the RSME.
Table 1. Usability Tasks.

<table>
<thead>
<tr>
<th>Number</th>
<th>Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unpack the activity tracker</td>
</tr>
<tr>
<td>2</td>
<td>Install the App Vitadock+</td>
</tr>
<tr>
<td>3</td>
<td>Charge the activity tracker</td>
</tr>
<tr>
<td>4</td>
<td>Identify the battery status symbol</td>
</tr>
<tr>
<td>5</td>
<td>Commission the activity tracker by login into the app and synchronization between activity tracker and smartphone</td>
</tr>
<tr>
<td>6</td>
<td>Apply activity tracker and measure your steps</td>
</tr>
</tbody>
</table>

Following the usability tasks participants fulfilled the PSSUQ in order to evaluate their first usability impression of this product. Finally, participants were paid an expense allowance of € 15 for this initial meeting and the follow-up meetings were determined. Participants were asked to use activity tracker according their personal preferences during following weeks. Each participant got an activity goal of 10,000 steps a day according the WHO (World Health Organization) suggestion (2010).

After two weeks the second meeting was performed. First, participants fulfilled the PSSUQ for the second time. This was done at the beginning to avoid interference by discussing questions, problems or other topics with the participant. Afterwards a semi-structured interview was performed to record positive and negative aspects experienced in the first two weeks of usage. Afterwards the same usability tasks as in the initial meeting were asked to perform while the RSME was evaluated. Finally, participants were paid a second expense allowance of 15 € for this meeting and the final meeting was determined. Again participants were asked to use activity tracker according their personal preferences, also the activity goal per day kept the same.

At the end of the fourth week the final meeting was held. This one also started with the participant fulfilling the PSSUQ. Afterwards technical affinity questionnaire as well as the semi structured interview from the second meeting was performed again. Then the participants were asked to perform the usability tasks a last time. Hereafter, they fulfilled the MeCue questionnaire and were asked some final questions about their attitude towards this product and its subjective use with in healthcare. In addition, participants accomplished the pairwise comparison of the different wearing positions, functions and requirements an activity tracker might fulfil. Before they left, the last expense allowance of 20 € was paid.

**Results**

All participants completed the full period of four weeks of activity tracker usage, which was validated by the recorded daily activity. Although this data might have inaccuracies due to the used activity tracker, data processing or the applied wearing position, this data does indicate that the participants regularly wear the tracker during the four weeks (see Figure 2). As an ANOVA revealed there is a significant main effect of the age group on the average activity in weeks two, three and four (see Table 2). As Figure 2 shows the older participant performed more steps a day then the younger ones.
Table 2. ANOVA results for average activity per week.

<table>
<thead>
<tr>
<th>Week</th>
<th>df</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>7.161</td>
<td>.012</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>8.432</td>
<td>.007</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>9.686</td>
<td>.004</td>
</tr>
</tbody>
</table>

Figure 2. Average activity per week.

The PSSUQ values evaluated at the first (PSSUQ1), second (PSSUQ2) and last meeting (PSSUQ3) indicate no significant difference for the usability evaluation within the four weeks study (see Table 3).

Table 3. Paired t-Tests for PSSUQ.

<table>
<thead>
<tr>
<th>Pair</th>
<th>old t</th>
<th>old Df</th>
<th>old Sig.</th>
<th>young t</th>
<th>young Df</th>
<th>young Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSSUQ1</td>
<td>-0.219</td>
<td>14</td>
<td>0.830</td>
<td>-1.402</td>
<td>14</td>
<td>0.183</td>
</tr>
<tr>
<td>PSSUQ2</td>
<td>0.904</td>
<td>14</td>
<td>0.381</td>
<td>0.408</td>
<td>14</td>
<td>0.690</td>
</tr>
<tr>
<td>PSSUQ1</td>
<td>-0.325</td>
<td>14</td>
<td>0.750</td>
<td>1.281</td>
<td>14</td>
<td>0.221</td>
</tr>
</tbody>
</table>
Regarding subjective mental effort some differences can be seen although the mental strain levels are still in the lower third of the overall scale: As shown in figure three older participants reported the highest mental effort during the tasks “2 - app installation”, “3 - charge” and “5 - putting into operation” (see Table 1). Within the younger group of participants just the task “5 - putting into operation” was evaluated with a higher mental effort. As a performed ANOVA reveals differs the mental effort for the tasks “app installation” and “charge” significantly due to the investigated age groups (app installation: $df = 1, F = 9.511, p = .007$; charge: $df = 1, F = 10.075, p = .006$). The evaluation of the RSME values within the second and third meeting revealed no differences and all participants rated the mental effort for the usability tasks to be zero, which indicates that the activity tracker is easy to use.

Based on the interviews participants felt comfortable using an activity tracker and they were willing to apply this kind of product to their everyday life. 14 out of 15 older participants reported in their last meeting that they would appreciate an activity tracker as therapy support due to motivational aspects (6 out of 14 participants) as well as an objective control (10 out of 14 participants). Within the group of younger participants 12 out of 15 participants reported this, too. Although they were unable to determine detailed reasons for their decision. Also in case of the intention to use the tracker for the next 12 weeks the elderly reported higher intentions. Measured by a seven points Likert scale (1 = I totally agree; 7 = I totally disagree) the average answer for elder participants was 2.57 (SD = 2.138) and for younger participants 3.87 (SD = 2.900).
To investigate if the technical affinity changes by the usage of an activity tracker, the questionnaire scores were compared between different points in time and age groups. But the ANOVA showed no significant differences of the technical affinity between the age groups (start: df = 1, F = .012, p = .912; end: df = 1, F = .817, p = .374). Further showed a t-Test between the two points in time no significant differences (see Table 4).

Table 4. Paired t-Tests for technical affinity.

<table>
<thead>
<tr>
<th>Age group</th>
<th>Pair</th>
<th>t</th>
<th>df</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Older</td>
<td>Start - End</td>
<td>1.465</td>
<td>14</td>
<td>.165</td>
</tr>
<tr>
<td>Younger</td>
<td>Start - End</td>
<td>-.312</td>
<td>14</td>
<td>.760</td>
</tr>
</tbody>
</table>

The pairwise comparison of wearing position (see Figure 4) shows quite similar preferences of the wearing position between the younger and elder group. A statistical analysis revealed no significant differences. Qualitative analyses revealed for both groups that the wristband is preferred.

Figure 4. User’s attitude regarding wearing position of an activity tracker based on a pairwise comparison. Whiskers represent the 95% confidence interval.

Figure 5 shows the pairwise comparison of basic requirements an activity tracker should fulfil. The Requirements “functional range” and “data accuracy” were rated highest by the older ones. Requirements like “price” or “design” were rated lowest (see Figure 5). The group of younger participants evaluated “functional range” and
“comfort” highest. Requirements like “price” and “battery life” were lowest rated by them. Significant differences between the younger and elderly group are revealed by an ANOVA for the aspects “data accuracy” (df = 1, F = 7.383, p = .011) and “design” (df = 1, F = 6.201, p = .019).

Figure 5. User’s attitude regarding basic requirements of an activity tracker based on a pairwise comparison. Whiskers represent the 95% confidence interval.

Figure 6 shows the pairwise comparison for different key functions an activity tracker might have. Therefore qualitative analysis was performed. In total elder participants weighted the functions “measuring pulse” and “counting steps” higher than the other available functions. Younger participants rated the functions “measuring distance” and “measuring sleep” highest.

The semi structures interviews support the results of the pairwise comparison. Participants stated that they prefer to use the activity tracker instead of a wristwatch. Therefore it should be waterproof, so users could wear the tracker in the shower or during swimming or aqua-fitness. A problem occurred with the interaction design: The activity tracker just had one button to interact with. Elder participants reported this interaction design to be difficult and annoying because they had problems to feel the button under the silicon wristband. Younger participants appreciated this interaction design as an easy one. The navigation on the activity tracker display works by pushing the mentioned button, so for example it is necessary to press twice to get the actual time, which was reported to be annoying for the above mentioned reasons, too: Both groups reported that the tracker should always display the time if no certain data like the number of steps or burned calories is accessed. Further participants reported that the provided tracker could only be worn on the left hand. If it was worn on the right hand the button could be accidently pushed by the participants’ cloths as well as the data was displayed upside down. A positive aspect
reported by all participants was the long battery life of the tracker: If fully charged the tracker could measure steps for up to seven days.

![Figure 6. User’s attitude regarding key functions of an activity tracker based on a pairwise comparison. Whiskers represent the 95% confidence interval.](image)

**Discussion**

Our results show a motivating effect of activity tracker and thereby support the results of Clemes et al. (2008) and Steinert et al. (2015) in context of younger users. Further this research does extend these results for the group of older users. Participants reported to be motivated as well as to appreciate activity tracker as motivational and objective support during a therapy as well as daily life. All participants applied the activity tracker. Although the data revealed a higher activity level for elder participants it is unclear if the motivation by the activity tracker or other external circumstances were responsible for this effect (e.g. exams for the younger group at this time).

The results show that activity trackers’ usability is commonly suitable for older users. All participants were able to use and put the activity tracker into operation without a certain training or support by the investigator. Nevertheless, usability could be improved: For instance the time should be displayed permanently on the trackers’ display, so it could be used as substitution for a wristwatch. Furthermore, a tracker should be universal in case of the hand the activity tracker is worn on. Older users prefer to wear such a product on the left as well as the right hand. Displays as well as the visualization of the displayed information should be suitable for both wearing positions. Furthermore a clip to attach the tracker at the waistband is appreciated by the users to increase the individuality of the wearing position.
Especially women liked to wear the activity tracker in a trouser pocket or even at their ankle especially in cases where they wore jewellery at their wrists.

The results of the evaluated RSME values show that the mental demand differs between the elder and younger participants. Elder participants reported high mental effort for installing the app. Reported main reason for this high mental effort was a lack of training. Similar in both groups is the high mental demand for the task “putting the tracker into operation”. During first initiation process all participants needed to login within the app, with a provided anonymous account. Further they needed to follow the integrated user training within the app. This training was experienced as difficult because the training used full screen images which looked like the real interface. Therefore the participants tried to interact with these images. As they experienced no reaction of the system they started to feel insecure and tried even harder until they understand that this screens are just example images. A solution for this problem might be a proper usability testing of the app before realising it. Furthermore the app did demand a Bluetooth connection which was difficult to handle for most participants. The Bluetooth connection needed to be initialized within the app for security reasons. Most of the younger participants tried to initialize the connection within the standard Bluetooth menu of their smartphone until they realized that the tracker could just be connected via app and is invisible within the standard Bluetooth interface.

The results of the pairwise comparisons revealed a significant difference between the younger and older group regarding the basic requirements “data accuracy” and “design” of an activity tracker. Older participants were more concerned about the data accuracy then the design and for younger participants it was the other way around. Thereby elder users seems to have a more benefit oriented view of an activity tracker, whereby younger once might see them as a product to express their individuality.

One limitation of this study might be that the group of participants was not representative for all elderly users as they are very sporty and active compared to others in their age groups. Furthermore only participants were selected using a smartphone on regular basis. Therefore technical affinity as well as intent of use of an activity tracker might not be representative for elderly in general.

Outlook

Actually, six participants of each group decided to join a long time study and are still using an activity tracker. They are monitored and thereby questions like the product lifecycle as well as the long-time effects (Fritz, Huang, Murphy, & Zimmermann) will be investigated.

Further the ethical and legal aspects in the context of the usage of such products will be investigated more deeply in different workshops with these participants to identify besides usability barriers also more subjective aspects in terms of accepting such products in medical context.
Acknowledgment

This publication is part of the research project “TECH4AGE”, which is funded by the German Federal Ministry of Education and Research (BMBF, Grant No. 16SV7111) supervised by the VDI/VDE Innovation + Technik GmbH.

References


