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# Tangible Cup for Elderly Social Interaction: Design TUI for & with Elderly

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## Abstract

Social interaction is found to have significant impacts in our quality of life. Information and communications technology (ICT) has been designed to improve our social interaction and well-being. Elderly people face challenges in learning and using ICT due to their age-related limitations and that they are non-digital natives. Their needs are not sufficiently addressed in ICT systems. Tangible user interface (TUI) which couples digital information to everyday physical object is considered to be more intuitive and suitable for elderly people. TUI has been adopted in some studies in order to improve quality of life in the elderly, but very few focus on the social aspect. Thus, this research aims to develop a TUI to improve elderly social interaction and well-being. We have adopted user-centered design and co-design approach in designing the Tangible Cup. Through the design process, we generated a list of lessons learned which can serve as a guide for what to consider when designing TUI for elderly people and when involving elderly people in the design process.

## Keywords

Tangible user interface; elderly; social interaction

## Introduction

People nowadays tend to live longer. Social participation is an important factor in elderly people's health and well-being (Gilmour 28). Studies have shown that loneliness is associated with heart disease, hypertension, stroke and lung disease (Petitte et al. 113). Thus, in order to remain healthy, elderly people must remain socially active. ICT has been designed to improve our social interactions and well-being. However, due to their age-related limitations and that they are non-digital natives, elderly people currently find ICT difficult to learn and use (Chou et al. 928). They face many challenges when it comes to learning and using ICT, and their needs are not always sufficiently addressed in ICT systems.

TUI couples digital information with everyday physical objects, and is thus considered to be more intuitive and suitable for elderly people (Spreicer 313). TUI has been adopted in some studies in improving quality of life in the elderly, but very few focus on the social aspect (Bong et al.). Issues such as lack of elderly user involvement throughout the research process, and lack of guidelines for developing and evaluating TUI for elderly people, have been identified. These issues can result in TUI that is developed for elderly people not being as intuitive and suitable as it should be. We aim to address these issues by providing a list of lessons learned from our design process for Tangible Cup.

By using user-centered design and co-design approach, we have involved elderly participants in our design and evaluation processes. The end product of this research, Tangible Cup, is expected to be a more intuitive and user-friendly ICT tool for elderly people, which can encourage their social interaction with others. Through designing Tangible Cup, we have developed a list of lessons learned in connection with designing TUI for and with elderly people.

## Discussion

### *The Prototype: Tangible Cup*



Fig.1. Tangible Cup.

Tangible Cup consists of four components: a cup, a cup attachment (under the cup), five cup coasters and a tablet (Fig.1). Users must first attach the cup attachment to the bottom of their own cup. After that they can perform desired actions by moving their cup (with the cup attachment already attached) and placing it on the various cup coasters. The cup attachment contains an RFID reader which reads the RFID tags on the cup coasters. The five coasters are assigned the following functions: *log in*, *log out*, *start call*, *end call* and *search contacts*. An app installed in the tablet enables the users to call other users who are online.

To start using Tangible Cup, users need to go online by placing their cup on the *log in* coaster. Once they are online, they can place their cup on the *start call* coaster whenever they want to call someone or to accept an incoming call. In order to end or reject a call, they have to

place the cup on the *end call* coaster. The *search contacts* coaster is used for finding other Tangible Cup users who are online at the same time. Finally, to log out they should place the cup on the *log out* coaster.

### *Methods and Results*

We adopted user-centered design and co-design approach. First, a focus group interview was conducted with three elderly participants and a volunteer to gather the initial requirements for Tangible Cup. The prototype was developed based on these requirements. Four iterations of design, implementation and usability testing were then carried out. Usability testing was conducted with two elderly participants at the end of every iteration. During the testing, the participants were asked to perform a series of tasks using the prototype while being observed. After that, they were asked about the design of the prototype and their experiences of using it. The comments and feedback from the usability testing were incorporated into the next iteration to improve the design. In addition, new features were implemented into the existing design.

The co-design approach was applied throughout the whole research process, from focus group interviews to usability testing of all iterations. This was done to ensure that the prototype was designed and developed with the perspectives and needs of our target group, the elderly, in mind (Steen et al.). All the participants (P1 to P10) were briefed and asked to give their consent prior to participating in the study. Information about the participants is summarized in Table 1.

Table 1. Information about Participants

| ID# | Age | Gender | Work Experience   | Years of Education | Participation |
|-----|-----|--------|-------------------|--------------------|---------------|
| P1  | 76  | M      | Management        | 14                 | Focus group   |
| P2  | 71  | M      | Computer engineer | 20                 | Focus group   |
| P3  | 71  | F      | Administrative    | 16                 | Focus group   |

| ID# | Age | Gender | Work Experience   | Years of Education | Participation                       |
|-----|-----|--------|---|--------------------|-------------------------------------|
| P4  | 17  | F      | Currently at upper secondary school.<br>Volunteer in elderly home care services | 12                 | Focus group                         |
| P5  | 74  | M      | Diver   | 12                 | Usability testing iteration 1       |
| P6  | 74  | F      | Secretary   | 14                 | Usability testing iteration 1, 2, 4 |
| P7  | 70  | F      | Finance   | 15                 | Usability testing iteration 2       |
| P8  | 77  | M      | Truck driver  | 8                  | Usability testing iteration 3       |
| P9  | 77  | F      | Housewife and catering  | 8                  | Usability testing iteration 3       |
| P10 | 81  | M      | Academia  | 19                 | Usability testing iteration 4       |

The focus group interview was conducted at a senior center where iPad courses and walk-in sessions on ICT assistance were held. First, questions were asked about elderly people's use of ICT and their social lives. They were then presented with the idea of Tangible Cup, together with three real cups of different sizes (a big mug, a medium-sized coffee cup and a small espresso cup). The participants were given blank sheets of paper and were asked to draw their own design for Tangible Cup (Figure 2). While they were drawing, they talked among themselves and made changes to their designs.

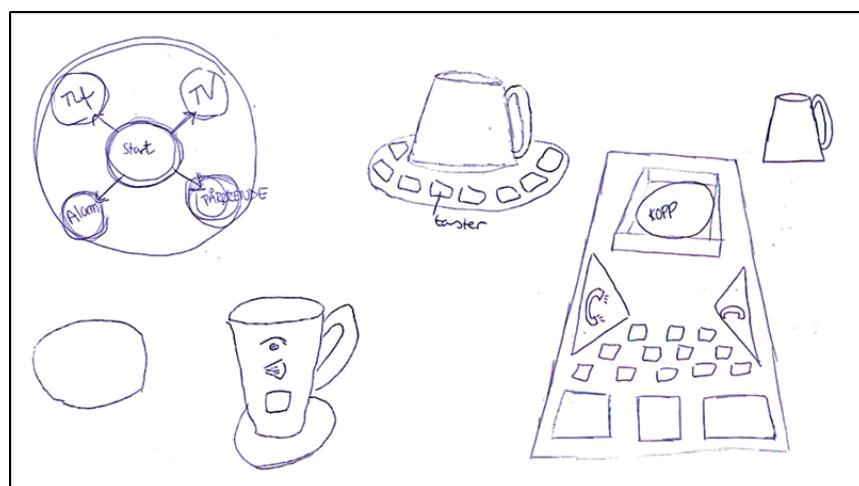


Fig. 2. Drawings of Designs for Tangible Cup Made by the Focus Group Interview Participants.

The following considerations were gathered from the focus group interview. The participants preferred a typical medium-sized coffee cup because it mostly closely represented Norwegian coffee-drinking culture. The cup had to be light and have a big, strong handle which the users could easily hold with their fingers to lift it. They coupled Tangible Cup with a saucer installed with buttons (Figure 2) to avoid having too many buttons on the cup itself. The elderly tend to have difficulties with small buttons and ‘confined’ user interfaces for interaction. In terms of functionality, they all agreed it should be kept to a minimum and that the interface should not have too many options. Finally, it should be dishwasher-proof, and the interface for interaction should be waterproof to protect it from spills.

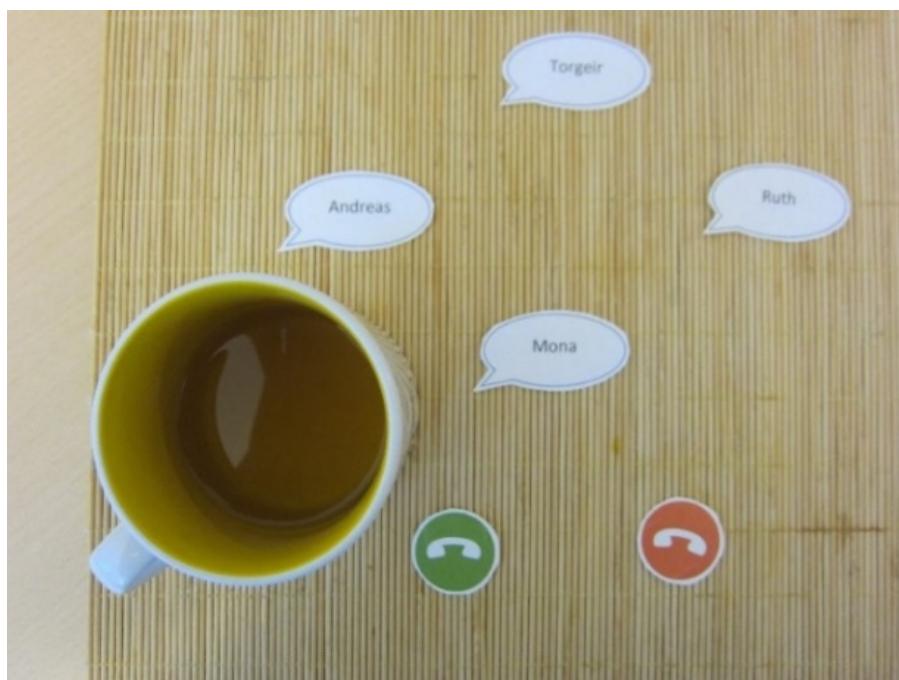


Fig. 3. First Iteration Prototype of Tangible Cup.

Based on input from the focus group interview, the first iteration produced a low-fidelity prototype using a table mat and a cup (Figure 3). The participants were given the tasks of making calls and receiving calls, and having conversations. A few usability issues were observed during

usability testing and pointed out during the interview, such as the table mat being too big to carry around, and too many names being displayed on the table mat.

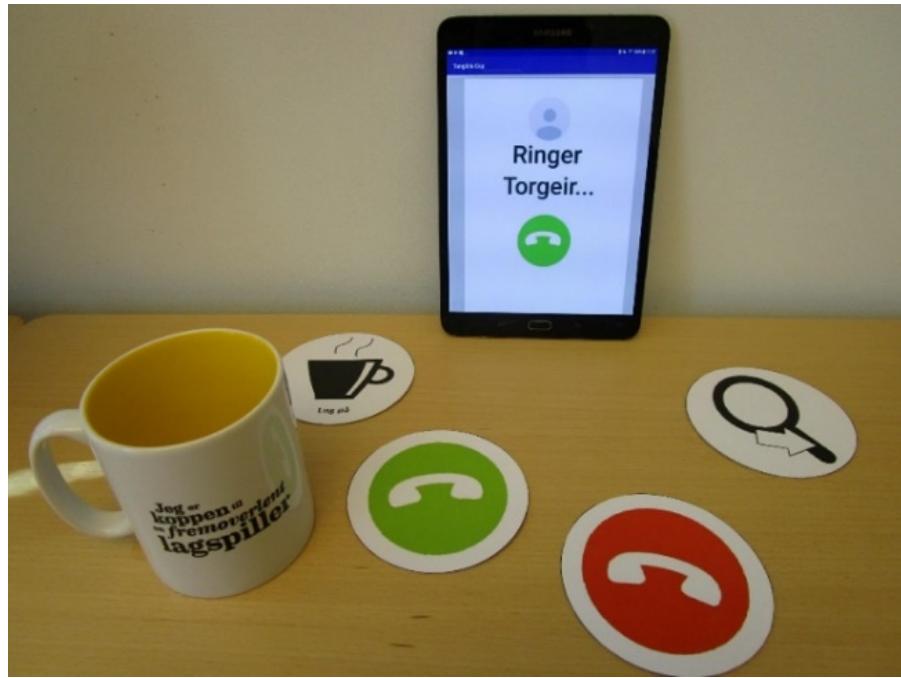


Fig. 4. Second Iteration Prototype of Tangible Cup.

In the second iteration, cup coasters replaced the table mat because they are easier to carry around. Four cup coasters (as shown in Figure 4 from left to right): *log in*, *start call*, *end call*, and *search contacts*, were designed to use to interact between the cup and a calling app in the tablet. The test tasks included logging in, recognizing someone who has just logged in, ringing that person, ending the conversation, receiving a call from another person and finding others who were logged in at the same time. The ‘Wizard of Oz’ technique (Kelley 33) was adopted in the testing.

A few usability issues and recommendations were gathered. The symbol on the *search contacts* coaster was found confusing. P6 suggested using a symbol showing multiple blank avatars instead. Confusion occurred when an upcoming action required users to use the same coaster as for the previous action. For example, when the cup was used to end a conversation by

placing it on the *end call* coaster, confusion would arise if someone called and the recipient wanted to reject the call using the same *end call* coaster. In addition, P6 found the ringing sound too sharp. She suggested that a favorite melody could replace the sharp ringing sound. Finally, there was no *log out* coaster.



Fig. 5. Design of Coasters in the Third Iteration. Left to right: *log out*, *end call*, *start call*, *log in* and *search contacts*.

In the third iteration, we modified the design of the coasters (Figure 5). We included log out from using Tangible Cup in test task in this iteration. The usability testing revealed two similar issues from the previous iteration. First, confusion when the upcoming action required users to use the same coaster as for the previous action. Second, the challenge of understanding the *search contacts* coaster (Figure 5). P9 did not understand the avatar icon, so she did not understand what the symbol with three avatars denoted. P8 and P9 agreed that it would make more sense if the avatars were made more human-like and given different colors.

During the interview, the users were also asked to co-design the cup attachment. The purpose of the cup attachment is to enable ordinary cups to function as Tangible Cups when the cup attachment is attached to them. They suggested that the cup attachment be designed to resemble a round fridge magnet so that it could be easily attached to the bottom of the cup, in the same way as a fridge magnet is attached to a fridge door.

In the final iteration, we added the cup attachment and modified the design of the *search contacts* coaster to show three human-like avatars (Figure1). In the user testing P6 and P10 were first explained about the cup attachment and how it could be attached to the cup. They were then asked to perform the same test tasks as in the third iteration. P6 and P10 found all the tasks easy to perform. They understood the design of the cup attachment and coasters, and thought that the idea of using Tangible Cup to communicate with the calling app on the tablet was good.

### *Lessons Learned*

Based on our experiences from the design process, we gathered an initial list of lessons learned. These lessons learned can serve as a guide for two purposes: i.e. what should be considered when designing TUI for elderly people and when involving elderly people in the design process. They are not limited to designing TUI for social interaction, and can be used for designing TUIs for elderly people in general. Lesson learned for involving elderly participants can also be applied when designing other digital and ICT tools for this user group.

#### **When designing TUI for elderly people**

1. ***Familiar physical objects.*** Elderly participants drew on their own personal experiences and those of others they had observed. The focus group participants told us that they wanted a typical coffee cup that they were used to: medium in size, and with a good handle. In the third round of usability testing, the design of the cup attachment was inspired by items commonly found in the kitchen. Such familiarity would increase user acceptance of the new technology (Spreicer 313).
2. ***Integration of TUI into daily life.*** Wallbaum et al. identified integration of new tangible objects in one's environment as a challenge. To address this, we kept in mind how the TUI object was to be used daily by the users. Tangible Cup was originally

coupled with a table mat, but elderly people do not use their cup in just one place, and the table mat was too big to carry around. The idea of cup coasters was adopted to address this issue.

3. ***Minimal functionality.*** The elderly users prefer few but useful functionalities.

Tangible Cup offers no functionality other than that of talking to others. Reducing the complexity of the interfaces may increase elderly people's interest and confidence in learning and using new technology (Bong and Chen 32; Fischer et al. 629; Ijsselsteijn et al. 20).

4. ***Avoid crowded interfaces.*** The elderly users prefer a simpler interface (Ijsselsteijn et al. 20). The interface of Tangible Cup was expanded from just one cup to a cup coupled with five coasters and a cup attachment. This expanded design is less crowded and elderly users will find it easier to use and learn and be less likely to make mistakes.

5. ***Consider elderly people's physical abilities.*** Reduced physical ability has to be considered in gesture-based applications for elderly people (Chen 190), and the same applies to TUI. The focus group interview participants informed us about their preference when it comes to the weight of TUI objects. Elderly users may have reduced arm strength. The weight consideration was also applied in the design of the cup attachment.

6. ***Provide necessary instructions.*** Instructions are essential to ensure that elderly users know what to do should they become confused. The aim of the instructions is error prevention and recovery (Nielsen). When users are not lifting their cup and placing it

on coasters to perform desired actions, the tablet will display instructions on what to do.

7. **Practicality.** For our Tangible Cup, it is important that the coasters are waterproof, in case of spills when using the cup. The cup attachment was added to the design of Tangible Cup so that the RFID reader does not have to be integrated into the cup itself. Any cup can be used as a Tangible Cup as long as the cup attachment is attached to it.

#### **When involving elderly people in the process of designing TUI**

1. **Use of actual objects to demonstrate.** The participants were first briefed about the project. However, it was difficult for them to understand the idea of Tangible Cup. When an actual (though not yet functional) cup was presented, the participants seemed to gain a better understanding of the idea. Without an actual object, it was difficult for the participants to imagine the Tangible Cup.
2. **Choice of words.** Elderly people have very different levels of ICT knowledge and skills. Thus, words such as '*log in*' and '*log out*' may be familiar to one person but totally unfamiliar to another. In such situations, it is better to explain in ways that elderly participants with lower levels of ICT literacy can understand (Pieri and Diamantinir 2424). In our communication we have explained them as 'be online' and 'be offline'.
3. **Find the most natural setting.** The focus group interview was conducted at a senior center, while usability testing was conducted in the participants' homes. We noticed that the participants felt more comfortable and natural at home. Their ideas and comments were linked to their surroundings. For instance, the idea of a fridge magnet

was proposed after P8 and P9 looked around the kitchen. The issue of the table mat being difficult to carry around was identified by P5 because he wanted to move from his kitchen to his living room to watch television. Their behavior and habits in natural setting must be considered when developing new technology (Intille et al. 165).

4. ***Motivation and encouragement.*** Keeping elderly people motivated and encouraged can build their confidence in using new ICT and thus increase their acceptance of new technology. We noticed that the participants were skeptical towards new technology. To motivate and encourage them, it is crucial to show them that their opinions are being heard and to encourage them to relate to their own experiences.

5. ***Consider the diversity of elderly people.*** Throughout our research, we tried to include elderly participants from different educational and cultural backgrounds, of different ages and with different knowledge levels in using ICT. It is essential to ensure that the diverse characteristics of the elderly people could be addressed.

6. ***Involve elderly users as early as possible.*** We involved elderly participants from the focus group interview, low-fidelity prototype to our final product. The design changed from iteration to iteration based on the co-design and usability testing feedback. Early involvement of elderly users can ensure that the end product properly addresses their needs and at the same time is easy and intuitive for them (Rodeschini 525).

## Conclusions

This paper demonstrates a design process for a TUI for and with elderly participants using user-centered design and a co-design approach. Elderly people constitute a diverse user group. Thus, we included participants with varied levels of experience in digital technology.

There are existing guidelines for designing for elderly people such as universal design principles and usability guidelines. However, these guidelines are not sufficient for designing TUI for the elderly. Through our experience with the process of a focus group interview, iterations of the design, and evaluations of the prototypes with the elderly participants, we provide a set of considerations for designing TUI for and with elderly people, which can also be applicable for designing other ICT tools.

We are currently planning a longitudinal study to validate the impact of Tangible Cup in terms of social interaction and quality of life for elderly users. We have yet to include some feedback from our usability testing participants in the current version of Tangible Cup, such as supporting the app as a stand-alone app without the use of Tangible Cup, and personalization. All in all, we hope that Tangible Cup will encourage elderly people to be socially active, particularly those who are not experienced in or who are skeptical towards new digital tools. The lessons learned generated can also help address the special needs of elderly people when it comes to introducing and designing new digital tools for them.

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