Does familiarity affect the enjoyment of touchscreen games for people with dementia?

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Abstract

Introduction: Previous research has indicated that people living with dementia are able to use touchscreen technology, which presents an opportunity to deliver meaningful and engaging activities for people to pass the time independently. The challenge is to identify suitable applications from the thousands that are currently available, and familiarity, where an app is a digital version of an existing real world game, may be one solution.

Objectives: To evaluate the concept of familiarity in gameplay with people living with dementia by comparing a known game with a novel game and measuring whether users are able to play these games independently and whether they enjoy doing so.

Methods: Thirty older adults living with dementia were recruited from local care services. Each participant was assigned to one of two groups. Group 1 played a familiar game (Solitaire) and Group 2 played a novel game (Bubble Xplode). Each participant played the same game on three separate occasions within one week. Number of gameplay attempts, whether a checkpoint was reached and how much time to reach the checkpoint were measured. A brief post-session interview was conducted to assess the participants’ enjoyment.

Results: Ninety percent of participants attempted gameplay independently with 17% of participants in the familiar group reaching the checkpoint compared with 93% playing the novel game. Regardless of which game was played or whether the checkpoint was reached, 88% of all participants reported enjoyment of the gaming sessions.

Discussion: People living with dementia can play touchscreen games independently, but familiarity does not ensure successful gameplay. Enjoyment appears to be independent of progression through a game. The potential of novel and unfamiliar games as meaningful activities that people with dementia can engage with independently should be further explored.

Keywords
Dementia; Games; iPad; Familiarity; Engagement; Learning

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1. Introduction

Dementia is an incurable, progressive neurological condition that currently affects an estimated 44.4 million people worldwide, and is predicted to rise to over 75 million by 2030 [1]. Dementia primarily affects cognitive functions, such as memory, language, attention, planning and initiating activities, which affects a person's abilities to look after and occupy him or herself. This places huge demands on families who provide the majority of dementia care [2], but also on health and social care services, which are increasingly stretched in trying to accommodate the growing numbers of older people with dementia [3].

Currently there is a lack of satisfying and enjoyable activities for people with dementia to pass the time in a meaningful way that does not place huge demands on caregivers [4]. Identifying independent activities for people with dementia that are both stimulating and safe would benefit both the individual and their caregivers [5]. Touchscreen devices, such as smartphones and tablets are increasingly available, affordable and accessible [6] and there is growing evidence that people with dementia are able to use them [7-9]. In the majority of examples to date where touchscreen technology has been used with people with dementia, the function has been either to present cognitive assessments [10-13] or to provide cognitive support or stimulation [14-17]. Whilst these functions are obviously beneficial, these devices also have the potential for providing activities for people with dementia to engage with and enjoy independently [18], and this is an area that is currently under-researched.

Where touchscreen interfaces have been used with people with dementia for entertainment purposes, it has been identified that activities that require constant interaction and an element of challenge can hold the user's attention and be enjoyable [5]. Here the importance of aesthetic design was highlighted as a contributor to the sustainment of the user's attention. The researchers addressed this by involving people with dementia and their carers throughout the development process; testing the various designs and making alterations iteratively.
based on observations and feedback. This work, along with more recent projects [19, 20], focussed on the development of original touchscreen games designed specifically for people with dementia. Whilst the advantages of this method are clear, there could also be value in looking at existing touchscreen applications (apps) that have not been designed specifically for people with cognitive impairment. The potential benefits are that there is a vast range of choice already available and by utilising apps that are available to the wider population, any risk of stigma is reduced [21]. These two approaches (bespoke and ‘off-the-shelf’) need not be considered mutually exclusive as any outcomes learned from one can serve to benefit the other. Evidence for this can be found in similar work involving the development of games for older adults without dementia or cognitive impairment, where existing games were used initially to collect design recommendations [22]. If suitable ‘off-the-shelf’ games could be identified for people living with dementia, and a model for selecting them be developed, this could provide users with a greater variety of choice whilst reducing the possibility of stigmatisation, and potentially inform the development of new games in the future.

An evaluation of available iPad applications carried out in 2012 offered people living with dementia a choice of ten touchscreen applications classified into two types: ‘competitive games’ (e.g. ‘Checkers’) and ‘sensory activities’ (e.g. ‘Pocket Pond’). [23]. The research, conducted in the Netherlands, had a researcher either sitting with or nearby the participants to help them navigate the iPad. One app, ‘Sjoelen’ (Shuffleboard), was by far the most popular, accounting for 76.83% of the 82 selections, with the second most popular accounting for only 23%. Sjoelen is a representation of a popular Dutch board game [24] that requires players to slide pucks along a playing board into any of four compartments that carry point values of one to four. The application’s title and icon, and the design of the board and playing pieces, are accurate to the original real-world game, which may have provided the necessary cues for the participants to recognise the game. The finding that people living with dementia consistently chose this game suggests that familiarity with the ‘physical’ version of the game could have influenced the
participants’ selection. However, because the participants were free to choose which application they used, it is not known whether familiarity had an effect on their ability to use the application or how much they enjoyed using it, compared with unfamiliar applications.

The current study therefore investigated the effect of familiarity on usability and enjoyment by people with dementia, focusing on apps identified as games (as opposed to sensory experiences). A series of selection parameters were developed on which to base decisions about the selections of apps, influenced by the findings of the previous Dutch study and previous work developing interactive activities for people living with dementia [25]. These criteria were used to select two games designed for individual play that were deemed accessible and user-friendly - one ‘familiar’ (a well known one-player card game) and one ‘novel’ (a tile matching game). The research questions were: 1. Are people living with dementia able to play games on the iPad independently (without a researcher or caregiver on hand)? Specifically, a) Does the familiarity of the game affect their ability to play it on the iPad? and b) Are they able to learn and improve their performance on the game over time? 2. Do people living with dementia enjoy playing games on the iPad independently? Specifically, a) Does the familiarity of the game affect their enjoyment of it? and b) Does their level of enjoyment change over time?

2. Method

2.1 Design

A 2 (groups) X 3 (time) mixed design was used. Thirty participants were recruited and randomly assigned to one of two groups: Group 1 played the familiar game and Group 2 played the novel game. Each participant was asked to play the same game at three different time points over the course of a five-day period.

2.2 Participants

Thirty people living with dementia were recruited from residential, specialist dementia and day care services. Twenty-five of the participants were female and five were male. Their median age was 86 (range 78-100; SD 5.34). The severity of
their cognitive impairment was assessed using the Montreal Cognitive Assessment (MoCA) [26] with a score of <21 required to meet the criteria for dementia. The participants’ mean score on the MoCA was 13.4 out of 30 (range 8-21; SD 3).

The study received a favourable ethical opinion from the School of Health And Related Research (ScHARR) Ethics Committee at The University of Sheffield. A member of the research team obtained consent from each participant. Members of staff from the care services supported the consent process as gatekeepers by identifying potential participants and providing them with an information sheet. The researcher only approached individuals if they were agreeable to finding out more information about the study. Those who consented were visited individually within their care service and the study was explained to them in full. A member of the research team assessed each person’s capacity to consent to participate in the research based on the criteria set out in the Mental Capacity Act 2005 (England & Wales) [27] and following recommended guidelines published by the British Psychological Society [28]. On receiving verbal consent to take part in the study and with satisfaction that the person had the capacity to make this decision, signed consent was obtained by the individual. As decisions are time-specific, the researcher reviewed this procedure at every point of contact with each participant. All participants were made aware that they were free to leave the study at any time. The input of relatives was not required as the participants retained the capacity to consent to participate, however it was agreed with the service managers and participants that relatives would be informed that the study was taking place.

2.3 Materials
2.3.1 Games
2.3.1.1 Familiar game. In selecting a familiar game, an app was sought that was a digitised version of an existing game that is sufficiently popular to have a high chance of being known to the target population (in the UK). ‘Solitaire’ (or ‘Patience’) is a one-player card game that has been played in England since the late 19th century [29] and that saw an increase in popularity during the 1980s through its
inclusion on personal computers [30]. The decision by Microsoft to include a version of the game as preloaded software on Windows 3.0 in 1990 was in an attempt to initiate people to the new ‘point-and-click’ technology, used throughout the operating system, through an activity that would be familiar and “soothing” to them [31]. Its inclusion in the current study can be seen as an attempt to replicate this experience for users who might be unfamiliar with touchscreen technology. Its selection as a ‘familiar’ game, was supported by members of a local consultation group who had all either previously played the game or were aware of the format and basic premise.

2.3.1.2 Novel game. A second game was sought with the requirement that it was not a computerised version of an existing game. The aim was to find a game with novel rules that is conceptually modern to minimise the chance of it being known by the target population. An exploration of the Apple iTunes Store revealed a plethora of games that can be categorised in the ‘matching tile’ game subtype, where players manipulate tiles in order to make them disappear, according to a set of matching criteria [32]. There are many conceptual variations of these games with different objects representing the ‘tile’ element (e.g. fruit, candy, jewels) that are all categorised in the broader ‘puzzle’ game genre within the Apple iTunes Store, thus making a search difficult. However, further exploration revealed that the term ‘bubble’ is often used in games of this subtype and, having sampled several examples within the genre, these games were deemed to have the greater potential for the target population, as their elements typically require less manipulation by the player.

A search of the Apple iTunes Store was conducted to select the most appropriate version of the games compatible with the Apple iPad, using the terms ‘Solitaire’ and ‘Bubble’. Each search returned 500+ results, arranged according to a combination of relevance to the search term and popularity. As it would have been unrealistic to review each of these apps individually, the first 10 apps judged appropriate from
their title and icon were downloaded and reviewed according to the set of parameters (available from the corresponding author).

The selected version of Solitaire was considered to be the most suitable for people living with dementia as it contains the largest range of accessibility options (e.g. background colour, size and style of the card face design), and was the only version reviewed to feature an automatic prompt system if the player was inactive for 15 seconds. A possible limitation was that the game did not automatically notify the player if there are no further moves possible (i.e. that the game is 'lost'). However, this was considered to be a surmountable issue for the purposes of this study, by locating the researcher in a position to view the participants’ progress and intervene if necessary. The selected version of a matching tile game, ‘Bubble Xplode” also had the largest range of accessibility options allowing the player to control, for example, the speed of gameplay and the size of the bubbles.

A member of the research team attended the South Yorkshire Dementia Research Advisory Group on 20th March 2014 to discuss the planned project and demonstrate the two selected iPad games. Attendees of the group were given the opportunity to play these games and they approved their selection as being potentially suitable for people living with dementia. They also provided feedback on their experience and on other aspects of the planned research, which was used to inform various elements of the protocol, as indicated in the relevant sections below.

2.3.2 Equipment
An Apple iPad (fourth generation) running iOS 7 was used in all data collection. The selection of the iPad over other tablet devices for this research was due to the greater availability of regulated apps in the Apple iTunes Store in comparison with other platforms [33, 34], which was considered to be important for the game review process. Operating system settings were set to provide an optimal experience for the user and to prevent unnecessary or accidental interference during gameplay. Brightness and volume were both set to maximum; app notifications were all turned
off; and multitasking gestures were turned off. The free version of the app Solitaire (by *MobilityWare*) was the game presented to participants in Group 1 (see Fig. 1). The game was presented in landscape mode as members of the consultation group suggested that this provided the clearest presentation of the game.

![Figure 1. Screenshot of Solitaire (used with permission of MobilityWare)](image)

The premium version of the app Bubble Xplode (by *Spooky House Studios*) was presented to participants in Group 2 (see Fig. 2). Within the application, the *classic* game mode was chosen.

![Figure 2. Screenshot of Bubble Xplode (used with permission of Spooky House Studios)](image)
The iPad was presented in a special, durable case made as part of the larger research programme (see Fig. 3, further details available at http://proudtoplay.com). The case provides protection for the iPad, prevents accidental interactions with the physical buttons and allows for portrait or landscape presentation of the device at a comfortable viewing angle.

![Figure 3. iPad in specially designed case](image)

Two Sony HD Handycam digital video recorders with tripods were used to record all data collection sessions.

2.4 Environment
A suitable environment to conduct the activity sessions was identified within each care service prior to the first data collection session. This was achieved through discussion with members of staff working at the care service. A room was chosen that could provide privacy to minimise distraction, prevent interruption and maintain confidentiality during the session, and with enough space for the participant to sit comfortably at a desk or table with two video cameras on tripods set up close to them. The first video camera was positioned facing the participant to capture a recording of their face whilst they played the game. The second video
camera was positioned allowing a view of the iPad screen over the participant's shoulder (this was over the left shoulder for a right-handed participant and vice-versa, to capture the clearest view of the screen).

2.5 Outcome Measures

2.5.1 Independently initiating gameplay. This was measured through the observation of whether the participants attempted to begin playing the game independently, once the rules had been explained to them and they were invited to start.

2.5.2 Independently advancing through the game. This was measured through observation of whether the participants were able to advance through the game independently to a pre-determined 'checkpoint'. In the case of Solitaire, this was determined by whether the participants were able to play through one cycle of the card deck whilst placing cards as the moves become available. In the case of Bubble Xplode, this was determined by whether the participants were able to play through until the first 'regenerated' row of bubbles falls (this occurs when the top two levels of bubbles are empty and the participant subsequently pops five bubble combinations).

2.5.3 Gameplay length. This was measured by timing how long it took the participants to reach the checkpoint, as described above.

2.5.4 Enjoyment. This was measured using a questionnaire designed for the purposes of this project, modified from the Game Experience Questionnaire (GEQ) [35] and the Eldergames project [36]. This questionnaire consists of seven questions relating to game involvement, challenge, responsiveness, control, game rules, concentration and enjoyment. The questions are designed to illicit closed responses ('yes' or 'no') and were delivered in an interview format at the end of each gameplay session (further details available from the corresponding author).

2.6 Procedure

For each participant at each data collection session the following procedure was used. At the beginning of each session, the researcher spoke with the participant and reiterated the purpose of the research project, using their signed consent form.
as a reference. If the participant provided verbal consent to continue and the researcher was satisfied that they had the capacity to do so, the session proceeded.

The iPad was presented to the participant with the start of the game (Solitaire [G1] or Bubble Xplode [G2]) ready on the screen. The researcher provided a rehearsed physical demonstration of the game, consisting of three ‘game moves’ (three card moves in Solitaire or three bubble groups popped in Bubble Xplode), in combination with verbal instructions describing the process (this method of demonstration was suggested by members of the PPI group). The researcher then reset the game to the beginning and invited the participant to begin in his or her own time.

Participants were given the opportunity to play the game through to completion unless they indicated that they wanted to finish earlier or if their gameplay session exceeded 10 minutes. As the focus of the research was on independent gaming, the researcher retreated out of the participant’s line of sight and resisted any initial requests for advice or support from the participant during gameplay by politely encouraging them to try and continue themselves. However, if the participant requested support more than twice, or was deemed to be in any discomfort or distress, then the researcher responded to the participant and offered support. In these cases, for the purposes of the data collection, the result would be recorded as having not met the criteria for advancement through the game (assuming that they had not already reached the checkpoint prior to the researcher’s intervention).

After the participant had finished playing the game, the researcher immediately conducted the post-gameplay interview whilst the game was still on the screen in front of the participant, to maximise their ability to recall their experience of playing the game [37]. After the interview had been completed, the participant was thanked and reminded of when their next session would be.
2.7 Observation of video recordings
Using the video recordings, each gameplay session was reviewed after all of the data had been collected. Each session was first examined for whether the participant initiated gameplay independently, followed by whether they reached the pre-determined checkpoint independently. In each case where the checkpoint was reached, the duration between their first touch of the screen and the last touch before the checkpoint was reached was measured in seconds and recorded. Finally, questionnaire responses for the item relating to game enjoyment were recorded for each participant. At this stage of the study, no further analysis of the video data or questionnaires took place. These data will be reported in a future publication focusing on the participants’ interactions and experience of using the iPad for gaming.

3. Results
Of the 30 participants recruited to the study, 26 engaged with the game at all three time points; 2 engaged at 2 time points; and 2 engaged at 1 time point. This resulted in a total of 84 sessions out of a possible 90 – 41 in the familiar game group and 43 in the novel game group. The missing data were accounted for by: participants being judged to having shown signs of discomfort at a previous session (four occasions); or participants missing a session/s through ill health (two occasions).

3.1 Independent gameplay
Twenty-seven participants (90%) attempted to play the game assigned to them independently on at least one occasion. Of the 71 sessions in which the participant attempted to play the game assigned to them, 40 (56.34%) resulted in the checkpoint being reached. Ten participants (33.33%) reached the checkpoint independently on all three occasions and a further sixteen (53.33%) played their game through to the checkpoint on at least one occasion.
3.2 Familiarity

Twelve of the fifteen participants (80%) in the familiar game (Solitaire) group attempted gameplay on at least one occasion, resulting in gameplay attempts in 28 (68.29%) of 41 sessions. Of the twelve participants who attempted to play, two (16.67%) were able to play through to the checkpoint on all three occasions (see Table 1), whilst the remaining ten (83.33%) did not reach the checkpoint in any of their gameplay sessions.

All fifteen (100%) participants in the novel game (Bubble Xplode) group attempted gameplay across all 43 attended sessions with fourteen (93.33%) of the fifteen playing through to the checkpoint on at least one occasion (see Table 1). Eight (53.33%) participants reached the checkpoint in all three of their gameplay sessions.

Table 1. Characteristics of participants and their performance over three sessions on the familiar and unfamiliar games

<table>
<thead>
<tr>
<th></th>
<th>Female</th>
<th>Male</th>
<th>Mean age (SD)</th>
<th>Mean MOCA score /30 (SD)</th>
<th>Mean playing time (seconds) of participants who reached the checkpoint (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Familiar</strong></td>
<td>n = 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>3</td>
<td>87.53 (5.89)</td>
<td>13.07 (2.84)</td>
<td>גר</td>
</tr>
<tr>
<td></td>
<td>T1: n = 2</td>
<td>T2: n = 2</td>
<td>T3: n = 2</td>
<td>329.16 (291.85)</td>
<td>264.38 (157.65)</td>
</tr>
<tr>
<td><strong>Unfamiliar</strong></td>
<td>n = 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>2</td>
<td>87.13 (4.93)</td>
<td>13.73 (3.22)</td>
<td>גר</td>
</tr>
<tr>
<td></td>
<td>T1: n = 15</td>
<td>T2: n = 15</td>
<td>T3: n = 12</td>
<td>140.45 (187.03)</td>
<td>121.41 (162.08)</td>
</tr>
</tbody>
</table>

3.3 Enjoyment

In 70 of the 71 sessions where the participant attempted to play the game, the post-game play interview was conducted (one participant declined on one occasion), of which there were 60 ‘yes’ responses (85.71%) to having enjoyed the game. Twenty-
three participants (88.46%) out of the 26 who completed the interview reported having enjoyed playing their game in at least one of their gameplay sessions with 16 (61.54%) reporting enjoyment in all of their sessions.

In the familiar group, 10 (90.91%) of the 11 participants who completed the post-gameplay interview reported enjoyment on at least one occasion, with 8 (72.73%) reporting enjoyment in all of the gameplay sessions they attempted. Participants in the familiar group reported having enjoyed playing their game in 24 (86.49%) of the 28 gameplay sessions. In the novel group, 13 (86.67%) of the 15 participants interviewed reported enjoyment on at least one occasion, with 12 (80%) reporting enjoyment in all of the gameplay sessions they attempted.

Table 2. Time (seconds) for participants in familiar group (n=2) and unfamiliar groups (n=8) who reached the checkpoint in all three sessions

<table>
<thead>
<tr>
<th>Familiar game (n=2)</th>
<th>Time taken to reach checkpoint (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant no.</td>
<td>T1</td>
</tr>
<tr>
<td>01</td>
<td>475.09</td>
</tr>
<tr>
<td>15</td>
<td>183.24</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Novel game (n=8)</th>
<th>Time taken to reach checkpoint (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant</td>
<td>T1</td>
</tr>
<tr>
<td>02</td>
<td>118.16</td>
</tr>
<tr>
<td>06</td>
<td>99.12</td>
</tr>
<tr>
<td>10</td>
<td>108.88</td>
</tr>
<tr>
<td>16</td>
<td>160.88</td>
</tr>
<tr>
<td>18</td>
<td>237.15</td>
</tr>
<tr>
<td>20</td>
<td>146.16</td>
</tr>
<tr>
<td>24</td>
<td>210.52</td>
</tr>
<tr>
<td>26</td>
<td>134.24</td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td>132.75</td>
</tr>
</tbody>
</table>

*Unable to record exact time due to video failure

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3.4 Learning

The times taken by the ten participants who reached the checkpoint in each session were examined for evidence of increased speed over time (Table 2). Of the two participants who played Solitaire through to the checkpoint on all three occasions, participant 01’s performance showed evidence of learning, as the time taken to reach the checkpoint decreased on each subsequent gameplay session (see Table 2). By contrast, participant 15, who had a much quicker baseline time, was far more consistent across the three sessions (see Table 2).

Among the eight participants in the novel group who played Bubble Xplode through to the checkpoint on all three occasions (see Table 2), there was an overall pattern of decreasing times between each of the three time points. However, the pattern was inconsistent with participants 06 and 24 showing faster times on each subsequent gameplay session. The other six participants, however, displayed less consistent patterns (see Table 2).

4. Discussion

When presented with a touchscreen game and left to play independently, the majority (27) of the 30 participants in the study made an attempt to play the game. Only three participants made no attempt to interact with the iPad independently in any of their sessions. This indicates the potential that touchscreen tablet devices have in providing independent activity for people living with dementia. None of the participants involved in the study had ever used a touchscreen device before and the researcher only spent a couple of minutes explaining the game assigned to them before leaving them on their own, yet this was enough for the majority of participants to attempt gameplay independently.

Participants’ success within the game was more varied, with just over half advancing through their assigned game to the pre-determined checkpoint on at least one occasion. However, this result highlighted the importance of selecting appropriate applications, as only two participants who played Solitaire were able to...
reach the checkpoint, compared with Bubble Xplode where all but one participant reached the checkpoint at least once (see Fig. 4). Although Solitaire was familiar to all of the participants in this group (when asked, all participants said that they recognised the game and the majority said that they could remember having played it before), it is evident from the observations and the results that most participants could not retain, or could not understand, the rules of the game sufficiently to advance through it. It is also possible that the digital representation was a barrier in that participants may have struggled with the mechanics of the application as opposed to the actual rules of gameplay. This is in contrast to Bubble Xplode, which was a game that none of the participants in the novel group were familiar with (when asked nobody recognised or had played the game before), yet all but one participant was able to progress to the checkpoint on at least one occasion. Therefore, these results suggest that familiarity is not enough of a factor on its own when selecting appropriate games that might be suitable for people with dementia.

Figure 4. Comparison of sessions where participants reached the checkpoint and where enjoyment was reported between each game

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Solitaire was felt to be comparable with Sjoelen (Shuffleboard) in terms of its familiarity to the participants within the respective countries where data collection took place. Also, like Sjoelen, the selected version of Solitaire was a ‘classic’ representation of the original game in name, icon and the design of the game components. However, it is apparent that Solitaire was not comparable with Sjoelen in terms of its difficulty level. In this respect, Sjoelen is actually much more similar to Bubble Xplode, where both applications have a ‘pick-up-and-play’ design, requiring players to repeat an input (slide puck; pop bubbles), with minimal options (which compartment to target; which colour bubbles to target) and only two outcomes (score or miss; explode or remain). Contrastingly, Solitaire is much more complex with players needing to concentrate on multiple aspects of the game concurrently (i.e. suit colour, card number/picture, the deck, the draw pile, descending card sequences, ascending card sequences, etc.). Familiarity may have been the factor that led participants to choose Sjoelen from the outset in the original study, but once playing a game, the present research suggests that familiarity alone does not promote usability. This distinction between familiarity and usability is important for guiding choice of apps for people with dementia, where familiarity is an obvious criterion when trying to select from the thousands on offer, but may not be the most useful for identifying suitable ones.

There is also evidence from this study that people living with dementia enjoyed playing touchscreen games independently. Further, despite the contrasting results in reaching the checkpoint between the groups, the type of game played or whether a person had managed to advance through the game to the checkpoint did not affect their reported enjoyment (see Fig. 4). It is possible that the novel experience of playing any game on a touchscreen tablet, whether familiar or not, was enough to facilitate enjoyment. However, this result further demonstrates the potential in touchscreen tablet devices for providing opportunities for independent activity that is also enjoyable [5,18].
The Apple iPad and iOS platform are just individual examples within a wide range of touchscreen tablet devices and operating systems available on the market. Whilst there are differences in both the hardware and software of all these devices (and given the regular release schedules of new models and operating systems, this is an unavoidable issue), the touchscreen technology remains consistent with the majority of devices using projected capacitive touchscreens [38]. The applicability of the findings of this study to other devices is therefore dependent on the apps themselves and their availability within the different app stores (for example, Mobility Ware’s Solitaire is available on both Apple and Android systems whilst Spooky House Studio’s Bubble Xplode is available on Apple, Android and Windows). It would be reasonable to assume that if an app is found to be playable by a user on one device, then that same app should also be playable on a comparable yet different device.

It is realistic to predict that anyone in a position of support or care for a person living with dementia might be responsible for setting up a new technological device such as an iPad. Therefore it will be these people, both family and formal caregivers, who are most likely to make decisions as to which applications to download for the person they are supporting. In these circumstances the people who know the person with dementia and know their hobbies might assume that a good starting point would be to download applications that recreate these hobbies in a digital format. Whilst an individual’s hobbies and interests will of course be a factor in the selection of games and activities for touchscreen devices, the results of this study suggest that it should not be the only factor. Applications should be carefully reviewed beforehand to assess their suitability, as a negative experience with an activity in the early stages of using a new technology such as this could lead to its abandonment [39]. To address this issue, one of the outcomes of the present study will be to create a resource offering guidance to people who might be selecting applications for people living with dementia to use (see www.actodementia.com). The aim of such a resource is to provide a smaller pool of applications to select from,
whilst still being able to make person-centred choices based on the hobbies and interests of the user.

The selection of a checkpoint in each game that players had to reach in order for the researcher to categorically answer the question of whether or not a person is able to play the game could be viewed as arbitrary, thereby undermining the validity of the study. However, this was felt to be a necessary step in order to compare performance on two very different games, and where that difference was a key requirement in the design of the study. It would not have been sufficient to simply use whether a player finished their game as a way of categorising whether they were able to play the game because Solitaire is not always winnable from the outset, as opposed to Bubble Xplode. Hypothetically, players could make all the right moves in both games, yet whilst Bubble Xplode would finish, Solitaire would not. As neither game was designed with a checkpoint or level system, the solution was to identify a checkpoint within both games that participants would naturally reach if they made the correct moves. This was attempted logically through the identification of a shared component between the two games; that of replenishment. In Solitaire, once the player has been through one cycle of the card deck, the deck is turned over (or, replenished) and the player starts from the top again. In the case of Bubble Xplode, players pop bubbles until enough room has been made at the top of the screen for a new row of bubbles to be added to the game (or, replenished). These checkpoints were considered to be comparable because they required the player to achieve the goals of the game in order to reach them. Therefore, it is possible to surmise that if a player did not reach the identified checkpoint of the game, they did not achieve the goals of that game.

Another issue that became apparent with hindsight was the use of time as an indicator for whether participants had demonstrated learning. This is because in both games the initial setup is randomised and therefore some games might require more moves to reach the checkpoint than others. In such a case, a player could play equally well on consecutive games yet take a longer amount of time to reach the
checkpoint on their second play because the game was setup differently, and this would be interpreted as a decline in performance. Clearly learning is a more complex concept for which time is not a sensitive enough measure. The video recordings of participants’ gameplay sessions will provide a greater opportunity to analyse performance and comment on learning, and this will be reported in a future publication.

5. Conclusion
This study has provided evidence that people living with dementia can play touchscreen games independently, and in this instance with minimal instruction. It has also demonstrated the importance of game selection, and particularly that prior familiarity with a game, particularly a non-digital version, is not a guarantee of usability. The ease of use and playability of Bubble Xplode highlights the importance of looking beyond familiar names to explore different game types, such as tile matching games. It has also shown that people can enjoy playing touchscreen games regardless of the level of success achieved. Further work should continue to support the process of identifying suitable design features within touchscreen apps.

Author contributions
AJA was responsible for overall management of the project, including designing the study, determining the analyses and contributing to the manuscript preparation. PJ recruited the participants, collected and analysed the data, and drafted the manuscript. HG carried out the preparatory work and previous study and contributed to the protocol development and commented on an early version of the manuscript. JdeL was involved in designing the study and discussing the data analyses and commented on an early version of the manuscript. MG was involved in developing the study design and linking it to the previous stage of the project (reported elsewhere). AC was responsible for developing the stand for the iPad and for the ergonomics of the study.
YS was responsible for the development of the original project, contributed to the study design and discussion of the data.

Conflicts of interest
None.

Summary points
What was already known on the topic:
- Independent activities can benefit people living with dementia.
- People living with dementia are able to use touchscreen tablet devices.
- People within this population are more likely to select digital versions of familiar activities, if given the option.

What this study has added to our knowledge:
- People living with dementia are able to play touchscreen games independently.
- It should not be assumed that familiarity within applications is enough of a reason to make them suitable, nor that novelty should be avoided.
- Enjoyment is possible within this population when playing games independently and success within the game is not necessarily required to achieve this.

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