Chapter

Usability Recommendations for Designers of Smartphone Applications for Older Adults: An Empirical Study

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Abstract

Older adults (OAs) are a growing and dominant part of the global population, with specific communication and usability needs. Information technology, such as smartphone applications, has the potential to help OAs stay connected, yet some designs do not appeal to this group of users. Current recommendations for the design of usable smartphone applications for OAs can be hard to apply and difficult to interpret. As a result, designers of smartphone applications do not have a clear set of recommendations for the design of smartphones for OAs. In this paper we elicit and transform usability trends and difficulties experienced directly by tech-savvy[1] OA users, into an organised set of recommendations. To do this we conducted an empirical study in four stages: (1) *Data extraction.* Digital context is extracted through conducting Think Aloud sessions with tech-savvy OAs (aged 50+); (2) *Data mapping*. Digital content extractions are mapped against 7 key aspects of usability; (3) *Validation*. Validated mappings through inter-rater reliability testing; (4) *Presentation*. Presented resultant recommendations as design patterns. Applying this method resulted in a set of 131 Usability recommendations with some overlap, transformed into a set of 14 design patterns that can act as a starting point for designers and developers of smartphone applications for OAs, and for pedagogy. Three of these patterns are presented in this study.

Keywords: Usability, Information Technology, Smartphone Applications, Software development, Recommendations, Design Patterns, Older Adults

1. Introduction

Across the globe, the proportion of older adults (OAs) is on the rise [1]. For example, Ireland's OA population increased by 19% in recent years [2]. This situation reflects that in most countries lifestyles have improved, however it does go hand in hand with impacting long-term care and welfare systems [3]. There are various definitions for what constitutes an older adult, and of course there is not a

[1] **Tech-savvy OAs** - OAs who spend more than 8 hours during a week on their mobile phone and use basic functionality as well as mobile applications and wearables. Examples of mobile applications are WhatsApp, Podcast, Headspace, and wearables such as Fitbit.

particular day in which someone moves from being a younger or middle aged adult to an older adult [4]. For the purpose of our study, however, we define OAs as someone who has reached the age of 50, basing our work on established studies e.g. TILDA[2] [5]. Additional qualifications to be included in our study is that the OA is already motivated to use smartphone technology.

The quality of life of OAs can be considerably improved through active social engagement, improved healthcare, and increased mobility through access to transportation [6]. Technology offers a ray of hope in providing access to these opportunities. But, the adoption rate of technology by OAs appears low [7]. Technology comes in many forms, to include public displays, virtual reality, websites and smartphone applications. As numerous technologies may have a different set of design requirements, our focus will be on smartphone applications only – smartphones are frequently used by OAs [8]. Furthermore, smartphone applications can help to provide access to digital services with no or low-cost [9].

To develop smartphone applications for OAs, designers must recognise the individual needs of this group such as the varying degrees of physical and cognitive decline [10, 11] and privacy concerns [12]. These specific features are not always considered, and a recent study advocates for better recommendations for age-friendly design of user interfaces on mobile phones [13]. A tried and tested way to elicit such specific recommendations is through participatory or human-centred development [14]; shown as a successful way to develop such guidelines [15] and checklists [16, 17], and for interface design of mobile phones for older adults [18]. However, existing guidelines deal with visual and haptic issues and omit many elements associated with the textual interface. Additional shortcomings of these guidelines are that they are rarely tested [15, 18] and lack extensive empirical validation [19]. Also, the guidelines for designing applications for OAs are not presented to designers and developers in an accessible format [20] and are sometimes merged in the discussion section of the papers e.g., [19, 21, 22]. A recent literature review summed up existing guidelines as piecemeal, lacking in characterisation, not easily actionable, and rarely validated [23]. In summary, the conflicting and disparate advice offered, results in arguably unreliable and hard to follow guidelines.

In this chapter, we focus particularly on the Usability recommendations for smartphone applications, for designing products to be effective, efficient, and satisfying. Usability includes user experience design. In our context, usability covers general aspects that impact everyone and do not dis-proportionally impact people with disabilities [24]. Furthermore, we look for better ways to disseminate our guidelines by transferring the recommendations into a set of patterns. This form of reporting is shown to lead to increased adoption of guidelines by practitioners [23, 25, 26].

We respond to the call to create a design patterns library aimed towards practitioners and pedagogical settings [20].

In summary, a few attempts have been made by the research community to produce guidelines or checklists, but for the most part they have not been validated or applied in practice [27]. Also, their implicit nature lacks explanation on how to apply these recommendations. Henceforth, this research fills this void by providing a structured and validated set of design patterns to support the design and development of usable smartphone applications for tech-savvy OAs. Our study aims to answer:

Research Question - What do tech-savvy older adults expect from smartphone applications?

[2] The Irish Longitudinal Study on Ageing, conducted at Trinity College: Dublin - URL: https://tilda.tcd.ie/

The next sections of this study are organised as follows. Section 2 describes the four different stages within the Research Methods and how the collected data was analysed. After that, Section 3 presents the results of execution of these stages and Section 4 depicts the transformation of findings i.e. recommendations in the form of design patterns. Section 5 then highlights how some of the threats to validity were catered for whilst conducting this research. Section 6 concludes this study and points towards potential future directions.

2. Methodology

2.1 Data collection methods

Data collection was conducted in two phases, firstly through Think Aloud sessions, followed by Digital Content extraction.

2.1.1 Think aloud protocol

The primary objective of the first phase i.e., Think Aloud (TA) sessions, was to understand the expectations of tech-savvy older adults regarding a set of smartphone applications. Think Aloud Protocol is a tool borrowed from cognitive science [28]. There are numerous variations of this method for Usability evaluation of technology. However, there is no consensus about the exact procedure to perform these sessions [29, 30]. These are usually performed by asking individuals to think out loud whilst interacting with the system [31]. If the user stops talking for long, then a gentle reminder is used to prompt him/her to start conversing again. The other option is to have a pair of users verbalise their thoughts retrospectively rather than concurrently [32]. For this study, the Think Aloud Process of [33] was used for conducting the sessions (as described below), because it is well established, widely used, and helps in Usability testing as shown in **Figure 1**. OAs in our study were given the liberty to choose two smartphone applications (already installed on their smartphones), use them, and highlight the good and bad things about them. Author 1 observed each OA and took field notes as they navigated through their chosen apps.

Instructions and Tasks - Older adults were instructed about how to interact with their mobile phones and given an explanation of how to think out loud. In addition, a pre-specified set of tasks was given to them in advance.

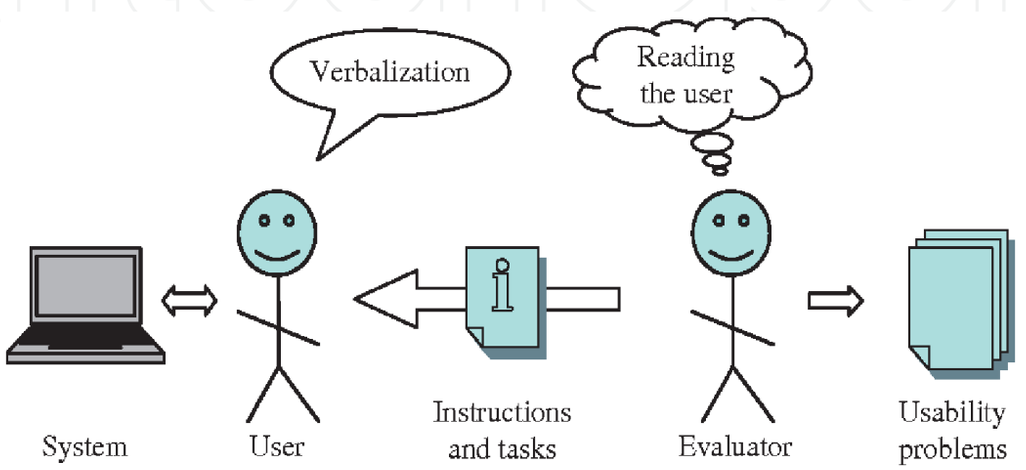

Figure 1.
Think aloud process [33].

This means that they had to use applications of their own choice and use one or two key features on them.

Verbalisation - During the process of performing the tasks, participants verbalised their thoughts. If they stopped talking, a gentle nudge was used to prompt them, e.g., through asking a question or just saying 'keep talking'.

Reading the User - Older adults' behaviour was observed to extract and describe the Usability problems. For example, how do they navigate the app? What elates or annoys them? What causes deadlock?

Relationship between User and the Evaluator - The researcher attempted to create an environment in which older adults felt comfortable to make both positive and negative comments. To achieve this, the venue chosen was a Cafe situated in the University of Limerick.

2.1.2 Digital content extraction

The second phase to further understand tech-savvy OA's user-interface needs was digital content extraction that comprised two sub-phases:

1. **Ageing Forums** - In order to strengthen the findings about the needs and wants of older adults who are tech-savvy, data from online ageing forums was collected. The recent trend of qualitative Internet research has resulted in a set of guidelines to effectively conduct such studies e.g., [34] and we have used the guidelines of [35] due to their practical nature. Two online forums for the 50+ age group were chosen, Seniorsonly[3] and SeniorForums[4]. The rationale for choosing these two forums was that they were both established forums (active since 2020), aimed at over-50 year olds, with active question and answer sessions and have a total of 4,500 subscribers. Recent conversations were observed. Participation in these groups as part of this from research was done in a non-invasive fashion.

2. **Mainstream Apps for Older Adults** - We investigated apps for older adults which were available on the Apple iTunes and Google Play store, as these two platforms share a combined market distribution of 99% of worldwide smartphone platforms as of December 2020[5]. We extracted the description and qualitative feedback pertaining to these apps. The objective of this data collection was to identify what older adults like and dislike and any changes they expect in the apps developed for them. The selection process of the applications for older adults and associated details is provided in [36]. Initially, the title, description and URL of the apps was extracted. Author 1 installed these apps on both an iPhone 6 and an Android phone and extracted the reviews, comments, and responses available on the play stores. The apps were then used for 10–15 minutes approximately to finally extract the key aspects, functional and non-functional, of the app. The qualitative data was accumulated and merged into an excel sheet.

2.1.3 Map recommendations

We coded and classified the recommendations into a structured vocabulary using a deductive approach. The recommendations were mapped into seven

[3] http://www.seniorsonly.club/

[4] https://www.seniorforums.com/

[5] https://gs.statcounter.com/os-market-share/mobile/worldwide

categories provided in Peter Morville's [37]. Usability honeycomb as shown in **Figure 2**. Usability is about designing products to be effective, efficient, and satisfying. Usability includes user experience design. This may include general aspects that impact everyone and do not dis-proportionally impact people with disabilities. The caveat here is that usability practice and research often does not sufficiently address the needs of people with disabilities [24].

We also considered two alternatives to Morville's definition of Usability. Firstly, in 1994, Jakob Nielsen [38] provided 5 attributes that together constitute usability i.e. Learnability, Efficiency, Memorability, Errors and Satisfaction. Then in 2003, Whitney Quesenbery [39] proposed a 5E model to describe usability i.e. Effective, Efficient, Engaging, Error Tolerant and Easy to Learn. Subsequently, in 2004, Peter Morville used a 'honeycomb' to illustrate usability with 7 sub-categories Useful, Usable, Findable, Valuable, Desirable, Accessible, Credible. The reason we choose the latter is that it is the latest and more granular than the former ones i.e. 7 categories compared to 5, and it is well recognised and highly cited.

2.1.4 Validate recommendations using inter-rater reliability

Different coefficients can be used for evaluating the agreement in classification of recommendations between the three raters or inspectors.

Proportion Agreement- A straightforward approach to evaluate the agreement is to consider the proportion of ratings upon which raters agree. This is, however, considered naive as the agreement may have occurred solely by chance. According to [40], using proportion or percentage of agreement tends to produce higher values than other measures of agreement. He discourages the use of proportion agreement, because science is inherently about conservatism rather than liberalism. In addition, the use of the proportion of agreement can be unreliable [41]. Therefore, the use of proportion or percentage agreement was not our choice for an evaluative measure.

S-Coefficient- Another option for evaluation of the agreements was the S-coefficient proposed by [42]. However, he assumes that the agreement by chance is due to raters assigning sub-categories/classes to the recommendations randomly at an equal rate.

Cohen Kappa- An alternative definition for agreement is the raters' tendency to distribute the classifications in a certain way. This seems a reasonable assumption

Figure 2.
User experience honeycomb [37].

a priori, in an inspection context. This is assumed to be the case with Cohen Kappa's coefficient [43]. We chose it because the three researchers, based on their theoretical knowledge of the domain, would be expected to classify the recommendations in a specific way, and given that we have 7 options in which to classify the text snippets from the forums, there was plenty of room for error or to highlight differences. It has been established that a good agreement as measured by Cohen Kappa's coefficient can produce slightly higher reliability results in the case of over seven categories [44]. Moreover, the Kappa coefficient is widely used in social and medical sciences and it has thousands of citations to date [45]. In the medical domain, it has been presented as a measure of agreement in reliability studies [46]. A variant of Kappa called weighted Kappa [47] was also considered, but it is most useful for non-nominal scales and when the relative costs of agreement can be quantified. The analysis of these three options led us to use Cohen's Kappa [48] because it is a robust and useful statistic tool for inter-rater reliability testing.

2.1.5 Transform recommendations to design patterns

Once we identified and developed a consolidated set of recommendations, we structured them into a design pattern format which consisted of sections: Problem, Rationale, Solution, Type, Sub-type, Related Patterns, References/Evidence as shown in [36], which explains each heading and what is included in each section.

Qualitative evidence suggests that design patterns can aid maintenance, but they do not appear to help novice designers learn about design [49]. Also, Bieman particularly observes that: 'there is very little empirical evidence of the claimed benefits of design patterns and other design practices when applied to real development projects' [50]. This implies that simply using patterns does not ensure good design, they should be used appropriately [49]. The initial attempt to develop design patterns was made by Christopher Alexander to document and discuss building architecture design and solutions [51]. Design patterns have become popular among software developers after the publication of "Gang of Four" [52]. It is defined as:

"A pattern is a structured document comprising of set of pre-defined sections; this means that all patterns in a given pattern language have the same general structure, making it easy for readers to find information" [53].

There are subtle differences in the structure of the design patterns used in existing research. This paper will follow the format proposed by [54] as this is also used in numerous studies e.g., [53, 55, 56].

2.2 Data analysis strategy

In qualitative research, the process of data collection, data analysis, and report writing is not always completed in distinct steps; they are often interrelated and occur simultaneously throughout the research process [57]. We used thematic analysis to develop themes that were emphasised during Think Aloud sessions or on the ageing forums. This is a method for identifying, analysing, organising, describing, and reporting themes found within a data set. Bruan et al. 2006 [58] presents a linear, six-phased method for thematic analysis. This involves becoming familiar with the data, generating initial codes, searching for themes, reviewing themes, defining and naming themes and producing the report. It is actually an iterative and reflective process that develops over time and involves a constant moving back and forward between phases. We have adapted the guidelines of [57, 58] to perform analysis of the qualitative data generated during the mixed methods. This was accomplished using Microsoft Excel. The snippets were matched with the theme columns and marked or annotated using zero, one, tick, cross. To facilitate code creation, we used a single

'sentence' as a unit of analysis for extracting and defining the themes. Author 1 developed an initial set of themes which were validated by author 3.

Step 1: Reading- Author 1 browsed through the transcripts verbatim and took notes from first impressions. After that, he re-read the transcripts line by line.

Step 2: Coding- Phrases, sentences, and sections with regard to the importance were labelled. A sentence was considered as important or relevant based on several factors, e.g., if the participant has explicitly said that this aspect is important, whether something new or surprising came up, whether something that had been previously published was discussed, or if something is repeated in several places.

Step 3: Categorising- Analysing the all the codes created, the most important and relevant codes were combined to form a category or a theme. Some trivial codes which had no relevance to the research objectives were ignored. The themes that were generated as a result of this stage were general and abstract.

Step 4: Label and Define the Categories- These high level themes were labelled and developed from the significant codes. These high level themes were the main results of this study which elaborate new knowledge from the perspective of tech-savvy older adults. The definitions of these themes were also outlined.

Step 5: Rectification of Unseen Bias- In order to alleviate any bias in the findings and to increase reliability, Author 1 randomly sent the snippets to author 3 without a theme assigned. The list and definitions of themes was sent separately. Author 3 commented, assigned these snippets to the themes and identified new themes. This resulted in the addition, deletion and modification of several themes. Any unresolved issues were discussed between all authors until a consensus was reached. After the completion of this step, we had a final set of mutually agreed 3 key themes and 24 sub-themes.

3. Results

3.1 Think aloud and digital content extraction

3.1.1 Think aloud protocol

Ten OAs, five female and five male, who had English as their primary language, participated in Think Aloud sessions. All of them had access to basic technology such as landline, internet and smartphones. Their median age was 64.7. Eight were fully or partially retired and two were working professionals. OAs were delighted to talk about the apps they use on a regular basis. For instance, the first participant, a retired Civil Engineer, talked about his experience with SmartTools[6] app. He said that SmartTools is his favourite app because he can perform basic civil engineering tasks using this simple and easy to use interface showing the tools. The tools include ruler, protractor, level, thread, range-finder, compass, metal detector, sound meter, vibrometer, flashlight, magnifier, mirror and unit converter. He was pleased about the real-world metaphor of 'Cupboard' used in this app. Also, he said that the labels used in the app are self-explanatory. On the other hand, he did not like using a budget airline app. He said the initial waiting time, excessive number of advertisements, hectic process to book a flight, small text size, icons without labels, and long and technical terms and conditions make him reluctant to use this app. He stated that this app does not cater for OAs and gave an example of a issue in the form completion section. The salutations, Mr, Mrs, need to be tapped for successful

[6] **Smart Tools:** http://androidboy1.blogspot.com/2015/12/smart-tools-v20.html

submission of the form, but there is no indication to select them. Also, they are represented in dull colours, reducing their importance in the eyes of the user. An array of recommendations given by this participant was collected such as "video based tutorials in the app to enable the user to become familiar with the app". Similarly, the analysis of data collected from other participants helped to generate recommendations.

3.1.2 Digital content extraction

We extracted data in two ways, firstly from online forums in which OAs were engaging with developers and the wider community on issues they were experiencing with their apps (see (A) below), and secondly by testing a sub-set of apps developed especially for OAs (see (B) below).

A. **Ageing Forums** In order to strengthen the findings about the needs and wants of OAs who are tech-savvy, data from two online ageing forums was collected.

   1. **The Seniorsonly**[7] **Club** - run by seniors for seniors. There are eight different sections of this forum on which seniors can post questions, Forum Administration and Notices, Education and Entertainment, Getting it Done, Hot Button Issues, I remember when, On the lighter side, Ourselves and Others, Off topic. In addition, the technology section on this forum was active and recent conversations were observed. Author 1 delved deeply into a subsection of 'Education and Entertainment' called 'Gadgets and Tech talk'. The objective of this section was to discuss seniors' issues related to electronic or mechanical gadgets, equipment, computers or computer software, phones or smart phone applications, electronic reading devices, or anything relating to gadgets and technology. Fifteen threads with a total of 238 posts were included during data collection of this study.

   2. **SeniorForums**[8] - Author 1 also looked into the 'Computers and Phones' section of SeniorForums, another forum for people over 50. Recent conversations in the technology section on this forum were observed. A total of 15 threads related to technology, particularly mobile phones, consisting of 170 posts, were included in this study.

OAs on these forums appear to be well-versed with technology. They would love to use more of the latest technology if it is inexpensive and privacy is ensured. This is in line with our previous research [59]. One of the older adults mentioned on the forum that he would prefer wearables rather than smartphones. Here is an excerpt from his comment:

"When they make them so that the Apple Watch is my cellphone, then I might consider it because carrying my iPhone is never convenient for me. I don't like carrying a phone in my shirt pocket, although having had cancer twice now, I don't suppose that's something I should worry much about, and there's no other convenient place to put it. I keep leaving it on the table at restaurants and have to go back for it. I would wear a watch if I could use it as a phone."

[7] http://www.seniorsonly.club/

[8] https://www.seniorforums.com/

OAs constantly discuss how to ensure privacy whilst using technology on these forums. Here is a solution proposed by a member on the question of ensuring privacy when using websites:

"Being stuck with a fixed, constant ISP number hinders one's privacy quite a bit. A roaming ISP number helps. Using a Proxy service server is useless, as I've found out. If you really want to operate some of your P.C. activities, do it at a public computer place, library, or the like, while setting your PCs security settings at maximum, reject all cookies. Set Temporary Internet Files to store for 0 days, and delete automatically each time you log off. Check them now and then for cookies, anyway. Always use In Private (Internet Explorer) or Incognito (Chrome) to boot."

B. Mainstream Apps for Older Adults.

A total of 32 mainstream apps were evaluated to find recommendations that are making these apps successful and/or unsuccessful. We started by identifying keywords, joining them together to define search strings. An example search string applied to app stores is 'apps for older adults'. Author 1 then searched Android and Apple app stores using the defined search strings. An initial search produced 177 and 18 results for the former and latter (these searches were conducted between May to August of 2019). A scrutiny was performed on these retrieved apps using an agreed inclusion and exclusion criteria [36]. This exercise reduced the number of apps, and we were left with a set of 101 android and 6 iOS apps. As the evaluation of 107 apps would have required a herculean effort, and more time than we had available, we selected a sample of apps from this set. In order to reduce the sampling error and achieve precision, we opted for a stratified sampling method. Hence, these 107 selected apps were carefully reviewed, arranged and classified into 9 different categories. These were Health & Safety, Launcher, Dating, Gaming, Shopping, Entertainment, Communication & Socialisation, Education and Tools. After stratification of the apps, a simple random sampling technique was applied on each of the nine sub groups. An equivalent percentage of 30% was selected from each type of app. This step resulted in a total of 32 finally selected apps, 30 android and 2 iOS based.

3.1.3 Qualitative analysis results

We analysed the qualitative data generated from Think Aloud Protocol and Digital Content Extraction using the strategy explained in Section 2. Likes, dislikes and recommendations for the development of smartphone applications for tech-savvy older adults were extracted.

1. Likes.

Source of Information Older adults really like a feature that serves as a source of information.

"This is a comprehensive app, which gives much information that the elderly need to know, from taking care of their health to advice on how to handle their finances to how to secure their property."

"Every information is available including elder abuse and rights of the elderly."

"It is a user-friendly app to get any sort of information on elders."

Video Tutorials Older adults liked to learn new information or even exercises through video tutorials available within the apps for them. For example, one of the older adults commented:

"Tried a lot of apps, finally landed here, it is a simple and useful app. The best part is the video tutorials".

Support Independent Living In addition, an app that supports independent living was really admired by older adults. One of the comments on the app stores was:

"My mom was looking for a personal fitness coach. Apparently, this app helped her achieve fitness goals without a trainer."

Allow Customisation Older adults preferred apps that allow customisation according to their needs and wants.

"After trying several app launchers, I settled for this launcher. Simple to use with enough customizing ability. Very clean too."

"Good app and easy to customise. Only if I could add widget and one more screen tab. It will be 5 star app."

Easy to Use and Learn One of the key things older adults look for in an app is how easy it is to use and learn.

"Recently, gifted a 5.5" android GS370 to my 70 year old mother and this launcher was one of the reasons to do so. Requires little to no explanation, easy to learn and manipulate - especially for the elderly. No superfluous apps installed or subscriptions required. Really appreciate the efforts by the developers."

"Great launcher, simple to use. I installed it for my mother. She is bad with technology, but got the hang of it pretty easy. 5 stars is not enough."

"Oh my God! so easy to use for seniors. No ads."

"Good for my mother, she feels it is easy to use."

Big and Attractive Icons Big icons also make it easier for older adults to operate the application and they mention it as often as they could at any forum where they had the liberty to speak about their expectations from an app for them.

"I like the big icon."

"My mom's phone also having it now. Big icon easy to operate."

"Great user interface, user friendly look like a stock launcher. Icon is bigger than others nice launcher."

If icons are ugly, older adults get demotivated and do not want to use the application or a particular version where the icons are not attractive.

"Downgraded to 4 stars due to ugly icons in latest update. Why? Actual bugs remain unfixed."

2. Dislikes.

Non-functional Features If a feature in an app did not function the way it was intended, then it reduced the motivation to use the app for older adults and they became sceptical of the entire system.

"Nobody receives the SOS calls."

"SOS is just an illusion created to attract people. No actual help from their side whatsoever."

Many Advertisements Older adults could only be truly satisfied with an app if there were no distractions, e.g., advertisements. One of the users clearly mentioned that he/she would only give a high rating to the app if there were not advertisements.

"Not downloading and only ads after each minute, fix this and I will give 5 stars".

Lack of Explanation Older adults dislike an app which did not clearly explain how to use its features. An example was a fitness app which tells the user what to

do, but did not explain how to do it neither in descriptive nor in pictorial or video format.

"Not much to it ….tells you how many reps to do but doesn't show or explain the exercise."

Non-durable Features Older adults do not like a non-durable application which has no reliability as to whether it will work or not. This means that if it works for some time and stops working or freezes or crashes during use, this will lead to un-installation of the app by older adults.

"Worked well for 6 days then packed in and refused to start even after uninstalling and reinstall."

"Crashes immediately when swiping up to open app list. I tested 2 different Huwaei Phones. Honor 7X and Honor 8. Both crashed."

"Since last update, today, has crashed at least 17 times in 30 minutes. Fix it".

"Had potential. Updates broke it."

"Excellent app, easy and nice large lettering, the developer of this app did a great job, it certainly deserves 5 STARS, have re-downloaded and working again fine, but still freezing after phone shut off or changing to another launcher temporarily."

"Crashes constantly."

Access to Sensitive Information OAs are very sceptical and want to understand the reason why an app would be constantly asking for access to files and location. They are very concerned about privacy and confidentiality. This is one of the consistent findings of our research, which is contrary to the widespread perception that OAs do not care about privacy and are easily scammed.

"Mandatory weather widget that demands location data. Weather widget won't allow users to enter their city manually, these developers want the user's exact location."

"The app requires a lot of permissions and refuses to even start without them. For example, must have access to your location."

"Access your files and know your location, Why?"

Compatibility Issues OAs want the app to work on any type of device they own e.g., android, iOS or windows based. They also want the app to work perfectly on different sizes of device, whether large or small.

"Not working on my Moto G6. From the home screen, every time I swipe up to open the application drawer Simple Launcher crashes. I want to use this app, but can't. The app does work on my OnePlus 6 without any problems, but crashes on my Moto G6."

"Please add support for long screens. In Redmi 5 I can see black bar on top."

Confusing If it is confusing for OAs to find or use the application, they become reluctant to adopt it. Here is one excerpt from a set of OA comments on an app designed for them.

"How to use it man..I am not even finding…where it had gone after my download.. Please find it for me."

3. Recommendations.

Constant Improvement To maximise usage, the apps must keep on evolving and improving with the passage of time, even if the users, older adults, are happy with the current version.

"Installed this app on my fathers phone. The exercises are good and basic. Looking forward to a better experience."

Pick and Move In case of an app that falls under the category of a launcher, OAs want to move the apps freely on the interface, rather than deleting and relying on auto-arrange. This recommendation is about those launchers, which currently do not allow drag and drop to move apps.

"Can you make it so the apps can be arranged by moving them around. The only way I can figure out how to do it is to delete them and carefully plan which apps, I would like in order. Not sure how many stars to rate the app as yet."

One Tap Calling The app should allow quick calling to the contacts through a single tap, instead of conventional navigation which requires multiple steps.

"Just enough! Great for seniors! But, I would love it more if it gave the option for one-touch calling. Currently, contact icons bring you to the contact page. Please enable a direct dial option, as this would make the app perfect!"

"Please try to dial contacts directly with one touch."

Multiple Themes The app should have a feature that allows you to choose a theme, colour combination, of users own choice.

"It would be nice to apply different icon packs for a really cool look."

"Nice simple launcher but would like to see more features like themes and icon pack support also ability to add widgets."

Allow Remove Feature The app should allow removal of any features which older adults do not want to use any more. This will also make the interface cleaner and simpler.

"Ability to remove SOS for those who do not need it and make the page a full screen for contact shortcuts."

Notification Badge on App Icon Older adults like to have notifications badge on the icon of the application to reduce annoyance.

"Really great app, but I'd like to have the option to display the date in UK format (dd/mm) and to change the font size and colour. It also doesn't show notifications on each app's icon - is this something the launcher could do?"

"Add a badge notification option for apps. I never know how many texts I have until I open the app which is annoying."

Incorporate Hold Down Gesture In some launchers, hold down gesture does not work, which older adults would love to use.

"Good clean nice looking launcher with a few missing things. 1: Holding down on an icon for a while does not open it. 2: On the contacts screen there is no option to SMS or send a message to the person. While I feel that it is good for many people to hide this option, for others it is essential."

Disable Hamburger or Drawer Icon Older adults can accidentally tap the drawer/ hamburger which opens the detailed menu making it confusing for them and difficult to return. It is therefore recommended to disable it in the apps for older adults.

"Please add an entry in the options menu to disable the app drawer so that an oldie does not swipe up and show the drawer by accident. This way the usable apps are limited to what is shown on the main launcher screen. Great app and great support. Thank you!! *"".*

Improve Colour Combination The apps for older adults must cater for users with visual problems or those who are colour blind. This means a high contrast should be used, which is a recurring theme that emerged throughout the previous studies as well as the evaluation of apps.

"Why did you ruin a great app. The notification panel has become transparent which looks odd over the dark launcher screen...rollback the update or fix it ASAP please."

Allow Multiple Metrics The features in the app must consider different locations and cultures and incorporate multiple metrics for easier understanding, particularly for older adults.

"Locked in metric. Can't change to Fahrenheit."

"So far really nice... Big icons and super easy interface..only complaint is that not sure how to set temp to Fahrenheit for us non metric luddites."

"Perfect except needs Fahrenheit not just Celsius."

Make Swiping Fast Older adults get concerned if the apps execution is slow, in particular with regard to swiping. They admire applications which have fast swiping.

"Great app, but please make the swipe up fast."

3.2 Map and validate recommendations

To reiterate, the Think Aloud Protocol and Digital Content Extraction were conducted concurrently. This produced an exhaustive list of recommendations to

Recommendation Description	Think Aloud	Digital Content Extraction
Incorporate generous spacing between the buttons in the application.	✓	
Label the icons in the application.	✓	
Make the app accessible without the need for a password.	✓	✓
Avoid the advertisements in the application.	✓	✓
Incorporate a home button in the app serving as a safe point of return for older adults.	✓	
Use minimal parameters for the request to access personal information in the installation prompt whilst installing the application.	✓	
Avoid technical jargon in the application.	✓	✓
Allow the older adults to choose a preferred theme in the application.	✓	✓
Include features which are necessary in the application only.	✓	
Enlarge the size of the components used in the application.	✓	✓
Allow performing most functions in the application through tapping rather than drag and drop.	✓	
Avoid the use of new and unfamiliar gestures in the application.	✓	✓
Use culturally acceptable terminology and icons in the application.	✓	✓
Use layman's language in the application for error notifications.	✓	
Incorporate a tutorial in the application to teach older adults how to use the application.	✓	
Use precise and easy to understand terms and conditions in the application.	✓	
Avoid overloading components with multiple input types.	✓	
Incorporate simple and quick signup process in the application.	✓	✓
Incorporate one feature on interface or one question with a progress bar in the application. This is sometimes referred to as gamification.	✓	
Verify the users of the application e.g., through an original selfie.	✓	✓
Avoid animations and marquees (e.g., text moving from top to bottom) in the application.	✓	✓
Incorporate fraud protection features in the application.	✓	✓

Recommendations in bold *are also presented as example design patterns in Section 4 in this chapter.*

Table 1.
Synthesised recommendations extracted from think aloud protocol and digital content extraction.

Raters	Author 1 and 2	Author 1 and 3
Main Category	**Cohen's Kappa (κ)**	**Cohen's Kappa (κ)**
Usability	0.698	0.809

Table 2.
Cohen's kappa score for mapping of recommendations.

develop smartphone applications for tech-savvy OAs. Some of these are described earlier along with sample quotations from the participants. There were a total of 131 recommendations for Usability with some overlapping [36]. However, for the sake of preciseness, a subset of synthesised versions of these recommendations mapped against the source from which they were derived are presented in **Table 1**. A total of 14 design patterns were created from these recommendations, and 3 of them are presented in this study.

Each unique recommendation was mapped by all authors against the 7 Usability categories outlined by Morville's Usability honeycomb and then validated using Inter-rater reliability as described in Section 2. The scores for inter-rater reliability exceeded 0.61, indicating a high level of reliability. The values of Cohen Kappa's coefficient (**κ**) for Usability, and all raters (author 1, 2 and 3) are shown in **Table 2**.

4. Transform to design patterns

We developed numerous design patterns for Usability after conducting Think Aloud and Digital Content Extraction. Patterns, derived from these, also include supporting literature, thus providing further information about how to develop applications for OAs. Other authors have used patterns to describe usability design recommendations, such as [20, 26]. We build on their work by applying a range of recommendations in this format. Design patterns are shown to be beneficial [60]:

Section	Description
Problem	Cognitive decline is one of the common issue related to ageing, making it difficult for older adults to remember complex things. In the context of technology, passwords are troublesome for older adults [1].
Rationale	The decrease in memory causes older adults to forget and ultimately leads to demotivation. This, in turn, acts as a major factor to stop using the system [1].
Solution	1. Make the app accessible without the need for a password. Use alternative access mechanisms such as bio-metrics, finger prints or face recognition or text message to phone number [1].
Type	Usability
Sub-type	Usable
Related Patterns	Incorporate one feature on interface or one question with a progress bar in the application. This is sometimes referred to as gamification.
References	[1] Boyd, K., Bond, R.R., Nugent, C.D. and Donnelly, M.P., 2018. EasiSocial: Recommendations in the development and training of social media tools for older people. In EasiSocial: Recommendations in the development and training of social media tools for older people.

Table 3.
Make app more accessible with easy log-in id - e.g. fingerprint instead of password.

- Improve communication between stakeholders through providing a common vocabulary e.g., developers and maintainers.

Section	Description
Problem	Older adults get confused by the fast moving objects or content on the smartphone applications. This is mainly due to difficulty associated with the level of perception [1–2].
Rationale	Fast moving objects and animations make it challenging for older adults to concentrate. They feel themselves as less able to understand the complexities of the applications and eventually stop using it [1–2]
Solution	1.Avoid animations and marquees (e.g., text moving from top to bottom) in the application [1–2].
Type	Usability
Sub-type	Desirable
Related Patterns	Allow the older adults to choose a preferred theme in the application.
References	[1] De Barros, A.C., Leitão, R. and Ribeiro, J., 2014. Design and evaluation of a mobile user interface for older adults: navigation, interaction and visual design recommendations. Procedia ComputerScience, 27, pp.369–378. [2] Nurgalieva, L., Laconich, J.J.J., Baez, M., Casati, F. and Marchese, M., 2019. A systematic literature review of research-derived touchscreen design guidelines for older adults. IEEE Access, 7, pp.22035–22058.

Table 4.
Avoid animations and marquees (e.g. text moving from top to bottom) in the application.

Section	Description
Problem	Older adults suffering from auditory problems might not be able to hear important notifications or voice-enabled conversation by the application [1–4].
Rationale	Hearing loss is one of the key problem that is associated with ageing and the applications should be designed for individuals who suffer from it. This will make the application inclusive, accessible and easy to use [1–4]
Solution	1.Incorporate auto-captioning for disabled users in the app [1–4]
Type	Usability
Sub-type	Accessible
Related Patterns	Make the tap sensitivity high to cater for older adults with dry and husky fingers.
References	[1] De Barros, A.C., Leitão, R. and Ribeiro, J., 2014. Design and evaluation of a mobile user interface for older adults: navigation, interaction and visual design recommendations. Procedia ComputerScience, 27, pp.369–378. [2] Nurgalieva, L., Laconich, J.J.J., Baez, M., Casati, F. and Marchese, M., 2019. A systematic literature review of research-derived touchscreen design guidelines for older adults. IEEE Access, 7, pp.22035–22058. [3] Al-Razgan, M.S., Al-Khalifa, H.S., Al-Shahrani, M.D. and AlAjmi, H.H., 2012, November. Touch-based mobile phone interface guidelines and design recommendations for elderly people: A survey of the literature. In International Conference on Neural Information Processing (pp. 568–574). Springer, Berlin, Heidelberg. [4] Leitão, R. and Silva, P.A., 2012. Target and spacing sizes for smartphone user interfaces for older adults: design patterns based on an evaluation with users.

Table 5.
Incorporate auto captioning for disabled users in the app.

- Improve programmer productivity and program quality.
- Encourage best practices even among experienced designers.

Due to limitations on the size and volume of this chapter, we present a subset of three example design patterns covering sub categories of usability, i.e. Usable, Desirable and Accessible, in **Tables 3**–**5**. The remaining set of design patterns can be accessed at [36]. Thus, these design patterns are the answer to the research question posed earlier:

Research Question - What do tech-savvy older adults expect from smart-phone applications?

5. Threats to validity

It is imperative to consider limitations and threats to validity of research [61]. This is particularly important for empirical studies in software engineering, where there is often a multitude of possible threats [62]. First and foremost, the targeted population of this study was tech-savvy older adults, so the findings might not be applicable as-is to age-related counterparts who experience further difficulties in learning and adopting new technology. However, additional findings which included non-tech savvy OAs are presented in [36]. Moreover, for construct validity, field notes taken during the two studies were added to the data collection form on the same day of the sessions. To improve participants' understanding, an information sheet was provided written in English, particularly for Think Aloud sessions. Moreover, Digital Content Extraction involved older adults from across the globe, which may have enhanced the external validity of this research. A known problem with every form of research is that the experience of the researcher can influence both the data collection and analysis positively or negatively. We tried to reduce this bias by involving all three researchers in evaluating the codes and by checking the criteria for data selection. In the context of Think Aloud sessions, the setting was only an approximation of a real-life situation, not the actual day-to-day life usage of technology by older adults. The primary limitation of the examination of online ageing forums was the focus on two forums only. Also, a limited sample of applications was selected from the mainstream app stores using stratified sampling. Despite the limitations, the results follow from the data collected via empirical studies. For reliability, the evaluation of recommendations, through the use of inter-rater reliability, added confidence that the study would yield similar results if other researchers were to replicate our methods.

6. Conclusion

The empirical studies conducted with tech-savvy OAs highlighted their specific expectations from smartphone applications. Through conducting Think Aloud Sessions and Digital Content Extraction we elicited a set of requirements that we categorised according to Peter Morville's Usability Honeycomb [37]. To provide a level of objectivity to our classification, we validated our results in a series of inter-rater reliability tests. The output of this study is a set of recommendations for developing smartphone applications for a tech-savvy ageing population. Finally, we transformed the recommendations into 14 design patterns (three of which are presented in **Tables 3**–**5**). These patterns will help make these recommendations usable for practitioners or for pedagogy. For academia, the research results aim to

provide an understanding of the recommendations for developing smartphone applications for OAs. For industry, the recommendations in the design patterns aim to help the development of usable smartphone applications for tech-savvy older adults, from development to testing of applications. We do not claim that the results presented are complete, but our research study provides significant results, and the design patterns in particular, are ready to be used by both developers and educators.

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