Older Users' Rejection of Mobile Health Apps A Case for a Stand-Alone Device?

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Abstract. Mobile health apps make up an enormous market in mobile phone app stores. These apps allow automatic measurement of vital parameters and transmission of data to the doctor. Older users often reject mobile health apps for various reasons. We investigate the influence of several user factors on the willingness to use a health app integrated in a mobile phone vs. a stand-alone device. Furthermore we look into the modality for data transmission and its influence on the overall acceptance. In a questionnaire study (n=245) we ask both healthy and chronically ill (heart disease and diabetes) for their preferences. Using multiple linear regression analysis we found that the motives to use such a device influence the preference for an integrated device four times more strongly than the participants age. Still, the older the users are the more they prefer a stand-alone device.

Keywords: Diabetes, Heart Disease, User Diversity, Mobile Phones, Aging, Technology Acceptance

1 Introduction

The size and structure of the global demography has changed drastically. Life expectancy has increased over 30 years and projections claim that within the next 40 years another two billion people will be added to the world population of already seven billion. This increase comes mostly from people over 50 years of age. And as a complication the amount of people with an age of 60 and older will quadruple by the year 2050[1]. According to the Statisches Bundesamt[2], Germany will have at least 22 million seniors older than 65 years in 2060.

The increase of life expectancy comes with a price tag. In regard to chronic diseases, a larger proportion of older citizens means a higher prevalence. Currently there are 285 million people diagnosed with diabetes worldwide[3]. A conservative projection goes as far as to assume 438 million diabetes patients in 2030, which would mean a doubling of total prevalence in comparison to 2000[4]. Similar projections can be made for heart disease[5]. In an effort to treat the chronically ill and prevent further surge in prevalence, mobile health applications are often used[6] in treatment and prevention[7]. Whether these approaches are feasible is still largely a question[8]. Very few studies go further than pilot studies when using mobile phones for health applications. Yet, we don't know whether using the mobile phone at all is the best approach for all users.

2 Related Work

Technical requirements for a mobile health device may be derived from literature [9] and interviews with medical experts, but when personal data is stored on the Web further considerations must be made.

Kollmann et al. [10] successfully tested a mobile application for type 1 Diabetes patients with ten patients of a mean age of 36 years. Data transmission of recorded data was still done manually in their study. Similar to an approach suggested by Tani et al. [11] who evaluated their solution positively with twenty patients. Their approach also needed manual transmission of data. With the discontinuation of Google Health in 2012, online patient records must be investigated again to find out whether application acceptance or privacy requirements triumph when storing vital parameters of patients in the cloud.

Using mobile phones or mobile applications for health applications has been tried several times, yet acceptance of these devices, critical to their success, is not fully understood. Lv et al.[12] investigated the application of a mobile phone health application with 492 participants. Yielding only self-efficacy as the major factor in acceptance for the elderly. Hung et al.[13] using the TAM model investigated acceptance of a mobile health application and confirmed the model, adding the notion that younger users are more likely to use mobile health applications. The TAM model based on the factors *ease of use* and *usefulness* also shifts the acceptance to more general questions: Why do I need it? Can I use it?

Self-efficacy in using a device stems from performance in using a device[14]. Performance itself requires domain knowledge[15] and an expertise with the technological framework (i.e. mobile phones). Suitable user interfaces may guide in constructing adequate mental models[16], but inexperienced users will revert to other models, insufficient to explain the behavior of the application, thus leading to poor performance. This is particularly true for elderly users. A device with no prior mental model, and thus not dependent on mobile phone UI frameworks, could theoretically appeal to these mobile phone "refuseniks".

The overall acceptance though may depend on further aspects than self-efficacy and mobile phone integration. The cultural context[17], the hedonic aspects of the design[18], the adequacy of the technological framework[19] and infrastructure[6] all influence acceptance of health technology. In some cases going "mobile" is not always the best option[20]. Maybe using a dedicated device harmonized with users privacy needs could bridge the gap of mobile health application acceptance.

3 Method

In this article we investigate the influence of user diversity on the preference to have a health application integrated into a mobile phone vs. a stand-alone device. We did this using two independent questionnaires, one for patients with diabetes and one for heart disease patients.

Here the applied methodology of the study is presented. This includes used scales as well as independent and dependent variables. The questionnaires were designed with SurveyMonkey.com[1] as an online survey. Half of the answers were assessed paper-based to reach a non-online audience as well. The target-audience for the diabetes survey was diabetics or people with a diabetes-precursor who might need to use a diabetes management assistant. A similar target group was selected for the heart patient survey.

3.1 Variables

As independent variables we assessed a persons age, gender, and health status. As dependent variables we assessed the following concepts using six- and four-point Likert scales. We assessed the decrease in vision using three items (PVD, see Table 1) under the assumption that small screens pose a barrier to people with hampered vision. We also assessed the perceived ease of use of mobile phones, by measuring the perceived ease of use of eight features of mobile phones (MPEoU, see Table 2). As the target variable we measured the desire for an integrated device using three items (MPI, see Table 3).

I am able to read letters on a mobile phone without my glasses.
I am able to read books easily without my glasses.
I am able to read writing on bill-boards without my glasses.

Table 1. Perceived Vision Disability scale (PVD). Scale Reliability: $\alpha_1 = .777$, $\alpha_2 = .728$, $\alpha = .738$. Explained variance: 67%

In order to get common scales, all items were z-transformed before generating additive scales. Subscripts indicate the sample (1=Diabetes, 2=Heart Disease). Using no subscript indicates the joint sample. In addition we measured items on how an integration might look like in a mobile phone in regard to automatic data transfer (see Fig. 2). These items measure the modality of how automatic data transfer should be conducted. Should the user be notified, asked for permission or be responsible for data transmission?

We also measured five additional motives and four possible barriers for a mobile phone integration to get further information for the reasons of user preferences (see Table 5 at the end of the article). These were derived from previous

[1] `http://www.surveymonkey.com`

On my mobile phone I find the following feature easy to use ...	
... making a call.	... sending/reading a text message.
... using the address book.	... using the calendar.
... using the integrated camera.	... using the GPS.
... surfing the Internet.	... setting an alarm.

Table 2. Mobile Phone Ease of Use scale (MPEoU). Scale Reliability: $\alpha_1 = .850$, $\alpha_2 = .889$, $\alpha = .874$. Explained variance: 70%

The device should ...
... be a separate device (in contrast to integrated into a mobile phone)*
... integrate various features (e.g. health and calendar).
... be integrated into a mobile phone.

Table 3. Mobile Phone Integration scale (MPI). Scale Reliability: $\alpha_1 = .806$, $\alpha_2 = .709$, $\alpha = .729$. Explained variance: 65%. *=inverted item

qualitative research (i.e. interview studies) are now being tested for their influence.

3.2 Hypotheses

Because of the results from previous studies and from related work we derive the following hypotheses (see also Fig.1). Older participants should have a stronger perceived disability in vision (H_1). They should also perceive mobile phones to be less easy to use (H_2) in accordance with previous results. Gender does often show a strong influence on technical self-efficacy [] and thus on perceived ease of use (H_3). The health status should influence the preference for data transfer modality (H_8) as diabetics have drastically more experience in dealing with data (i.e. diary keeping). This should also influence the motives and barriers for a possible mobile phone integration (H_4).

Furthermore we expect the users expertise with a mobile phone to influence the willingness to have a health app integrated into their mobile phone. Thus PVD (H_5) and MPEoU (H_6) should influence the MPI. Also the motives and barriers should influence the MPI (H_7).

4 Results

Both surveys are evaluated descriptively on their own while common results are derived after z-transformation of the same variables. We report the descriptive statistics for both surveys separately and jointly, when applicable. Here, central tendency (means and standard errors) are reported in figures (error bars denote

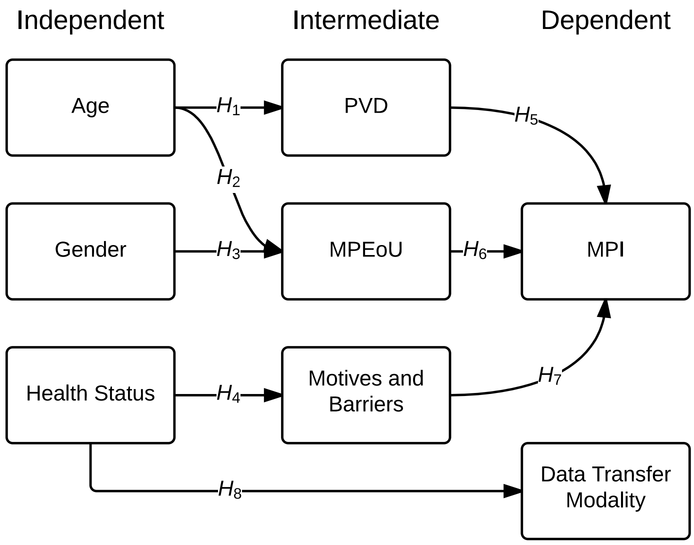

Fig. 1. Hypotheses between indepdent, intermediate and dependent variables.

the standard error). We then report bi-variate correlations for the hypotheses that we investigate. For normally distributed data we use Pearson's r in all other cases we use Spearman's rank coefficient ρ. We assume a level of significance of .95 and .99 for the α-error probability. This means that there is a 1/20 chance of significant findings being caused by chance and a 1/100 chance for highly significant findings.

In order to understand the strength of prediction, multiple linear regression analyses for MPI is used. The Remove-Method was chosen. Reported are the model and its predictors. The increase of explained variance over the scale mean is reported for the assumed underlying population (adj. R^2). Furthermore the F-Value with its degrees of freedoms for the model are reported along with its significance ($F(df1, df2)$, p). Additionally the parameter estimates and their standard errors (B, SEB) are reported, as well as non-standardized and standardized slope (β). When a single predictor does not increase the explained variance significantly, it is excluded from the model.

For effect sizes the r (correlation, student's t-test) or adjusted R^2 (MLR) values are reported.

4.1 Description of the Sample

A total of $N = 310$ participants took part in our study ($n_1 = 120$,$n_2 = 190$) from which $N = 245$ completed the questionnaire fully ($n_1 = 59$,$n_2 = 186$). Out of the participants completing the survey 134 were men (54%) and 111 were women. We had 56 diabetics, 80 heart disease patients and 109 healthy participants. The latter were all showing precursors for either disease nonetheless. The age of the sample ranged from $16-87$ ($r_1 = 16-87$,$r_2 = 19-85$), with a mean age of $M = 51.2$ years ($SD = 16$). Both samples showed a similar age distribution ($M_1 = 43.4$, $M_2 = 53.6$, $SD_1 = 16$, $SD_2 = 15.7$).

4.2 Descriptive Results

In general when looking at the modality preferences for automatic data transfer, healthy and heart disease patients show a similar picture (see Fig. 2). Both groups agree with data transmission in general, although they prefer to be informed, asked for permission or want to trigger the transfer themselves. Diabetes patients on the other hand show a stronger preference for not transmitting data automatically. Their preferences can be seen to be inverse to both healthy and heart disease patients. Diabetics mostly prefer to trigger the data transfer themselves (see Fig. 2).

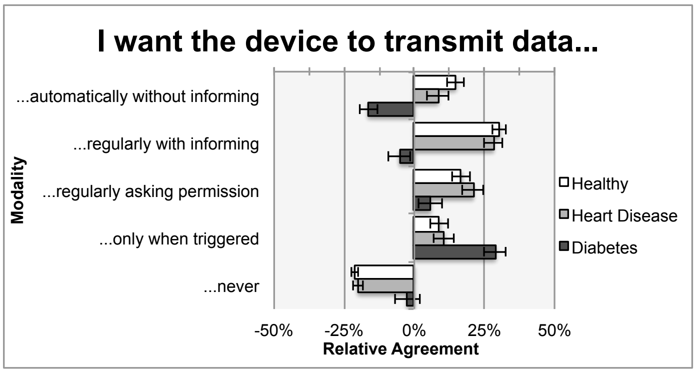

Fig. 2. Comparison of means for data transfer modality. Data transfer means transfer to the personal doctor in this case. Scaled to relative agreement (range: -50% to 50%)

When looking at what would get a participant to argue in favor of mobile phone integration the five investigated motives show very similar behavior as the data transfer modality. Healthy and heart disease patients show similarly high agreement with the motives *practicality* and *familiarity*, indicating that they assume the integration would benefit from their prior mobile phone experience. Diabetics on the other hand are not so convinced about *practicality* but almost agree on *familiarity* (see Fig. 3). The motive *usage frequency* seems irrelevant for diabetics (they have to use their glucose meter anyways) while healthy and heart disease participants do see a benefit. A very similar pattern can be seen for the motive *enjoyment*. The highest agreement between the three groups can be seen in the *inconspicuousness* motive. All agree that having a health app integrated into a phone is a benefit because it is inconspicuous (see Fig. 3).

The barriers to use a mobile health app when integrated into a mobile phone are perceived less strongly than the motives. Here, the three groups show rel-

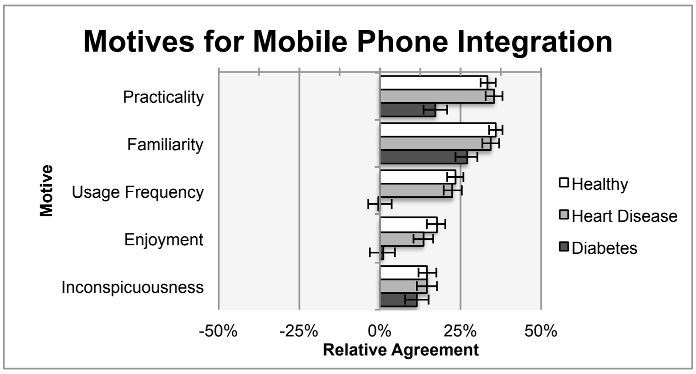

Fig. 3. Comparison of means for mobile phone integration motives. Scaled to relative agreement (range: -50% to 50%). See Table 5 at the end of the article for items.

atively similar behavior. *Data loss* and *device failure* are seen as the most important barriers for a mobile health application. The general tendency to reject mobile phones is not pronounced and the *ease of use* is also not seen as a barrier. Diabetics in particular disagree that a lack of *ease of use* would pose a barrier for mobile health applications (see Fig. 4).

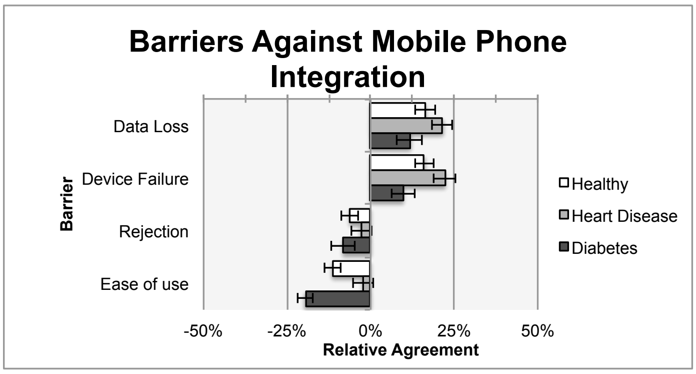

Fig. 4. Comparison of means for mobile phone integration barriers. Scaled to relative agreement (range: -50% to 50%). See Table 5 at the end of the article for items.

Both motives and barriers can be used as a additive scale and will be used in correlation analyses. Here motives showed a good reliability (Cronbach's $\alpha =$ .818) where the barriers only showed a questionable to acceptable reliability (Cronbach's $\alpha = .699$).

4.3 Interaction Analysis

In order to verify our hypotheses we look at various correlations between independent, intermediate and dependent variables (see Fig. 5). We were able to verify a correlation between age and all intermediate variables, the strongest for the perceived ease of use of mobile phones ($r = .464$, $p < .01$). The older a participant was, the less they perceived a mobile phone to be easy to use (H_2✓). Even an association with both barriers and motives were found ($r = -.210$, $p < .05$), albeit a small one. Older participants show stronger agreement with barriers and less agreement with motives. Also as expected (H_1✓), older users were more disabled in regard to their vision capabilities ($r = .291$, $p < .01$).

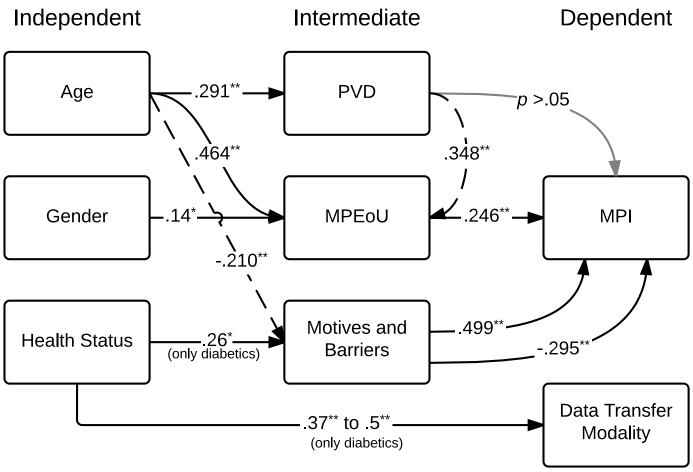

Fig. 5. Bi-variate correlations between variables. Numbers denote Pearson's r or Spearman ρ depending on scale level. Dashed lines indicate correlations that were not hypothesized.

Gender did influence MPEoU as expected (H_3✓). The difference between means was $\Delta M = -.199$ ($t(235) = -2.134$, $p < .05$, $r = .14$) and variances were equal (Levene's $F = .141$, $p > 0.5$).

Health did influence automatic data transmission (H_8✓) but only for diabetics (see also Fig.3 and Fig.4). Diabetics agreed less to having uninformed automatic data transmission ($t(160) = -5.052$, $< .01$, $r = .37$), uniformed data transmission ($t(159) = -6.016$, $p < .01$, $r = .43$) and agreed more with self triggered transmission ($t(163) = 5.884$, $p < 0.1$, $r = .42$) and in their rejection of transmission overall ($t(157) = 7.212$, $p < .01$, $r = .5$). Furthermore being a diabetic influences the motive of *usage frequency* ($t(163) = -3.44$, $p < .01$, $r = .26$), making the motive highly significantly less important to diabetics (H_4✓).

When looking at the interactions of intermediate and dependent variables, no interaction of PVD and MPI was found (H_5✗, $p > 0.5$) and only a small correlation was found for MPEoU ($H_6\checkmark$, $r = .226$, $p < .01$). Motives ($r = .499$, $p < .01$) and barriers ($r = . - 295$, $p < .01$) both correlated with MPI ($H_7\checkmark$). In order to clarify the determination of MPI multiple linear regression analysis will be performed.

4.4 Linear Regression Analysis

Using all factors that correlate with MPI and removing predictors that fail to reach significance, we derive a model of MPI consisting of only three predictors ($F(3, 238) = 35.878$, $p < .01$, see Fig. 6). This model was able to explain 30% more variance than the scales mean alone (adj. $R^2 = .303$).

Interestingly, the general agreement with motives for the integration was about two times more influential in predicting MPI than both age and barriers combined. One must note here that MPI is z-transformed where negative values indicate a higher willingness for integrated devices. This means the older a person is the less he wants to use an integrated device (see Table 4).

Predictor	Non-standarized coefficients		Standardized slope		
	B	SEB	β	t	VIF
(Constant)	-0.329	0.149	-2.213		
Age	0.006	0.003	.126	2.291	1.042
Motives	0.496	0.059	.458	8.377	1.035
Barriers	-0.211	0.062	-.189	-3.403	1.069

Table 4. Linear regression table for MPI. All predictors increased the explained variance significantly.

Astonishingly, neither gender nor ease of use of mobile phones remained in the model. This indicates that not the expertise with mobile phones was determining the readiness to integrate into a mobile phone, but truly the factor age itself. Health status was removed as the last predictor, failing to reach significance ever so slightly (but nonetheless so).

5 Discussion

Overall when looking at our results, we can see that the willingness to have a health application integrated into a mobile phone is dependent on the users age. Furthermore whether the user sees motives to use a device (often based in previous experience) is important, as are perceived barriers (often fear of data loss).

Whether these factors are optimized in a stand-alone device must be investigated in the individual case. A case can be made for a standalone devices that do not require a mobile phone, particularly for the oldest user group.

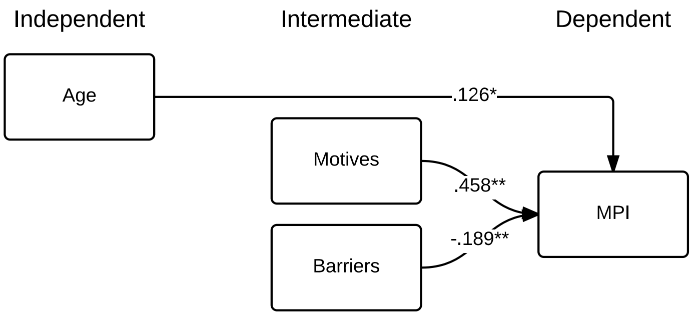

Fig. 6. Visual linear regression results. Numbers denote standardized beta values from the final model.

The question of data privacy can not be fully answered in this article. Yet, a striking difference between diabetics and healthy/heart disease patients becomes clear. This might be due to the diabetes stricken patients' experience with constant diary keeping, device failures, stronger experience in diabetes applications, and higher domain knowledge in both theoretical (information about the disease as such) and also the practical experience.

The vital data recorded for heart disease patients and diabetics is also different in nature. Heart disease patients often only report few numeric parameters (e.g. weight, blood pressure, blood coagulation), while diabetics report more lifestyle related parameters (e.g. food intake, physical activity). A mobile application would get a deeper insight into the private life of a diabetic when automatically recording data. This might explain the reluctance of diabetics to uninformed or even non permitted data transfer. Diabetes also degenerates over a far longer period of time than heart disease, which can immediately become life-threatening in a cardiac arrest situation. The heart disease patients on the other hand might perceive the vital parameters by far more life-saving in the hands of a doctor than in their own hands.

In regard to motives in the discrepancy in *ease of use* perception can be explained by the sheer amount of data input by diabetics. Diabetics record data multiple times daily, while heart disease patients often only do so once per day.

6 Outlook and Future Work

In this research we looked at age as a numerical value. The model is able to predict only a small portion of the variance in mobile phone integration acceptance. Research on aging shows that age is not a mere numerical number, as people age differently. Age solely intensifies the strength of diversity in different capabilities. When the numerical age still is a dominant factor in acceptance prediction, the question on generational differences arises. This must be investigated.

A general case for a stand-alone device could be derived from this research. Yet, when designing a product series it is helpful to keep the user diversity in mind. Market segmentation will lead to both stand-alone and mobile phone integrated solutions — in best case scenarios integrating seamlessly.

Limitations The healthy subgroup of this research was mostly addressed in the heart disease questionnaire. Although both surveys used the same wording, by sending the survey to a heart disease aware healthy person, similar responses as to a heart disease patient are to be expected.

Motive or Barrier	Item
Practicality	I find it more practical to use only one device.
Familiarity	I am already comfortable using my phone.
Usage Frequency	I would use the device more often.
Enjoyment	I would have more fun using the device.
Inconspicuousness	The device would be less conspicuous.
Data loss	I fear that my data could get lost.
Device Failure	I fear that the device would not work properly.
Rejection	I don't want to use a mobile phone.
Ease of Use	I find mobile phones hard to use.

Table 5. Items for motives and barriers for mobile phone integration and the measured concepts.

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