2015 International Workshop on Personalisation and Adaptation in Technology for Health
Preface

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Abstract. This full day workshop on Personalisation and Adaptation in Technology for Health (PATH) showcases innovative user modelling and personalisation research that focuses on promoting access, improving efficiency and enhancing quality within healthcare. There is a clear need for user modelling and personalisation for patients as they are diverse and have widely varying needs. Moreover, healthcare professionals, carers and stakeholders also differ in their informational, practical and technological needs. This workshop aims to connect the more theoretical work in user modelling and personalisation with the more grounded needs of healthcare workers and manufacturers to promote research that is timely, innovative, and focused on the needs of users.

1 Introduction

We have reached a critical point in Healthcare where both professionals and patients alike have the technology available to them to give and receive personalised health support. The WHO [8] has recognised the importance of the eHealth industry in improving the quality of care and encourages investment in this area. This eHealth technology can be used in a diverse range of areas to promote access, improve efficiency and enhance quality within healthcare. Key goals in this field are to facilitate personalised health information to promote self-management, to identify and act upon support needs, to improve communication between patients and healthcare workers, to assist with the use of medicine and assistive technology and to generally maximise practice efficiency and inform decision-making between healthcare workers [4].

The 2015 International Workshop on Personalisation and Adaptation in Technology for Health (PATH 2015) showcases innovative user modelling and personalisation research that focuses on promoting access, improving efficiency and enhancing quality within healthcare. PATH aims to promote discussion between multidisciplinary researchers on how personalisation and adaptation can be used to optimise outcomes in the healthcare sector. It builds on five related previous workshops presented at UM 2005, UM 2007, 21st IEEE CBMS (2008), AIME 2009 and EHealth 2010 and a special issue on Personalisation for E-Health in UMUAI 2011.

2 Themes

This workshop focused on the many aspects of personalisation for health delivery, related to e-Health environments. Topics of interest included, but were not limited to, the following areas:

- Adaptive and personalised e-Health information systems (including adaptive content, search and interface)
- Tailored health education and advice (written and online)
- Promoting trust and compliance to health advice
- Personalised assistance, including for special citizens (e.g. disabled, elderly)
- Personalisation in chronic care (e.g. asthma or diabetes management) as opposed to acute care (e.g. ICU setting)
- Novel personalisation approaches to facilitate improved communication between healthcare professionals and patients
- Personalisation and user modelling to support patient self-management
- Privacy issues for health related user models
- Personalisation based both on biometric or genomic factors and clinical information
- Tailored decision support (for patients and practitioners)
- Supporting the implementation of guidelines and protocols in healthcare
- Models of user learning, knowledge, attitude and behaviour change (including compliance)
- Tailored behaviour change interventions to promote healthy living (e.g. diet, exercise).
- Business models (personalisation to various stakeholders)
- Ontologies for user models (including provenance) for tailored health care delivery
- Methods for evaluating user satisfaction with personalised ehealth systems (weblog analysis, tracking users, quantitative and qualitative methods)
- Reports on evaluation studies of personalised eHealth systems
- Mobile and wearable healthcare systems for the personalisation of eHealth
- Smart Healthcare (Internet of Things) systems
- Tailored emotional support for patients, healthcare professionals and carers
- Innovative representations of personal health profiles and models
- Personalisation in online support for health and wellbeing
- Using personalisation in technology to support medical procedures
- Healthcare systems that adapt to physiological and environmental cues

3 Contributions

A peer-reviewed process was carried out to select the workshop papers, with three members of the Program and Organizing Committee reviewing each paper. This resulted in 6 accepted submissions (1 rejected), which discuss ideas and progress on several interesting topics, including physical activity coaching, personalising health reminders, unobtrusive health monitoring, adapting emotional support to personality, textile sensors and the evaluation of health-monitoring interventions.

Wolvers and Vollenbroek-Hutten [7] present a study aiming to develop an intervention strategy to decrease cancer-related fatigue by integrating a physical activity coaching system in primary care physiotherapy. Interviews were conducted, resulting in a 9-week intervention strategy that could benefit a large variety of patients with chronic cancer-related fatigue, that has the potential to be integrated successfully in current primary health care, and is currently being evaluated in a large randomised controlled trial.

Dennis et al. [3] explore the potential of personalising health reminders to melanoma patients based on their conscientiousness, for use in an eHealth intervention. Participants rated 6 reminders developed through persuasive principles and chose their preferred reminder and an alternative reminder to send if that one failed. They found that conscientiousness had an effect on both the ratings of reminder types and the most preferred reminders selected by participants.

Cabrita et al. [1] present the results of a pilot study on monitoring physical functioning in older adults, using an accelerometer and experience sampling method on a smartphone. They found that location, social interactions, type of activities and day of the week significantly influence the participants' daily activity level. They plan to use the results in the further development of an unobtrusive monitoring and coaching system to encourage daily active behaviour.

Smith et al. [6] investigate whether adaptation to the personality trait 'Emotional Stability' affects the amount and type of emotional support a fictional informal carer is given. They found that participants gave more praise to the carer with high Emotional Stability carer with a trend towards other support types for the carer with low Emotional Stability. These results will be used when developing an intelligent agent to provided tailored emotional support to carers experiencing stress.

Coyle et al. [2] propose that wearable technology can provide the capacity to track long-term health trends, but in order for this to be adopted, the technology must be easy to use and comfortable to wear. This work discusses a fabric stretch sensor glove that can measure body movements for the home assessment of Rheumatoid Arthritis. The aim is to have a better understanding of joint stiffness by monitoring dynamic movements of the hand at different times of the day. Having such information can help to develop a personalised approach to management and treatment of various chronic conditions.

Nieroda et al. [5] use principles from Regulatory Focus Theory (RFT) and Regulatory Fit Theory (RF) to facilitate the understanding of (non)acceptance of mobile applications (apps) for health self management. RFT was deployed to position different apps as strategies aligned with promotion/prevention goal orientation, and the Promotion-Prevention (PM-PV) scale was developed to measure this. It was established that RF principles can be used to understand that promotion/prevention congruence is important in the acceptance of mHealth apps.

All these contributions are testimony to a vibrant field of research in this area, and will ensure a fruitful exchange of ideas at the workshop.

4 Acknowledgements

We would like to take this opportunity to thank our hosts at UMAP 2015 and our authors, without whom this event would not be possible and who we hope enjoy what promises to be an interesting and stimulating event. We also thank the dot.rural RCUK Digital Economy Hub for providing time and resources. Lastly we thank our Programme Committee, who did an excellent job in providing detailed and timely feedback to all submitted papers: Luca Chittaro, Silvia Gabrielli, Jesse Hoey, Jane Li, Helena Lindgren, Judith Masthoff, Wendy Moncur, Matt Mouley-Bouamrane, Sara Rubinelli, Nava Tintarev, JP Vargheese and Miriam Vollenbroek-Hutten.

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An Unobtrusive System to Monitor Physical Functioning of the Older Adults: Results of a Pilot Study

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Abstract. The Aging phenomenon entails increased costs to health care systems worldwide. Prevention and self-management of age-related conditions receive high priority in public health research. Multidimensionality of impairments should be considered when designing interventions targeting the older population. Detection of slow or fast changes in daily functioning can enable interventions that counteract the decline, e.g. through behavior change support. Technology facilitates unobtrusive monitoring of daily living, allowing continuous and real-time assessment of the health status. Sensing outdoors remains a challenge especially for non physiological parameters. In this paper we present the results of a pilot study on monitoring physical functioning using an accelerometer and experience sampling method on a smartphone. We analyzed the relation between daily physical activity level and a number of different properties of daily living (location, social component, activity type and the weekday). Five healthy older adults participated in the study during approximately one month. Our results show that location, social interactions, type of activities and day of the week influence significantly the daily activity level of the participants. Results from this study will be used in the further development of an unobtrusive monitoring and coaching system to encourage active behavior on a daily basis.

Keywords: monitoring · physical functioning · physical activity · daily living · older adults · experience sampling method

1 Introduction

The World Health Organization estimates that the percentage of world population aged above 60 will double between 2010 and 2050 from 11% to 22% [1]. The problem is particularly apparent in the Western world where it is expected that by 2060 approximately 30% of the population in the European Union will be aged above 65 years old [2]. Such demographic change brings socio-demographic challenges, of which the increased burden on the healthcare system is one of the most relevant. It is expected that by 2060, 8.5% of the global GDP in EU-27 will be spent on healthcare and 3.4% on long-term care [3]. There is a growing trend towards developing technologies that aim to reduce the burden on health care systems by improving self-management skills and delaying institutionalization.

Frailty is an age-related condition with high prevalence worldwide. The exact estimates differ according to the definition of frailty adopted, with rates among community dwelling older adults varying between 7% [4] and 40-50% [5]. In this paper we use the following definition: *"[frail elderly are] older adults who are at increased risk for future poor clinical outcomes, such as development of disability, dementia, falls, hospitalization, institutionalization or increased mortality"*[6]. Frailty can be associated with, but is distinct from, natural age-related impairments and it often predicts disabilities in activities of daily living [7]. Therefore, prevention of frailty relates to early detection of daily functioning decline. Daily functioning monitoring requires a multi-domain approach in which physical functioning is one of the domains addressed. Regular monitoring through conventional methods such as self-assessment questionnaires can be time consuming and troublesome. Technological developments provide reliable substitutes. From robotic companions to smart and caring homes, researchers are working on unobtrusive solutions to monitor the daily life of the elderly. Much of these solutions concern the home environment, while monitoring outdoors remains a challenge. Recent developments in ambulant sensing allow for easy monitoring physiological parameters such as physical activity or heart rate. Experience sampling (also known as ecological sampling) is also becoming a widely adapted method to study daily life.

The use of technology for health monitoring can be of value as a tool to create self-awareness as well as to improve the health care delivery through communication of the gathered information to health care professionals. Technology allows in-time alerts and interaction with the user, if necessary. Furthermore, the data acquired can serve as input to health behavior change recommendation systems, for example sending motivational messages that, based on the current status, encourage the user to adopt healthier lifestyles [8]. When designing technological interventions for the aging population one should take into account the multidimensionality in impairments of the target population and possible changes over time. As such, there is a need for personalized interventions that adapt to the health status of the user over time. Personalization is not a new term in healthcare. Concepts such as personalized medicine and personalized healthcare have been used in the literature when tailoring treatment to individual patients' needs and characteristics [9]. Specifically in Telemedicine systems that aim to provide health services remotely, personalization can range from decision support systems to aid healthcare professional when selecting treatments [10, 11], to computer based health interventions to improve patient's health conditions [12–14] and increase patients' health literacy [15].

This paper presents the initial ideas for the development of an ambulant monitoring and coaching system that continuously monitors daily functioning of the older adults, physical functioning being one of the domains addressed. To do so, a pilot study was performed to investigate the relation between several determinants of physical functioning in a sample of robust elderly. The paper is outlined as follows. Section 2 refers to physical functioning monitoring on the daily life. A pilot study on ambulant monitoring of physical functioning is introduced in Section 3. Finally, a discussion of the results and insights for future work is given in Section 4 and conclusions of the work are stated in Section 5.

2 Physical Functioning Monitoring

Physical functioning is one of the domains contributing to daily functioning decline and also the focus of our study. As an initial step for our ambulant monitoring system, we analyze the relation between physical activity level and parameters of daily living as, for example, location and social interactions.

An active lifestyle is of great importance during the whole lifespan. Physical activity plays a crucial role in the prevention and management of chronic conditions [16] and the practice of physical activity only 1-2 times per week is associated with decreased mortality [17]. Physical activity has also shown benefits in improving mental health of older adults [18, 19]. Daily activities such as walking or cycling, household tasks, or playing games are seen as important contributors to the general level of physical activity. Physical activity can be monitored using self-administered questionnaires (e.g. PASE questionnaire [20]) or, unobtrusively, using wearable accelerometer-based sensors.

Besides the contribution of daily activities to the overall level of physical activity, changes in the daily living of the elderly can be a good indicator for daily functioning decline. Before disabilities in activities of daily living manifest (i.e. bathing, dressing, toileting, transferring, continence and feeding), older adults might, to some extent, change their extra activities — i.e. activities on top of what the elderly minimally need to do — as for example the leisure activities. Performance of leisure activities seems inversely related to frailty and positively related to delay of functional decline [21]. Daily living (or performance of daily tasks/activities) can be monitored through self-reported measurements as answering a validated questionnaire of (instrumental) activities of daily living (e.g. [22]). In this type of questionnaire, individuals are asked about their ability to independently perform activities such as shopping or laundry. This solution might be time consuming and cumbersome when applied for a long period of time. We support the idea of using a smartphone application to monitor daily living through Experience Sampling Method [23]. This method can be used to ask several questionnaires at random moments throughout the day regarding, e.g. current activities. With the experience sampling method it is possible to get an overview of the daily living of the participants as well as to obtain indices of behavior.

In the next section of this paper we describe a pilot study developed in the Netherlands which aimed at studying the relation between daily physical activity level of a sample of older adults and their daily living using a wearable sensor and a smartphone.

3 Pilot study

3.1 Methods

Five older adults aged 67.2±2.3 years (3 female) participated in the study during 29±3 days. Before the start of the experiment, the participants answered several questionnaires to assess the current health status. Among others, the level of frailty was assessed through two self-rated questionnaires — Groningen Frailty Indicator [24] and the INTERMED [25, 26], to guarantee that all participants were robust.

Daily Living – Three properties of daily living were assessed using the experience sampling method on a smartphone application (Figure 1): activity category (*what are you doing?*), location (*where are you?*) and social interaction (*with whom are you?*) (Figure 1). Questions were prompted approximately every hour from 08:00 till 20:00. A set of common activities (e.g. preparing food, eating, resting, and playing with children) was shown on the screen as well as the option to enter an additional activity. Common examples were also shown regarding location and social interaction.

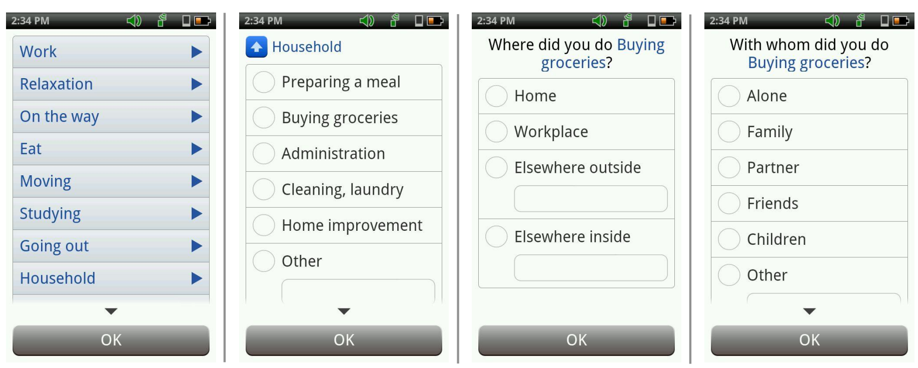

Fig. 1. Screenshots of the experience sampling application showing the hourly questionnaires.

Daily Physical Activity – Physical activity was assessed continuously over the measurement period with the Activity Coach, a system composed of a 3D accelerometer counting energy expenditure as the Integral Module of the Bodily

Acceleration (IMA) [27] averaged per 10 seconds intervals and a smartphone application [28]. Participants were told to wear the sensor from 08:00 to 20:00. No goal or feedback on the physical activity level was received during the experiment.

3.2 Data Analysis

The daily activity level day was defined based on the sum of IMA values for each day and it was represented by a nominal variable with three categories: 'Inactive', 'Moderately Active' and 'Highly Active'. The K-means clustering algorithm was used to categorize the activity level of each day as it could adapt to each participant's activity level in contrast to using pre-defined cutoff points for all participants.

Answers from participants were categorized as shown in Figure 2. Each set of questions answered was considered an **Event**. Each Event has four properties: **Location**, **Social Component**, **Activity Category** and **Time**, each having at least one possible value. After this categorization, the frequency of episodes with a certain value registered per day was calculated.

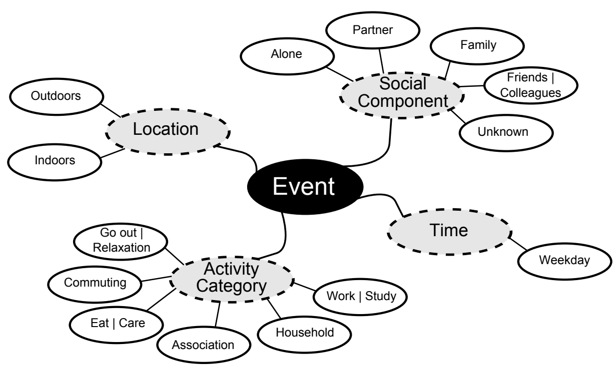

Fig. 2. Categorization of the answers provided on the smartphone. Each **Event** is a set of questions with four properties (*gray circles*) each. Every property has at least one possible value(*white circles*).

We investigated the relationship between physical activity level and daily living properties with Nominal Regression analysis. Variables associated at $p < .15$ were tested for their association with activity level with a Kruskal-Wallis test. Variables associated with the activity level were entered in the univariate Nominal Regression analysis. We did not perform multivariate analysis considering the clear dependency between the properties of the events (e.g. 'commuting' will always be performed 'outdoors'). All statistical calculations were performed with SPSS statistical package.

3.3 Results

Participants have shown different levels of daily physical activity on the total of 146 days analyzed (Figure 3). Subject 3 was the least active amongst other participants while subject 1 and 5 were, on average, the most active. Moreover, the outliers in the boxplot suggest that there have been some days in which the participants had been highly physical active or have had a very sedentary behavior.

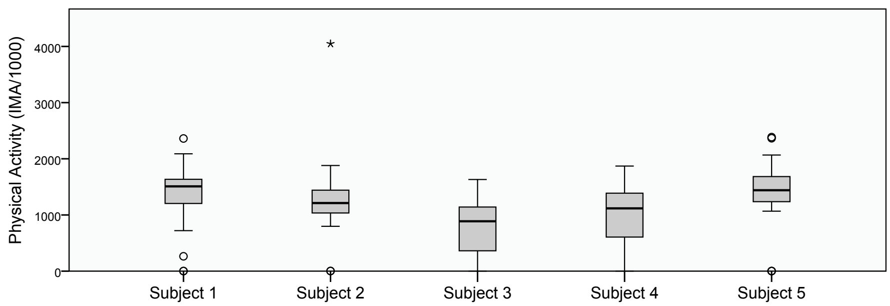

Fig. 3. Boxplots of daily physical activity in 5 subjects.

Each cluster centroid represents the average value of physical activity of a specific participant for a cluster and is tailored to the participant's daily physical activity in the study period (Table 1). As an example, a daily physical activity value of 1000 can label the activity level of that day as 'Moderately Active' for subject 3, but will label the day as 'Inactive' for subject 2 due to his/her being generally more active. Table 1 also shows the frequency of days falling within each cluster.

	Inactive		**Moderately Active**		**Highly Active**	
Subject	Centroid	Frequency	Centroid	Frequency	Centroid	Frequency
1	935.9	30.3	1568.8	57.6	2085.6	12.1
2	1103.6	62.1	1602.6	31.0	3511.7	6.9
3	453.4	16.7	988.4	63.3	1535.4	20.0
4	436.3	23.3	1094.8	50.0	1609.9	26.7
5	1252.6	41.7	1564.1	41.7	2191.6	16.7
All	**924.3**	**34.2**	**1560.6**	**49.3**	**2827.2**	**16.4**

Table 1. Overview of results from K-means clustering showing the cluster centroids (in IMA/1000) and frequency (%) of days falling within the defined clusters. The last row shows the centroids and frequencies of each cluster when data from all subjects was considered.

A total of 1534 experience sampling (ES) points were collected. Participants reported most of their events at home (65.7%-82.6%). Regarding the social component, the majority of the events were reported as 'alone' (34.5%-52.8%), followed by 'with partner' (24.7%-56.6%), 'family' (5.0%-15.1%) and finally 'friends or colleagues' (6.8%-10.4%). The most frequent activity reported was 'relaxation or going out' (32.8%-40.5%), followed by 'eat or care' (20.7%-31.1%), 'household' (8.6%-23.3%), 'commuting' (7.7%-20.2%), and finally 'work or study' (0.7%-11.1%). Only two subjects reported 'association' activities (0.9%-1.3%) — i.e. participation in religious, political or sports associations. Figure 4 shows the relative frequency of the values registered for each one of the properties of daily living.

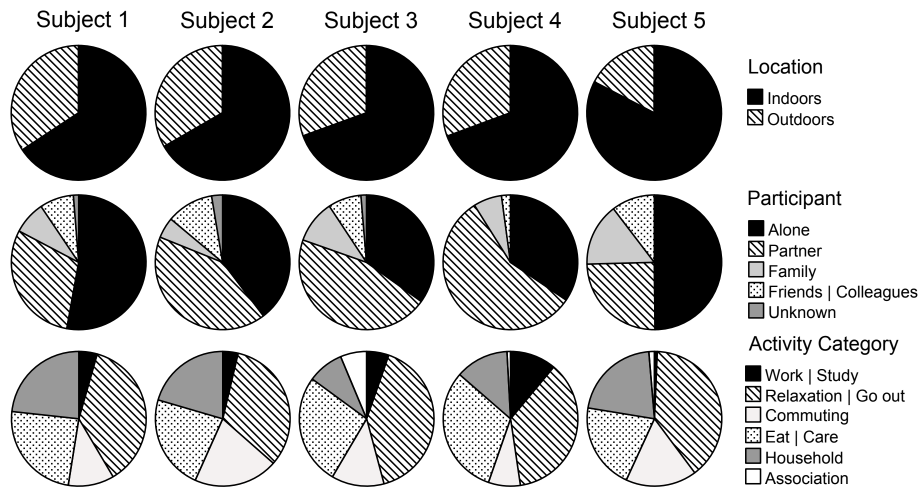

Fig. 4. Relative frequency (%) of values for each property and subject showing results of the reported categories from the experience sampling method.

Concerning the data from all subjects, 'indoors' (property *Location*), 'friends or colleagues' (property *Social Companion*), 'work or study', 'relaxation or go out', 'commuting', 'eat or care' and 'association' (property *Activity Category*), and 'weekday' (property *Time*) showed association with the physical activity levels ($p < .15$). Also, within each subject separately the association between the frequency of each value and physical activity level was tested, only minor changes were detected. The data of one of the subjects did not show any significant association between values of daily living and the physical activity level. Nominal Regression analysis was used to further analyze the relation between each one of the values aforementioned and the physical activity level. Considering that we are interested in predictors of physical activity in the daily living, "Inactivity" was set as reference in Table 2.

An increase in frequency events reported 'indoors' decreases the chance of having a highly physically active day compared to an inactive day. This means that days with higher frequency of events reported outside the home environment are more likely to be highly physically active days. An increase in the frequency of events with 'friends or colleagues' gave a 0.663 fold risk of 'Moderately Active' days compared to 'Inactive days'. Concerning the Activity Category property, the frequency of events classified as 'relaxation or go out' had a 0.721- and 0.619-fold increased risk of 'Moderately Active' or 'Highly Active', respectively. The frequency of 'Work' events on a day had a 1.9 fold increased risk of 'Highly Active' versus 'Inactive'. Finally concerning the property Activity Category, the frequency of 'Eat and Care' events on a day had a 1.475 fold increased risk of 'Moderately Active' versus 'Inactive' days. Regarding time, participants seem to be more likely to have 'Moderately Active' days at the end of the week. Within subject analysis resulted in similar results with a few notable cases. For one of the subjects, the frequency of events reported with 'friends or colleagues' gave a 3.836 fold increased risk of having a highly active day compared to an inactive day. For two subjects an increase in the frequency of being alone gives a higher chance of 'Moderately'- and 'Highly Active' days compared to an 'Inactive' day.

	Moderately Active vs. Inactive			**Highly Active vs. Inactive**		
Values	OR	95%CI	p	OR	95% CI	p
Indoors	0.970	0.811-1.161	0.741	0.777	0.617-0.979	**0.032**
Friends | Colleagues	0.663	0.480-0.915	**0.012**	0.896	0.628-1.279	0.547
Work | Study	1.325	0.837-2.096	0.230	1.900	1.152-3.135	**0.012**
Relaxation | Go-out	0.721	0.574-0.905	**0.005**	0.619	0.453-0.846	**0.003**
Commuting	1.023	0.764-1.370	0.877	1.393	0.975-1.991	0.069
Eat | Care	1.475	1.031-2.111	**0.034**	1.276	0.801-2.032	0.304
Weekday	1.251	1.037-1.509	**0.019**	1.120	0.874-1.435	0.369

Table 2. Nominal regression analysis of the values from the experience sampling events vs. physical activity level.

4 Discussion

The aim of the pilot study was to investigate the relation between physical activity level (as either inactive, moderately active, or highly active) and daily living through a set of different properties of daily events reported on a smartphone. The first step of the data analysis consisted of clustering the physical activity data of each participant in three categories. Inactive days of subject 5 are almost three times more active than inactive days of subject 3 or 4. Similar differences are seen in the other clusters. This justifies our choice in performing within-subject clustering analysis and emphasizes the need for developing personalized interventions to coach physical activity of the older population. Such applications should also adapt to the user following the behavior change over time.

The second step was the categorization of the events. Useful insights were gained into the daily life of the older adults during this phase. It is noteworthy that most of the events were reported in the home environment, suggesting that this might be a good place for interaction with the elderly users of a behavior change coaching system. Such a system can provide reminders or motivational messages at the right moment to increase adherence to the telemedicine platform and to facilitate behavior change in the older adults. In what concerns the social companion, looking at our results, most of the events were reported alone or with a partner. Other social interactions counted only for 8.9%-25.4% of the events. Socialization is mentioned as a motivator of physical activity by active and inactive groups in the study from [29]. This endorses the idea of recommending physical activity with peers as a way to encourage physical activity and stimulate social activities which are very important also in older age [30]. Regarding the type of activity, relaxation related activities count for a big part of the day. Only approximately half of the events reported related to eat, care, household or commuting. Knowing the time when these routine activities take place can also optimize the timing when a motivational message is sent and increase the compliance. Our results relate to a certain extend with the study performed by Chad et al. with 764 Canadian older adults, in which housekeeping activities had the greatest contribution to the PASE score [31]. The PASE questionnaire assesses physical activity level of the elderly by, among other factors, the time spent on occupational, household and caring activities [20].

Next steps in the development of the monitoring system include improvement of the sensing mechanism. During the time of the experiment the number of events reported per day varied but did not decrease over time. However, all the subjects were aware that the data would be used for research purposes and were motivated to finish the study. We believe that in normal daily life, without a research purpose, answering questions every-hour can be troublesome and lead to disuse of the technology after a certain period of time. Longer studies with monitoring of other parameters could be interesting to ascertain whether changes in daily living precede or succeed changes in health status. The results can be used to model participant's behavior and provide tailored recommendations on how to maintain a healthy lifestyle. Initial ideas for such a system are found in [32].

The present study has a number of limitations. The small sample size means that the participants might not be representative of the typical elderly population making our results inconsistent. However, the amount of data gathered per subject is large, enabling our detailed qualitative study. We have a total of 146 days of measured physical activity and a total of 1534 experience sampling events acquired. Therefore, we consider that our data is useful to receive insights in the daily living and physical activity of the older adults. Another limitation concerns the categorization of the events. Subjects were asked to report their daily events approximately every hour. In the first question they had to select the category of the activity. When analyzing our data we realized that the categorization is vulnerable to subjectivity, meaning that the same event can fall into a category for one subject and other category for other subject. For example, two subjects reported "taking care of the grandchildren" as "care" while others reported as "relaxation". This means that the same activities fall into different categories according to the each subject. The fact that the data was acquired only between 08:00 and 20:00 can exclude relevant data. In any case, we consider that our study is relevant for getting insights on diurnal behavioral of older adults.

5 Conclusion

In this work we studied physical activity and daily living in a sample of robust older adults. We underline the importance of learning physical activity levels from personal data instead of using general cut-off points when studying the older population. Our results show that location, social interactions, type of activity and day of the week significantly influence the daily physical activity of the participants. Instead of motivating people to get physically active, a coaching strategy could thus be to motivate people to engage in outdoor- or social activities, increasing physical activity indirectly. This *motivation by proxy* could add to the diversity of coaching of such systems and potentially increase adherence and pleasure in using the system.

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[3] www.perssilaa.eu

An mHealth Intervention Strategy for Physical Activity Coaching in Cancer Survivors

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Abstract. Many cancer survivors experience severe fatigue long after they have finished curative treatment. The aim of this study was to develop an intervention strategy that aims to decrease cancer-related fatigue by integrating a physical activity coaching system in primary care physiotherapy. This development started from the current state of the art. Therefore, firstly, an overview is given about physical activity goals for cancer-related fatigue, relevant cognitive behavioral change factors in this context, and recommendations for using mobile Health applications. Subsequently, interviews with five experienced health professionals were held to define recommendations for the first draft intervention strategy. Via an iterative process with two physiotherapists and a patient, the final intervention strategy was developed. The final result is a 9-week intervention strategy that could benefit a large variety of patients with chronic cancer-related fatigue, that has the potential to be integrated successfully in current primary health care, and is currently evaluated in a large randomized controlled trial.

Keywords: physical activity · activity monitoring · cancer-related fatigue · mHealth · behavior change

1 Introduction

1.1 Chronic Cancer-Related Fatigue

Fatigue is a frequent and debilitating residual symptom of cancer and its treatment. It is estimated that more than 20% of cancer survivors report severe fatigue one year after treatment [1]. Survival rates and life expectancies of cancer patients are rising, and cancer is increasingly often considered a chronic disease. The 10-year prevalence of cancer patients in the Netherlands is expected to grow by 40% between 2011 and 2020 [2]. As a result, the number of patients suffering from cancer-related fatigue will increase rapidly.

Currently, cognitive behavioral therapy, multidisciplinary rehabilitation programs, exercise, and energy conservation interventions seem effective in reducing fatigue. The Dutch Cancer Society recommends to partially shift such oncological aftercare to primary care, and to encourage patients' self-management with respect to their health problems. It is expected that this will make health care accessible to a larger group of patients, and is more cost-effective. In order to achieve the necessary changes, new treatment strategies for the primary care need to be developed.

1.2 Physical Activity Coaching

Physical activity is considered an important element in treatments of chronic cancer-related fatigue. An upcoming trend to achieve changes in physical activity is the use of Mobile Health (mHealth) applications [3], such as UbiFit Garden [4] and Fish`n`Steps [5]. Such systems use information from accelerometers or pedometers to send text messages to subjects in order to encourage physical activity, based on personalized step goals. Another example is the Activity Coach, which has been developed by Roessingh Research and Development (RRD, Enschede, The Netherlands) [6]. Previous research showed that subjects with chronic fatigue syndrome and chronic obstructive pulmonary disease were able to increase their daily physical activity by using this system [7, 8]. Based on this, it is expected that patients with chronic cancer-related fatigue might benefit from using this system as well.

However, despite the short term effectiveness of the use of such mHealth systems, current research shows that adherence and longer term effects are often still limited. One reason could be that mHealth systems are often deployed as a standalone tool: It is hypothesized that the use of mHealth systems should be better integrated in the everyday care practice [9]. A motivating role of the health professional in using mHealth systems will enhance a patient to generate insight in the usefulness and rationale of its use, which will promote compliance. Also, the mHealth system can be used in a much more personalized way, and behavior change processes can be supported more effectively. Conversely, by using mHealth technology, the professional can monitor and stimulate behavioral change in a patient's home environment. Therefore, the aim of this work was to develop an mHealth intervention strategy for patients who suffer from chronic cancer-related fatigue that utilizes the Activity Coach, integrated in primary care physiotherapy.

2 Background

The next paragraphs describe the starting points for the development of the intervention strategy. First, the activity coaching system is described in more detail. Without trying to give a complete systematic review, the three subsequent paragraphs describe the state of the art considering physical activity, behavioral change principles, and experiences in the context of cancer-related fatigue with the use of mHealth systems.

2.1 The Activity Coach

The Activity Coach consists of a smartphone and a 3d-accelerometer (ProMove3D, Inertia Technology B.V., Enschede), shown in Figure 1. The sensor is worn on the hip by means of an elastic belt or clipped onto the waistband. Both devices communicate with each other real time through Bluetooth. The accelerometer converts the accelerometer data into IMA's, Integral of the Modulus of the Accelerometer output, as described by Boerema et al. [10], which can be used as a measure of physical activity and correlates well with energy expenditure as measured with oxygen consumption for many activities [11]. The smartphone displays a real time visual of the patient's cumulative activity, relative to a line of reference, and generates automated feedback messages about the patient's current activity level relative to that line of reference. The smartphone uses its wireless internet connection to send the converted data to a database, so that the data can be retrieved on a web portal. The level and shape of the reference line, the content of the feedback messages, and functionalities on the web portal were subject to change in the development of this intervention strategy.

Fig. 1. The Activity Coach. Left: Smartphone (HTC Corporation, Taiwan) showing the application. Right: ProMove 3D accelerometer (Inertia Technology, The Netherlands).

2.2 Physical Activity

Many behavioral change interventions that target fatigue in cancer survivors use physical activity goals such as increasing physical activity and/or physical exercise [12–16]. Walking programs, aerobic training, and resistance training have shown to be beneficial. For example meta-analyses by Brown et al. (2011) [15] suggest that intensity of exercise is strongly related to the effect of the intervention on cancer-related fatigue. Two other reviews on the effects of exercise interventions are more cautious in their conclusions, but acknowledge positive effects of strength training on physical functioning [17, 18]. In addition, Jacobsen et al. [19] did not find significant effect sizes of physical activity interventions on fatigue outcomes in their meta-analysis. Multiple activity types and intensities were included. However, they did find that home interventions more often had a positive effect when compared to supervised interventions.

Other examples of goals that target physical behavior to reduce fatigue in cancer survivors could include balancing activity throughout the day, or energy conservation [20, 21]. This would include the management of opportunistic activities, which are activities that a patient incorporates in their daily life, such as cycling to work and taking the stairs.

So, despite contradictory results from various meta-analyses, relevant goals for patients with chronic cancer-related fatigue could be adjusting their physical behavior by increasing the amount of opportunistic activities and the volume of aerobic or strength training. However, energy conservation seems to be a promising focus for this population too.

2.3 Cognitive Behavioral Change Principles

Exercise interventions seem more effective in reducing fatigue in cancer survivors when they are guided by behavioral change or adaptation theory [15]. One of the relevant factors in this context is improving self-efficacy over physical activity [22, 23], as it seems to be one of the most important mediators of exercise interventions on fatigue in cancer survivors. This can be achieved by (1) setting realistic but challenging subgoals and giving the possibility to monitor progress easily, so make sure the patient experiences ‘he can do it’, (2) social comparison: make sure the patient knows that comparable patients before him have been able to make comparable adjustments of behavior, (3) verbal persuasion per e-mail. Learning to formulate implementation intentions could help patients to change their physical behavior [24] in order to attain the goals that they have set. The use of text messages in mHealth interventions can help remind people of their implementation intentions [25].

Also, the patient’s stage of change should be acknowledged throughout the intervention in order to decide on (when to change the) the focus of the intervention: i.e. informing and raising awareness, motivating or maintenance [26]. The Activity Coach could be used to give insight in the patient’s progression in order to increase the perceived behavioral control.

Servaes et al. [27] reported on other cognitive elements that are associated with cancer-related fatigue: Patients with low sense of control over fatigue symptoms (and high anxiety and high impairments in role functioning) are more likely to suffer from persistent fatigue after cancer treatment. Therefore, targeting such cognitions could increase the effect of interventions for fatigue. The involvement of a health professional in the intervention could provide in this need, and make sure the patient is guided and coached in a personalized manner.

2.4 mHealth Recommendations

A patient’s compliance can make or break a behavioral therapy, whether or not mHealth technology is utilized. However, the use of mHealth brings new challenges considering this topic, of which some are closely related to the previously mentioned cognitive aspects. According to Fogg [28], persuasive technologies should keep in mind three factors in order to be successful in their aim: motivation, ability, trigger. His framework gives useful support for utilizing the Activity Coach. Consolvo et al. [29] formulated recommendations more specifically for activity coaching applications successfully: 1) give users proper credit for activities, 2) provide personal awareness of activity level, 3) support social influence, and 4) consider the practical constraints of users’ lifestyles. Moreover, varying and personalizing feedback messages could make it more interesting to use the system and therefore learn from it [8, 30]. It also possibly extends the patient’s use of, and compliance with, this system. Also, activity goals, when using a reference line in an mHealth application, should be based on a the individual patient’s baseline activity pattern rather than on for example a “healthy” norm value of physical activity [7].

Finally, “increased interaction with a counselor, more frequent intended usage, more frequent updates and more extensive employment of dialogue support significantly predicted better adherence” [31].

3 Methods

Taking into consideration the existing system and background knowledge, the development of the intervention strategy started. In order to do so, the guidelines published by Huis in ‘t Veld et al. were used [32]. These guidelines suggest, as we did, to start from current state of the art and evidence based medicine, and work in close co-operation with the intended users: both professionals and patients. In order to do so, first, semi-structured interviews were held with five health professionals in the field and with one patient. The interviews allowed plenty space for discussing new ideas and followed the personal interests and concerns of the specific interviewee. The activity coaching system was presented and discussed in these sessions in order to get first ideas about how this system could be utilized successfully in their current practice. Ideas and recommendations were pooled and summarized. Then, a first version of the intervention strategy was drafted.

Secondly, an iterative process of discussions and testing with two other physiotherapists was performed. This was completed with a test session with a patient, after which the intervention strategy was finalized.

4 Results

4.1 Step 1: Insights from Health Professionals

One psychotherapist, three physiotherapists, and an occupational therapist of the multidisciplinary cancer-rehabilitation team of Rehabilitation Centre Roessingh (Enschede, The Netherlands) were approached for interviews, and all agreed to cooperate. The health professionals were all very experienced with treating patients that suffer from either chronic fatigue syndrome or chronic cancer-related fatigue, and two of them also had prior experience with using a previous version of the activity coaching system. These semi-structured interviews focused on three aspects: “How would you use the activity coaching system in an intervention for chronic cancer-related fatigue”, “Given the fact that such an intervention takes place at home solely, would e-mail be an appropriate means of communication?”, and “What would enable the system to be incorporated successfully in current primary health care?” The following issues arose:

1. E-mail was generally considered an efficient and effective medium to communicate between patient and health professional.
2. In the Netherlands, complementary health insurance packages for physiotherapy often cover up to nine consults, this should be taken into account.

3. Two therapists would recommend at least one face-to-face contact.
4. One therapist was concerned about whether patients would like to be monitored all over again, and questioned if patients would appreciate to wear the system.
5. There should be weeks planned in which the patient does not have to wear the system. In that way, the patient will have to translate what he has learned to daily living and compliance to the system in the other weeks might increase.
6. Personalized and well-justified goals are easier to attain than acting upon a standard, "healthy" reference line, so a therapist should be able to adjust that line. In that way, the end goal can be divided into sub-goals and adjusted throughout the intervention in order to support the patient in a flexible manner.
7. Large inter-individual differences exist in baseline activity patterns and personal goals should be set, which requires tailoring of the automated feedback.

4.2 Draft of the Intervention Strategy after Step 1

Based on the background knowledge and the results of the interviews, a first draft of the intervention strategy was developed with as main characteristics that it includes a theoretical framework, weekly instructions, e-mail examples, and guidelines for the incorporation and use of the activity coaching system.

The Activity Coach. Adjustments to the technology were made to the web portal and the software on the smartphone that generates the feedback messages.

Web Portal. The therapist enters the web portal at the home page, which shows a "traffic light"-visual of each patient's compliance to wearing the accelerometer of the current week. More detailed information on each patient is shown in three tabs:

1. "Patient": a summary of demographics and contact details of the patient;
2. "Activity monitor": tab on which different graphs of the patient's activity are shown in line charts that show either the cumulative (Figure 2) or raw IMA data from each day, or in a bar plot that represent the three day-parts or separate days.
3. "Measurement settings": tab in which the Activity Coach can be set up for patients: level and shape of the reference line and the content of the feedback messages on the smartphone.

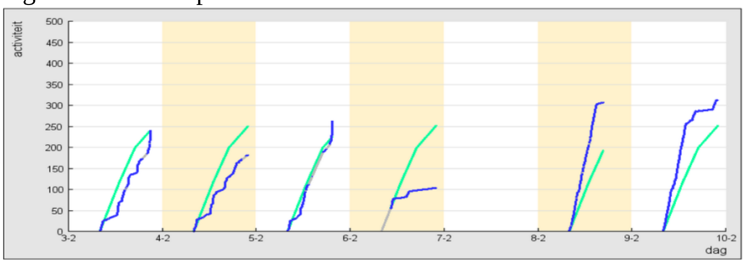

Fig. 2. Screenshot of the activity viewer on the therapist portal, showing the reference line (green) and the actual cumulative activity (blue). Grey segments represent missing data, which are inter- or extrapolations of the reference line.

Feedback Scenarios. In order to create flexibility for the therapist, and acknowledging the great inter-individual differences between patients, three different feedback scenarios were created. They differ from each other in terms of content of the feedback messages. The first scenario is for persons who are prone to being not physically active enough (activate). The second scenario is meant for patients who are used to push their boundaries, and could use encouragement of taking rest above a certain point (temper). The third scenario (balance) is the most neutral scenario, and can be used for patients who require to balance their activities throughout the day, and especially to conserve energy in the morning. Figure 3 shows a visual of the classification of the three scenarios. The messages differ on three scales. Firstly, the goal of the feedback message can be to reward or acknowledge the physical behavior (green), or to stimulate the patient to change the physical behavior (yellow, orange, red). These messages differ in rigorousness of the feedback or the proposed behavior (for example "a nice stroll" (yellow) versus "a brisk walk" (red)), as can be seen in the intensity of the colors in Figure 3. Boundaries for all three scenarios are set at a deviation of respectively +/-10 and +/-20% from the reference line. Secondly, the messages can either be suggestive or imposing, for example "Is there any chance that you can plan a brisk walk this afternoon?" or "Is your current activity in line with your intentions?" versus "Time for a brisk walk".

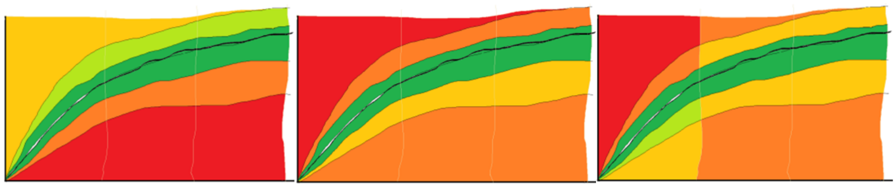

Fig. 3. Visual representation of the feedback scenarios. Left: activate, middle: temper, right: balance. The black line in the middle of the green strip represents the reference line.

Process Guidelines. The intervention strategy starts as the patient completes an intake questionnaire about demographics, medical condition, and fatigue complaints. Questionnaires can be administered online, and the hardware can be sent by direct mail easily. The patient wears the system for a week to create a baseline activity measurement. In this week, the smartphone does not display any feedback about the patient's activity. However, the therapist should keep in mind that the simple act of wearing the device might influence the results of this measurement.

After the baseline week, the therapist logs into the web portal to see the results of the baseline measurement, and to change the settings of the Activity Coach. The therapist selects a reference line that is equal to, or is based on the patient's average daily activity during the baseline week. In that way, the patient can get used to using the Activity Coach. Subsequently, the therapist approaches the patient through e-mail, gives an introduction about himself and the intervention, and gives a rough planning for the upcoming 9 weeks. The patient is asked to introduce himself too and to use the system for a minimum of three days to get used to the feedback scenario.

For the patient, the first feedback period now starts. Each hour, a feedback message is selected and pops up at the smartphone. The patient can retrieve the message the entire hour, until another message is generated.

In the second week, by phone contact, the patient and the therapist set personal goals for the upcoming eight weeks, and define and plan tasks to accomplish these goals. Goals and sub-goals can vary from "doing groceries independently by bike in week 9" to "Being able to take effective rest moments during the week". Accordingly, the therapist translates sub-goals into a set of reference activity patterns that will be adjusted throughout the nine weeks of intervention. When desired, also the feedback scenario can be adjusted by the therapist.

The intervention strategy suggests to change the reference activity pattern of the Activity Coach in at least three steps throughout the 9-week intervention. This likely stimulates the use of feasible goals and consequently increases the self-efficacy of the patient. The therapist supports and coaches the patient with weekly e-mails during nine weeks. The intervention strategy suggests that in week 7, the patient is asked to not wear the system, and the patient is stimulated to translate his experiences and future goals in terms that relate to day-to-day activities and planning. Exercises that could be used in this week include keeping a fatigue or energy diary. The intervention is concluded by evaluating the progress of the patient, the benefits and difficult parts of the intervention, and setting goals for the future.

4.3 Step 2: Feedback from the iterative test phase

The first draft of the intervention strategy was presented, explained, and discussed extensively with two physiotherapists (PMI Rembrandt, Veenendaal, The Netherlands), after which it was tested and evaluated with these therapists and a patient.

The most important results from the therapists are that it is difficult to formulate goals and tasks for the intervention, and to explain the use of the system by e-mail. Also, it was recommended that the patient should get access to an online environment in which he can look up his past physical behavior in order to monitor and evaluate his own progress. Finally, it was suggested that a normative reference line could support the therapist to value a patient's activity level.

The patient's feedback was that the system is bulky and can be bothering to wear during exercise. Also, it is sometimes short of power for an entire day. Furthermore, more information about the reasoning behind the suggested activities in the automated feedback messages would be considered useful. The informative feedback messages were preferred over the direct messages. Finally, the lacking recognition of activities, and underestimations of certain physical activities was sometimes frustrating for them.

4.4 Adjustments to the draft intervention strategy after Step 2

The Activity Coach. Power-saving software adjustments were made to ensure that the battery of both devices will last an entire day. However, no adjustments to address the bulkiness of the system were made, because the choice for hardware was among the starting points for this study. Also, the system was not adapted to recognize activities. It is expected that this issue will be only a minor limitation in the current intervention, because individual goals are based on patients' own baseline activity patterns, which likely incorporate a constant underestimation throughout the intervention.

Web Portal. In order to support the decision making of the therapist, a normative reference line was incorporated in the portal. It represents the average daily activity pattern of twenty patients who suffered from severe chronic cancer-related fatigue, and wore the activity coaching system for one week consecutively. This reference line is shown when the therapist reviews the baseline activity of the patient.

Patients were also enabled to have access to a web portal. For patients, it consists of an 'activity viewer' that is similar to the one that is shown in the therapist portal, but without plots of the raw data.

Feedback Scenarios. The content of the messages was not further adjusted as a reaction to the patient's feedback. We hypothesize that such preferences are likely dependent on for example the stage of change of the patient, learning style, and personality. Adjusting the system to tailor the set of feedback messages for each individual was not technically feasible for this project. A mixed approach was therefore maintained.

Process Guidelines. A phone-call was implemented in the protocol during the second week in order to set goals. Also, the intervention strategy now suggests introducing the patient to the portal from the fifth week on. It is expected that from that moment on, patients are used to wearing and using the Activity Coach, and can interpret the line charts properly. The use of this portal creates an evaluation moment, and goals can be adapted accordingly if necessary. Also, example exercises were added to the intervention strategy that review earlier physical behavior and achievements during the intervention, thereby using the patient portal.

As the Activity Coach is known to underestimate the intensity of certain activities, caution should be taken when interpreting absolute IMA counts, and (any change of) type of activity should be kept in mind when doing so. The intervention strategy therefore now includes thorough recommendations for the therapist on informing patients explicitly about the possibilities, strengths and weaknesses of the system.

5 Discussion

This paper has described the development of an mHealth intervention strategy that targets chronic cancer-related fatigue. Feedback was obtained by involving potential end-users with various backgrounds in all phases of the development process. Such development was intended to result in a highly accepted intervention, contrasting technology-driven approaches that often do not come beyond the pilot stage [32].

The added value of this work is mostly the explicit involvement of a health professional for deploying the mHealth technology. Although this seems to be an obvious improvement, to our best knowledge, other examples of such use of activity coaching systems have not been published so far [33, 34]. By involving a health professional, more subtle and tailored physical behavior goals can be attained, such as creating awareness and improving energy conservation. Being able to set flexible goals is a huge advantage for the targeted population because of the population's heterogeneous character.

Another important feature of this intervention is that it is directed at opportunistic physical activities and at low-to-moderate intensity exercise, rather than high-intensity exercise. This serves two goals: to accommodate the diverse nature of the population, and to establish safety of the patient; physical tests cannot be performed because no face-to-face sessions were incorporated. However, we are confident that increasing the volume of opportunistic activities and actively managing their daily activities will have beneficial health outcomes for many patients. This could be strengthened by improving cognitions about physical behavior: Some argue that perceived amount of physical activity or the self-efficacy over physical activity is even more important than the amount of the physical activity itself [35]. Future research that focusses on the role of physical activity in interventions for fatigue should therefore also focus on cognitions and on other dimensions of physical behavior than just the objective daily amount.

Although the current employment of the Activity Coach was realized by extensive collaboration with experts and based on a broad spectrum of literature, many of the features have not been optimized so far. Firstly, the bulky hardware can be an important bias for the effectiveness of this intervention strategy. Also, personalizing the feedback messages to the subject's stage of change or learning style, and the way that the boundaries are set within the feedback scenarios have not been subject of this work, but could be an interesting topic for subsequent studies. Currently, the system is being adjusted to generate tailored motivational feedback messages considering for example timing and content [36]. Also, the visual representation of the activity measurement on both the smartphone and the web portal should be improved and personalized. The current visualization is rather simplistic, however, ideally they should explicitly support the goals they serve: visualize the longitudinal change or highlight improvement of the patient in order to strengthen self-efficacy and sense of control. Relevant examples for comparable goals yet exist [37]. Finally, the current experiments are limited due to the small number of patients that were involved, and the limited structure of the interviews.

Conclusion. This paper is a first step in order to develop an mHealth intervention to support patients who suffer from chronic cancer-related fatigue. The intervention strategy succeeds in meeting many of the recommendations that were extracted from relevant literature or formulated by health professionals in the field. However, the actual usefulness, acceptability, and effectiveness of the final intervention strategy have not been established yet. A randomized controlled trial (The Netherlands Trial Register, number NTR3483) is conducted currently to study the effectiveness, working mechanisms, and effect predictors of the intervention within the target group.

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Adapting Emotional Support to Personality for Carers Experiencing Stress

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Abstract. Carers - people who provide regular support for a friend or relative who could not manage without them - frequently report high levels of stress. Good emotional support (e.g. provided by an Intelligent Virtual Agent) could help relieve this stress. This study investigates whether adaptation to personality affects the amount and type of emotional support a carer is given and possible interaction effects with the stress experienced. We investigated the personality trait of Emotional Stability (ES) as it is interlinked with low tolerance for stress. Participants were presented with 7 stressful scenarios experienced by a fictitious carer and a description of their personality and asked to rank 6 emotional support messages. We predicted that people with low ES would be given more emotional support messages overall and that ES would affect the type of emotional support messages given in each scenario. We found that participants gave more praise to the high ES carer with a trend towards other support types for the low ES carer.

Keywords: Ehealth; personality; emotional support

1 Introduction

Carers - people who provide regular support for another person, without payment - save the UK economy £119 billion every year [2], but frequently report high levels of stress [22]. Good quality emotional support can relieve this stress and reduce negative affect [20]. This work is motivated by the fact that Intelligent Virtual agents that react to affect can be effective in delivering emotional support [12, 18, 20]. Studies for First responders [6] and carers [20] have found that people provide different types of emotional support to people experiencing difference types of stress. In this study we wish to expand on this to investigate whether the personality of the person experiencing stress affects the type of support they are offered and whether this interacts with the stressor experienced.

Personality describes who we are and how we react in given situations. There are many ways to measure personality. One of the most popular and reliably validated is the Five-Factor Model (FFM) [8], which describes an individual's personality on a set of scores on five different factors or traits: Extraversion (I), Agreeableness (II), Conscientiousness (III), Emotional Stability (or Neuroticism) (IV) and Openness to Experience (V). We hypothesize that carers with different personalities may require different types and amounts of Emotional Support. In this paper, we focus on Emotional Stability. Highly emotionally stable individuals are calm, non-neurotic and imperturbable [11], while low ES individuals (those with low Emotional Stability) are more likely to worry, feel negative affective states and experience depressive symptoms [23, 14, 13], and as such may require more support to deal with these emotions.

There is evidence that people provide different types of emotional support to low ES people. [5] investigated the provision of Emotional Support for learners, and found that Low ES learners received more emotional support than emotionally stable learners. Additionally, the type of emotional support provided differed, with low ES learners receiving additional 'emotional reflection' (acknowledging how the learner is feeling) where they had performed poorly. We want to investigate whether these findings also apply to the carer domain.

The field of tailored health communication has long established the need to personalise health messages in order to improve the cognition of the message and incite behaviour change [10]. While the aim of emotional support is not to incite behaviour change per se, such personalisation is likely to also be beneficial in creating more impactful emotional support.

Conducting research with carers is difficult, owing to the fact that the people who need support most (i.e. people who care over 50 hours a week and experience social isolation) do not have the time or freedom to participate in multiple experiments. As carers do not belong to a discrete cultural group and are very common within society, we expect that the general public are capable of empathising with carers. Therefore our approach is to present members of the public with a scenario about a carer and ask what support they think the carer would like. In this way we can generate a model of the types of support that people think a carer would appreciate without taking up a carer's time. We of course will validate this model by consulting carers at a later date.

2 Study

In this study we examine the impact of high or low emotional stability on the type and quantity of emotional support messages given to a fictional carer experiencing different types of stress.

2.1 Methods

Design. We used a mixed design. As a between subject factor, each participant saw only one personality level. As within subject factors, each participant saw all 7 scenarios and 6 messages. Participants rated their empathy with the scenario (here called 'Sympathy' to disambiguate it from the message category 'Empathy'), to allow us to control for low empathy. They also ranked 6 support messages. The Independent Variables were Scenario (7 levels), Message (6) and

Personality (2); the dependent variables were Sympathy (1-7) and Message Rank (0-6, coded as First=6... Sixth=1 and unranked=0).

Materials.

- Stressful Scenarios of seven key stressors (adapted form the NASA-TLX [9] by [6]) depicting carers were taken from [20] (see Table 1).
- Two validated descriptions of a high and low ES person (with neutral other traits) were taken from [5] (see Table 2).
- Six validated emotional support messages depicting six different categories of emotional support were taken from [20] (see Table 3).

Table 1. Scenarios depicting Stressors taken from [20]

Stressor	Scenario
Interruption (IN)	James is John's carer. Today James needed to get John ready for bed, but people kept phoning him.
Isolation (IS)	James is Fred's carer. Fred spends most of the day asleep. Today James was alone all day and no home carers were scheduled to visit.
Mental Demand (MD)	James is Julia's carer. Today James had to carry out minor medical tests. The tests are not dangerous if he does them wrong but the procedure is complex and requires concentration.
Physical Demand (PD)	James is Max's carer. Today James moved heavy furniture and boxes from Max's upstairs bedroom to his new bedroom downstairs.
Temporal Demand (TD)	James is Samantha's carer. Today James had to drop Samantha off at the doctors at 4.30pm, collect her prescription from the pharmacy at the other side of town before it closed and collect some groceries before collecting her at 5pm.
Emotional Demand (ED)	James is Gary's carer. Today Gary was confused and very upset and James comforted him.
Frustration (FR)	James is Diane's carer. Today James wanted to drop Diane off at the day care center so he could have some free time, but the center was closed.

Participants. Participants were recruited from Mechanical Turk [15] and were paid \$0.80. Participants had to complete an English comprehension test, have an acceptance rate of at least 90% and reside in the US. There were 61 participants (31 female). 11 were aged 18-25, 28 were 26-40 and 22 were 41-65.

Procedure. Participants were told what a carer was and that they would be shown 7 scenarios involving a carer called James. They were then shown a short

Read and follow the instructions below. Take your time - there are no right or wrong answers; we are interested in what you think.

The following scenarios depict a carer in a stressful situation. A carer is a person who provides regular support for another person (typically a friend or family member) without formal payment.

These scenarios are about a carer called James. He cares for Susan.

James often feels sad, and dislikes the way he is. He is often down in the dumps and suffers from frequent mood swings. He is often filled with doubts about things and is easily threatened. He gets stressed out easily, fearing the worst. He panics easily and worries about things. James is quite a nice person who tends to enjoy talking people and tends to do his work.

Scenario 1 of 7
Today James wanted to drop Susan off at the day care center so he could have some free time, but the center was closed.

Imagine you are James.
How well do you think you can empathise with the stress he is experiencing in this situation?

Very poorly= "I don't understand this situation/would not find this stressful"
Very well="I have experienced a similar situation and understand exactly how stressful it is"

Please Select ▼

Imagine you are James's friend.

Below is a selection of support messages.
Rank as many messages as you think he would like to receive in this situation. Rank the most important one as Best'. the next as 'Second best' etc.
You don't need to rank all of them if you don't think James would like to receive them.

Support Message	Ranking
You are an amazing person.	Please Select ▼
Let me help you.	Please Select ▼
Your work is very appreciated.	Please Select ▼
You can do this.	Please Select ▼
Just take it one step at a time.	Please Select ▼
I understand how stressful it must be.	Please Select ▼

Please explain why you have given these rankings.

Fig. 1. Screenshot of Experiment. James the carer is introduced and a low/high ES description given. The Scenario (1/7) is followed by a) an empathy rating b) the possibility to rank as many or few out of 6 support messages.

Table 2. High and Low ES personality stories from [5]

Emotional Stability(ES)	
Low	High
James often feels sad, and dislikes the way he is. He is often down in the dumps and suffers from frequent mood swings. He is often filled with doubts about things and is easily threatened. He gets stressed out easily, fearing the worst. He panics easily and worries about things. James is quite a nice person who tends to enjoy talking people and tends to do his work.	James seldom feels sad and is comfortable with himself. He rarely gets irritated, is not easily bothered by things and he is relaxed most of the time. He is not easily frustrated and seldom gets angry with himself. He remains calm under pressure and rarely loses his composure.

Table 3. Emotional Support Messages with categories

Category	Message
Appreciated (APP)	Your work is very appreciated.
Supported (SUP)	Let me help you
Empathy (EMP)	I understand how stressful it must be
Practical Advice (PRA)	Just take it one step at a time
Encouragement (ENC)	You can do this.
Praise (PRS)	You are an amazing person

description of James' personality, either depicting high or low ES. This remained at the top of the screen for all scenarios. They were then presented with each scenario in turn, asked to rate their empathy with the carer's situation and were asked to give as many of the 6 support messages as they wished and to rank the messages they had chosen (see Figure 1).

Hypotheses.
H1 People will give different support messages to the low ES carer.
H2 People will give more support messages to the low ES carer.

2.2 Results

Effects of Scenario×Personality on Message Rankings. Figure 2 shows the mean ranks of each message for the 2 ES levels and the number of messages overall. Previous research has found that empathy with a situation affects emotional support [19, 4]. Thus in order to ensure that the empathy level did not impact our results, this was controlled for as part of our analysis. A 7×2 within-subjects ANCOVA was performed of Scenario×Personality, controlling for Sympathy, on Message rankings (6 levels). This was chosen as the most appropriate test for this data (ANCOVA is a powerful test and can be used for non-normal data) [21]. This was significant at $F(1,419)=186.50$, $p<0.01$. There were significant effects for Scenario ($F(6, 419)=3.54$, $p<0.01$) and significant interaction effects for Message×Scenario ($F(30, 2095)=11.67$, $p<0.01$) and Message×Personality ($F(5, 2095)=2.44$, $p<0.05$).

Post-hoc tests on Scenario revealed that the Mental Demand, Physical Demand and Temporal Demand scenarios had significantly higher message rankings than Isolation, indicating that more messages were given for these scenarios. Post-hoc tests for the interaction of Message×Scenario revealed the most popular messages for each scenario, shown in Table 2.2. These results are similar to the findings in [20].

Table 4. The best ranked messages for each scenario. Significantly better than other messages at $p<0.05$

Scenario	Highest Ranked Messages
Mental Demand	PRA, ENC, EMP
Temporal Demand	SUP, APP, ENC, PRA
Physical Demand	SUP, APP
Frustration	SUP, EMP, APP
Interruption	SUP, EMP, ENC, APP
Isolation	APP, PRS
Emotional Demand	APP, PRS

Post-hoc tests on Personality revealed a significant effect of personality on the Praise message. Participants ranked Praise significantly higher for the high-ES carer (Mean=2.94, S.E.=0.15) than the low-ES carer (Mean=2.41, S.E.=0.15). This supports hypothesis **H1**.

Effects of Scenario×Personality on Number of Messages ranked. A 7×2 within-subjects ANCOVA was performed of Scenario×Personality, controlling for Sympathy, on Number of Messages ranked. This was significant at $F(14,419)=3.59$, $p<0.01$. There were significant effects for Scenario ($F(6, 419)=2.64$, $p<0.05$). Post-hoc tests showed that fewer messages were given for the Isolation Scenario (mean=3.75, S.E.=0.24) than for Mental Demand (mean= 4.82, S.E.=0.24) and Temporal Demand (mean=4.90, S.E.=0.24). This supports findings in [20]. There was no effect of personality, contrary to **H2**.

These results suggest that there is some variability in the type of emotional support that people give to carers with high and low ES. The low ES carer received less Praise; however, there was no significant difference of the number of messages ranked for each personality. This implies that the low ES carer must have received more of another type of support. From Figure 2 we can see that the low ES carer received more Empathy, Practical Advice and Encouragement than the high ES carer. Although not significant, it may be that the low ES carer received a mixture of these three support types instead of Praise and this has diluted any effect, as rankings were split between them.

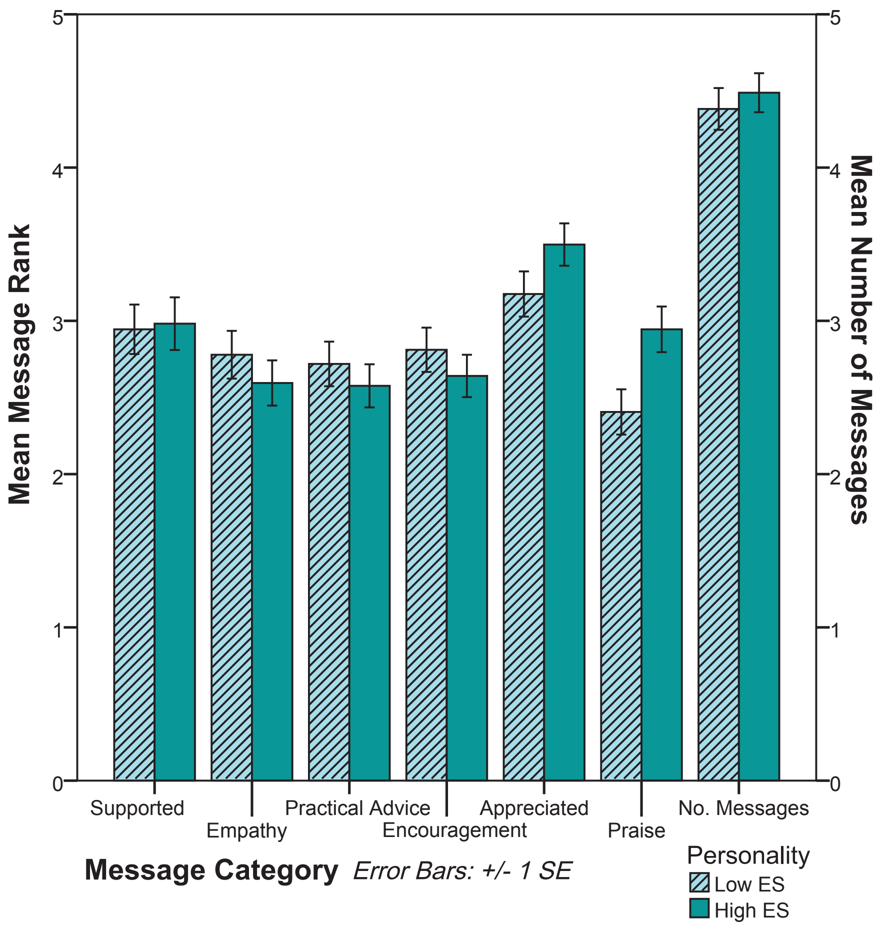

Fig. 2. Mean rank of messages and mean no. messages for ES High and Low

3 Discussion

We found that the High emotionally stable carer was given more Praise than the low ES carer. The data also suggests that low ES carers receive a wider range of emotional support. This might be because neurotic individuals are more worried about failing a task [7] and so are not praised but reassured with empathy, encouraged and given advice. The High ES carer isn't given as wide a variety of support as they aren't perceived as needing it. Encouragement has an advantage over Praise in that it can be delivered when things are going badly, while Praise is appropriate only when someone has performed well in a task - thus encouragement could be seen as a better motivator [17] and so was provided to the low ES carer.

It is of course hard to tell why participants picked certain messages over others for the carer as we did not obtain useful qualitative data about their choices. It is possible that the changing scenarios became more salient to the participants than the personality description and that they neglected to consider personality when they were picking messages. Identifying participants with high and low ES and investigating which messages they pick for the carer would perhaps yield clearer results.

This study uses Mechanical Turk. This is a useful tool for crowd-sourcing a large number of diverse participants (vs typical university student samples). Furthermore, data obtained from Mechanical Turk has been found to be high quality and reliable [3]. 36% of our participants were aged 41-65; in England and Wales, people aged 50-64 are most likely to be carers [1]. By examining our demographic data about our participants, 20 out of 61 reported to be informal carers, while a further 25 claimed to be professional carers, from forced choice of 'professional carer', 'informal carer' and 'other'. While it is not clear whether all these responses are honest, it is at least an indication that many Mechanical Turk users are familiar with caring.

While this study distinguishes between different types of stressor that a carer might experience, we do not distinguish between carers of people with different health conditions. There might be a considerable difference between offering emotional support for palliative care and long-term mental health care for instance.

This study investigates which type of support to use if the stressor is known - we do not investigate how the stressor can be detected. We anticipate that this emotional support could implemented in a system that makes use of sentiment analysis [16] to detect the stressor from social network status posts or by prompting the carer to write something about their day.

4 Conclusion

We have found evidence that the emotional support to provide to carers in stressful situations may need to be adapted to carer personality. We have also found support for [20], that emotional support should adapt to stressor. In future work we plan to investigate other personality traits, expand on the number and type of messages provided and consider the effects of gender and culture. Additionally, whilst this paper has investigated the emotional support people would provide, this may not be the same as what people would like to receive. We will therefore also investigate the effectiveness of emotional support messages and adaptations on carers with differing personality traits.

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Personal sensing wear:

The role of textile sensors

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Abstract. Wearable sensors for fitness tracking are becoming increasingly popular and are set to increase as smartwatches begin to dominate the wearable technology market. Wearable technology provides the capacity to track long-term trends in the wearer's health. In order for this to be adopted the technology must be easy to use and comfortable to wear. Textile based sensors are ideal as they conform to the body and can be integrated into the wearer's everyday wardrobe. This work discusses fabric stretch sensors that can measure body movements. An application using a sensor glove for home assessment of Rheumatoid Arthritis is presented. This work is the result of a multidisciplinary effort, involving expertise in material science and functional design, computer science, human health and performance and influenced by the end user needs.

Keywords. Wearable sensors, piezo-resistive textile, home monitoring, rheumatoid arthritis, personal health, smart garments, interactive textiles

1 Introduction

For healthcare delivery to become more personalised it is essential to find ways to track the long- term physiology of the person. Clinical visits are sporadic, and rely on patient's subjective reporting of their symptoms. Quantifiable measures of physiological output could provide a more definitive account of personal well-being. Smartphones are already equipped with motion and location sensing devices which, from a healthcare perspective, can be used to monitor activity levels and exercise. The use of a smartphone is a successful model as it does not encumber the user with additional technology, and many people have access to this hardware. The concept of a smart garment is similar; by integrating miniature or textile-based sensors into garments, the garment functionality can be extended to monitor the wearer's health without the need for additional technology, wires or supplementary devices. Wearable sensors and smart textiles therefore offer the possibility of monitoring the body in an unobtrusive manner (Castano and Flatau, 2014, Coyle et al., 2014, Stoppa and Chiolerio, 2014, O'Quigley et al., 2014). Smart garments may be used to assess chronic conditions at home and as a rehabilitation tool. As part of a user interface system, visual and audio feedback can be given to motivate users and encourage adherence to prescribed exercises. Home monitoring of exercise performance can also be used to indicate the effectiveness of treatment to therapists. This can allow a personalised approach to healthcare delivery and rehabilitation strategy. The wearer's own "smart" garments can log their physiology automatically as they go about daily tasks creating a personal physiological diary of their wellbeing.

Rheumatoid Arthritis (RA) is a chronic condition requiring on-going treatment and disease management. It is an auto-immune disease which attacks the synovial tissue lubricating skeletal joints and is characterized by pain, swelling, stiffness and deformity(National Collaborating Centre for Chronic Conditions (UK), 2009). This systemic condition affects the musculoskeletal system, including bones, joints, muscles and tendons that contribute to loss of function and Range of Motion (ROM). Early identification of RA is important to initiate correct drug treatment, reduce disease activity and ultimately lead to its remission.

This paper discusses the use of textile stretch sensors that can detect kinematics of the body to monitor joint movements. We present the design of a sensor system to assist the management of RA through home monitoring of hand exercises. The glove has been designed with the user's dexterity and comfort in mind. Fabric sensors are comfortable to wear, lightweight, stretchable and conform to the user. The glove was first designed using a single sensor on each finger and thumb, and its performance compared to a commercial data glove. While the commercial data glove is not a gold standard for measuring joint angles it gave an indication that the textile sensor system could be suitable for our application. Following on from this the glove design was improved by adding additional sensors to differentiate between different finger positions. Testing of this was carried out using Vicon motion capture to evaluate its performance in controlled laboratory conditions. A graphical user interface was developed to guide patients through prescribed exercises, providing motivation while also giving the option of logging daily performance. The aim is to be able to monitor the patient's level of stiffness and range of motion throughout the day, away from the clinical setting, in order to develop a personalised treatment for their condition.

2 Methods

2.1 Glove design

A sensor glove has been developed using fabric stretch sensors integrated into an oedema glove. It is important that the glove design does not restrict or influence movement. The stretch sensors are made of a knit fabric coated with conducting polymer, giving them piezoresistive properties. This means that when the fabric is stretched the resistance changes, which can be measured using straightforward circuitry and captured with a microprocessor platform. An Arduino Fio with integrated Xbee radio was used to collect and wirelessly transfer the data to a laptop.

Two glove designs are presented here. First a glove with five sensors was created and tested (Design 1). After testing its performance, an improved design (Design 2) was created which integrated more sensors to identify more specific finger movements. Design 1 was a straightforward design using just one stretch sensor on each finger. Each stretch sensor covered all three finger joints - the distal interphalangeal joint (DIP), proximal inter-phalangeal joint (PIP) and metacarpal-phalangeal joint (MCP), Fig. 1(b). Strips of sensor fabric of 5mm width were stitched in place using conductive stainless steel thread, shown in Fig. 1(a). A circular sew-in prototype board (Lilypad protoboard) was used to connect to the electronic circuitry. The sensor fabric and conductive thread were covered using a lycra® fabric for protection and this layer also held the sensor in place over the joints. The protoboard was encased with moulded silicone (Sugru®) to secure the connections. The Arduino Fio and its Lithium Polymer battery were housed in a 3D-printed custom fit enclosure designed to fit the curvature of the wrist. A battery of 400mAh was chosen for its small size, providing an operation time of approximately one hour continuous use. This was sufficient for initial tests based in a laboratory setting with constant wireless data transmission. Longer term battery use could be achieved using power optimization strategies e.g. integrating an SD card and transmitting data when necessary.

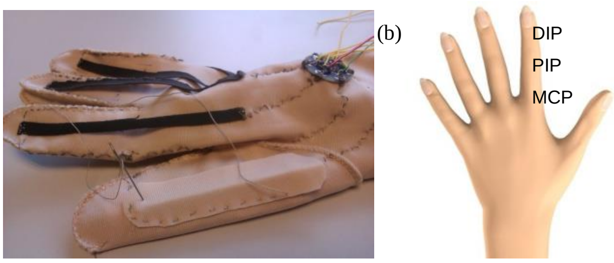
(a) (b)


Fig. 1. (a)Glove design 1 with stretch sensor on each finger and thumb, each sensor strip covered three joints on the finger (b) location of the finger joints, Distal interphalangeal joint (DIP), Proximal inter-phalangeal joint(PIP) an Metacarpal-phalangeal joint(MCP).

Design 1 may be sufficient for some applications, and is easier to manufacture, but due to the nature of the sensors it cannot identify the location of the bend. Therefore the second glove was designed to have more specific measurement of the position of each joint. Two sensors were positioned on each finger – one covering DIP and PIP (these joints tend to move together) and the other one covering MCP. A digital 3-axis MPU-6050 containing an accelerometer/gyroscope (Sparkfun Electronics, 2012) was included on the back of the hand (see Fig. 2(a)). The MPU-6050 contains a MEMS accelerometer and a MEMS gyro in a single chip. It has a digital output and uses the I2C interface for communication. A multiplexer (74HC4052) was used to expand the inputs on the Arduino Fio board from six to twelve, allowing ten fabric sensor inputs and two inputs for the MPU-6050. As with the first glove prototype the sensors were covered using fabric and the wired connections reinforced using moulded silicone (Sugru®).

Fig. 2(b) shows the 3D printed enclosure for the Arduino Fio, multiplexer circuit and battery. The enclosure also allowed a Velcro strap to be fastened around the wrist.

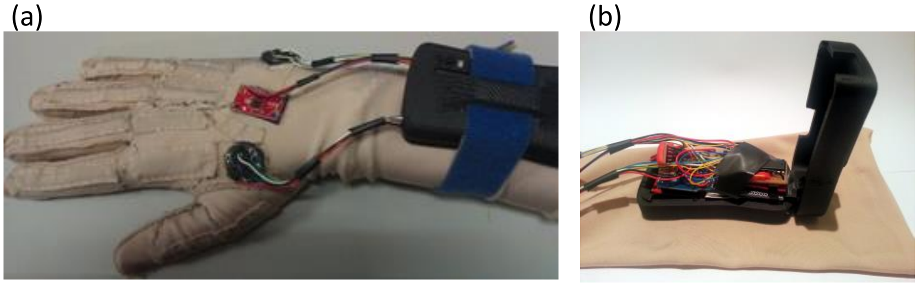


Fig. 2. (a) Glove design 2 with two sensors on each finger and a 3-axis accelerometer, gyroscope on the back of the hand. (b) 3D printer enclosure showing control circuitry

To connect to the user interface this glove was given Wi-Fi capability using a RN-XV WiFly module (Roving Networks, 2011). This component provides wireless communication with any device capable of receiving 802.11 b/g data. It contains built-in applications for DHCP, DNS, Telnet, FTP and HTML. This interface can be attached directly to any suitable device through an ad-hoc network, or can be configured to attach to a network infrastructure by TKIP authentication and communicate using its integrated TCP/IP communication stack. The Wi-Fi module is configured with an SSID, TCP socket number, and static IP address. The SSID is broadcast from the Wi-Fi module once the data glove is powered on. A local device capable of detecting the SSID broadcast may connect to the Wi-Fi interface to create an ad-hoc network with the data glove. The Wi-Fi module is configured using a static link-local (Cheshire et al., 2005) IP address 169.254.1.1. A link-local address is suited to the typical operating environment of the ad-hoc connection between data glove and connected device.

2.2 User interface

The graphical user interface developed by the School of Computing and Intelligent Systems at Ulster University provides the motion capture software to regulate glove functionality. This includes sensor calibration, sensor recording and playback, alongside detailed statistical analysis of recorded movement to measure and evaluate variance within exercise routines. The interface has been designed in collaboration with target patient and clinician end-users in Altnagelvin Hospital in Co. Derry.
The custom software captures real-time data streamed from the data glove and post-processes it using software algorithms. The software also provides real-time user feedback and analysis of exercise recordings for clinicians to assess. The bespoke software records objective routines that are defined by the clinician and performed by the patient at home at prescribed times throughout the day.

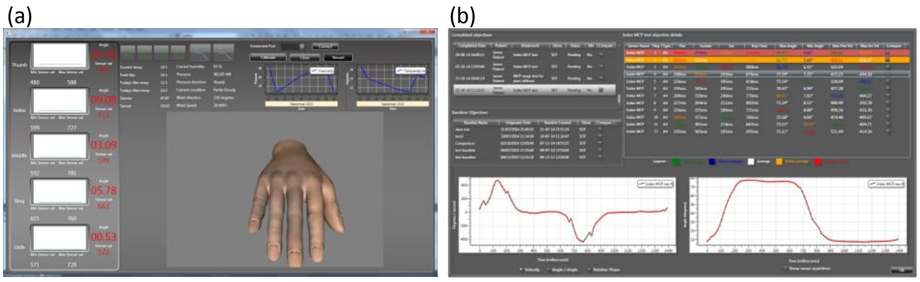


Fig. 3. (a) Screenshots of the graphical user interface providing visual feedback during hand exercise routine. (b) Data analysis window showing measurement information for completed hand exercises

Fig. 3(a) shows a screen capture of the visual feedback window with a real-time hand animation and detailed information on calculated joint angles. The 3D hand mimics patient finger joint movement as detected by data glove sensors; therefore the hand exercise routines completed remotely by the patient at home can be played back and viewed by the clinician. Each routine is analysed by controlling software and automatically partitioned into constituent repetitions. Each repetition is further subdivided and provides timing information on flexion and extension movement as well as minimum and maximum angular and velocity information calculated for each repetition. Fig. 4 shows one typical flexion and extension angular movement profile for a finger joint. Individual flexion and extension movement is sigmoidal shaped as demonstrated by the flexion and extension lines, and one complete open-closed hand movement produces a Gaussian shaped curve. This information is used to provide indicators of changes in movement kinetics between exercise routines. Information is presented to the clinician as an assistive tool to aid with finger joint ROM assessment (see Fig. 3(b)). Colour coding of each exercise routine visually identifies variation in patient movement. Such information can help support the clinician during initial patient diagnosis and to measure progression or decline throughout patient treatment.

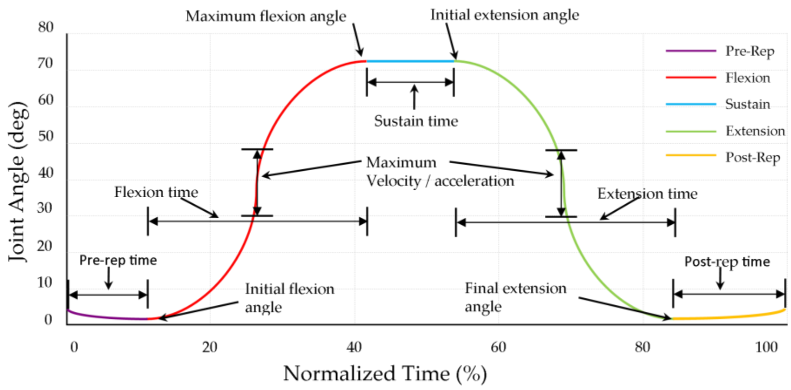


Fig. 4. Chart demonstrating segments that characterise a typical repetition within an exercise routine

2.3 Testing procedures

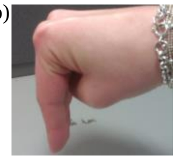
Glove design 1 - Comparison with 5DT data glove.
The oedema fabric sensor glove has been compared to the 5DT Ultra 14 off-the-shelf virtual reality glove to determine accuracy of ROM measurement. The 5DT glove is a popular high-end commercial product that is representative of current state-of-the-art data gloves (5DT Data Glove, 2011). Both gloves were calibrated using software algorithms within the controlling software. Both gloves were then simultaneously worn on the dominant right hand of a subject with 19.7cm hand size and were connected to individual computers hosting identical copies of the controlling software system. An exercise routine was configured on the controlling software that consisted of 12 flexion and extension repetitions that measured movement of the middle MCP finger joint. The first repetition was used to synchronise recordings between computers and to remove unintentional delays in initial finger movement. Data was sampled every 25 ms from both data gloves. The controlling software segmented data into constituent flexion and extension movement.

Hand extension

Hand flexion:

Fig. 5. Hand position during exercise routines

Glove design 2 - Comparison with Vicon Nexus Motion system.
A 12 camera Vicon Nexus system (Vicon Motion Systems, 2013) was used as a gold standard reference for testing the performance of the second glove prototype. This procedure was carried out in collaboration with the School of Health & Human Performance at DCU. The Vicon system is generally used for larger range movements of the body. The markers used were 12 mm diameter and the cameras covered a space of 5m x 5m. The subject sat on a chair and raised their hand above their head and away from the body to reduce the risks of occlusion and inaccuracy of the Vicon system. Testing focused on a single finger at a time as placement of markers on every finger joint caused reading inaccuracies by marker-ghosting. Markers were placed on the flat part of the joint as placing them directly on top of the joint caused too much movement of each marker and affected angular accuracy. Three markers were used to study an individual joint in each trial. Fig. 6 shows the placement of markers for studying the middle finger MCP joint and Fig. 7 shows the placement of markers for studying the middle finger PIP joint.

(a)  (b) 

MCP flexion

Fig. 6. (a) Placement of Vicon markers for MCP joint measurements (b) position of hand during MCP full flexion

(a)  (b) 

PIP flexion

Fig. 7. (a) Placement of Vicon markers for PIP joint measurements (b) Hand position during PIP flexion:

3 Results

Study 1 – Textile sensor glove 1 compared with 5DT data glove.
Initial results demonstrate a high correlation (r = 0.96) of recorded angular movement between the oedema fabric sensor glove and 5DT virtual reality glove. Fig. 8 shows a comparison of the recorded angular and velocity movements from the two gloves during a single flexion/extension movement. These are results captured from the middle finger MCP joint.

The minimum and maximum angular measurements for the middle finger MCP joint were averaged across the twelve repetitions, for each glove. Fig. 9 illustrates these results. The average minimum angle during hand flexion for the textile glove was 7.9º (standard deviation of 0.5º) and for the 5DT glove was 3.9º (standard deviation of 1.1º). The maximum angle during hand extension for the textile glove was 72.97º (standard deviation of 1.17º) and for the 5DT glove was 87.94º (standard deviation of 1.68º). The minimum angle would ideally be 0 º and the maximum 90 º. A gold standard system such as Vicon is needed to verify the actual value of the angle as the 5DT glove is not a gold standard system. Fig. 10 shows the average timings of the hand movements, the sustain time is the time between hand flexion and extension, as illustrated in Fig 4.

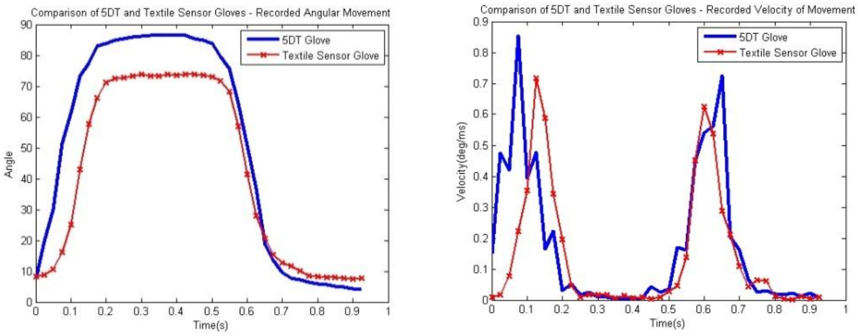


Fig. 8. Comparison of recorded angular and velocity movements from 5DT and Textile Sensor Glove for a single extension/flexion movement

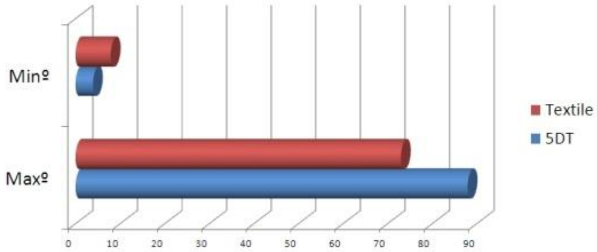


Fig. 9. Average minimum and maximum angular measurements from 5DT and Textile Sensor Glove

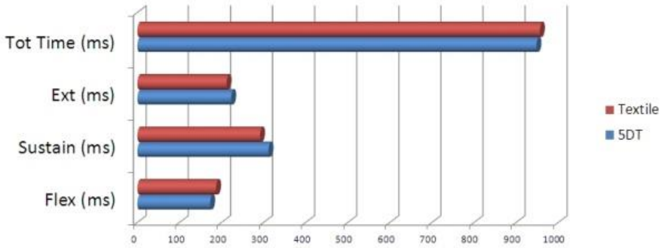


Fig. 10. Average timing measurements from 5DT and Textile Sensor Glove

Study 2 – Textile sensor glove 2 compared with Vicon Nexus Motion system.

To analyse the Vicon data the distance between each marker was calculated to give 3 sides of a triangle. Then the cosine rule was used to determine the internal angle which corresponds to the joint under analysis. The measurements for movements of the hand from full extension to full flexion are shown in Fig. 11 and Fig. 12. At the start of data collection the hand was held closed for 5 seconds to synchronise the data. Fig. 11 shows movement of the PIP joint for three flexion/extension actions. The glove sensor shows repeatable measurements for this, correlating to the Vicon measurements. There is a lag in the time response of the fabric sensors, before reaching the maximum value there is approximately a 2 second delay with the glove fabric sensor. Fig. 12 shows the measurements taken during the middle finger MCP trial. Six hand flexion/extension actions were performed, the first held for 5 seconds at the start. Measurements from this first exercise were used to calibrate the glove data for the following five exercises. The average error based on the maximum and minimum measurements was ±10.7º.

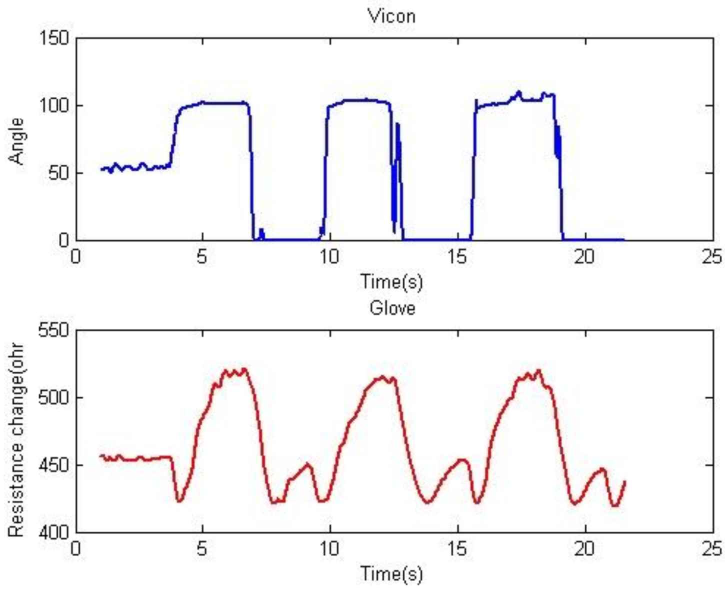


Fig. 11. Middle finger PIP measurements using Vicon and the sensor glove

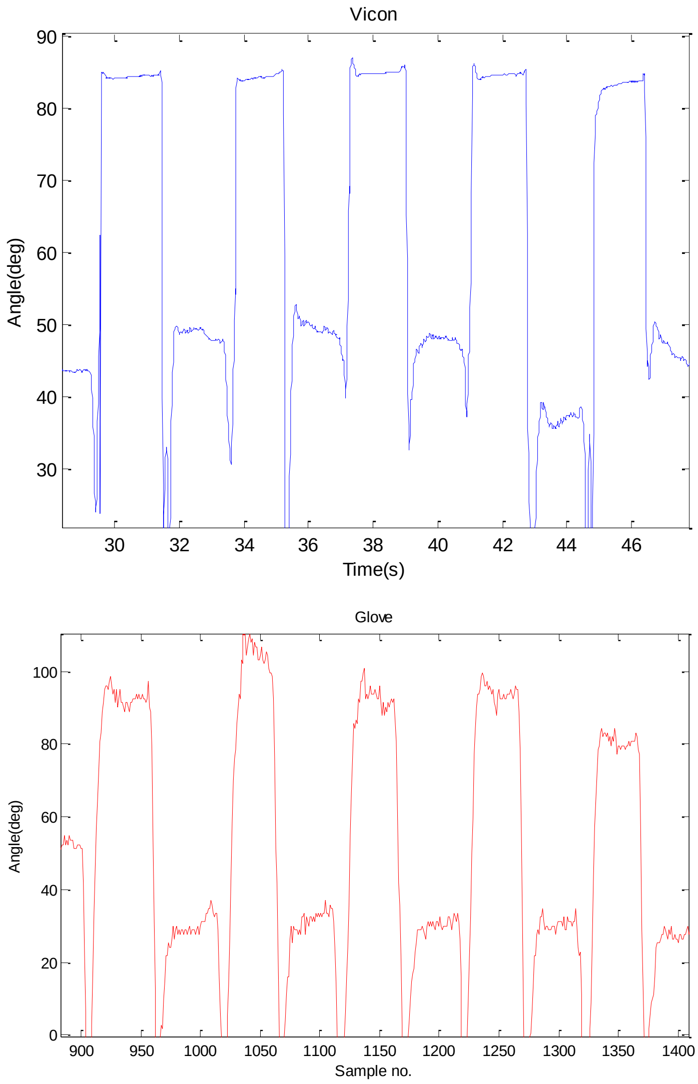


Fig. 12. Middle finger MCP measurements using Vicon and the sensor glove

4 Discussion

In the first part of the study the textile sensor glove shows similar performance to the 5DT commercial data glove and therefore shows potential for a home monitoring wearable system. The textile glove has the advantage of being comfortable to wear and suitable for wearing in cases of impaired dexterity. To evaluate the accuracy of the textile sensor glove testing with Vicon was carried out in the lab setting. While there is error of up to 10º and a small latency in the textile sensor signals the glove may be useful in monitoring day to day flexibility and range of movement. Gold standard systems such as the Vicon Nexus Motion system used in this study are very expensive and not practical for everyday use by patients.

The sensors may also be integrated into other smart garments to monitor other joints to provide long-term measures and trend analysis of the patient's condition in the home setting. Such objective measurements would reduce dependence on patient memory and provide the clinician with accurate information for better and targeted care proposals. This information may help the patient and the clinician to understanding the individual condition and assist in disease management. Combined with a user interface to motivate users a personalised care and treatment plan may be formulated. Shorter patient analysis times also would enhance patient care through increased possibilities for clinician-patient interaction. A glove that fits the user may help analyse trends and daily variance in flexibility and mobility. Improving sensor accuracy could address problems of traditional inter-tester and intra-tester reliability of finger joint measurement (Lewis et al., 2010) using current measurement systems.

A smart glove was designed with a focus on fit and comfort for the wearer. In this work the sensors and the glove itself are made from a Lycra® material. Conventional bend sensors and fibre optics typically used in computer gaming and motion capture gloves tend to be more rigid. These are not ideal for use in people with impaired dexterity and mobility as to enhance uptake and use the glove must be straightforward to put on and must also not restrict movement. Textile sensors may be integrated into support garments such as knee support sleeves, which may already be worn to help alleviate an injury. The ideal strategy therefore is to provide additional functionality to such medical textiles. An oedema glove was used in this work as an initial motivation for the glove development was for another application in stroke rehabilitation, where patients would often wear oedema gloves to reduce swelling, and compression gloves are often use in arthritis also. A key to the success of wearable technology is to build on garments that are already being worn and to seamlessly integrate the sensing technology technology into the garment. Recent developments in flexible circuitry and stretchable conductive inks will help the integration of fabric sensors in this way.

5 Conclusions

Initial comparative testing between the oedema fabric sensor glove and 5DT virtual reality glove demonstrate high levels of correlation. This achievement exhibits the gloves capabilities when compared to a commercial state-of-the-art glove product. Further testing is needed with a Vicon system that is set up with smaller markers and using cameras in a closer range. Initial results show repeatable measurements using the glove compared to Vicon. Long-term testing to ensure reproducibility and robustness of design is also required.

This project is a multidisciplinary effort, involving expertise in material science and functional design, computer science, human health and performance, and influenced by the end user needs. The aim is to have a better understanding of joint stiffness by monitoring dynamic movements of the hand at different times of the day. This quantifiable information can be measured offline from the clinic. The controlling software manages user access throughout each exercise recording. It controls data glove functionality for accurate, reliable and repeatable measurement of joint movement to determine limitation and variance throughout each day of measurement. Having such information can help to develop a personalised approach to management and treatment of various chronic conditions.

Acknowledments

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Acceptance of Mobile Apps for Health Self-management: Regulatory Fit Perspective.

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Abstract. This study addresses (non)acceptance by individuals of mobile applications (apps) for health self-management (e.g., apps for running). Regulatory Focus Theory (RFT) and Regulatory Fit (RF) principles are used to facilitate understanding of acceptance of such apps within a goal pursuit process. First, RFT was deployed to position different apps as strategies aligned with promotion/prevention goal orientation (supporting pursuit of achievement/safety). The Promotion-Prevention (PM-PV) scale was developed to allow differentiation between such apps. Second, through experimentation it was established that RF principles can be used to understand m-health adoption where promotion/prevention oriented apps can be (mis)matched to individuals' congruent goal orientation (promotion/prevention). The experiment was a first study confirming fit effects resulting from product antecedents in combination with a chronic (individual long-term) goal orientation; this condition was necessary to understand m-health tools adoption in "real-life" situations. Implications for healthcare practitioners are outlined.

Keywords: Regulatory Fit, Regulatory Focus, mobile apps for wellness, health promotion

1 Introduction

Poor health around the world and low individual involvement in health self-management are a major threat to healthcare system sustainability [1]. Some perceive technology, particularly mobile health applications (m-health apps), as a transformation factor facilitating individual engagement with health [2], e.g., mobile tracking provides a 40% advantage for retention of weight-monitoring behavior over pen-and-paper methods [3]. Despite the promise of m-Health, evidence indicates low acceptance and adoption of such initiatives especially when individuals do not feel that tool use is compatible with their health goals [4]. Thus, understanding the role of technology in relation to individual goals may facilitate adoption of these tools and provide practical guidance for healthcare practitioners to successfully recommend use.

Technology acceptance models are traditionally used to explain technology adoption [5]. Those models predict behaviors based on individual beliefs and attitudes relating to a given behavior or technology – not on individual preferences for goal pursuit. A growing body of literature criticizes these models for failing to recognize individual differences for taking an action, e.g., preferred ways of goal pursuit [6].

We propose a goal orientation framework for understanding m-health adoption guided by principles of Regulatory Focus (RFT) and Regulatory Fit (RF) theories [7], which focus on individual preferences for prevention or promotion oriented strategies of goal pursuit. We further propose that prospective users perceive m-health apps as promotion or prevention oriented and that a fit between user and app orientation will increase uptake. To this end, we developed the Promotion-Prevention (PM-PV) scale to differentiate between m-health tools and then conducted an experiment to test this proposal.

2 Conceptual Foundations

2.1 Mobile Apps: Promotion/Prevention Focused Strategies of Goal Pursuit?

RFT distinguishes between two individual motivational orientations dictating different concerns during goal pursuit [7]. Promotion-oriented individuals want their chosen strategy for goal pursuit (means) to help them satisfy their needs for accomplishments (gains), striving for positive outcomes from the goal pursuit. Promotion-oriented individuals see their goals as dreams or aspirations. Prevention-oriented individuals want their chosen goal pursuit strategy to help them meet their needs for safety, tending to use vigilant strategies to meet their goals believing that such strategies will help them avoid negative outcomes (losses). Prevention-oriented individuals see their goals as duties, responsibilities, and obligations [8]. RF posits that when individuals pursue their goals with a matching goal pursuit strategy, they tend to be more engaged in their goal pursuit and are more likely to progress with their tasks at hand [7].

This research proposes positioning mobile apps as promotion/prevention oriented strategies of goal pursuit, which when matched with promotion/prevention oriented individuals are more likely to be adopted. However, the evidence that products have their own focus is limited. A few scholars have implied (but not reliably measured) that different products have their own inherent promotion/prevention characteristics [10]. However, most of the studies highlight promotion/prevention attributes of a given product, [e.g., 9], concentrating on added product attributes, not inherent characteristics of the product. Products and their inherent characteristics have been verified as goal pursuit strategies appropriate for promotion- and prevention-oriented individuals, though the products were not differentiated on their promotion/prevention dimensions but rather on categories such as hedonic and utilitarian [11]. Therefore, our first objective was to demonstrate that m-health applications can be (reliably) differentiated by consumers as promotion- or prevention-oriented strategies for health self-management.

2.2 m-Health Tool + Individual (Mis)match: Regulatory Fit in Action

To understand apps acceptance in "real world" situations we need to make sure that the fit conditions can result from individual chronic (long-term) goal orientation rather than a temporary, primed (short-term) goal orientation (predominantly used in previous studies). Knowing how people with chronic predispositions react to different tools enables provision of appropriate guidance for health professionals for successful app recommendation.

Research using behaviours or messages (not products) differing on strategies aligned with promotion/prevention goal orientation confirms that RF can have varying participative outcomes, for example, that RF correlates with individuals "feeling right" about goal pursuit [12], favorable attitudes toward the tasks at hand [13, 14] and willingness to expend effort on such goal pursuit [15]. While most of these effects resulted from primed goal orientation, Higgins [7] states that the same effects should be observed when chronic goal orientation is used as a fit antecedent. Hence:

- **H1a:** A (mis)match (nonfit/fit) between an individual user regulatory orientation and a mobile app leads to a (weaker)stronger sense of "feeling right" about using the tool.
- **H1b:** A (mis)match (nonfit/fit) between an individual user regulatory orientation and a mobile app leads to (lessor)greater input of effort to use the tool.

3 Methodology and Results

Research included a scale development process and an experiment. Scale development involved 7 studies following Churchill [16] and DeVellis [17] recommended steps. Study 1a was a health support tool categorization task validating the concept. Study 1b collected data for scale item generation; Studies 2 and 3 were two rounds of evaluation of item face and content validity and purification, Study 4 (n = 210) comprised the initial scale evaluation including exploratory and confirmatory factor analysis and evaluation of convergent and predictive validity, resulting in item reduction, Study 5 (n=86) validated the reduced scale using the same analyses and evaluation of predictive and nomological validity. Study 6 (n=242), the final validation, used different tools but the same range of analyses and range of validity checks.

The result, apart from the actual PM-PV scale (see Table 1), was support for our proposition that mobile health apps can be reliably differentiated as aligned with promotion or prevention-oriented goal pursuit strategies. An experiment, using a 2 (promotion, prevention chronic) by 2 (promotion, prevention tool) factorial design appropriate for tool manipulation, tested H1. (US respondents n =126, from Amazon Mechanical Turk online panel [18]). Experimental treatment involved promotion/prevention-oriented individuals being exposed to description and photographs of either (a) a promotion-oriented tool, e.g., a running app, or (b) a prevention-oriented tool, e.g., a health information app. The outcome variables were expected invested effort in using the app [15] and "feeling right" about app use [19].

Table 1. Final items in the PM-PV scale

PM-PV scale items
Promotion (PM) items
1. Improve their health
2. Fulfill needs for their ideal health
3. See themselves as striving to fulfill their health plans and goals
4. Focus on achieving desired health outcomes
5. Be successful in attaining future health goals
6. Achieve hopes and aspirations for their health
Prevention (PV) items
1. Take precautions to lead a safe and healthy life
2. Focus on protecting themselves from unwanted health outcomes
3. Safeguard against mistakes that might impact their health
4. Prevent health failures
5. Stop unwanted health crises

Individual respondent focus was assessed using the Regulatory Focus Questionnaire (RFQ) [20]. The questionnaire inquires about strength of chronic promotion and prevention focus. Summated scales of prevention foci are subtracted from summated scales of promotion foci and scores of the differences above median value indicate promotion focus, below indicate prevention focus. After data screening/manipulation checks, the results supported H1a, with higher perceptions of "feeling right" (M=.33, SD .74) in the case of a match (fit) between individual orientation and tool orientation than in a mismatch (non-fit) (M=-.06, SD=.97, F (1: 124) = 4.18, p=.04). In a test of H1b, a 2 x 2 ANOVA of participants' effort in using the tool showed a significant individual goal orientation x tool orientation interaction (F (1,122) = 4.57, p=.035). Effort under fit (match) conditions (M=.21, SD=.89) was significantly higher than effort in non-fit (mismatch) conditions (M=-.19, SD=.96).

4 Discussion

The main contributions are: (1) The development of the PM-PV scale for tool differentiation as promotion or prevention orientated. The scale is an important practical tool and also a contribution to RFT theory; 2) Tool-individual matching possibilities based on chronic goal orientation contributes to RF theory as the first to evaluate product acceptance when matched/mismatched to chronic goal orientation. This is important for understanding "real-world" situations in which individuals are encouraged to use self-management tools.

Recommendations for different industry stakeholders are as follows. First, different parties involved in the development and distribution of m-health tools can use the scale development research findings to design and customize m-health tools for various consumer groups. The PM-PV scale helps in the differentiation of existing tools and whether newly developed tools have an intended promotion or prevention appeal. Second, health service providers can use the match/mismatch principles to improve tool acceptance and consequently health outcomes. For instance, a test for individual goal orientation might offer one approach for physicians and healthcare insurers [20]. Such a customized approach should make those tools more relevant for different individuals, thus making them more acceptable.

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How Can Skin Check Reminders be Personalised to Patient Conscientiousness?

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Abstract. This paper explores the potential of personalising health reminders to melanoma patients based on their personality (high vs low conscientiousness). We describe a study where we presented participants with a scenario with a fictional patient who has not performed a skin check for recurrent melanoma. The patient was described as either very conscientious, or very unconscientious. We asked participants to rate reminders inspired by Cialdini's 6 principles of persuasion for their suitability for the patient. Participants then chose their favourite reminder and an alternative reminder to send if that one failed. We found that conscientiousness had an effect on both the ratings of reminder types and the most preferred reminders selected by participants.

Keywords: Personalised reminders, personality, persuasion, eHealth

1 Introduction

Melanoma (skin cancer) is one of the most common cancers in 15-34 year olds. More than 1/3 of cases occur in people under 55 and, in the UK, it kills over 2,000 people every year [1]. The risk of malignant melanoma is between 8-15 times greater in people who have been diagnosed with a previous melanoma [2] and early detection of these recurrences is a critical goal of follow-up programmes [28]. For this reason it has been proposed that patients treated for cutaneous melanoma perform Total Skin Self-examinations (TSSEs) at frequent intervals [4]. Patients treated for cutaneous melanoma who detected their own recurrences have up to a 63% reduction in mortality [9, 20]. However, even if patients are taught to self-check often, it is likely that their self-checking will decrease over time without an intervention to sustain their behaviour [16, 19]. There is extensive evidence to suggest that mobile telephone and internet interventions can help promote health behaviour change (e.g. [13, 34, 30]), and evidence to suggest that apps (i.e. mobile or tablet applications) can be used to support a sustained health self-management strategy [35].

With this in mind, the ASICA (Achieving Self-directed Integrated Cancer Aftercare) Skin-Checker app was developed at the University of Aberdeen in 2013. The app is part of an intervention that aims to remove barriers between patients treated for melanoma and specialists in dermatology by enabling remote screening and diagnosis of skin changes. One goal was to ensure that patients complete TSSEs regularly (at least once per month). In a six month pilot study, patients were provided with a tablet with the skin checker app. The same reminder was sent by a member of the team monthly to all patients. We found that the reminders were generally effective, but not for all 20 patients. Accordingly, we decided to investigate how reminders could be personalised. It is likely that personality plays a role in a patient's response to a reminder (along with other relevant factors such as their affective state, daily schedules, etc.), and as personality is relatively stable in adults, it seems a relevant characteristic to consider for the personalization of reminders.

Personality can be measured using many methods, however, the Five-Factor model [14] from trait theory is one of the most popular and reliably validated constructs in use by psychologists. This model describes five personality dimensions: Agreeableness (I), Extraversion (II), Conscientiousness (III), Neuroticism (IV) and Openness to Experience (V). In this paper, we focus on Conscientiousness which describes how meticulous and hard-working an individual is, because this might affect their motivation to perform skin checks. We describe a study where we asked participants to rate twelve different types of reminder for their suitability, based on the conscientiousness of the patient. The results from this study will provide an indication of how reminders could be personalised by the ASICA skin checker app in the future.

2 Related Work

Experts in persuasion have proposed many different sets of strategies (from 6 up to over 100 persuasive strategies per set) that can be used to motivate certain behaviours [22]. In this paper we make use of Cialdini's 6 principles of persuasion [8] (shown in Table 1), as they have been used in multiple contexts including reminders [22]. Cialdini's persuasive principles [8] have been used in reminders for clinic appointments [33] and interaction with an activity monitor app [22].

An effective way to persuade people to interact with a system is to provide reminders [12]. Arguably, in the health domain, reminders should be even more potent, as patients are already motivated by the possible threat to their well-being. Health reminders have been researched for several decades. In 1991, [29] found that computer-generated reminders effectively improve adherence to preventative health services. This has been found in multiple domains - for example, using text message reminders in HIV patients [11]; for malaria management [36]; attending healthcare appointments [17] and using mobile notifications to increase well-being logging on an app [3].

Personalisation in reminders is however a relatively new field. [26] identified the need for the personalisation of reminder systems, beyond adaptation to scheduling preferences. Some research has been done on personalising reminders, e.g. adapting to the user's location and movement when providing medication reminders [23]; adapting affect in hand washing reminders for pa-

Table 1. Cialdini's six principles of persuasion [7]. The alternative terminology in brackets is used in this paper and is taken from [22].

Principle	Description
Liking	"People like those who like them." If a request is made by someone we like, we are more likely to say yes.
Reciprocity	"People repay in kind." People are more likely to do something for someone they feel they owe a favour.
Social Proof (Consensus [22])	"People follow the lead of similar others." People will do the same as other people who are similar to them.
Commitment (and Consistency [22])	"People align with their clear commitments." People will do something if they have committed to it. Also, they will act consistently with previous behaviour.
Authority	"People defer to experts." If a doctor advises you to take a medication, you are likely to comply.
Scarcity	"People want more of what they can have less of." People will take the opportunity to do something that they can't leave until later.

tients with Alzheimers Disease [24]; and tailoring mammography reminders to personal risk and the patient's personal barriers to having a mammogram [25].

There has also been research into the link between personality and the result of reminders in the healthcare domain, e.g [18] found that conscientious people would likely be the most successful at achieving their health objectives, and persuasive categories with a social aspect were likely to be the most successful for conscientious people. Patients low in conscientiousness typically have lower adherence to treatments [5, 6]. Therefore, it is likely that patients who are low in conscientiousness would require different types of reminders, and perhaps more frequently, than those patients who are normally highly conscientious.

3 Study Design

This study investigates which types of reminder are best for patients with different levels of conscientiousness. There were two parts to the study. The first part asked participants to rate the reminders for their suitability for "John", a fictional patient, who would either be described as having high or low conscientiousness. The second part asked participants to pick the best reminder to send. Subsequently, participants were asked how long they would wait before sending a second reminder if the first one failed, and then asked to pick a second reminder to send.

3.1 Participants

The study was administered as an online questionnaire on Amazon's Mechanical Turk [27]. Mechanical Turk allows the creators of tasks (*requesters*) to approve or reject completed work before payment. As a further check, we included a Cloze Test [32] for English fluency to ensure that workers possessed enough literacy skills to understand the language based nature of the task. Participants had to have an acceptance rate of 90%, be based in the United States and pass the fluency test in order to be eligible for the study. There were 68 participants (50% female, 50% male; 24% aged 18-25, 50% aged 26-40, 35% aged 41-65, 1% over 65) with a random allocation for conscientiousness (30 low, 38 high).

3.2 Materials

Table 2. Stories used in the study to convey high and low conscientiousness

high	low
John is always prepared. He gets tasks done right away, paying attention to detail. He makes plans and sticks to them and carries them out. He completes tasks successfully, doing things according to a plan. He is exacting in his work; he finishes what he starts. John is quite a nice person, tends to enjoy talking with people, and quite likes exploring new ideas.	John procrastinates and wastes his time. He finds it difficult to get down to work. He does just enough work to get by and often doesnt see things through, leaving them unfinished. He shirks his duties and messes things up. He doesnt put his mind on the task at hand and needs a push to get started. John tends to enjoy talking with people.

This experiment conveys the patient's personality using short stories previously validated for describing low or high conscientiousness [10]. Originally the stories were adapted from the NEO-IPIP 20-item scales [15] by combining the phrases into sentences to form a short story, with the addition of a very common male name, John, shown in Table 2.

12 persuasive reminders were developed depicting Cialdini's six persuasion categories [8], two for each category. These were generated with a panel of experts in eHealth in a brainstorming session, and are shown in Table 3.

3.3 Experimental design

The independent variables are the conscientiousness of the patient "John" (low or high, between-subjects), and the persuasive reminder (12 reminders, within-subjects).

The dependent variables are: Suitability; the most preferred ('best') reminder to send first; the best reminder to send second; and the length of time between the two reminders. Suitability was based on the average rating of each reminder of four measures: effectiveness, helpfulness, appropriateness and sensitivity developed by [21]. These have been found to be internally consistent and to contribute to a single factor in a Principal Component Analysis [31].

Table 3. Reminder types and examples used in this study.

Reminder Type	Reminder Text
Liking (LIK)	Your friends would feel better knowing that you are OK. Please check your skin now.
	Dear John, I would appreciate it if you performed your monthly skin check so I don't need to worry about you as much. Love, your daughter, Mary.
Reciprocity (REC)	The Skin Checker iPad was provided to you to help you check your skin. Please check your skin now.
	We would love to receive confirmation that you have checked your skin. Please check your skin now.
Consensus & Social Proof (CON)	90% of people with the Skin Checker iPad have already performed their skin check this month. Please check your skin now.
	Thousands of people are actively checking their skin each month. Join them - please check your skin now.
Commitment & Consistency (COM)	You have checked your skin frequently in the past. Please check your skin now.
	When you decided to participate, you agreed that checking your skin monthly is a good idea. Please check your skin now.
Authority (AUT)	Doctors recommend that you check your skin at least once a month as health outcomes are better if you do. Please check your skin now.
	According to experts, checking your skin regularly is an effective way of identifying recurrent skin cancer. Please check your skin now.
Scarcity (SCA)	This is your last opportunity for your monthly skin check. Do not miss out - please check your skin now.
	If a recurrent skin cancer gets detected quickly, health outcomes are much better. Please check your skin now.

3.4 Procedure

The study began by asking participants to complete the English fluency test. If they passed, participants were asked to select their gender and age from a range (both fields were optional). On the next screen, the participants were shown a short explanation of why skin checking is important, and the story about "John", conveying high or low conscientiousness (see Figure 1). Participants were told that John had not performed his skin check yet this month, and that the app needed to send an automated reminder. Next, they rated each of the 12 reminders in turn for their suitability for 'John' using the 4 scales (see Figure 1).

Subsequently, participants were asked to select the reminder that they felt was best for John. The information about the importance of skin checking and John's personality were repeated to remind the participants (shown in Figure 2). They were then asked how long they would wait before sending a second reminder if the first one failed to provoke John to perform his skin check (from 1-30 days, or 'longer'). Finally, they were asked to pick the reminder that they would send as the second reminder. Participants could choose to send the same reminder again if they wished.

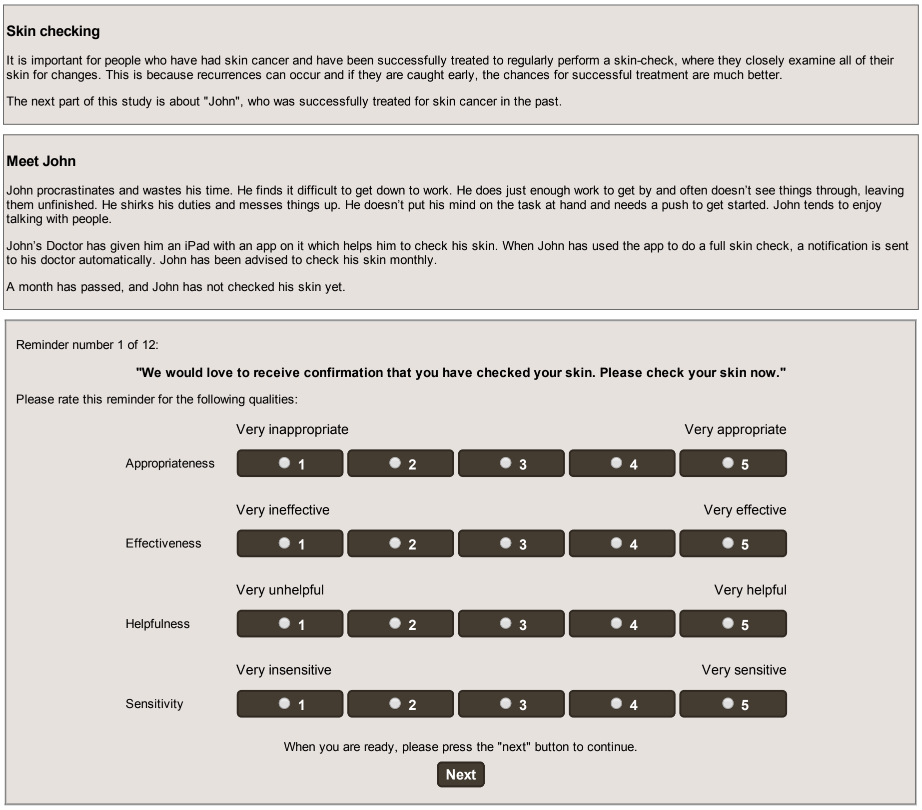

Fig. 1. Screenshot of the rating part of the study

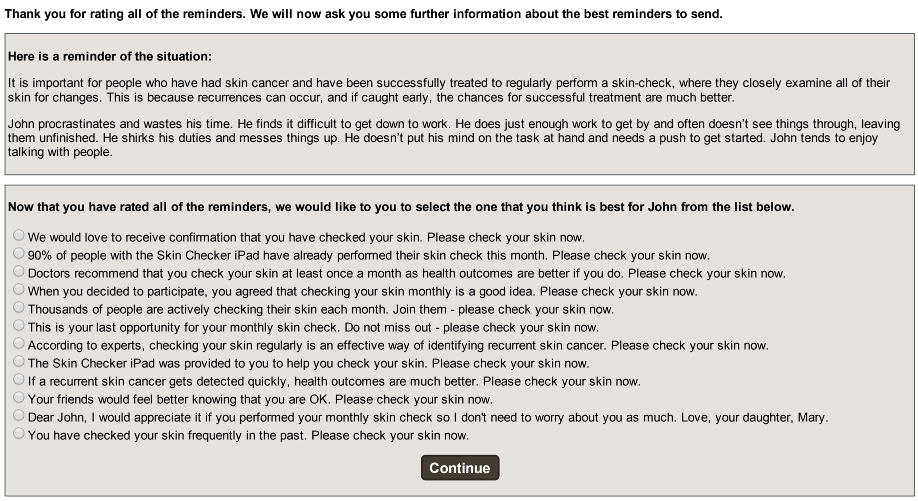

Fig. 2. Screenshot of the best reminder selection part of the study

3.5 Hypotheses

Given the exploratory nature of this study, the hypotheses are open-ended with two-sided comparisons between levels of concientiousness.

- H1: People will rate different reminder types differently overall (some may be better than others).
  - H1a: People will rate the reminder types differently between levels of conscientiousness.
- H2: There will be a difference in the best first reminder type between levels of conscientiousness.
- H3: The second reminder type will differ from the first reminder type.
  - H3a: The second reminder type will differ between levels of conscientiousness.
- H4: The length of time between reminders will vary between levels of conscientiousness.

4 Results

4.1 Analysis of Ratings

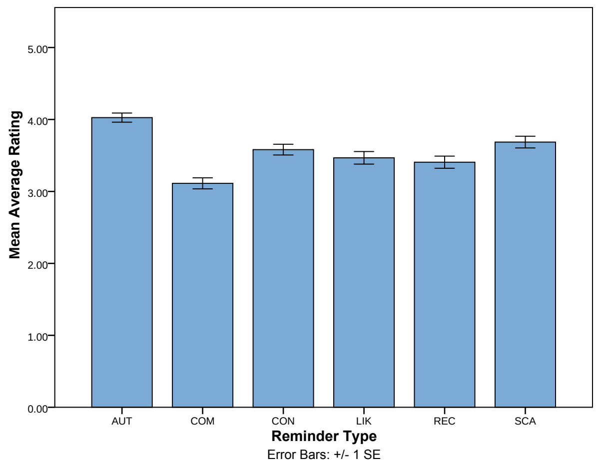

Fig. 3. Graph of Overall Reminder Type Average Rating

Figure 3 shows the overall average rating for each of the reminder types. To investigate if these differences were significant, and to explore the differences for conscientiousness trait level, we performed a 6×2 2-way ANOVA of reminder type × trait level on average rating. Confirming hypothesis H1, there was a significant overall effect of reminder type ($F(5, 804) = 14.50$, $p < 0.01$), and the interaction of reminder type × trait level ($F(5, 804) = 2.54$, $p < 0.05$), supporting

H1a. Pairwise comparisons of Reminder Type revealed 3 homogeneous subsets. Authority was the best, followed by the subset containing Scarcity, Consensus, Likability & Reciprocity. The final subset of Reciprocity and Commitment and Consistency. These can be seen in Table 4.

To investigate the interaction effect, pairwise comparisons (Bonferonni corrected) were performed on Reminder Type × Trait Level. There was a significant effect for Liking - this was rated significantly higher for the low trait level. There were also significant differences in the highest rated reminders for each trait level (m=4.10 vs 3.74) - shown in Table 4 and Figure 4.

Table 4. Homogeneous Subsets for the post-hoc tests of Reminder Type alone and Reminder Type × Trait Level on Average Rating.

Effect of Reminder Type		Effect of trait level x Reminder Type			
		High		Low	
Rem Types in Subset	mean	Rem Types in subset	mean	Rem Types in subset	mean
AUT	4.03	AUT	4.10	AUT, LIK, SCA, CON	3.74
SCA, CON, LIK, REC	3.53	CON, SCA, REC, LIK	3.47	CON, REC, COM	3.38
REC, COM	3.26	REC, LIK, COM	3.22		

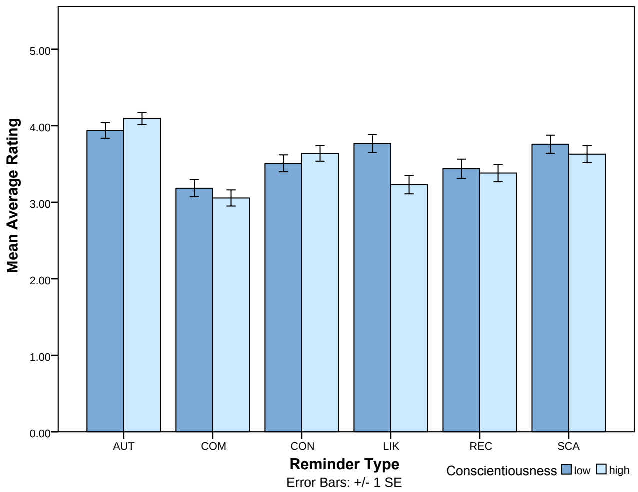

Fig. 4. Graph of Average Rating for each Reminder Type for High and Low Conscientiousness

Table 5. Chi Squared frequencies for Best Reminder Type.

Trait Level	Reminder Type AUT	COM	CON	LIK	REC	SCA	Total
Low	10	1	3	11	2	3	30
High	11	4	0	5	7	11	38
Total	21	5	3	16	9	14	68

4.2 Analysis of Best Reminder

In the second part of the experiment, we asked participants to pick the best reminder to send to John out of all twelve reminders. To analyse this, we performed a Chi-squared test of trait level × Best Reminder Type. This was significant at $\chi^2(5) = 13.70, p < 0.05$, supporting hypothesis H2. Table 5 shows the frequency of each Reminder Type selected for each trait level. For low conscientiousness, participants most commonly selected the AUT and LIK reminders, while for high conscientiousness, participants selected AUT and SCA.

After selecting their best reminder, participants were asked to choose a second reminder to send if their first reminder failed. A Chi-squared test of trait level × Second Reminder Type was not significant at $\chi^2(5) = 3.01, p > 0.5$, meaning H3a is not supported. We explored this further by counting how many participants chose different Reminder Types for their first and second reminders (*changed reminder*). We performed a binomial test of *changed reminder* with Test Proposition of 0.50. This was significant at $p < 0.01 - 56$ of 68 participants changed their reminder type, supporting H3. This shows that participants preferred a different reminder type for the second reminder if the first failed. We did not identify a predictable pattern for the second choice, in terms of direction or level of conscientiousness.

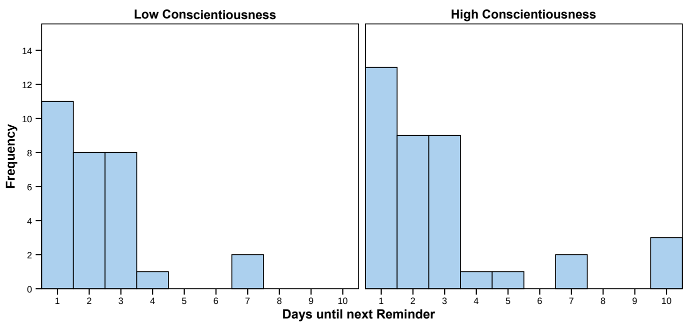

Fig. 5. Frequency Histogram of Number of days to wait before issuing a second reminder for high and low conscientiousness

We also asked participants how long they would wait to send the second reminder (1-30 days or longer). As shown in Figure 5, most participants would wait for 1-3 days (Low trait mean $= 2.30 \pm 1.56$, High trait mean $= 2.92 \pm 2.57$), with a maximum of 10 days in between reminders. A Mann-Whitney test showed no difference for conscientiousness, giving no support for H4.

5 Conclusion

In this paper, we described a study where participants were asked to rate the suitability of different reminders for a fictional patient (with either high or low conscientiousness) to check their skin. We found that the level of conscientiousness of the described patient had a significant effect on both the ratings of the reminders, and the most preferred reminder.

For low conscientiousness, reminders of the 'liking' type (where the reminders appear to come from someone they like) were the most popular, followed closely by reminders of the 'authority' type (where the reminder informs the patient of what doctors recommend). For high conscientiousness, reminders of the authority type were tied with reminders of the 'scarcity' type (reminders that inform the patient that they cannot leave the skin check until later) were the most popular. We found that participants chose a reminder of a different type for a second reminder, but not in a predictable way. Surprisingly, we found no effect of conscientiousness on the time between reminders, with most waiting 1-3 days.

This leads to several interesting questions and directions for future work. Although we found significant differences, reminders of the 'authority' type were universally popular. It is possible that this would be a useful default if the personality of the patient is not identified. Further, the 'liking' type reminders were only marginally more popular than 'authority' for low conscientiousness, and equally as popular as 'scarcity' reminders for high conscientiousness. We still need to establish which type would be best to send. Additionally, we have not found a trend to establish the type of the second reminder if the first fails.

A limitation of our approach is that we only investigated what people think the best reminder would be, and we do not know the effects of these reminders on real patients. If there is a difference between the method preferred by advice givers and which reminders are most effective for patients, this could have a large impact on how advice giving is adapted. We also did not investigate differences based on what participants perceived the application as representing (doctor, friend, etc.). We will work with clinicians to ensure that reminders are appropriate and safe to send to patients. After this, we can begin investigating their effect on patients, and incorporate them into the skin-checker app.

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