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Designing Novel and Engaging Interactions with and for Residents Living with Dementia and their Visitors

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Abstract: This paper describes the interaction mechanism and content design of the "A Better Visit app" — a collection of touch screen tablet mini-games developed for people living with dementia and their visitors to create enjoyable shared experiences and spark social interaction between them. The published collection, available on the App Store and Google Play for tablet devices, is made up of eight different mini-games. The games were developed and refined over an 18-month co-design and observation process and matured to solutions that support easy to use games leading to meaningful interactions during the visit. Emphasis is placed on different sensory and creative experiences, skill development, and communication between the visitor and resident to live their relationship in the moment of time. The outcome are a specialised set of interaction mechanisms and recommendations developed to aid in the accessibility of the technology experience for people living with advanced dementia.

Keywords: interaction design; dementia; engagement; games

1. Interaction Design for Dementia

Presently, there are nearly 460,000 Australians living with dementia (Dementia Australia, 2020). Dementia is comprised of symptoms linked to exacerbated cognitive deterioration caused by disorders affecting the human brain. Some of these symptoms include memory loss, confusion, changes in behaviours and ability to communicate (WHO, 2017). As time progresses, families and friends may struggle to communicate with people living with dementia as they might not be able to follow conversations, often leading to increased stress levels for everyone involved (Maresova & Klimova, 2015). Engagement is crucial for people living with dementia in order to maintain capabilities and participate in stimulating activities leading to greater quality of life (Craig et al, 2014). Technologies have emerged as capable stimulation and engagement tools in formalised care settings and can be an important component of ageing well (Collier & Jakob, 2017).

The benefits of tablet computing have been established within the dementia care space for over a decade demonstrating clear benefits to quality of life (Favilla & Pedell, 2014; Upton et al, 2011; Tyack & Camic, 2017). However, the majority of technology currently developed for people living with dementia focuses on creating life stories, entertainment and brain training (Health Direct, 2019). Not many technologies focus on the social aspects such as everyday communication with an emphasis on the here and now. Additionally, existing commercial apps are not always suitable for people living dementia due to their interactions, content or disruptive in-app advertisements. We see a need to design and develop technology that enhances quality of life for people living with dementia through social encounters where the technologies support maintaining and building of relationships. Hence, the developed app presented in this paper aims to facilitate meaningful interactions between family members and friends visiting residents with advanced dementia in aged care homes. We have adopted a point of view towards the development of our apps that respects the older adult and gives them choices instead of assuming what they would like and make decisions for them (Rogers & Marsden, 2013; Light et al, 2016).

Designing digital solutions for people living with dementia also requires taking into consideration impairments linked with age-related decline such as poor vision, hearing loss, limited touch and motor skills (Favilla & Pedell, 2013). Older people with moderate to advanced dementia may not be able to operate a touch screen without frequently resting their palm on the screen. They may also register multiple touches resulting in software crashes or require specialised interaction mechanisms to support feedback (Bree et al, 2017). Furthermore, levels of digital literacy are likely to be lower amongst older demographics as they still face barriers with adoption of new technologies (Anderson & Perrin, 2017).

In order to compensate for the challenges mentioned above, easy interaction mechanisms needed to be found. However, usability is not sufficient for a positive experience between two people. Aspects such as participants' engagement experiences with the technology (O'Brien & Toms, 2008) were considered throughout the co-design process. Non-patronising visual design and content based on the interests of the residents was also strongly emphasised. In addition, there are very limited resources on how to go about creating engaging apps for people with dementia — especially when also seeking to engage a visitor for a shared and meaningful social experience. Here we do not describe the whole co-design process with the older residents and their visitors, as this is detailed in Pedell et al. (2019). Rather, we focus on a selection of novel interaction mechanisms designed to address user experience challenges across a range of interactive touch screen tablet activities that were developed as part of exploring the research question "How can we co-design suitable touch screen interactions in order to maximise the benefits for older adults living with dementia and their visitors?".

2. Method and Design Process

In order to answer the research question, an eighteen month co-design process with residents, visitors and aged care staff was applied. The process consisted of three phases:

1. Understanding the needs of both residents and visitors during a visit (interest-based design);
2. Systematic co-creative development and investigation of interactions;
3. Iterative evaluations.

The research and development were done by a multidisciplinary team consisting of a developer, psychologist, a musician and sound expert and a digital media designer completing their capabilities in this project. All team members had additional expertise and experience in interaction design.

We applied an iterative co-design process – this means people living with dementia and their care network were not mere participants in the project but co-creators and co-evaluators throughout each project phase (Sanders & Stappers, 2008) for every two weeks. The co-creative process took place in four different living locations of our residential care collaborator. During the regular visits we were applying the interaction studies with the participants. The co-design approach focused on including several stakeholders in the design process to ensure that the results meet the user needs (older adults living with moderate or advanced dementia, aged care staff, and visitors). Effectively, the role of the user transcends that of 'user as subject' and becomes one of partnership with the designer (Sanders & Stappers, 2008, p.1). Co-design is highly beneficial in the development process, as it gives a unique insight into user needs, preferences and ideas, and hence creates products that are more likely to be taken up while these needs were addressed (Taffe, 2015). When it is carefully organised and implemented, co-design can result in a sustainable solution and enhance quality of life of its users (Sanders & Stappers, 2008).

At the commencement of this process we spent time with participants, learning about their interests and trialling touch screen applications to assess the suitability of pre-existing software, and elements therein. Craig (2017) recommends that meaningful activities need to be informed by interests and aspirations to increase quality of life. We also had a strong focus on their emotions during technology use. Demiris et al. (2004) argue that "the challenge as we create new technologies, is to understand the personal effects of the technology in order to make it better serve our human purposes" (p. 93). Hence, emotional aspects of the desired user experience was investigated through the co-design process, too. The technology developed in this project was particularly challenging, as it must fulfil very specific needs and hard-to-define feelings such as "feeling engaged" and "sharing an experience". Previous research has found that adoption rates are particularly low when technologies do not address the emotional and social needs of the older demographic (Pedell et al, 2015). Hence, incorporating emotion-led design as developed by Pedell et al. (2019; 2015) and interest-based methods (Beh et al, 2019,) at the start of the innovation lifecycle of the technology interface is critical to the objective of achieving a high level of

adoption of this technology and consequently an experience of the positive effects of its use. During the co-design process we used iterative prototyping as a way of refining requirements (Beynon-Davies et al, 1999) and as a data collection tool to provide insight into technology supported engagement of adults living with dementia. Participation was leveraged directly from discussion and observation during on-site activity every two weeks. Residents with dementia, staff members and visitors were participating by interacting in real context with the maturing high-level prototypes that were derived through many iterative development cycles. This approach ensured that the team's primary focus remained on the goals and daily activities of the residents. This is important, as they will not merely evaluate the usability of the technology via concrete traditional and measurable tasks but will focus on the impact of the technology supporting adults with dementia through engaging and calming experiences. After every visit, we refined the interactions, and towards the end of the co-design process came up with recommendations for touch screen design for people with advanced dementia. In this paper, these co-design activities with older adults comprised of what we call 'designing interactions'. The co-design process gave all stakeholders a strong voice in the design concept and content and ensured agency was applied. For details on the process please refer to Pedell et al. (2019).

3. Designing for Meaningful Shared Interactions

Eighteen residents living with moderate to advanced dementia and their main visitors (often partners, children and carers) were recruited from four separate residential care homes. Many of the participants had no previous technology experience and a range of conditions including loss of touch and tactile sensitivity, restricted vision, aphasia, and shortened attention spans. Hence, a wide range of interaction solutions needed to be found to accommodate these challenges in order to achieve an enjoyable and sociable experience. Our objective was to develop a range of novel, non-patronising tablet-based interaction mechanisms that engaged people living with moderate or advanced dementia and people from their support network (family, loved ones, carer staff) in a shared social experience.

3.1 Interactions for advanced dementia

Traces (see figure 1) was an interaction designed specifically for people with advanced dementia but was also often used as an activity to introduce participants to touch screen interactions or as warm up. Traces presents an empty screen that transforms touches into colourful traces of light which follow the path of the input multiple times before dissipating. This simple interaction aims to reward all forms of touch, with nothing being a mistake and no specific game objective. Through multi-touch, both players were able to interact at the same time, copying or chasing each other's traces around the screen. It was also easy for visitors to guide the resident's hand to help facilitate interactions. The default trace length and loop count values were set to avoid the scene becoming too cluttered but were also configurable by the users.

During co-design, we found lively music paired well with the activity influencing the participants' input and flow. Uplifting background music was produced based on user preferences and music memories encouraging engagement in the form of humming, nodding and finger-tapping. The interaction was successful at engaging people with advanced dementia, and in particular, participants with severe speech aphasia.

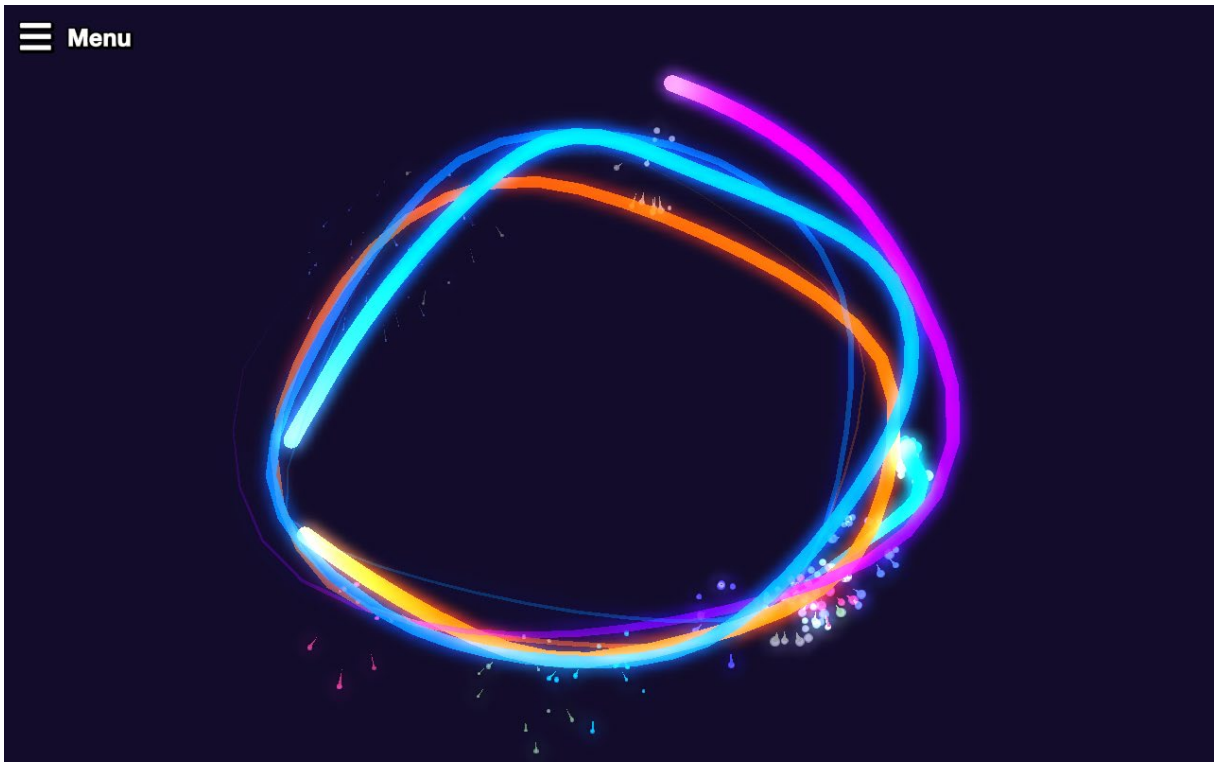

Figure 1 *Traces. The application enables users to experience in free exploration how a touch screen works.*

3.2 Competitive game activities

Tic Tac Tango was based on the traditional game of Tic Tac Toe but with a musical, ballroom dancing twist. This design flair responded to a number of participants' life experiences embracing ballroom dancing culture. Noughts and crosses were replaced by the silhouettes of dancing couples in respective player colours. With each move, music loops selected from familiar dancing styles including Foxtrot and Mambo, sequenced through highlights of the dance track recordings. The integration of music into the activity, played a key role in maintaining concentration and engagement. Participants would play to a driving groove, the carer or loved one amazed when they would genuinely lose a round in a match.

The presentation of the interaction is supported with bold type and strong contrasting colours (see figure 2). Colours were also used to cue game turns indicated by grid lines and the gameboard background.

An accessible tap mechanic was introduced here to aid in the games core interaction of claiming tiles. This was combined with a tile cool-down mechanic: a minimum length of time that users need to wait after claiming a tile before being able to claim another, which helped reduce accidental interactions and premature selections (see smaller, transparent icon in figure 2). The duration of the cool-down was refined overtime to maintain responsive gameplay, which was important to avoid frustration or confusion, while still fulfilling the intent of the cool-down.

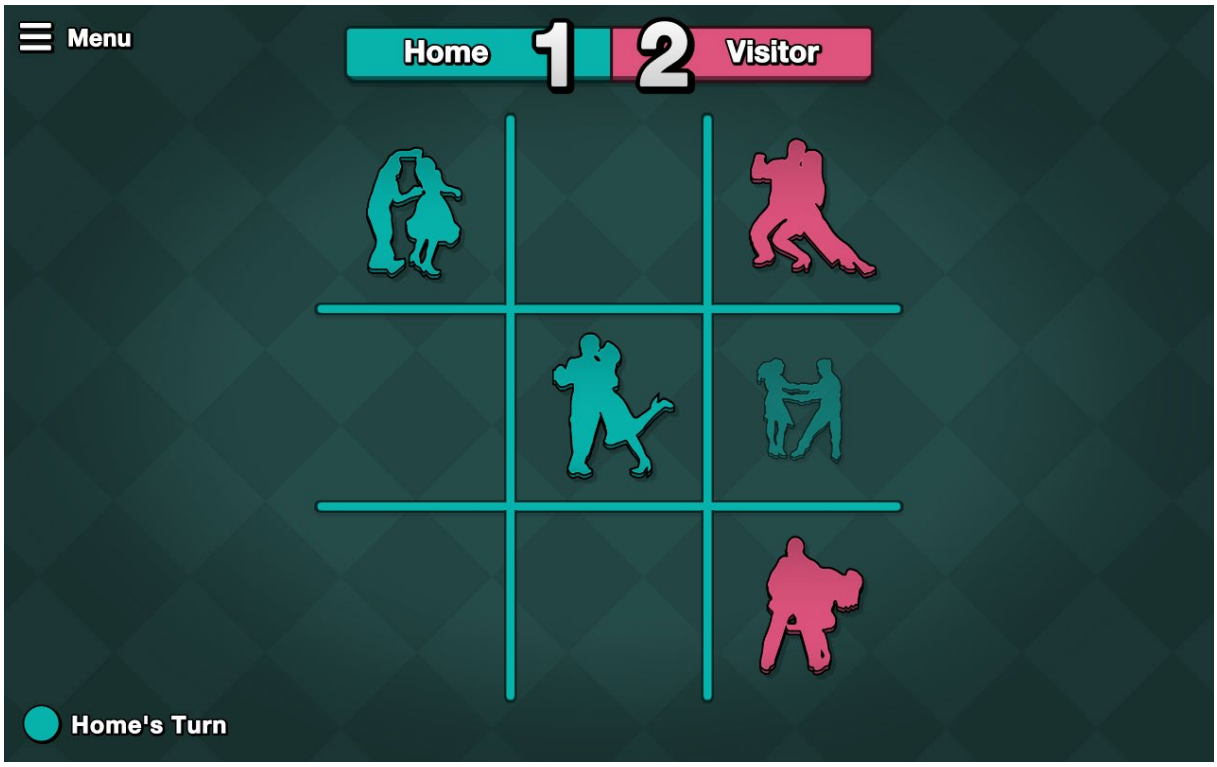

Figure 2 *Tic Tac Tango. Taking turns in a classic game of Tic Tac Toe supported by music to try and be the first player to place three marks in a row (horizontally, vertically or diagonally).*

Bowls, a lawn bowling game (see figure 3), included the most complex interactions of the different games, requiring a degree of mechanical precision from users. Despite the potential complexities of the mechanics, we were intent to pursue with the development due to the popularity of lawn (and carpet) bowls amongst the participants. Furthermore, we felt this may also be a suitable candidate to engage younger co-players who are visiting their relatives.

Early prototypes included an enclosed 8 x 40 metre virtual rink with a ditch at the far end. The game was presented from a bird's eye view using a device in a portrait orientation which naturally catered to the elongated dimensions of the rink.

We explored several interaction methods for launching the bowls including swiping and dragging. The swiping interaction, which interpolated directional input velocity of a swipe

into a launch vector, quickly proved to be difficult for users to control. The drag-based interaction was split into two methods:

1. “Forward”, dragging the bowl forwards, towards the intended launch direction;
2. “Slingshot”, dragging the bowl backwards, inverse to the intended launch direction.

Both drag methods imposed a limited radius in which to drag the bowl, with the resulting distance between the launcher origin and input position dictating the power of the shot rather than the velocity of a swipe. This allowed users to control the launch without time being a factor, thus making for a more manageable interaction.

Our observations indicated that the “Slingshot” method provided a better experience. This was particularly evident when the person with dementia needed support, it was much easier for the co-players to gently guide a finger backwards than pushing it forward. While the drag-based methods provided more control they still presented some challenges:

- Staggered or interrupted touches—common for older users with dry skin and impaired motor control—would lead to premature launches;
- Unintentional extra touches could also misdirect a shot.

Refinements were made to the launchers to only process a single touch input at a time; however, to more thoroughly resolve the issues, a confirmation mode was introduced.

The confirmation mode allowed users to continually adjust the trajectory and power of a shot over multiple touches and then release it, when ready, by tapping a separate button. This extra step greatly reduced accidental launches whilst also leaving a window for co-operative intervention or guidance. The “Quick Release” mode was retained as an option for those who preferred to bowl in one fluid motion. Nonetheless, the confirmation mode was designated as the default mode due to the benefits it brought for the broader player base.

A dynamic camera system that allowed us to match and highlight the current game state with specific views (Pinelle et al, 2008) was introduced when the game was switched to display in landscape orientation. When taking a shot, the view was from the perspective of the player looking down the rink, placing focus on the launch interface (see figure 3). After a shot was played the camera would look down at the play area to review the resulting lay of the shot and potential strategy at play.

Familiar sounds were introduced to support interactions and increase immersion:

- Swooshing for launching;
- The subtle crinkle of the bowl rolling on the grass;
- Clanks and bounces for collisions with volume based on impact velocity;
- Crowd cheers for celebrating the end of a round.

The collisions between bowls became a satisfaction point for many, regardless of how successful a shot ultimately was in the scope of the game. A weighted bias was added to the bowls to create curved trajectories, a feature requested by participants to mimic the real-

world equivalent. To avoid adding another layer of complexity, the launcher determined the curve direction automatically. If a shot was aimed to the left of the jack it would then curve right and vice versa. A button indicating the direction of the curve was also added to the graphic interface. This button could be toggled by advanced users to override the automatic curve direction on a shot by shot basis. While the curve sometimes surprised players, most became comfortable with the mechanic over the course of a round.

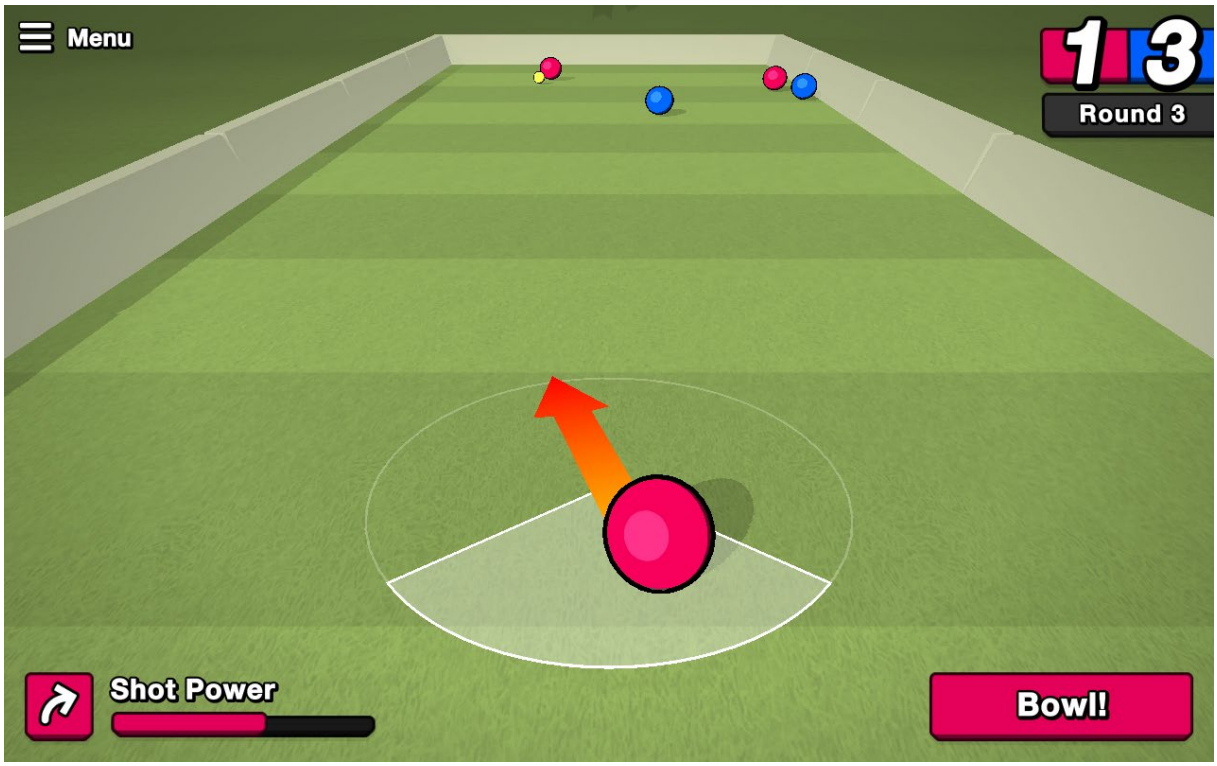

Figure 3 *Bowls. The slingshot mechanism combined with the "Bowl!"-button enables the user to adjust direction and strength of the shot before it is launched.*

Early user testing revealed that a high ratio of shots wound up in the ditch at the end of rink. Therefore, we opted to remove the ditch entirely. This allowed bowls to bounce off the rear barrier, keeping all shots in play and eased the punishment of high-powered shots that missed their mark.

We aspired to make a game that would be considered competitive for both players. This included experimenting with an assistive software shot-making agent, and redirecting shots towards the jack for the person living with dementia. However, no matter the subtlety, the automatic assist was often far too obvious, disrupted shots that might have been intentionally directed elsewhere or simply ineffective. Additionally, residents and co-players would often play as different teams and only for a single round making determining when to use the assistant problematic. Ultimately, curating the launcher's properties to fit the rink by limiting trajectories to a forward arc; clamping power levels along a curve; allowing rebounding off walls; and removing the ditch to keep all shots in play, allowed us to effectively make more shots, and good shots.

3.3 Picture–based games to increase communication

Reveal (see figure 4) presented a grid of tiles which can be tapped to reveal part of an image. While the activity is similar to a jigsaw puzzle the pre-positioned tiles avoid the need to place pieces in a specific position, a task that can be next to impossible for some people with dementia. The tile-based interactions also lend themselves to turn taking while generating natural discussion between players as they tried to decipher who or what the image might be. We also presented a question or talking point alongside the title of the image when it was completed to encourage further discussion and mutual storytelling.

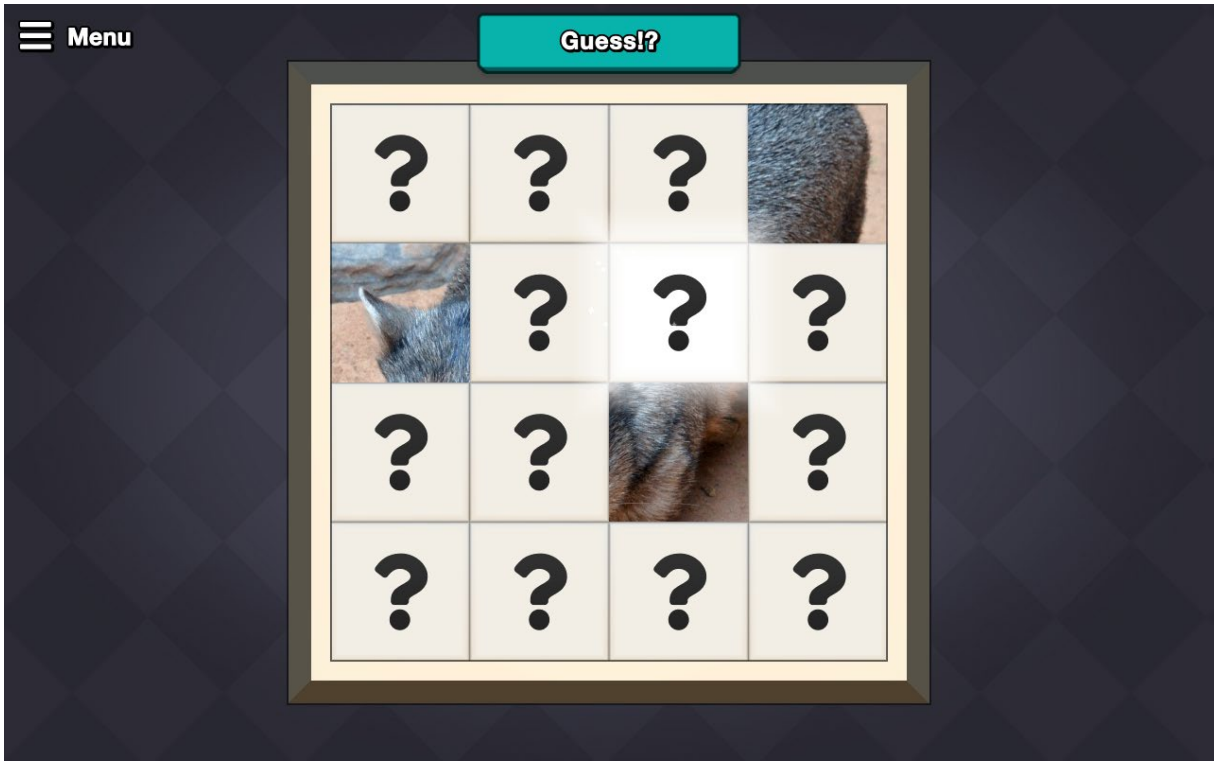

Figure 4 Reveal. Tiles that are turned successively to uncover pictures of popular motives.

Initially, guessing the hidden image was an informality. However, some users were keen to move onto the next image once they believed they had identified it. To address this, we added an optional guess mechanic which was available after each tile turn. The guess dialogue presented a selection of four options, with a correct guess automatically completing the image. Gameplay was also supported by audio queues helping to keep players engaged or spark conversations.

One visitor appreciated the guidance and prompts for the conversation in the activities of the games, feeling it gave her something to share that was easy to relate to for both:

> "Oh yeah the animals. Oh yeah, the sounds! I remember saying to dad: 'what sound would that be?' it gave a question, for me to say something, instead of just bumbling on. More about yeah, trying to have something where we're relating to this thing and speaking about it there and now instead of just waffling about 'oh the tree down the road' or whatever."

Instead of turning tiles to reveal an image, the colouring book inspired Co-Colouring (see figure 5). The activity used free form multi-touch swiping to magically colour-in a series of outlined artworks, which come to life with animation when completed (such as the parrot picking the seed pot). With multi-touch support, users were free to colour-in the images together as carefully or as carefree as they liked. The original artworks were based around familiar Australian themes (e.g. featuring native birds and backyard cricket), with the aim of presenting relatable and meaningful content that had the potential to encourage discussion and storytelling.

Figure 5 *Co-Colouring is easy to use while providing a feeling of accomplishment through an animation element once the picture is filled in.*

Similarly, Washing Windows utilised the same interaction mechanics as Co-Colouring but instead tasked users with wiping clean windows. Each window revealing a highly detailed location photograph. The locations themselves were again designed to encourage discussions and storytelling, often related to travel. Squidgy sound effects accompanied the users' swipes providing interactive feedback. Once completed, the view zoomed into the window for a clearer look at the revealed scene, whilst also displaying the location's name.

4. General Recommendations and Conclusions

The process of routine and tight iterations, co-design and interest-based design led to the development of interactions that were engaging, enjoyable and intuitive. Through the shared engagement, it was possible for care staff to gauge capabilities:

> "It helped me with some of the residents to find out their cognitive abilities which helped me judge what activities I could take them to. We have a lady that we did it with and after doing the app with her you realised that she could remember or that she knew a lot so she wasn't coming to activities that she should be really. That helped us out." The games helped with an experience in the present and without any obligation to deal with the past. One staff member explained: "Because you've been married to someone for so long and… so it was really good I think for couples like that, because it's irrelevant to the past, it's just something that they can do there and then and they're having that memory there and then."

In this section we summarise some interaction mechanisms from our research process as recommendations that helped to create these easy to use and enjoyable interactions.

4.1 Tapping

While the interaction of tapping on touch screens is generally intuitive, to people with moderate as well as advanced dementia it can be challenging. If moving a finger across the screen to an interactive element or continually holding a button would not result in anything happening, frustration or loss of interest would occur. Therefore we advise allowing for held interactions of around 1.5 seconds to trigger tap events. Additionally, tap and trigger events should accommodate touches that begin outside the target element space, meaning users could slide a finger onto a target element and release (or hold) rather than requiring touch events to begin immediately on the target element.

4.2 Layout and Language

The positioning of many interactive elements requires diligence. For instance, we believe menu buttons used for navigating between games and options, should be given a small footprint and positioned in the top left corner. This positioning is less prone to accidental touch input for older people with dementia. Menu screens should also always present a clear route to return to an interaction (or game) in the event they are accidently engaged.

While interaction is generally scaffolded by a co-player there is no guarantee to the level of digital literacy of this individual. Therefore, it is important to present simple, navigable interfaces with accessible language. In addition, moderate and advanced dementia users unfamiliar with touch screens would require quality visual and audio feedback (e.g. audio pings, clicks and visual sparkles) to support their interactions.

4.3 Audio

Music can greatly assist with mood, attention, and engagement. Playing favourite tracks in the background during test sessions can also create positive co-design input through better attention and prompt reminiscence. Music where possible should be selected based on personal or generational preferences of users.

4.4 Default Settings

Many of the games allowed the users to modify a selection of dynamic settings to suit their

preferences. However, the majority of users always played with the default settings. This reinforces the importance of selecting the right base values through rigorous play-testing. Interactions should be iteratively tuned as much as possible throughout the entire co-design cycle.

4.5 Exploration and Instruction

Even when interactions for people with dementia are extremely simple, instructions may still be required. To that end, we recommend including modest tutorials explaining how to play. Tutorials are best displayed at the commencement of each game, just once per session. We also suggest allowing tutorials to be manually disabled in settings panes if preferred by regular users of these activities.

4.6 Consistency and Device Recommendations

We strongly advise for a consistent screen orientation when presenting a collection or range of different activities. A landscape orientation is better suited for dual use settings. Touch screen operating systems often employ special gestures to facilitate system navigation or other functions. Unfortunately, for those unfamiliar with these actions, they can quickly and unintentionally interrupt the use of an app by accidentally send the app to the background (minimising the app). Where possible this should be avoided, for instance, requiring two consecutive edge swipes to trigger the dock on iOS. However, some of these settings are set from a system level, such as multi-tasking gestures, making them difficult to override. Therefore, we advise the inclusion of instructions recommending the disabling of multi-tasking gestures from the application's "How to Play" menu and App Store page.

4.7 Conclusions

This research showed the relevance of carefully designed interaction for social engagement using touch screen tablets. Through a range of activities and suitable interaction mechanisms, older adults living with moderate to advanced dementia were able to engage in a shared social experience. The diverse mini activities were matched to the limited attention span of people living with dementia. Our in-depth understanding of the capabilities and needs through the co-design process allowed us to come up with novel interaction mechanisms specifically for older adults with dementia and formulate some guidelines that we suggest can support designers for development of touch screen applications in the future. Rather than showing off the touch screen capabilities, it was more important to focus on interactions and adaption of the tablet to the residents' needs and interests. The extensive time window in designing the interactions proved to be important to the app's success. Engagement is highly relevant for people living with dementia and promising for future technology extending the activities stepwise towards new use scenarios. In particular, the engagement responses (such as nodding of heads and tapping of fingers) are an important indicator for quality of life as during the progression of the level of dementia often emotions increasingly diminish (Vink et al, 2003). A careful balance between stimulation and familiarity

needs to be maintained to create successful and supportive technologies in social settings. Providing common ground and a familiar setting are crucial for interactions for positive experiences – while we consider the interaction mechanism implemented in the "A Better Visit" app as novel we recommend not to overdo 'novelty' or try to revolutionise the setting itself or the activities, but learn from the older adults' interests.

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