Co-creating Digital Services to Promote Active Lifestyle among Older Adults: The Turntable Project

Benedek Szakonyi[1], István Vassányi[1], Angelika Mantur-Vierendeel[2], Daniela Loi[3], Guilherme Correia[4] and Bojan Blažica[5]

[1]*Medical Informatics Research and Development Centre, University of Pannonia, Veszprém, Hungary*
[2]*EuroFIR AISBL, Brussels, Belgium*
[3]*Department of Electrical and Electronic Engineering, University of Cagliari, Cagliari, Italy*
[4]*Laboratory for Automation and Systems, Instituto Pedro Nunes, Coimbra, Portugal*
[5]*Jožef Stefan Institute, Ljubljana, Slovenia*

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Abstract: In this paper findings from co-creation sessions for the Turntable Solution addressing challenges around vitality, activity, and social interactions amongst older adults (over 60 years of age) are reported. Having digital skills is more common, even amongst older adults, and some digital services can be utilized to support healthy ageing. During the co-creation sessions, held in Portugal, Italy, Belgium and Slovenia with five participants each, features of a gardening mobile solution were discussed. In the form of hands-on trials using mock-ups and prototypes, users' lifestyle and general acceptance of mobile technology was surveyed, along with their experience with using the existing and planned features. Results showed that, if accessibility for the target age group (i.e. good user experience) is provided, even less technologically proficient users would try the Turntable App for gardening hints, nutritional guidance, and social interactions.

SCIENCE AND TECHNOLOGY PUBLICATIONS

1 INTRODUCTION

1.1 Background

People tend to become more sedentary and less active as they age, expediting age-related physical and cognitive decline. Maintaining social activity and eating healthily prove increasingly challenging (Amarya et al., 2015). Due to continued decline in muscle mass, strength and power, falls become both more frequent and dangerous. Even everyday tasks seem to be more intimidating than before. The resulting inclination of avoiding risky situations (e.g. by not leaving the house) not just worsens the physical condition, but also causes social isolation (as people stop visiting each other). This decay contributes to the occurrence of chronic diseases, the main causes for healthcare expenditure, making this problem significant not only on an individual level, but on a global level too.

It has been proven that physical activity, good nutrition and social interaction have powerful impacts on both the actual and perceived quality of life in older adults (McReynolds and Rossen, 2004; Shinkai et al., 2016; WHO, 2015). Thus, motivating and supporting them in preserving (or re-adopting) healthy habits is vital (Urtamo et al., 2019). Helping individuals prepare healthy meals to achieve a balanced diet, and assisting them with an active lifestyle through recreational social activities is crucial.

One potential activity addressing physical, cognitive and social aspects all at once is (leisure) gardening (Howarth et al., 2020). There is increasing evidence in recent scientific literature that home and community gardening have numerous physical, health and restoration benefits (Gagliardi and Piccinini, 2019; Soga et al., 2017; Spano et al., 2020). The positive effects include improved self-perception related to aging (Scott et al., 2020), and even the risk of premature death can be lowered (Lêng and Wang, 2016; Wannamethee et al., 2000). As most people like and benefit from spending time in nature, gardening can be used as a motivator in solutions aiming for achieving lifestyle changes, and in turn, healthy living.

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Having basic digital skills is necessary to participate in modern societies, even for older adults (European Commission, 2016), and using digital solutions could prove to be an effective intervention with the right motivation. Thus, providing well-designed applications can even support older adults in developing and maintaining these much-needed skills.

1.2 The Turntable Project

Based on these concepts, the development of a platform able to promote active aging among older adults began in the Turntable AAL project (Turntable, 2019). The project also aims to help older users to prolong their autonomous and independent lives. As a first stage of the project, co-creations sessions were held in four European Member States (Portugal, Italy, Belgium and Slovenia), to investigate gardening habits and needs of target users, and to discuss and test possible features of a gardening-oriented mobile solution. In this paper, findings of these co-creation sessions are reported, along with a brief introduction to the main components and features.

2 RELATED WORK

Already in 2013 a literature review (Wang and MacMillan, 2013) has found that there is ample evidence that gardening (horticultural activities) has positive effects on the lives of older adults, including overall quality of life, health, physical and cognitive ability, and socialization. Since then, other reviews examining the findings of more recent works have also confirmed these positive effects (Gagliardi and Piccinini, 2019; Soga et al., 2017; Spano et al., 2020). The similar results of their reviewed studies, with participants from multiple different countries (China, Hong Kong, Iran, Japan, Netherlands, Norway, South Korea, Taiwan, UK, USA) suggest that the positive effects of gardening can be perceived by older adults regardless of their cultural background. Findings from Australia (Cheng and Pegg, 2016) and Singapore (Sia et al., 2020) also confirm this. This makes gardening a potent tool for addressing the difficulties facing older adults in achieving healthy living, on a global scale.

The number of available assistive technologies for older adults is increasing. There are generic smart living solutions in the form of wearable devices (Akbar et al., 2018), programs for cognitive stimulation (Álvarez-Lombardía et al., 2018), and applications used by home care organisations (Honor Technology Inc., 2020) and more. While useful, these solutions in general focus on only one or two aspects needed to achieve healthy living, not all at once (or at least as much as possible).

As an initial gardening based solution, Lekjaroen et al. introduced a so-called IoT Planting solution that allowed users to monitor soil moisture, temperature, light via an Android application, and found that older adults have the willingness and capacity to use such solutions (Lekjaroen et al., 2017). However, the offered functionality can be considered quite limited, being more like a remote-controlled plant manager instead of aiding users in active gardening. Moreover, it completely lacks the sociality and skill sharing aspect of gardening, which is one of its key domains (Maddali and Lazar, 2020).

In (Wherton et al., 2015), through co-design workshops, 4 main topics were able to be revealed that assisted living applications must consider: raising awareness and sharing knowledge, offering sufficient customisation and adaptation, providing social support, and ensuring effective coordination of care services. Feedback provided by participants trying already existing applications (e.g. fitness applications) can provide both a beneficial foundational basis for newly created solutions and ways for improving already existing ones, allowing applications to be made more suitable for older adults (Harrington et al., 2018). Including older adults in the design process can also find the key barriers towards digital solutions, such as the accessibility of technology, technology literacy, data privacy and management, and the need itself for having co-design in technology (Wang et al., 2019). Co-design sessions with individuals living with physical or mental health conditions can reveal additional specific needs to be addressed, such as crisis support and advanced emotional support, along with the general need of being informed and motivated (Easton et al., 2019).

With this in mind, the main goal of the Turntable project is to develop a solution covering all important aspects of gardening, by constant inclusion of older adults, in order to provide an effective tool for assisting them in achieving healthy living.

3 DIGITALS SERVICES INCLUDED

In the development phase of the Turntable Solution, five already existing components with thousands of registered users serve as the foundations. These

components are *OPEN, Tomappo, Lifely, IntegrAAL Social Engine* and *MARIA*. The aim is to integrate these into one single solution tailored to provide the necessary features.

The *OPEN* nutrition app serves as a dietary assessment and personalized meal logging and planning tool. It aims to help users to pay more attention to their eating and physical activity habits, as well as providing a basis for planning changes and setting goals.

Tomappo, a web- and mobile application, helps users manage their garden, so they can grow their own vegetables. It guides them through a whole gardening season with daily advice, from preparing the soil and planning where and what to plant (i.e. garden planning) to taking care of the plants themselves. With its seed exchange feature, users are encouraged to connect with other fellow gardeners, to exchange not only seeds or seedlings, but experience too, and it aims facilitate social interaction.

Lifely Agrumino is a gardening device comprising a wireless sensor monitoring temperature, light water reservoir and soil humidity. The device is to be installed in the user's garden, and uses a mobile application to manage it. Apart from providing "raw data", it also allows users to set the type of the plant it is attached to. This helps users in interpreting the measured values (e.g. "the plant needs more sunlight, and much less water", etc.).

The *IntegrAAL Social Engine* (*ISE*), working in the background, is aimed to build a user profile that can monitor user behavioural patterns and detect unusual changes, to trigger an alert or other action when non-conformant trends or events are detected.

MARIA is a region-specific multi-audio device for voice recognition. It allows voice interaction for sensors and services used by users in their own house.

Additional information about the components (with screenshots) can be found in Appendix A0.

The idea behind the integration process is that a single application could be created to combine and exploit the various features of the standalone components. To allow users to do everyday tasks such as designing their garden based on their food preferences (by extracting the information from their dietary logs). Or vice versa, to plan their next meal based on what can be harvested from their garden. To learn or share gardening tips with old or new friends, exchange seeds, request help with chores, etc. All in order to promote and support achieving an active and healthy lifestyle.

4 CO-CREATION SESSIONS

User-oriented co-creation sessions took place in Portugal, Italy, Belgium and Slovenia, each with five participants each. The mean age for the 20 participants (11 female, 9 male) was 67.35 years with standard deviation 5.285. Scenarios (topics to be asked and covered) were divided into three sessions, resulting in a total of 60 sittings. The inclusion criteria were being aged 60 or over, being able to give informed consent and having an interest in gardening activities. I.e. the exclusion criteria were being unable to give consent and/or having any kind of impairments that would interfere with executing the sessions. Ethical approvals needed to execute these sessions were managed and acquired locally in each participating country, as necessary.

The co-creation sessions complied with public health measures related to control of Covid-19 and took place between the end of June and the middle of July 2020. The originally planned multiple group sessions were replaced with one-on-one sittings or remote sessions, where all necessary precautions were adhered to (e.g. social distancing, face coverings, hand washing or sanitizing).

All sessions followed the same structure, where first the project goals and the main components were introduced and users were allowed to ask any questions. This was followed by a pre-session questionnaire, where more general topics were discussed (usually regarding the habits of the participants). In the following task completion part users were asked to test prototypes and mock-ups available on mobile devices (smartphone, tablet) or in some cases, on computers (online sessions). The mock-ups were used to represent the user interfaces, functionality and possible features that might be present in the solution. While users were executing the tasks, investigators present monitored their progress. They assessed user results on a 5+1 point scale (1 – user tried to complete but with no result at all, 5 – perfect solution, 0 – the user did not even try due to reluctance, technical or any other problems) and free text. Finally, a post-session questionnaire was completed where participants were asked to describe and rate their experience (with regard to both conceptual and accessibility aspects). In general, during the pre-session phase open-ended and dichotomous questions were asked (e.g. "What is the main reason you garden?", "Do you use any social network application like Facebook, Twitter, Instagram, etc.?"). In the post-session rating procedure, mostly 5-point Likert scale questions were used (1 being the most negative, 5 the most positive

response). The questionnaires used can be found in Appendices A1, A2 and A3, the tasks (user manuals on what to do) in B1, B2 and B3, respectively.

During the first session, questions related to gardening habits and information technology proficiency were asked prior to task completion. The tasks consisted of testing the standalone *OPEN, Tomappo* and *Lifely* components, in the development status they were in at that time (e.g. logging a meal in the nutrition app, planning a garden, setting up a sensor for a plant). After completing the tasks, users were asked to rate their experience with each standalone. They were also asked to express any ideas about possible features of *ISE* and *MARIA* (e.g. "Would you like to have a function that alerts your friends if something was unusual in your activity?", "Do you find voice more useful than buttons to manage Turntable?").

The second session explored social interactions and activity. Users were asked about their habits related to contacting family and friends, such as frequency (e.g. once a week) and means of making contact (e.g. via mobile, landline or online calls/messages). During the testing phase, a mock-up representing the so-called *Dashboard* component was used. This component will be used for social interaction and managing other application users (e.g. adding friends, messaging others), and editing personal settings (e.g. what personal information is visible to whom, which components the users allow to access their data). Similarly to the first session, users were then asked to rate their experience with the features tested.

The third session focused on future *Integrated features* of the platform and its possibilities. Users were asked how they imagined using such a system, what information should be shared amongst the components, and how they should work together. During the testing phase, possible workflows were tested and rated by the users (e.g. importing sensor data into the garden planner, having *OPEN* plan a meal based on the status and content of the garden managed in *Tomappo*, etc.).

Data gathered during the sessions were anonymized locally before being forwarded to the partner doing the data analysis, to maintain the protection of sensitive personal data.

5 DATA ANALYSIS

5.1 Data Preparation and Conversion

The first step in processing the data provided was quality assessment. As for any data collection process, some inaccurate, incorrect and missing items were found. Reasons behind these were human error (interviewer mistakes), technical and/or coding anomalies (e.g. the number of assists needed for a user to complete the task is set to zero while the text report clearly states that two interventions were needed). Where possible, such mistakes were corrected, and missing values were replaced when related answers could be used as a reference.

As another basic step for data analysis, to obtain meaningful results, the key numerical and textual

Table 1: The nominal variables defined for user-level statistics.

Variable name	Multiplicity	No. of classes	Note
Age	For each user	2	Younger, older
Gender	For each user	2	Male, Female
Country	For each user	4	Country no. 1, 2,3 and 4
Completion time	For each user	3	Avg. time needed to complete a session: low, middle, high.
Task scores	For each user in each task	5	Score given by the manager: 1, 2, 3, 4, or 5.
Component scores	For each user, avg. for each app	5	Component-wise average of task scores: 1, 2, 3, 4, or 5.
User score	For each user	5	User-wise average of task scores: 1, 2, 3, 4, or 5.
Task assists*	For each user in each task	4	Number of occasions when assistance was requested by the user: 0, 1, 2 or 3.

Table 2: The global values of the satisfaction indices related to tested components.

	Component					Dashboard	Integrated features	Overall
	Open	Tomappo	Lifely	ISE	Maria			
Average	3,2	4,13	4,08	2,6	3,47	4,15	3,83	3,58
Standard deviation	0,73	0,51	0,63	1,44	0,97	0,51	0,48	0,48

variables were transformed (categorized) into nominal variables wherever possible, based on a priori classes or actual data ranges and distributions. User- and task-level descriptors and satisfaction indices were also introduced. Free text answers were processed one-by-one and conclusions were drawn based on majority opinions.

A total of eight variables were defined as user-level descriptors (shown in Table 1). These were gender, age, scoring parameters and average completion time. For the age, two categories were defined, the first including those above the average age (68 years) and the second all other users. Scoring parameters were divided into three groups: the task scores given by investigators (rating user's success in completing a given task); the component scores (component-wise average of task scores); and the user scores (user-wise average of task scores). As an additional variable, "task assists" was added, i.e. the number of occasions when assistance was requested by the user for given a task (values were derived manually using text logs of the tasks).

The average task completion time for a user, calculated from the time needed for a user to complete all sessions, shows how much time the user needed to complete one session. Based on these average values, three classes were defined: LOW (0-17 minutes), MIDDLE (18-26 minutes) and HIGH (more than 26 minutes).

For task-level descriptive statistics, a total of nine variables were defined. These are the minimum, maximum and average values for completion time, number of assists needed, and scores given for each task.

Satisfaction indices were computed based on specific post-session answers to provide insights into the overall impressions of users about the features introduced. Indices range from 1 (did not like at all) to 5 (really liked). A total of 8 assessment categories/indices have been defined: 5 indices for the five main components, one index for the *Dashboard* mock-up, one for the *Integrated features* mock-up, and one as an *Overall* rating index (i.e. the weighted average of the other 7 indices). These indices were calculated for each user, and their average values, which are shown in Table 2. The questions they were based on and the user-wise indices and can be found in Appendices C1 and C2.

5.2 Results

Attribute rankings were generated based on predictor (explanatory) nominal variables age, gender, country, completion time and component score. Class labels were the seven satisfaction indices used (without *Overall*). The source table used for this analysis can be found in Appendix C2.

The ranked attributes (shown in Table 3) specify the information content of predictor variables with respect to the selected class variable, in the order of importance. An attribute with higher value means that it has more influence over how the given item is perceived than others.

For example, *Country: 0.6250* as the highest value in the *OPEN* satisfaction list means that the *country* attribute of users (i.e. their nationality / where they live) had most influence on user satisfaction with regard to *OPEN*, and it had about twice the influence as the *Score* attribute with the weight (information content) 0.28.

Based on task-level statistics, session I proved to be the most demanding in terms of completion time and number of assists. It was also shown that, except for *OPEN*, components used were considered satisfactory regarding usability. The exact task-wise values computed are shown in Appendix C3. All categorized answers for the questions can be found in Appendix C4.

Based on the free text answers given, the following conclusions were formed:

1. Overall acceptance of Turntable was highly positive. Most users would be glad to use the solution once available (this is also shown by the high average scores of the post-session answers).
2. With only a few exceptions, users were able to master the mobile technology presented in the form of working prototypes and mock-up applications.
3. Most users would avoid using individual components, as they preferred a single integrated solution.
4. A significant number of the users did not use social media, and would prefer not to create such. This means that the *Dashboard* app's social functionality must be implemented to provide related features.
5. Many users missed a health profile and related functions, even if Turntable is primarily aimed at healthy users (as it offers no condition specific recommendations or features).
6. Users had more interest in *Tomappo* and *Lifely*. *OPEN* should be coupled more tightly to those.
7. Users stated that the *Dashboard* app should be integrated in the other component apps (if possible).
8. *ISE* must be better positioned and explained, as users found behaviour assessment and profiling intrusive and unwarranted.
9. User proposals for additional functionalities should be considered carefully during fine-tuning.

10. Regarding usability, the user interface of *OPEN* should be redesigned, and some minor changes might prove beneficial for other components too. Almost all users preferred using checkboxes to toggle switches as they find the latter perplexing. While text and button sizes were adequate, means for personalizing them should be provided. Tooltips or other support features should also be available to support those with lower proficiencies.

6 DISCUSSION

In accordance with the initial concepts of the Turntable project, it was found that users consider the gardening oriented approach quite interesting, and use of information technology solutions to be accessible. This confirms that Turntable has the potential to be an effective way for assisting aging people in (re)adopting and maintaining healthy habits.

The number of 20 participating users (five from each country) can be considered to be a low sample count, and is not enough to offer statistically significant conclusions nor statements. In practice, however, it can serve as an adequate starting point, and observations made only on the trend level still provide useful information (Nielsen, 2000).

Satisfaction indices calculated verified that users were positive about most of the components tested. *Tomappo, Lifely*, the *Dashboard* and the *Integrated features* mock-ups received the best remarks and were liked the most. Users showed less interest in *OPEN*, but this might be related to user interface reasons (this is detailed later in this paragraph) rather than its concept. Low satisfaction indices for *ISE* comply with remarks made in free text answers, i.e. most users found its features and functionality to be too intrusive. It must be noted, however, that in Portugal, where *ISE* was developed, users gave highly positive remarks, which might be related to its presentation or social factors. In general, however, positioning and introduction of this component must be better matched with users' needs. Providing better transparency about how it works and what are its purposes is vital. Doing this correctly is important as the profiling aims solely to aid users, without any purpose for gaining financial profit (e.g. by targeted marketing). Regarding *MARIA*, some discrepancies appeared between the indices calculated and other answers given. Most users stated that they preferred voice control over touch screens. However, when asked specifically about using the main features of the components by voice, and how useful that is, they gave low(er) ratings. Moreover, when asked to give hints about what kind of questions they would ask the voice assistant, no meaningful answers were offered. This might indicate that these questions were not formulated correctly, or that the functionality of the component was not explained adequately.

The country attribute was found to be the most important in how users perceived components and which ones they preferred. While this could be interpreted as a country- or culture-specific difference, alternatively, results might be affected by translation and/ or subtle differences in how sessions were run. Also, some missing or inaccurate answers could not be substituted, reducing the accuracy of analysis in some cases. Nevertheless, if the country attribute is disregarded, completion time has the most notable effect on user satisfaction. This means that those needing more time to complete tasks tend to like them less – which confirms the generally accepted perception that users do not like gruelling chores.

As anticipated, usability and user experience had an immense impact on how users perceived applications. The best example for this is that *OPEN* received the most criticism and was the least desirable service with a graphical user interface (GUI). The reason behind is that only this component had a GUI not following widespread and generally accepted design principles such as the ones given in Flat Design (2.0) or Material Design. Unsurprisingly, even self-declared low proficiency users could complete tasks easily when components with interfaces adhering these design principles were used. Thus, for the solution to be effective, providing good user experience is crucial.

Table 3: Satisfaction index-wise ranked attributes values.

Ranked attribute	Component							
	OPEN	Tomappo	Lifely	ISE	MARIA	Dashboard	Integrated features	Overall
Age	0.1050	0.2052	0.2350	0.3170	0.1684	0.1972	0.0680	0.2420
Gender	0.2310	0.0529	0.2770	0.1500	0.1041	0.2278	0.2057	0.2090
Country	0.6250	0.3697	0.5910	1.6250	1.0735	0.4596	0.3079	0.6110
Completion time	0.5190	0.2560	0.1720	0.7250	0.3498	0.0591	0.1565	0.4170
Score	0.3810	0.2456	0.2800	0.3530	0.1395	0.1972	0.2461	0.4070

One interesting observation regarding GUIs was that the majority of the testers (17 out of 20) had problems understanding and using toggle switches, preferring checkboxes instead. This is surprising as most users reported being familiar with apps that use toggle switches, and as more and more software use these elements in general. One possible explanation is that these elements appear mostly in the settings part of applications (but there they are used extensively) – features that most users seem to ignore. Accepting this as it is, however, is not appropriate from neither a legal nor an ethical perspective, especially when personal data are involved. This means that all application developer should take this into consideration when user interfaces are created, to develop them to be accessible in fact.

7 CONCLUSION AND FUTURE WORK

Results from the co-creation sessions showed that users found the concepts, purpose and available (initial) versions of the Turntable Solution interesting and potentially beneficial. The insights gained from their ideas and expectations allow for further improvements of existing features and serve as a guide for the implementation of future functionalities.

An additional testing phase is being planned to validate whether beneficial effects on quality of life are measurable for users who engage with Turntable for a longer time period. To obtain statistically significant results, complete data of at least 50 users from each country is anticipated (which means that about twice as many, 100 participants should be included, due to possible quitters). If this hypothesis is confirmed, it would mean the solution is indeed capable of supporting older adults in achieving successful aging.

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APPENDIX

Additional material, due to page limits, is available at http://rebrand.ly/submisAppndx_ACT4AWE2021.