Towards Design Patterns for Developing Smartphone Applications for an Ageing Population - A Technical Report

Lero Technical Report No.
2021_TR_02_Design_Patterns_ReDEAP

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July 4, 2021

Introduction

Accessibility and Usability are closely related aspects in creating software applications that work for everyone. There exists an overlap between them. The better approach is to address them together whilst developing applications. This technical report (Section 1 and 2) presents the Accessibility and Usability recommendations to develop smartphone applications for older adults generated during the different phases of the PhD research transformed into 44 design patterns [1]. These design patterns were derived through an incremental mixed methods research, with results of different phases published in related studies [2–7]. The structure of design patterns and reasons to include specific sections are explained in Table 1. Followed by this, the design patterns categorised into sub-categories of Usability and Accessibility are presented.

Table 1. Structure of ReDEAP Design Patterns

Name	
Problem	A couple of sentences to describe the goal or problem that is going to be solved with the help of this pattern.
Rationale	This section describes the reason to solve the problem and provides clarity by putting the problem and solution in context.
Solution	This section presents the list of actions that need to be taken to solve the problem.
Type	Identifies the type with to which the pattern belongs e.g., Usability or Accessibility.
Sub-type	This section depicts the sub-type to which the pattern belongs.
Related Patterns	Some patterns have strong relationships to other patterns. This section lists those that are related to the current pattern.
References / Evidence	The basis of the ReDEAP pattern library is that the recommendations provided in it should be empirically grounded. This section provides links to research literature and snippets from the associated empirical work from which the pattern is derived. This includes interviews, surveys, Usability study, think aloud, online ageing forums and apps analysis.

1 Usability

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. Usability practice and research often does not sufficiently address the needs of people with disabilities [10].

1.1 Usable

To make the smartphone app usable, it needs to be simple and easy to use. The smartphone app should be designed in a way that is familiar and easy to understand. The learning curve an older adult must go through should be as short and painless as possible [8]. For non-tech savvy OAs, use clear text instead of pictorial stimuli to relay information, give specific and clear instructions and make help and documentation available in the application. For tech-savvy OAs, make the app accessible without the need for password, e.g., finger prints and incorporate one feature on interface or one question in the application. This is sometimes referred to as gamification. The Sub Goal 1.1. - Usable is shown in Figure 1 followed by the design patterns.

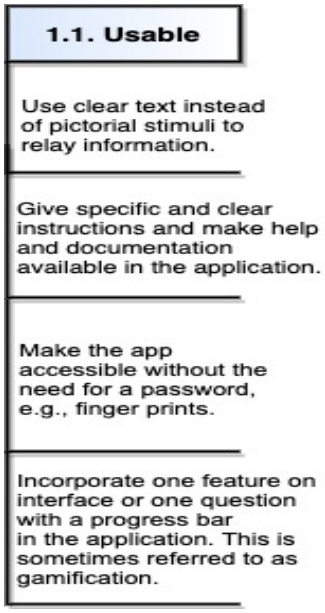

Fig. 1. Sub Goal 1.1. - Usable

1. Use clear text instead of pictorial stimuli to relay information.	
Problem	Older adults find it difficult to remember pictorial stimuli in comparison with their younger counterparts. This is associated with deficiencies in working memory related to aging [1-3].
Rationale	Cognitive decline is one of the key issues that need to be taken care of in the context of older adults. The underlying reason is that when older adults find it difficult to remember and understand the application, they loose their motivation and eventually stop using it [1-3].

Continued...	
Solution	**1.** Substitute complex pictorial stimuli such as icons, animations and marquees, which older adults often find hard to remember with readable text [1,2]. **2.** Use clear text instead of pictorial stimuli such as icons to relay information, where possible [3].
Type	Usability
Sub-type	Usable
Related Patterns	Give specific and clear instructions and make help and documentation available in the application; Make the app accessible without the need for a password, e.g., finger prints; Incorporate one feature on interface or one question with a progress bar in the application. This is sometimes referred to as gamification.
References	[1] Calak, P., 2013. Smartphone evaluation heuristics for older adults (Doctoral dissertation). [2] Silva, P.A., Holden, K. and Nii, A., 2014, June. Smartphones, smart seniors, but not-so-smart apps: A heuristic evaluation of fitness apps. In International Conference on Augmented Cognition (pp. 347-358). Springer, Cham. [3] Carmien, S. and Manzanares, A.G., 2014, June. Elders using smartphones–a set of research based heuristic guidelines for designers. In International conference on universal access in human-computer interaction (pp. 26-37). Springer, Cham.

2. Give specific and clear instructions and make help and documentation available in the application.	
Problem	Due to lack of experience with technology and smartphone applications, older adults require nudges to operate effectively [1-4].
Rationale	For any user, if there is a how to guide available, the level of understanding will be high so as the use [1-4].
Solution	**1.** Give specific and clear instructions and make help and documentation available in the application [1-4].
Type	Usability
Sub-type	Usable
Related Patterns	Use clear text instead of pictorial stimuli to relay information; Make the app accessible without the need for a password, e.g., finger prints; Incorporate one feature on interface or one question with a progress bar in the application. This is sometimes referred to as gamification.

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References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932). [3] I think its (using technology) is really a matter of confidence... and the confidence comes from training. - OA5 [4] A simple thing like registering for the courses I could not do because it kept on saying put in your registration name, but it was wrong, it was actually registration number ... I actually started crying because I thought I was really stupid and I really was not able to do this, so every time I got frightened. - OA5

3. Make the app accessible without the need for a password, e.g., finger prints.	
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 de-motivation. 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	Use clear text instead of pictorial stimuli to relay information; Give specific and clear instructions and make help and documentation available 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.
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.

4. Incorporate one feature on interface or one question with a progress bar in the application. This is sometimes referred to as gamification.	
Problem	Newbie older adults are overwhelmed by the registration forms on the applications which are long, time consuming and distracting [1-4].
Rationale	The long list of questions make it difficult to follow the registration process with ease. They may miss certain fields before submitting the form resulting in a lot of errors. This situation demotivates older adults and make them feel less able to use technology [1-4].

Continued...	
Solution	1. Make the registration process simple by asking just one question on one interface. And pressing next button should reveal the next question and so on [1-4]. Incorporate one feature on interface or one question with a progress bar in the application. This is sometimes referred to as gamification.
Type	Usability
Sub-type	Usable
Related Patterns	Use clear text instead of pictorial stimuli to relay information; Give specific and clear instructions and make help and documentation available in the application; Make the app accessible without the need for a password, e.g., finger prints.
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 Computer Science, 27(27), pp.369-378. [2] Microsoft Corporation. Button control design guidelines for Windows Phone. [3] Leitão, R. and Silva, P.A., 2013. A study of novice older adults and gestural interaction on smartphones. [4] Interview Snippet - I did not learn computers in school, so I did not start using computers until the early 90s at which stage I already thought I was behind. And somebody from arts background I always thought oh my God, if I hit the wrong button I will loose everything.

1.2 Desirable

To make the smartphone application desirable, the visual aesthetics need to be attractive and easy to translate. Design should be minimal and to the point [8]. For non-tech savvy OAs, allow sufficient white space to ensure a balanced user interface design and use font-type: serif or sans serif. Allow tech-savvy OAs to choose a preferred theme and avoid animations and marquees in the application. The Sub Goal 1.2. - Desirable is shown in Figure 2 followed by the design patterns.

5. Allow sufficient white space to ensure a balanced user interface design.	
Problem	Older adults face problem when using applications that have components e.g., buttons, icons, very close to each other, because of large and husky fingers. They accidentally press the wrong button or one button multiple times [1-5].
Rationale	The lack of enough space between components will result in wrong buttons being pressed at the wrong time [1]. This will result in unexpected behavior by the application, eventually leading to frustration and low motivation to use the system [2-5].
Solution	1. Provide additional space between components, buttons and icons that require interaction by the users. 2. Use the minimum recommended spacing between components as defined by [2]. However, decide the exact gap after testing with older users [3-5].

Continued...	
Type	Usability
Sub-type	Desirable
Related Patterns	Use font-type: serif or sans serif, Helvetica, Arial or Times New Roman in the application; Allow the older adults to choose a preferred theme in the application; Avoid animations and marquees (e.g. text moving from top to bottom) 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 Computer Science, 27(27), pp.369-378. [2] Microsoft Corporation. Button control design guidelines for Windows Phone. [3] Leitão, R. and Silva, P.A., 2013. A study of novice older adults and gestural interaction on smartphones. [4] Interview Snippet - I did not learn computers in school, so I did not start using computers until the early 90s at which stage I already thought I was behind. And somebody from arts background I always thought oh my God, if I hit the wrong button I will loose everything. [5] Calak, P., 2013. Smartphone evaluation heuristics for older adults (Doctoral dissertation).

6. Use font-type: serif or sans serif, Helvetica, Arial or Times New Roman in the application.	
Problem	The decline in vision makes it difficult and irritating for older adults to use certain fonts which are too fancy [1-2].
Rationale	The fonts that are pleasing to eye can help older adults stick to the application and keep on using it [1-2].
Solution	**1.** Use font-type: serif or sans serif, Helvetica, Arial or Times New Roman in the application [1, 2].
Type	Usability
Sub-type	Desirable
Related Patterns	Allow sufficient white space to ensure a balanced user interface design; Allow the older adults to choose a preferred theme in the application; Avoid animations and marquees (e.g. text moving from top to bottom) in the application.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

7. Allow the older adults to choose a preferred theme in the application.	
Problem	Older adults, like their younger counterparts, prefer that the application should have a color combination which they love to see [1].
Rationale	Personalization can lead to increase usage and may help to get older adults accustomed to the application quickly [1].

Continued...	
Solution	**1.** Allow the older adults to choose a preferred theme in the application [1].
Type	Usability
Sub-type	Desirable
Related Patterns	Allow sufficient white space to ensure a balanced user interface design; Use font-type: serif or sans serif, Helvetica, Arial or Times New Roman in the application; Avoid animations and marquees (e.g. text moving from top to bottom) in the application.
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.

8. Avoid animations and marquees (e.g. text moving from top to bottom) in the application.	
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 [1-4].
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 [1-4].
Solution	**1.** Avoid animations and marquees (e.g., text moving from top to bottom) in the application [1-4].
Type	Usability
Sub-type	Desirable
Related Patterns	Allow sufficient white space to ensure a balanced user interface design; Use font-type: serif or sans serif, Helvetica, Arial or Times New Roman in the application; 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 Computer Science, 27(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.

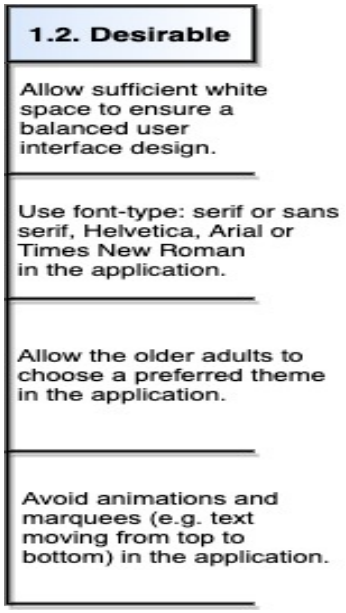

Fig. 2. Sub Goal 1.2. - Desirable

1.3 Findable

To make the smartphone application findable, information needs to be easy to navigate. If older adults have a problem they should be able to quickly find a solution. The navigational structure should be set up in a way that makes sense [8]. For non-tech savvy OAs, disable inactive user interface objects and use consistent and explicit step by step navigation. For tech-savvy OAs, avoid or use vertical scrolling in the application and incorporate simple and quick signup process. The Sub Goal 1.3. - Findable is shown in Figure 3 followed by the design patterns.

9. Disable inactive user interface objects.	
Problem	Some older adults perceive any objects such as buttons as actionable which are visible. Therefore, they try to perform action by clicking them. If they do not work, this leads to skepticism and reduced usage [1-3].
Rationale	To avoid getting distracted whilst using the app, it is really important to enable only those objects such as buttons, which are necessary [1-3].
Solution	**1.** Disable inactive user interface objects in the application [1-3].
Type	Usability
Sub-type	Findable

Continued...	
Related Patterns	Use consistent and explicit step-by-step navigation and user interface elements in the application; Avoid scrolling in the application or only allow vertical scrolling in for such scenarios; Incorporate simple and quick signup process in the application.
References	[1] Calak, P., 2013. Smartphone evaluation heuristics for older adults (Doctoral dissertation). [2] Silva, P.A., Holden, K. and Nii, A., 2014, June. Smartphones, smart seniors, but not-so-smart apps: A heuristic evaluation of fitness apps. In International Conference on Augmented Cognition (pp. 347-358). Springer, Cham. [3] Carmien, S. and Manzanares, A.G., 2014, June. Elders using smartphones–a set of research based heuristic guidelines for designers. In International conference on universal access in human-computer interaction (pp. 26-37). Springer, Cham.

10. Use consistent and explicit step-by-step navigation and user interface elements in the application.	
Problem	If there is a need to have multiple interfaces for different functionalities, then the application might appear different. Older adults consider that they have to re-learn the new features, leading to reduced usage [1-2].
Rationale	If consistent navigation and menus are used throughout the application, it will aid older adults with cognitive decline [1-2].
Solution	**1.** Use consistent and explicit step-by-step navigation and user interface elements [1, 2].
Type	Usability
Sub-type	Findable
Related Patterns	Disable inactive user interface objects; Avoid scrolling in the application or only allow vertical scrolling in for such scenarios; Incorporate simple and quick signup process in the application.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

11. Avoid scrolling in the application or only allow vertical scrolling in for such scenarios.	
Problem	Due to lack of experience of older adults with technology, they might perceive the application as a brochure, showing everything together in one place. This might lead them to think that there is nothing else to view or use [1].
Rationale	In some applications, where the information is too much, then it might go to next pages. The use of horizontal scrolling might lead older adults to miss crucial information [1].

Continued...	
Solution	**1.** Avoid scrolling in the application or only allow vertical scrolling in for such scenarios [1].
Type	Usability
Sub-type	Findable
Related Patterns	Disable inactive user interface objects; Use consistent and explicit step-by-step navigation and user interface elements in the application; Incorporate simple and quick signup process in the application.
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.

12. Incorporate simple and quick signup process in the application.	
Problem	One of the major concern amongst older adults is the long, hefty and complex process for registration with the system [1-4].
Rationale	The conventional sign up process involving filling multiple fields is cumbersome for older adults. This situation becomes more complex when certain fields are necessary and the passwords should be a mix of numbers, alphabets and characters [1-4].
Solution	**1.** Incorporate simple and quick sign-up process in the application e.g., just putting the mobile number for getting registered and later signing in [1-4].
Type	Usability
Sub-type	Findable
Related Patterns	Disable inactive user interface objects; Use consistent and explicit step-by-step navigation and user interface elements in the application; Avoid scrolling in the application or only allow vertical scrolling in for such scenarios.
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 Computer Science, 27(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.

1.4 Accessible

To make the smartphone application accessible, it needs to be designed so that even older adults with disabilities can have the same user experience as others

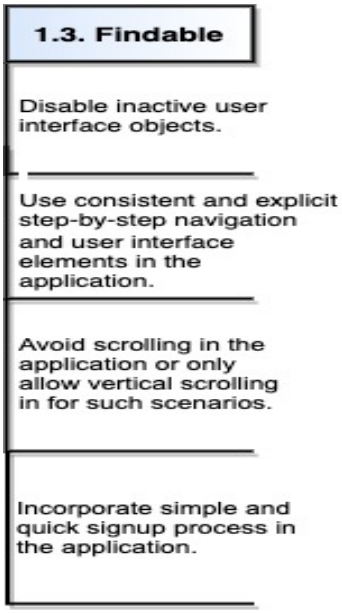

Fig. 3. Sub Goal 1.3. - Findable

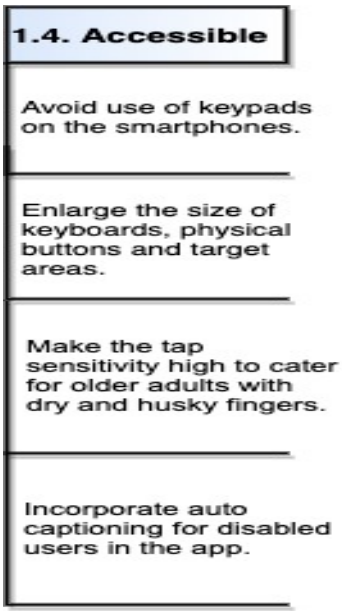

Fig. 4. Sub Goal 1.4. - Accessible

[8]. For non-tech savvy OAs, avoid use of keypads and enlarge the size of physical buttons and target areas. For tech-savvy OAs, make the tap sensitivity high and incorporate auto captioning in the application. The Sub Goal 1.4. - Accessible is shown in Figure 4 previously, followed by the design patterns.

13. Avoid use of keypads on the smartphones.	
Problem	Older adults find it difficult to use small keys with their dry and husky fingers [1-3].
Rationale	Dry and husky fingers cause older adults to press wrong keys leading to incorrect results and operations [1-3].
Solution	**1.** Avoid use of keypads on the smartphone and associated applications [1-3].
Type	Usability
Sub-type	Accessible
Related Patterns	Enlarge the size of keyboards, physical buttons and target areas; Make the tap sensitivity high to cater for older adults with dry and husky fingers; Incorporate auto captioning for disabled users in the app.
References	[1] Calak, P., 2013. Smartphone evaluation heuristics for older adults (Doctoral dissertation). [2] Silva, P.A., Holden, K. and Nii, A., 2014, June. Smartphones, smart seniors, but not-so-smart apps: A heuristic evaluation of fitness apps. In International Conference on Augmented Cognition (pp. 347-358). Springer, Cham. [3] Carmien, S. and Manzanares, A.G., 2014, June. Elders using smartphones–a set of research based heuristic guidelines for designers. In International conference on universal access in human-computer interaction (pp. 26-37). Springer, Cham.

14. Enlarge the size of keyboards, physical buttons and target areas.	
Problem	The motor and visual decline associated with ageing, makes it difficult for older adults to distinguish and use small components on the screen effectively [1-2].
Rationale	Small components can lead older adults to either tap multiple times or several components together. This can halt the application or produce unexpected and erroneous results. This situation eventually has the potential to lead older adults to stop using the application [1-2].
Solution	**1.** Enlarge the size of components within the smartphone and the associated applications e.g., virtual keyboards, physical buttons and target areas [1,2].
Type	Usability
Sub-type	Accessible
Related Patterns	Avoid use of keypads on the smartphones; Make the tap sensitivity high to cater for older adults with dry and husky fingers; Incorporate auto captioning for disabled users in the app.

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References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

15. Make the tap sensitivity high to cater for older adults with dry and husky fingers.	
Problem	With ageing the motor abilities decline, especially the fingers of older adults become dry and husky. This can lead the application to stop responding even when a button or component is tapped [1].
Rationale	The dry and husky fingers lead older adults to press the same control several times which will result in unexpected results [1].
Solution	**1.** Make the tap sensitivity high to cater for older adults with dry and husky fingers [1].
Type	Usability
Sub-type	Accessible
Related Patterns	Avoid use of keypads on the smartphones; Enlarge the size of keyboards, physical buttons and target areas; Incorporate auto captioning for disabled users in the app.
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.

16. Incorporate auto captioning for disabled users in the app.	
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	Avoid use of keypads on the smartphones, Enlarge the size of keyboards, physical buttons and target areas, Make the tap sensitivity high to cater for older adults with dry and husky fingers.

Continued...	
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 Computer Science, 27(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.

1.5 Credible

To make the smartphone application credible, it needs to be trustworthy [8]. For non-tech savvy OAs, make sure that the back button in the application behaves predictably and prevent an error than having a recovery mechanism for it. For tech-savvy OAs, do not have links to dodgy websites and verify/vet the users of the application e.g., through an original selfie. The Sub Goal 1.5. - Credible is shown in Figure 5 followed by the design patterns.

17. Provide and make sure that the back button behaves predictably.	
Problem	Older adults do not understand complex hierarchies and deep system structure due to lack of familiarity with the latest technology and cognitive decline [1-6].
Rationale	An application that has multiple features with some of them sharing common characteristics might tease the designer to nest them. But this situation makes the app difficult to learn and understand for an older adult. Occasionally, an older adult might get stuck and forget where he/she is in the application [1-6].
Solution	**1.** Provide a back button on all interfaces that takes back older adult to the home or previous page of the application. This will act as a safe point of return for the older adult [1-6].
Type	Usability
Sub-type	Credible
Related Patterns	Prevent an error than to have a recovery mechanism for it; Do not have links to dodgy websites in the application, that may entice older adults to pay for certain things; Verify/Vet the users of the application. e.g., through an original selfie.

Continued...	
References	[1] 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. [2] Carmien, S. and Manzanares, A.G., 2014, June. Elders using smartphones–a set of research based heuristic guidelines for designers. In International conference on universal access in human-computer interaction (pp. 26-37). Springer, Cham. [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] 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 Computer Science, 27(27), pp.369-378. [5] Calak, P., 2013. Smartphone evaluation heuristics for older adults (Doctoral dissertation). [6] Silva, P.A., Holden, K. and Nii, A., 2014, June. Smartphones, smart seniors, but not-so-smart apps: A heuristic evaluation of fitness apps. In International Conference on Augmented Cognition (pp. 347-358). Springer, Cham.

18. Prevent an error than to have a recovery mechanism for it.	
Problem	Older adults struggle with an application, if any error occurs and they are unable to resolve it [1-3].
Rationale	The avoidance of erroneous scenarios in an application can lead to increased usage and acceptance by older adults [1-3].
Solution	**1.** Prevent an error than to have a recovery mechanism for it [1-3].
Type	Usability
Sub-type	Credible
Related Patterns	Provide and make sure that the back button behaves predictably; Do not have links to dodgy websites in the application, that may entice older adults to pay for certain things; Verify/Vet the users of the application. e.g., through an original selfie.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932). [3] I did not learn computers in school and I did not, so I did not start using computers until the early 90's at which stage I already thought I was behind, and somebody from an arts background I always thought Oh my God, if I hit the wrong button I will loose everything. - OA5

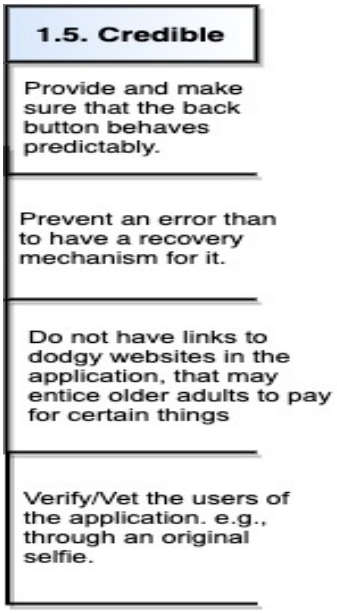

Fig. 5. Sub Goal 1.5. - Credible

19. Do not have links to dodgy websites in the application, that may entice older adults to pay for certain things.	
Problem	Older adults are one of the major demographic of population affected by spammers across the globe, due to their lack of familiarity and experience with the technology [1].
Rationale	The links to un-reliable sources on the application may cause older adults to navigate to them, resulting in loosing their personal information or even money [1].
Solution	**1.** Do not have links to dodgy websites in the application, that may entice older adults to pay for certain things [1].
Type	Usability
Sub-type	Credible
Related Patterns	Provide and make sure that the back button behaves predictably; Prevent an error than to have a recovery mechanism for it; Verify/Vet the users of the application. e.g., through an original selfie.
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.

20. Verify/Vet the users of the application. e.g., through an original selfie.	
Problem	Due to constant attention towards spammers in the main stream media, older adults are concerned about their privacy and safety on online systems and technology. They do not want to use a system or an app that involves interaction with unknown people who are not reliable or trustworthy [1-3].
Rationale	The presence of spammers or fake users on an app can be a cause for financial or personal information loss. Any such users are real risk and threat for the application and should be monitored [1-3].
Solution	**1.** Verify/Vet the users of the application. e.g., through an original selfie [1-3].
Type	Usability
Sub-type	Credible
Related Patterns	Provide and make sure that the back button behaves predictably; Prevent an error than to have a recovery mechanism for it; Do not have links to dodgy websites in the application, that may entice older adults to pay for certain things.
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 Computer Science, 27(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.

1.6 Useful

To make the smartphone application useful, it must fill a need. If the smartphone application is not useful or fulfilling older adult's wants or needs then there is no real purpose for it [8]. For non-tech savvy OAs, incorporate a feature for active social engagement and for increasing their awareness. For tech-savvy OAs, incorporate a feature that helps OAs to keep track of and maintain their health and incorporate fraud protection features in the application. The Sub Goal 1.6. - Useful is shown in Figure 6 followed by the design patterns.

21. Incorporate a feature for active social engagement in the application, e.g., a volunteer hub.	
Problem	Social isolation and loneliness is one of the major problem in older adults. This situation is appalling, despite the skills which older adults have achieved throughout their lives, which if harnessed can lead to their inclusion in the community [1-2].
Rationale	Providing a solution for social isolation of older adults via technology has the potential to improve their health and quality of life in general [1-2].

Continued...	
Solution	**1.** Provide a feature to enhance active social engagement of older adults e.g., a feature that suggests them the opportunities available in their local community, which they can provide or receive, based on their needs [1,2].
Type	Usability
Sub-type	Useful
Related Patterns	Incorporate a feature that increases awareness of older adults, e.g., an information hub; Incorporate a feature that helps older adults to keep track of and maintain their health. It can be presented in pie charts and graphs for tech-savvy OAs; Incorporate fraud protection features in the application.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

22. Incorporate a feature that increases awareness of older adults, e.g., an information hub.	
Problem	Older adults want to stay informed about the local, national and international news. They usually accomplish this goal through television and radio, but the problem is that they have to switch channels to attain a breadth of knowledge [1-4].
Rationale	The acquisition of knowledge of latest trends help older adults to make decisions regarding a lot of things e.g., traveling [1-4].
Solution	**1.** Incorporate a feature that increases awareness of older adults, e.g., an information hub. [1-4].
Type	Usability
Sub-type	Useful
Related Patterns	Incorporate a feature for active social engagement in the application, e.g., a volunteer hub; Incorporate a feature that helps older adults to keep track of and maintain their health. It can be presented in pie charts and graphs for tech-savvy OAs; Incorporate fraud protection features in the application.

Continued...	
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932). [3] Yeah, more information will be great, that's the main thing, yeah, if there was an easy website, I would be on it tomorrow. - OA12 [4] If I am waiting for somebody I will just turn on the news here because I am a news junkie ... you know the expression. I love politics and all that I love world politics. - OA6

23. Incorporate a feature that helps older adults to keep track of and maintain their health. It can be presented in pie charts and graphs for tech-savvy OAs.	
Problem	Decline in health is directly proportional to the increased age for most older adults. This situation requires older adults to stay informed about their health conditions, which is conventionally tedious e.g., going to the General Practitioner (GP) [1].
Rationale	An app providing details of health metrics to older adults in plain language will keep them self-aware. In addition, they can visit GP based on the information they receive through the app. Moreover, they can also get guidance on how to keep them active or avoid certain foods [1].
Solution	**1.** The health related information should be provided to OAs. Incorporate a feature that helps OAs to keep track of and maintain their health, e.g., a healthcare hub. It can be presented in pie charts and graphs for tech-savvy OAs, and plain language for non-tech savvy OAs [1].
Type	Usability
Sub-type	Useful
Related Patterns	Incorporate a feature for active social engagement in the application, e.g., a volunteer hub; Incorporate a feature that increases awareness of older adults, e.g., an information hub; Incorporate fraud protection features in the application.
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.

24. Incorporate fraud protection features in the application.	
Problem	Older adults get into the traps of smishing[1] and other fraudulent activities easily in comparison with their younger counterparts [1-3].

[1] A form of phishing, smishing is when someone tries to trick you into giving them your private information via a text or SMS message. https://us.norton.com/internetsecurity-emerging-threats-what-is-smishing.html

Continued...	
Rationale	The lack of awareness and presence of security measures in an application can cause a lot of loss to older adults leading to permanent distrust in technology and smartphone applications [1-3].
Solution	**1.** Incorporate fraud protection features in the application [1-3].
Type	Usability
Sub-type	Useful
Related Patterns	Incorporate a feature for active social engagement in the application, e.g., a volunteer hub; Incorporate a feature that increases awareness of older adults, e.g., an information hub; Incorporate a feature that helps older adults to keep track of and maintain their health. It can be presented in pie charts and graphs for tech-savvy OAs.
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 Computer Science, 27(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.

1.7 Valuable

To make the smartphone application valuable, it needs to deliver value to the business which creates it and to the older adult who buys or uses it. Without value it is likely that any initial success of the application will eventually be undermined. [8]. For non-tech savvy OAs, add a feature to assign badges or stars based on usage of the application and avoid advertisements to an extent where they are not causing confusion. For tech-savvy OAs, grant physical rewards, probably in the form of certificates upon completion of services through the application and provide an alternative paid version of the application with no advertisements. The Sub Goal 1.7. - Valuable is shown in Figure 7 followed by the design patterns.

25. Add a feature to assign badges or stars to the users based on their usage of the application.	
Problem	Older adults do not like applications that are solely for communication or getting information related to their health [1].
Rationale	The inclusion of features that can keep older adults motivated will help them adapt technology persistently [1].
Solution	**1.** Assign badges or ratings e.g., stars, based on older adults' usage of the system and activities performed through it [1].

Continued...	
Type	Usability
Sub-type	Valuable
Related Patterns	Avoid the advertisements in the application; Grant physical rewards / certificates to the user upon completion of certain services through the application; Provide an alternative paid version which does not contain commercial advertisements.
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

26. Avoid the advertisements in the application.	
Problem	Older adults do not want to see the advertisements flashing whilst using the application [2]. They feel exploited or distracted and sometimes tap on these advertisements and then face difficulties on how to go back to the previous screen [1-3].
Rationale	Financial gains are a necessity for app developers, but third party advertisements can distract and exploit older adults. This situation can lead to mistrust and even older adults may stop using the application [1-3].
Solution	1. Avoid pop up/ animated advertisements or multiple overlapping windows in the application [1,2]. 2. Provide an alternative paid version which does not contain commercial advertisements [1]. 3. The ideal scenario is to avoid advertisements in all versions of the app [1,3].
Type	Usability
Sub-type	Valuable
Related Patterns	Add a feature to assign badges or stars to the users based on their usage of the application; Grant physical rewards / certificates to the user upon completion of certain services through the application; Provide an alternative paid version which does not contain commercial advertisements.
References	[1] Díaz Bossini, J.M. and Moreno, L., 2013. Accessibility to mobile interfaces for older people. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932). [3] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205.

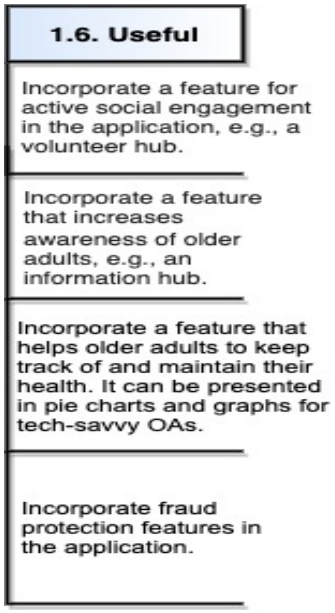

Fig. 6. Sub Goal 1.6. - Useful

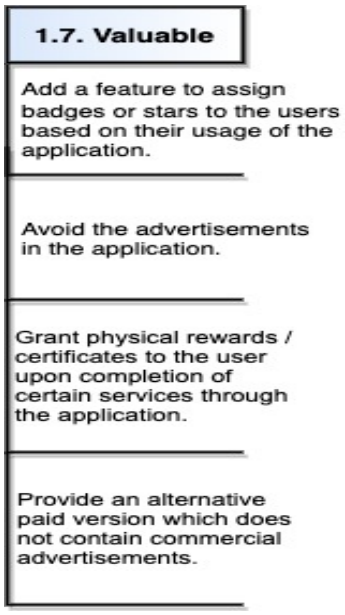

Fig. 7. Sub Goal 1.7. - Valuable

27. Grant physical rewards / certificates to the user upon completion of certain services through the application.	
Problem	Existing applications lack mechanisms to financially reward older adults or even send them certificates of appreciation [1].
Rationale	The lack of physical rewards via using the system leads to lack of motivation in older adults to use the system [1].
Solution	**1.** The app should reward, both virtually and physically, the older adults, as it drives and motivates them [1].
Type	Usability
Sub-type	Valuable
Related Patterns	Add a feature to assign badges or stars to the users based on their usage of the application; Avoid the advertisements in the application; Provide an alternative paid version which does not contain commercial advertisements.
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.

28. Provide an alternative paid version which does not contain commercial advertisements.	
Problem	One of the key concern of older adults is the presence of advertisements whilst using the applications [1-5].
Rationale	The presence of advertisements distracts the older adults. In addition, they only want to use/see something that is useful to them. They want to avoid irrelevant material [1-5].
Solution	**1.** One solution is to have a business model advocating for no or less advertisements for paid versions of the application [1-5].
Type	Usability
Sub-type	Valuable
Related Patterns	Add a feature to assign badges or stars to the users based on their usage of the application; Avoid the advertisements in the application; Grant physical rewards / certificates to the user upon completion of certain services through the application.

Continued...	
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 Computer Science, 27(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. [5] Not downloading and only ads after each minute fix this and I will give 5 stars.

2 Accessibility

Accessibility addresses discriminatory aspects related to equivalent user experience for people with disabilities. It means that people with disabilities can equally perceive, understand, navigate, and interact with application. It also means that they can contribute equally without barriers [10].

2.1 Perceiveable

Perceivability means that the older adult can identify content and interface elements by means of the senses. For many older adults, this means perceiving a system primarily visually, while for others, perceivability may be a matter of sound or touch. New and emerging technologies may include sensory cues for smell and taste; these would also be considered examples of perceivable technology [9]. For non-tech savvy OAs, make the entered character hearable in the application and use small high-speed adjustments for user vibration feedback. For tech-savvy OAs, make the sound of the notifications loud and incorporate video based tutorials in the application. The Sub Goal 2.1. - Perceiveable is shown in Figure 8 followed by the design patterns.

29. Make the entered character hearable.	
Problem	Older adults suffering from visual acuity can not make the best use of the applications [1-2].
Rationale	The interaction of older adults with the application only through tapping and reading text on the applications is good, but those with visual acuity might not be able to get the full meaning of certain things due to small text size [1-2].
Solution	**1.** Make the entered character hearable in the application [1, 2].

Continued...	
Type	Accessibility
Sub-type	Perceiveable
Related Patterns	Use small high-speed adjustments for user vibration feedback to provide easily detectable sensation above threshold; Make the sound of the notifications loud in the application; Incorporate video based tutorials in the application.
References	[1] Díaz Bossini, J.M. and Moreno, L., 2013. Accessibility to mobile interfaces for older people. [2] Mi, N., Cavuoto, L.A., Benson, K., Smith-Jackson, T. and Nussbaum, M.A., 2014. A heuristic checklist for an accessible smartphone interface design. Universal access in the information society, 13(4), pp.351-365.

30. Use small high-speed adjustments for user vibration feedback to provide easily detectable sensation above threshold.	
Problem	The sense of touch also gets affected with ageing and current technology should cater for this as well [1-2].
Rationale	Older adults might not be able to notice the existing vibration feedback. This might lead them to miss important calls or messages or reminders [1-2].
Solution	**1.** Use small high-speed adjustments for user vibration feedback to provide easily detectable sensation above threshold [1, 2].
Type	Accessibility
Sub-type	Perceiveable
Related Patterns	Make the entered character hearable; Make the sound of the notifications loud in the application; Incorporate video based tutorials in the application.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

31. Make the sound of the notifications loud in the application.	
Problem	Older adults with auditory problems can not hear notifications with lower-frequency [1].
Rationale	The soft sound of notifications can be missed by older adults resulting in missing important stuff and things to do [1].
Solution	**1.** Make the sound of the notifications loud in the application [1].
Type	Accessibility
Sub-type	Perceiveable
Related Patterns	Make the entered character hearable; Use small high-speed adjustments for user vibration feedback to provide easily detectable sensation above threshold; Incorporate video based tutorials in the application.

Continued...	
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.

32. Incorporate video based tutorials in the application.	
Problem	Older adults do not want to read long and tiresome documents to learn how to use the system or application [1-5].
Rationale	The use of alternative modalities to teach older adults how to use the app and technology in general has the potential to increase the uptake by older adults [1-5].
Solution	**1.** Incorporate video based tutorials in the application [1-5].
Type	Accessibility
Sub-type	Perceiveable
Related Patterns	Make the entered character hearable; Use small high-speed adjustments for user vibration feedback to provide easily detectable sensation above threshold; Make the sound of the notifications loud 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 Computer Science, 27(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. [5] Tried a lot of apps, finally landed here, it is a simple and useful app. The best part is the video tutorials.

2.2 Operable

Operability means that the older adult can successfully use controls, buttons, navigation, and other necessary interactive elements. For many OAs, this means identifying an interface control visually, and then clicking, tapping, or swiping. For others, using a computer keyboard or voice commands may be the only means by which they can operate and control the interface [9]. For non-tech savvy OAs, allow cancellation of a selection made by OA in the application and make the smartphone fit easily into the hands of the OA. For tech-savvy OAs,

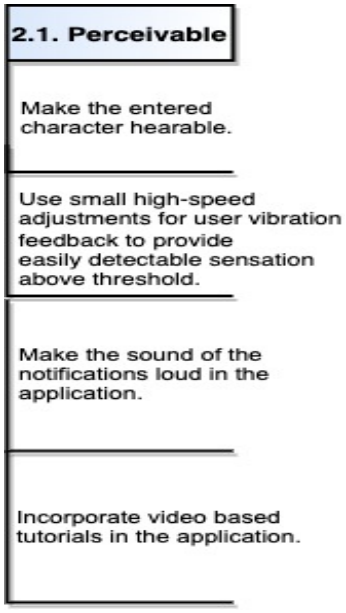

Fig. 8. Sub Goal 2.1. - Perceiveable

allow alternative modality to receive a call, e.g., the mechanisms of a flip phone can be used. Also, incorporate fast swiping in the application. The Sub Goal 2.2. - Operable is shown in Figure 9 followed by the design patterns.

33. Allow cancellation of a selection made by the user in the application.	
Problem	During interaction with the system, older adults might make a mistake that may not produce the expected results [1-2].
Rationale	The wrong selection of a control or submitting a form with wrong details by older adults might result in an in-effective use of the system by them [1-2].
Solution	**1.** Allow to cancel a selection made by the older adult in the application [1, 2].
Type	Accessibility
Sub-type	Operable
Related Patterns	Make the smartphone fit easily into the hands of the user; The smartphone/app should allow to receive a call using alternative modality instead of tapping, for instance, the mechanics of flip phone can be used; Incorporate fast swiping in the application.
References	[1] Díaz Bossini, J.M. and Moreno, L., 2013. Accessibility to mobile interfaces for older people. [2] Mi, N., Cavuoto, L.A., Benson, K., Smith-Jackson, T. and Nussbaum, M.A., 2014. A heuristic checklist for an accessible smartphone interface design. Universal access in the information society, 13(4), pp.351-365.

34. Make the smartphone fit easily into the hands of the user.	
Problem	With ageing, size of hands become large and the fingers become dry and husky leading to decline in motor control [1-2].
Rationale	The presence of technology e.g., smartphones that can be easily usable by older adults with motor decline will increase adoption by this demographic [1-2].
Solution	**1.** Make the smartphone fit easily into the hands of the user [1, 2].
Type	Accessibility
Sub-type	Operable
Related Patterns	Allow cancellation of a selection made by the user in the application; The smartphone/app should allow to receive a call using alternative modality instead of tapping, for instance, the mechanics of flip phone can be used; Incorporate fast swiping in the application.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

35. The smartphone/app should allow to receive a call using alternative modality instead of tapping, for instance, the mechanics of flip phone can be used.	
Problem	Motor control and dry/husky fingers of older adults require technology to cater for these problems [1].
Rationale	If alternative solutions are provided to OAs with problems in motor control, this will help them effectively use the applications [1].
Solution	**1.** The smartphone/app should allow to receive a call using alternative modality instead of tapping, for instance, the mechanics of flip phone can be used [1].
Type	Accessibility
Sub-type	Operable
Related Patterns	Allow cancellation of a selection made by the user in the application; Make the smartphone fit easily into the hands of the user; Incorporate fast swiping in the application.
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 OAs.

36. Incorporate fast swiping in the application.	
Problem	Older adults find it cumbersome and hectic if the application stucks, whilst they are using it [1-4].
Rationale	The efficient operation of application might increase the motivation of older adults, resulting in increased adoption [1-4].
Solution	**1.** Incorporate fast swiping in the application [1-4].
Type	Accessibility

Continued...	
Sub-type	Operable
Related Patterns	Allow cancellation of a selection made by the user in the application; Make the smartphone fit easily into the hands of the user; The smartphone/app should allow to receive a call using alternative modality instead of tapping, for instance, the mechanics of flip phone can be used.
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 Computer Science, 27(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] Great app, but please make the swipe up fast.

2.3 Understandable

An understandable application is consistent in its presentation and format, predictable in its design and usage patterns, concise, multimodal, and appropriate to the audience in its voice and tone. Older adults should be able to comprehend the content, and learn and remember how to use the interface [9]. For non-tech savvy OAs, concentrate the information mainly in center in the application and use simple, clear and consistent terminology and navigation in the application. For tech-savvy OAs, use layman's language in the application for error notifications and use precise and easy to understand terms and conditions in the application. The Sub Goal 2.3. - Understandable is shown in Figure 10 followed by the design patterns.

37. Concentrate information mainly in center in the interface of application.	
Problem	The information that is available in the corners or bottom can be missed by older adults, even-though, there could be critical bits of information there [1-2].
Rationale	The presentation of information that is flowing all across the screen, may lead to lack of focus by older adults [1-2].
Solution	**1.** Concentrate information mainly in center in the interface of application [1, 2].
Type	Accessibility
Sub-type	Understandable
Related Patterns	Use simple, clear and consistent terminology and navigation in the application; Use layman's language in the application for error notifications; Use precise and easy to understand terms and conditions in the application.

Continued...	
References	[1] Díaz Bossini, J.M. and Moreno, L., 2013. Accessibility to mobile interfaces for older people. [2] Mi, N., Cavuoto, L.A., Benson, K., Smith-Jackson, T. and Nussbaum, M.A., 2014. A heuristic checklist for an accessible smartphone interface design. Universal access in the information society, 13(4), pp.351-365.

38. Use simple, clear and consistent terminology and navigation in the application.	
Problem	Heterogeneous interfaces can cause confusion in older adults whilst using the application [1-2].
Rationale	The consistent interface design and simple navigation and layout has the potential to sustain the older adults on the system [1-2].
Solution	**1.** Use simple, clear and consistent screen layout, navigation and terminology [1, 2].
Type	Accessibility
Sub-type	Understandable
Related Patterns	Concentrate information mainly in center in the interface of application; Use layman's language in the application for error notifications; Use precise and easy to understand terms and conditions in the application.
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

39. Use layman's language in the application for error notifications.	
Problem	Older adults do not understand the technical jargon used within applications and do not prefer such-apps [1-4].
Rationale	It is obvious that every app requires labels, icons, buttons and descriptions. If they are tailored towards the expectations of older adults, then the adoption of such apps can be increased [1-4].
Solution	1. Use simple language and wording that suits older adults semantic field [1,3]. 2. The choice of the words should be based on the educational background and experience of the older adults [2,4].
Type	Accessibility
Sub-type	Understandable
Related Patterns	Concentrate information mainly in center in the interface of application; Use simple, clear and consistent terminology and navigation in the application; Use precise and easy to understand terms and conditions in the application.

Continued...	
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 Computer Science, 27(27), pp.369-378. [2] Microsoft Corporation. Button control design guidelines for Windows Phone. [3] Leitão, R. and Silva, P.A., 2013. A study of novice older adults and gestural interaction on smartphones. [4] Interview Snippet - I did not learn computers in school, so I did not start using computers until 90s. I already thought I was behind. And somebody from arts background I always thought oh my God, if I hit the wrong button I will lose everything.

40. Use precise and easy to understand terms and conditions in the application.	
Problem	One of the problems in all of the existing applications is the long and technical terms and conditions statement [1-4].
Rationale	The technical jargon in the terms and conditions statement leads to total confusion of older users, when it is really necessary for them to understand their rights [1-4].
Solution	**1.** Use precise and comprehend-able terms and conditions in the application for older adults [1-4].
Type	Accessibility
Sub-type	Understandable
Related Patterns	Concentrate information mainly in center in the interface of application; Use simple, clear and consistent terminology and navigation in the application; Use layman's language in the application for error notifications.
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 Computer Science, 27(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.

2.4 Robust

A robust application is standards-compliant, and designed to function on all appropriate technologies. Older adults should be able to choose the technology

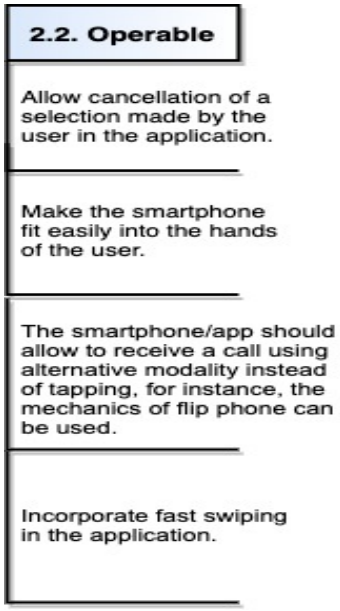

Fig. 9. Sub Goal 2.2. - Operable

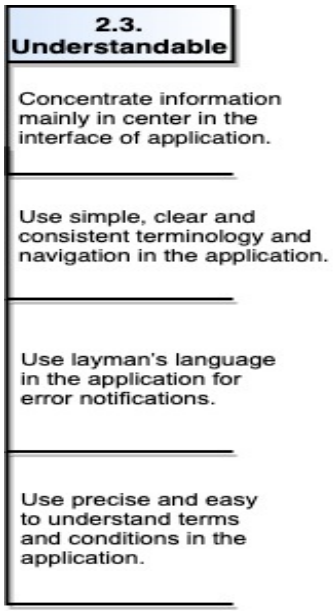

Fig. 10. Sub Goal 2.3. - Understandable

they use to interact with websites, online documents, multimedia, and other information formats [9]. For non-tech savvy OAs, incorporate ALT tags for the images in the application and a display without glare or reflection from the screen. For tech-savvy OAs, the application should not break during execution and show the right keyboard at the right time. This means that when there is a need to enter numeric data e.g., a phone number, only show numeric keys and vice versa. The Sub Goal 2.4. - Robust is shown in Figure 11 followed by the design patterns.

41. Incorporate ALT tags for the images.	
Problem	Sometimes due to poor internet connection, the images in the app or system might not be displayed [1-2].
Rationale	The crossed rectangle showing nothing distracts older adults and keeps them wandering if something will be shown or is missing [1-2].
Solution	**1.** Incorporate alt tags for the images in the application. This means that if due to low bandwidth the image does not load, text in the alt tag should appear to guide the older user as to what it was about [1, 2].
Type	Accessibility
Sub-type	Robust
Related Patterns	Incorporate a display without glare or reflection from the touch screen; The application shouldn't break during execution of functionality; Show the right keyboard at the right time. This means that when there is a need to enter numeric data, e.g., a phone number, only show numeric keys and vice versa.
References	[1] Díaz Bossini, J.M. and Moreno, L., 2013. Accessibility to mobile interfaces for older people. [2] Mi, N., Cavuoto, L.A., Benson, K., Smith-Jackson, T. and Nussbaum, M.A., 2014. A heuristic checklist for an accessible smartphone interface design. Universal access in the information society, 13(4), pp.351-365.

42. Incorporate a display without glare or reflection from the touch screen.	
Problem	Older adults suffering from visual acuity can not use the smartphones with glare or reflection [1-2].
Rationale	The glare or reflection irritates some of the older adults, leading to reduced usage [1-2].
Solution	**1.** Incorporate a display without glare or reflection from the touch screen [1, 2].
Type	Accessibility
Sub-type	Robust
Related Patterns	Incorporate ALT tags for the images; The application shouldn't break during execution of functionality; Show the right keyboard at the right time. This means that when there is a need to enter numeric data, e.g., a phone number, only show numeric keys and vice versa.

Continued...	
References	[1] Coelho, J. and Duarte, C., 2016. A literature survey on older adults' use of social network services and social applications. Computers in Human Behavior, 58, pp.187-205. [2] Norval, C., Arnott, J.L. and Hanson, V.L., 2014, April. What's on your mind? Investigating recommendations for inclusive social networking and older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (pp. 3923-3932).

43. The application shouldn't break during execution of functionality.	
Problem	One of the main thing that de-motivates older adults to use the system or application is if it breaks or stops working while they are using it [1].
Rationale	The breakable application with poor exception handling behind the scenes cause distrust in older adults perception about technology and smartphone applications [1].
Solution	**1.** The application should not break during execution of the functionality [1].
Type	Accessibility
Sub-type	Robust
Related Patterns	Incorporate ALT tags for the images; Incorporate a display without glare or reflection from the touch screen; Show the right keyboard at the right time. This means that when there is a need to enter numeric data, e.g., a phone number, only show numeric keys and vice versa.
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.

44. Show the right keyboard at the right time. This means that when there is a need to enter numeric data, e.g., a phone number, only show numeric keys and vice versa.	
Problem	Older adults get confused when they have to enter information through virtual keyboard, due to a lot of mixed, textual, numeric, emojis, keys [1-4].
Rationale	The availability of different types of keys- numeric, text, emojis- causes difficulty in use for older adults with cognitive decline [1]. They might press the wrong keys, which will result in unexpected behavior by the application, eventually leading to frustration and low motivation to use the system [1-4].
Solution	**1.** Show the right keyboard at the right time. This means that when there is a need to enter numeric data, e.g., a phone number, only show numeric keys and vice versa [1-4].
Type	Accessibility
Sub-type	Robust

Continued...	
Related Patterns	Incorporate ALT tags for the images; Incorporate a display without glare or reflection from the touch screen; The application shouldn't break during execution of functionality.
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 Computer Science, 27(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.

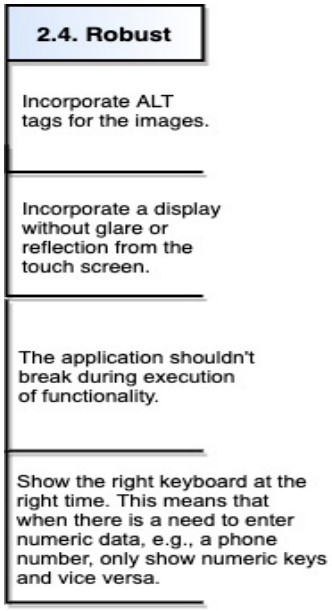

Fig. 11. Sub Goal 2.4. - Robust

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Acknowledgements

This work was supported, in part, by Science Foundation Ireland grant 13/RC/2094, co-funded under the European Regional Development Fund through the Southern & Eastern Regional Operational Programme to Lero - the Science Foundation Ireland Research Centre for Software (www.lero.ie) and IBM Ireland.