Exploring User Opinion on the Benefits of Cognitive Games through an Online Walkthrough and Interview

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Abstract. Online walkthrough interviews were conducted via internet video-calling, which formed part of wider Patient and Public Involvement activities investigating perceptions of digital and gamified cognitive assessment and training/coaching applications. Participants were invited to play a series of mobile mini-games which have been developed for the purposes of training of executive functions and the assessment of memory, whilst verbalizing their thought processes, using a process based on the Think-Aloud Protocol and Cognitive Walkthrough principles, before concluding with a semi-structured interview. The enquiry was particularly interested in wider motivational aspects surrounding these technologies, including identifying potential barriers to engagement and facilitators of adoption. In general, there was broad acceptance of digital cognitive assessments and training, although issues of data handling and trust were raised by participants. Several usability issues were also captured.

Keywords: User-centered design, evaluation, pervasive healthcare.

1 Introduction

In recent years there has been a growing interest in the application of digital technologies designed to promote healthy lifestyles; particularly in the prevention, management, and mitigation of dementia and within the context of applications designed to protect cognitive health more generally [1-4]. Robert et al. [5] highlight the importance of serious games for dementia, suggesting uses such as rehabilitation, stimulation, and treatment, as well as providing the capability to monitor the disease severity and progression. However, there are still open research questions about the effectiveness and uptake of such interventions [6, 7]. Likewise, there are still complex and unresolved issues

surrounding digital cognitive interventions and cognitive assessments and their acceptance to people living with dementia and their carers [8, 9].

As part of a European collaboration Alzheimer's Disease Detect and Prevent that is investigating the design, effectiveness, and suitability of cognitive (also termed 'brain') training/coaching and memory assessment games for people at risk of dementia [10], we are conducting a series of patient and public involvement (PPI) activities for the purposes of understanding user requirements, improving usability of the software and to guide future trials with end-users. This work is being conducted in addition to in-house usability testing to investigate the broader determinants of adherence and overall perceptions of the specific software, as well as people's perceptions of the utility of serious gaming for dementia. As these aspects are relatively under-explored, we are seeking to explore user opinion on motivation, adherence, and trust.

2 Background

2.1 Dementia, Persuasive and Serious Gaming

Persuasive games are a form of 'serious game' designed to change human behaviors or attitudes, often within a public health context [11]. Persuasive technologies may provide additional functionality which make behavior change easier and may be better able to use cues to engender trust, therefore supporting engagement and subsequent behavior change [12].

Games aimed at reducing the public risk of dementia and helping those with dementia to mitigate and manage the symptoms are becoming increasingly commonplace. Some of these games have been specifically designed with dementia-related issues in mind or are aimed at cognitive health of older adults more broadly, whilst others may have been developed for other purposes or audiences but offer relevant experiences.

Dementia games may have preventative, rehabilitative or informative purposes, in addition to their entertainment value. In a systematic literature review, McCallum and Boletsis [13] identified research studies of games related to dementia and mild cognitive impairment, including games with a physical component. They note that many of the games which have been evaluated for their benefits within the dementia population were actually developed for the "typical user" and that despite the fact that these games may not necessarily meet all of the requirements of people living with dementia-related conditions, these applications were widely used amongst the elderly and those with cognitive impairments. McCallum and Boletsis [13] suggest that physical-based games may help to improve the mobility of people living with dementia and other games were also shown to provide benefits to cognition. They also note that there may be emotional benefits to playing certain games, but caution that many games suffer from usability problems which impede or discourage usage for dementia-related populations. Finally, they highlight that bone fide games tend to place more of a focus on the emotional and social aspects of play, which may lead to higher engagement than the more therapy-based cognitive training programs.

Similarly, digital gaming for community dwelling older adults is seen to promote lifelong learning, optimize mental, physical and social stimulation and foster independence [14].

Fanfarelli [15] argues that although some studies seem to show positive results for dementia-related games, these have primarily been low sample size pilot studies, or studies which fail to examine whether improvements in games can have real-world transferrable benefits. Overall, they conclude that the field is in the early stages of research and lacks the evidence base which would be necessary to implement these games with confidence. It is suggested that future studies should enlist larger samples of participants and consider outcome measures applicable to the lived experience of users.

However, evidence is emerging demonstrating measurable improvements in certain cognitive domains following game-based brain training in older populations. A systematic literature review and meta-analysis conducted by Wang et al [16] revealed that game-based cognitive training software significantly improved executive functions such as processing speed, selective attention and short-term memory. Wang et al identified 15 randomized control trials utilizing game-based brain training interventions for populations of community dwelling adults aged 60 and above, representing a total sample size of 759. However, the reported quality of the evidence of the three primary outcome measures was judged to range between low and very low, further emphasizing the need for high quality clinical trials in this area.

Robert et al. [5] highlight the importance of serious games for dementia, suggesting uses such as rehabilitation, stimulation, treatment and monitoring. Through stakeholder workshops attended by healthcare professionals, technology companies, family association representatives and IT experts, attendees discussed the numerous items discovered from a preliminary literature review and were asked to prioritize them, as well as to propose new ideas. Serious games can enhance motivation, positive mood and improve assessment and facilitate independent practice and self-assessment. Serious games may have advantages over standardized cognitive assessments as the person is less focused on the fact they are being 'tested', which may be distressing to some people. They may also have built-in social elements to facilitate interactions among peers; both by having people physically co-present or online and connected via remote locations. On the other hand, unfamiliarity with the technology could be a barrier to engagement for some people.

2.2 Motivation and Engagement

Motivation is identified as a key aspect of cognitive gaming, and one that needs further attention in research [17]. Motivation is often considered to be comprised of two aspects; intrinsic and extrinsic [18]. Intrinsic motivations are those motivations which are directly related to the task; the activity is performed for its own sake, because it is rewarding. Game-based mechanics may contribute towards fostering intrinsic motivations, through interactions, progressions, and contextualization; and this could give players a sense mastery, autonomy and competence [17]. Some have argued that performance feedback is a primary source of motivation for the player [19], others have

suggested the use of affective computing models to increase the adoption and effectiveness of cognitive assistive technologies for people with dementia [20].

Extrinsic motivation are those motivations which are external to the task, for example, the potential cognitive health benefits conferred such as dementia risk reduction [21]. Mishra, Anguera and Gazzaley argue that whilst intrinsic motivation may be important for cognitive games, engagement with even very enjoyable games may wane over time, suggesting the need for independent and externally motivating factors, which may include the adoption of motivational frameworks, goal-setting, and habit formation [22].

More generally, there is a clear and established link between learning outcomes and motivations in traditional educational settings [23]. However, in a cognitive training study which varied gamified and motivational features between two cognitive training programs, there were no statistically significant group differences between those that had undertaken training with gamified elements and those who had completed similar training with less gamification [24]. Despite this, those who completed the gamified training exerted more effort in training, improved more, and enjoyed the training more. The relationship between game mechanics, motivation, and improvements in following cognitive training is not well-understood. Engagement and motivation may have more of an impact outside of laboratory settings, where a person is engaging in an activity of their own volition and for a potentially longer, undetermined period.

2.3 Perceptions about Cognitive Screening

A systematic literature review investigating people's attitudes about cognitive screening for dementia concluded that screening raises complex issues around preference and choice for both clinicians and the public and suggested that clear communication is a vital part of patient acceptance of testing that could otherwise lead to confusion or a misunderstanding of results [25]. Furthermore, patients may find tests to be strenuous or stressful, due to a perceived pressure to perform well which could be addressed by managing expectations, clear explanation beforehand, and a debrief afterwards.

Other studies have suggested that being healthier (taking fewer medications) was associated with less willingness to accept dementia screening [26]. Conversely, those who perceive themselves as more susceptible to illness, and those who experiencing cognitive difficulties have been shown to be more likely to accept cognitive screening [27].

Stigma may also play a part in the acceptability of cognitive screening. People who have had experience in caring for people living with dementia are less likely to be accepting of screening technology and more likely to perceive it as inducing suffering than their non-caregiving counterparts, despite there being no difference between the two groups about the perceived benefits [26].

It is suggested that those living in rural areas may be at particular risk of developing Alzheimer's, being undiagnosed and being at risk of a higher rate of falls and unintentional harm [28]. Therefore, this is a population which may significantly benefit from prompt cognitive screening. This finding is also supported by a meta-analysis conducted by Lang et al. who investigated the determinants of undetected dementia.

In light of the Coronavirus pandemic, many countries have had to adopt to remote and online services in lieu of otherwise routine checkups [29], encouraging a heightened interest in the area. In a recent qualitative study involving interviews with 148 Indian physicians, a prominent theme was that Tele-health was the future of dementia care [30]. However, those interviewed stated multiple challenges, some felt unable to build therapeutic rapport or struggled to apply traditional psychometric scales over the phone and video. Gamified cognitive training and monitoring may help to overcome issues faced when access to clinicians is scarce and may also provide support in addition to the unique benefits discussed earlier.

3 Method

Drawing influence from the Think-Aloud Protocol [10] and Cognitive Walkthrough principles [11], we designed an interview procedure in which participants played a series of mini-games designed to assess and train various components of cognition, whilst verbalizing their cognitive process. In total, the interview consisted of participants completing four mini-games before being presented with results which reflect their relative performance in the different cognitive domains (see figure 1). After the mini-games, interviewees were asked broad questions about their views of technology to assess and train cognition in order to reduce the risk and manage the symptoms of dementia.
We are currently conducting interviews with a small number of people over the age of 45 with no diagnosis of cognitive impairment and are reporting here on the first three interviews conducted to date (February 2021). This work is complementary to and followed focus groups, conducted in 2019 and reported on elsewhere [9], in which we invited people living with dementia and carers to discuss a range of similar issues.

Because of restrictions placed upon UK universities and society during the Coronavirus pandemic, these interviews are now being conducted remotely via Microsoft Teams video conference calling (see Fig. 1). We modified our procedure to split the interview session into two separate one-hour sessions which allowed for additional opportunities to resolve any technical problems which might arise during the installation of third-party software on participants' personal devices, and reduced the demand placed on participants. Participants were recruited using word of mouth and email campaigns, and organization of the interview sessions was arranged via email. In the two sessions, participants were called on Microsoft Teams on a desktop PC whilst they used the app in front of the camera in such a way that the interviewer could see the screen at times and guide the interviewee through the gameplay before proceeding to the questions at the end, as shown in Figure 1. The typical interview procedure for the first session consisted of 15 minutes for introduction, information and consent, followed by approximately 10 minutes of software installation, 20 minutes of cognitive assessment games, and finishing with 10 minutes of an initial semi-structured interview. The second session involved approximately 20-25 minutes of cognitive assessment, followed by approximately 20-25 minutes of a second semi-structured interview before conclusion and debrief.

During the interviews, several probes were used during the cognitive assessment phase, to ensure that participants were verbalizing their thought process “Please keep saying what you are thinking” and to elicit their understanding of the task requirements, “What are you being asked to do?”

In addition, probing questions which formed part of the semi-structured interview process included questions such as “What do you think the purpose of the mini-game was?”, “Is this something that you would do in your everyday life?” and “Do you think this application would be of benefit to you?”.

Ethical approval for the original protocol as well as the amendment suitable for a fully online method was granted by the Faculty of Medicine and Health Sciences Research Ethics Committee (Approval number: 333-1906).

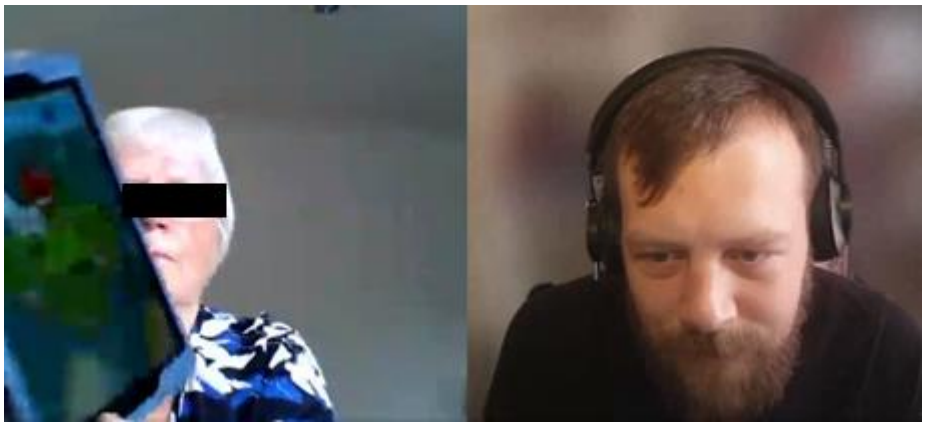

Fig. 1. Illustration of online video call with participant and researcher

4 Results

Initial findings from the three interviews conducted so far show that the mobile software application was well-received, and participants could imagine using these types of cognitive training and assessment games in their everyday life. Participants indicated a general interest in using these types of applications, if it could be shown to be of some benefit to them.

Table 1 shows the results from the main session divided into motivations, capabilities, concerns and usability.

Overall, participants were well-motivated to engage in these types of activities and participants also mentioned that their own personal routines often included word and number puzzles, as well as more typical video games. Two of the participants also commented on the satisfaction of seeing self-improvement in the games that they already played (crosswords and strategy games), and in the case of the latter, they said that the in-game rewards for good performance kept them engaged; an example of intrinsic motivation.

Table 1. Summary of Results

Theme	Example	Detail
Motivations	Fit of the App with personal routines	Already play puzzles on similar devices
	Importance of Cognitive Health.	Participants aware of the importance of maintaining good cognitive health through cognitively stimulating activities.
	Like the idea of competing against one's self and objective measures of improvement.	Several participants mentioned that they like to see improvements when they play games or learn new skills. Personal high scores, etc.
	Unsure of life-expectancy.	One participant said that he had a family history of heart problems and was unsure of his life expectancy. This meant that they were unsure they would reach an age to be at risk of dementia.
	Unsure of whether the risk can be reduced.	Several participants were unsure whether the risk of dementia could be lessened.
Capabilities	Find learning new things difficult.	Participants claimed that they are not used to learning new skills and find it more difficult to do so with age.
Concerns	Use of feedback in the games.	May cause unnecessary anxiety. How can the cognitive domain be improved? Can it be improved?
	Data handling.	Participants concerned that their data may be used in ways they have not agreed to.
Usability	Instructions.	Game starting before task was fully understood.
	Interaction.	Confusion of drag versus point-and-click.
	Affordances.	Confusion over targets vs distractors in visual search task. Confusion with symbols used in planning task.

In general, participants were unsure whether dementia could be prevented or whether anything could be done at the present to lessen the severity of possible dementia symptoms at some point in the future. Despite this, participants linked the concepts of engaging with cognitively stimulating activities with good brain health and had an implicit understanding of the importance of maintaining this, including conceptualizing cognitive training as "mental exercise". This finding is supported by the associated focus groups research conducted previously [9]. These are all extrinsic motivations.

One participant commented that they thought cognitive health would be increasingly important as life expectancy increased, with a growing number of people becoming at risk of acquiring dementia. Another participant spoke of a family history of heart disease and did not necessarily expect to reach an age where they would be at risk of dementia. This meant that they saw little reason to undertake activities to reduce the risk of dementia. Participants were open to the possibility of cognitive training and cognitive assessments to form part of routine healthcare.

"I don't know, it depends if there's something I could do about it. It's hard to say, isn't it? I mean, if I was to get dementia in twenty years, I'd be lucky if I lived twenty years" – Participant #3.

Whilst participants liked the fact that individual tests could target specific cognitive domains, concerns were raised about the feedback of cognitive assessments, which may cause unnecessary anxiety for people concerned about their cognition. One participant commented that they would like their scores to be shown against average scores for that age bracket but suggested that being presented with a below average score might be disappointing for some people. The participant commented that whilst it might motivate some people to work on the areas of cognition that they are less proficient in, it could deter or demotivate others.

Another participant commented that when being presented with a score for a certain cognitive domain, it is important that the cognitive domain is understood, and that the person knows, in very concrete terms, how they might improve their score in the future.

"Do we want the scores back?... Some people might really want to. But some people who are fearful like me, fearful of the dementia, actually, I'm happy not to know…but actually I could imagine some people really, really want to know"
- Participant #1.

One participant commented on the presentation of problems, suggesting that they preferred very visual problems such as map reading and spatial transformations above word-based memory problems, they liked the idea of cognitive tasks which related to real-world activities but commented that abstract tasks (such as word or symbol recall) would be less enjoyable.

Broader issues relating to cognitive training and assessments were also discussed and participants were invited to make suggestions and recommendations. Participants commented on the presentation of results and expressed concern about who would have access to the results of these cognitive tests and how they could be used. Whilst

participants were made aware of their anonymity in our research, their concern was that if cognitive tests became more widely accepted, a growing number of people would want access to the results and may use them in ways the participants had not agreed to (for example, health insurers or governmental departments like the Department for Work and Pensions that make decisions about access to welfare benefit payments).

"I think the main thing is, it would have to be secure and you'd have to be comfortable it wasn't being shared. I don't think I'd be too comfortable about sharing it". – Participant #2

Whilst usability of individual functions or games within the app was not the direct focus of this enquiry, we observed more specific perceptions about some of the cognitive assessments. For instance, one task was specially designed to evaluate working memory deficits. The task involved participants remembering a series of intentionally difficult to verbalize objects, followed by a distractor task, then a recall task and finally, dragging the recalled object to the position onscreen where it was first seen. The target objects were designed to be difficult to verbalize and so the design utilized small constellations of stars. However, one participant attempted to name these shapes in order to facilitate recall. The participant stated that they did better in shapes which they could assign a name to. In another example, the participant misunderstood the control mapping of the task on the touch screen, which caused a mismatch between expected and observed behavior, and led to the participant underperforming in the assessment.

5 Discussion

Whilst cognitive training and at-home cognitive assessments are becoming increasingly popular research topics and have promising real-world practical applications, there are still several barriers to adoption, including ambiguity around the potential benefit for the person being assessed [31]. Interventions designed to form part of a person's daily routine need to ensure that there is involvement from patients and the public in the testing and evaluation of cognitive technologies; this is likely to facilitate better uptake and ensure that the application is being used as intended [32]. Similarly, there are open questions about whether cognitive training increases the subjective well-being in older adults, over and above more traditional leisure time activities [33]. Interviewees in our study were able to articulate knowledge and opinion about the trajectory of dementia and more broadly about health in aging although it was apparent from the one comment about cardiovascular health that there was lack of knowledge about the vascular dimension of dementia risk. Preferences for particular types of game were apparent as well as preferences for gamification mechanisms, such as rewards. Participants were able to identify possible demotivating factors in gamification for themselves or potential for this in others. Personalization was also explicitly mentioned, with people expressing the desire to have custom training programs. Participants raised concerns about privacy, security and the handling of data, as well as complex issues about autonomy and self-mastery [34]. Research into assistive technologies for people living with or at risk of

cognitive impairment needs to further explore the consequences of technology in relation to quality of live, digital rights and overall wellbeing to facilitate better usability and acceptability [35].

Overall, participants enjoyed the games, and of those interviewed so far, all had either experience playing computer games, or paper-based puzzles (crosswords, Sudoku, other video games). However, it was clear that in some instances, the participants struggled to think their way through the problems (designed to evaluate their working memory, planning, etc.) whilst verbalizing their thought process. Think-aloud protocols can reveal insights about information which is being actively processed in working memory, but high cognitive load (as in this case) may hinder the verbalization process and as such the procedure can only offer a partial glimpse into cognition. [36].

Whilst we designed prompts in our interview script to remind participants to keep talking, it was clear during the interviews that too many prompts would interrupt participants' thought process and impact upon their performance. This may present unique challenges to using 'Think-Aloud' inspired protocols during tasks specifically designed to test the maximum limits of certain cognitive domains. Other studies using methodology inspired by Think-Aloud Protocols have also identified similar methodological issues, such as a higher level of guidance required, and the unfeasibility of asking participants to verbalize their thoughts whilst reading [37]. Alternative approaches to more typical Think-Aloud protocols have employed retrospective think-aloud procedures, sometimes called 'virtual revisits' [38] and this has been shown to be useful in areas where the Think-Aloud protocol impacted upon task-performance [39]. However, the focus of our work was to explore motivational issues surrounding the use and adoption of cognitive training technologies with experienced participants, and we were less interested in the specific usability issues encountered by participants. A more appropriate use of participant time was the exploration and discussion of broader motivational issues, such as what value participants thought it might have to them personally, and whether or not they would consider using cognitive training games in their everyday lives.

Conducting these interviews during national lockdown restrictions presented a variety of challenges to research. We found it more difficult overall to recruit participants for online studies than in previous similar projects. In part this is because we were unable to provide mobile devices for those who did not have devices compatible with the software. Conducting this study remotely also meant that in addition to a compatible mobile device, participants also needed access to another device with a camera to conduct the interview.

Whilst these challenges were not insurmountable, they forced us to change our initial methodology to ensure that participants were adequately supported during remote interviews. For instance, splitting the interview over two consecutive days gave us more opportunity to resolve any technical issues and ensured that participants did not feel too overwhelmed or unduly burdened.

6 Conclusion

Motivational aspects of cognitive gaming are still an under-researched area, but in light of the globally aging population and increased burden on healthcare services; there is an increasing focus on technology used to support people living with dementia, and to encourage lifestyle changes to reduce lifetime risk [40]. However, various questions remain about privacy and utility of such interventions, and these may be potential barriers to wider adoption. Patient and Public Involvement, as well as research exploring broader perceptions of cognitive technologies may help to overcome barriers to adoption, and improve engagement with training and assessment regimes; improving overall outcomes and reducing the strain on healthcare services.

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