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## Touchscreen interventions and the wellbeing of people with dementia and caregivers: A systematic review

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### Abstract

**Background:** Dementia can have significant detrimental impacts on the wellbeing of those with the disease and their carers. A range of computer-based interventions, including touchscreen-based interventions have been researched for use with this population in the hope that they might improve psychological wellbeing. This article reviews touchscreen-based interventions designed to be used by people with dementia, with a specific focus in assessing their impact on wellbeing.

**Method:** The data bases, PsycInfo, ASSIA, Medline, CINAHL and Cochrane were searched for touchscreen-based interventions designed to be used by people with dementia with reported psychological wellbeing outcomes. Methodological quality was assessed using Pluye *et al.*'s (2011) Mixed Methods Appraisal Tool (MMAT) checklist.

**Results:** Sixteen papers were eligible. They covered fourteen methodologically diverse interventions. Interventions were reported to be beneficial in relation to mental health, social interaction and sense of mastery. Touchscreen interventions also reportedly benefit informal carers in relation to their perceived burden and the

quality of their relationships with the people they care for. Key aspects included the user interface, provision of support, learning style, tailored content, appropriate challenge, ergonomics and users' dementia progression.

**Conclusions:** Whilst much of the existing research is relatively small-scale, the findings tentatively suggest that touchscreen based interventions can improve the psychological wellbeing of people with dementia, and possibilities for more rigorous future research are suggested.

**Keywords:** dementia, Alzheimer's disease, touchscreen tablet, wellbeing, social support

## **Introduction**

The current review focuses on computer-mediated interventions for people with dementia and/or their carers, delivered using touchscreen devices. The aims were to explore the impact on psychological wellbeing of touchscreen-based interventions for people with dementia and/or their carers, identifying relevant theories and key aspects of these interventions. The benefits and drawbacks of the various intervention approaches are presented, concluding with recommendations for further research and a discussion of implications for mental health practitioners.

## **Dementia**

As life expectancies increase, support for people with a dementia (PWD) and the people who care for them is becoming increasingly important. There are an estimated 850,000 people living with dementia in the UK with the overall annual cost about £26 billion including the cost of 670,000 people acting as primary informal carers (ICs), which the latter is estimated to save the national health budget £11 billion pounds (Alzheimer's Society, 2014). "Dementia" encompasses a range of subtypes, including Alzheimer's disease, vascular dementia, dementia with Lewy bodies and frontotemporal dementia. These subtypes can occur independently or simultaneously in those affected. Dementia is a progressive condition and currently there is no known cure, so interventions that can support wellbeing for people with dementia and informal carers can make substantial improvements to people's lives and can have positive financial implications for the nation.

## **Wellbeing**

The concept of wellbeing has proved difficult to define. Subjective wellbeing (Diener, 2006) denotes experience of positive emotion, low levels of negative

emotions and high life satisfaction. Quality of life (QoL), defined as “An individual’s perception of their position in life, in the context of the culture and value systems in which they live, and in relation to their goals, expectations, standards and concerns” (World Health Organization QoL Group, 1995, p. 1404) has been described as synonymous with subjective wellbeing (Camfield and Skevington, 2008). Huber *et al.* (2011) proposed a definition of wellbeing that takes chronic disease into account, by defining health and wellbeing through ability to adapt to changing physical, emotional and spiritual challenges, and to self-manage. This shift in conceptualisation is reflected in the World Health Organization’s 2011 definition of mental health as, “a positive state of wellbeing, one which allows individuals to fully engage with others, cope with the stresses of life and realise their abilities” (p. 1). Deci and Ryan’s (2000) self-determination theory linked wellbeing with three related psychological needs: autonomy, competence and relatedness. This was key in developing the concept of wellbeing by linking it to intrinsic goals such as improving society, cultivating close relationships and personal development rather than extrinsic materialist goals.

Bowling *et al.* (2015) reviewed sixteen dementia-specific QoL measures. Their theoretical bases ranged from being poorly defined to being more well-elaborated. The level of involvement of people with dementia in the development and completion of the measures was limited, with many scores based on proxy assessments. The authors concluded that the wider applicability of all of the measures had not been satisfactorily established, nor had their predictive validity. They recommended the development of a more all-encompassing and robustly tested measure, which reflects the perspectives and requirements of people with dementia. Furthermore, they acknowledged the necessity of pragmatic compromise between the information

provided by a comprehensive measure compared with the reduction in respondent and researcher burden posed by briefer measures.

### **Technological interventions**

If the UK's ageing population continues to grow as predicted (Alzheimer's Society, 2014), it is anticipated that the burden posed by dementia on carers, social services and healthcare will increase (Lewis & Torgersen, 2017). A range of types of non-pharmacological interventions have been trialled with people with dementia and their carers. Technological approaches present a possible solution to this issue, as they can allow people to be live independently for longer through the use of smart technology to monitor potentially dangerous situations in the home, or more contentiously (White & Montgomery, 2014), electronic tagging, to monitor 'wandering'.

Astell (2006) reviewed various types of technological interventions (e.g. electronic tagging, assistive technologies, and psychosocial interventions) and found they "run a particularly high risk of crossing the line into doing things to people with dementia, rather than with them" (p. 15), possibly diminishing their personhood. Earlier, Kitwood (1997) had defined *Personhood* as, "a standing or status that is bestowed upon one human being, by others, in the context of relationship and social being. It implies recognition, respect and trust." One recommendation from the review suggested that maintenance and enhancement of personhood should be central to the design of technological interventions, and that to this end they should be developed in partnership between those with dementia and caregivers. According to Astell, future developments should "put the needs of people with dementia first

and make explicit how the technology will both enable them and maintain them as human beings” (p.23).

In a review of technological interventions for people with dementia and their carers, Topo (2009) described that whilst published research was mainly trialled in care-home settings with people with moderate to severe dementias, 15 of the studies involved people with dementia as users, leaving the author to conclude that technology could be used to support people at various stages of dementia, but stressed the importance of individually tailoring the applications and support for users: they were not to be provided as a replacement for personal support and follow up. This suggests that whilst some have recommended caution that technology might undermine personhood, others have argued there might also be ways in which technological innovations could be implemented to maintain personhood. Smith and Mountain (2012) suggested that touchscreen technologies had “far reaching implications for [people living with dementia and those that care for them]” and recommended research by various disciplines including psychology.

McKechnie *et al.* (2014) reviewed the outcomes of computer-mediated interventions for carers of people with dementia and found that higher quality studies reported greater beneficial impacts on carer burden and mood, supporting the value of computer-based interventions for carers. They suggested subsequent investigations into computer-based support might benefit from mixed-methods approaches. Godwin *et al.* (2013) reviewed eight studies from four randomised controlled trials (RCTs), which covered three interventions, looking at the psychosocial effects of technology-driven interventions for carers of people with dementia. They concluded that whilst the studies all reported beneficial outcomes, the delivery of the interventions was inconsistent, as was outcome measurement.

Joddrell and Astell (2016) reviewed touchscreen interventions for people with dementia, exploring the intended usage, reasons for using touchscreens, hardware and software specifications and whether people with dementia independently operated them. The interventions included assessment tools, assistive and cognitive rehabilitation tools, and leisure activities. They concluded that since the usability of touchscreen technology by people with dementia had been established, further effort could be made to use touchscreens to deliver independent activities that led to enjoyment, fun and meaningful purposes “to improve lives in many different contexts” (p. 7).

In summary, reviews have explored various aspects of technology-based interventions for people with dementia and their caregivers. To date, there has not been a review that we are aware of, which focuses on the wellbeing impact of touchscreen interventions for people with dementia. The present review sought to examine this aspect of touchscreen use for those with dementia and caregivers.

### **Methodology**

In order to explore existing research into the use of touchscreen-based technology with people with dementia and their carers, a systematic review (Grant and Booth, 2009) was carried out. Initial searches were conducted in relation to technology-based interventions with people with dementia and their carers. Correspondence with colleagues also yielded additional papers, which guided our thinking and search patterns. For the main literature search, PsycInfo, ASSIA, Medline, Cinahl and Cochrane databases were searched; only peer-reviewed journal articles were included. The search terms used and the results from each database are shown in Table 1. In order to capture as many relevant papers as possible, and



since touchscreen technology itself is a relatively recent development, no date constraints were used. Inclusion and exclusion criteria can be seen in the section below. Reference lists from the papers that were read and included were checked for other potentially eligible papers. A flow chart of the search process can be seen in Figure 1. Since much of the research uses mixed-methods or qualitative approaches and small sample-sizes, it was decided that a systematic review with narrative and tabular synthesis of findings would be the best way to combine the research evidence with views of service users and practitioners. Quality of papers was appraised by reviewing designs and methodologies. The Mixed Methods Appraisal Tool (MMAT) checklist (Pluye *et al.*, 2011) was used as a guide for appraisal. This tool was selected as it allows concomitant appraisal and scoring of mixed methods, qualitative and quantitative designs, is designed for use in reviews, has been pilot tested for reliability and content validated with feedback from experts and workshops. Where papers reported quantitative measures related to psychological outcomes, these were reported (Table 2). Outcomes were grouped into domains for review in the narrative section. Findings reported by researchers in relation to aspects of the interventions they believed to be important were grouped into domains and reported in a narrative style.

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TABLE 1 HERE

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### **Inclusion and exclusion criteria**

1. At least part of the intervention was delivered via touchscreen, operated by people with a diagnosis of any type of dementia.

2. Psychological wellbeing outcomes were reported for people with dementia or their informal carers. 'Psychological outcomes' was kept to a broad definition, including related outcomes such as carer burden and independence of people with dementia.
3. Studies must have described an intervention. Studies without an intervention component (e.g. only assessment use) were excluded.
4. Studies without explicit methodology were excluded.
5. Limited to articles published in English.

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FIGURE 1 HERE

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TABLE 2 HERE (LANDSCAPE)

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## Results

### Interventions

There was a wide range of interventions that employed touchscreen technology to engage people with dementia. These will be briefly described in chronological order; the range and affordability of touchscreen devices has increased since their inception. The earliest reported intervention was interactive computer-based cognitive training (ICT) (Hofmann *et al.*, 1996; Hofmann *et al.*, 2003), running on a computer connected to a 21-inch touchscreen. ICT simulates various activities of daily living, such as shopping, and encourages the user to make decisions in relation to navigation, or answering questions. The simulations are tailored to each individual, via actual photographs of each person's social and local environments. The Picture Gramophone (Topo *et al.*, 2004), which ran on computers connected to touchscreens, was designed as a pleasant pastime; it facilitates selection of artists, genres or themes of music to listen to, displays images and lyrics as the music plays, then facilitates further music selections.

A prototype 'cognitive prosthesis' (Cole, 1999) was developed by Alm *et al.* (2004) in order to support conversation. The initial version ran on a computer connected to 20-inch touchscreen displaying a multimedia reminiscence package, which allowed people to view photos and videos, and listen to songs and music related to their local area, recreation and entertainment. The prototype was eventually developed into the computer interactive reminiscence and conversation aid (CIRCA) (Alm *et al.*, 2007; Alm *et al.*, 2009; Astell *et al.*, 2008; Astell *et al.*, 2010). CIRCA runs on a computer connected to a 20-inch touchscreen monitor. The interface is designed to be "error-free" in that there are no wrong responses or dead-

ends in possible decision trees. As a prosthesis, CIRCA is designed to augment the working memory of the user thereby supporting their conversations with others. A spinoff from the CIRCA project is ExPress Play (Alm *et al.*, 2009; Riley *et al.*, 2009). ExPress Play is a touchscreen interface that allows the user to generate chord-based music by touching the display, and to choose the emotional tone of the music output. ExPress Play aimed to build on evidence showing that people with dementia can maintain and also develop their creative skills; it also built on Hanneman's (2006) theory that in this population, "art and creativity offer a path of opening up the windows to people's emotional interiors". A related project was 'interactive entertainment' activities (Alm *et al.*, 2009). This comprised virtual environments such as botanical gardens, and virtual activities like football penalty shootouts that people could interact with via touchscreen interfaces.

Meiland *et al.* (2012) evaluated the prototype COGKNOW Day Navigator (CDN), an 'integrated digital prosthetic' designed to support people with dementia with daily activities. The system comprised a stationary touchscreen in the home and a mobile device. These devices were connected to various sensors around the home. The system offered support in the areas of memory, social contacts, daily activities and safety. Nijhof *et al.* (2013) evaluated PAL4-dementia, a similar touchscreen system installed in the home designed to act as a daily organiser, memory game console, diary keeper, information source, 'life album' and video link with family or professional caregivers. Imbeault *et al.* (2013) developed and evaluated an electronic organiser for people with dementia (*agenda personnalisé pour des personnes avec maladie d'Alzheimer* [AP@LZ]). AP@LZ is smartphone-based, and provides the user with information about current time and appointments,

appointment scheduling, personal information, medical information, contact information and a notepad function.

The engaging platform for art development (ePAD) was developed and trialled by Leuty *et al.* (2013). This consists of a multi-touch display mounted on a wooden easel that can be used to create visual art via the client interface, and modified to meet specific clients' needs by art therapists on a separate interface. Artificial intelligence is employed by ePAD to evaluate the level of user engagement. Lim *et al.* (2013) assessed the usability of Apple iPads by people with dementia, both with their informal carers and independently. The eleven applications used were classified as "creative (art or music)" such as musical instrument simulators, "simple interactive games" such as spot-the-difference and "relaxation" such as a peaceful music and visual image player. Leng *et al.* (2014) also looked at iPad applications, but used to facilitate group activities. Applications were "chosen with the characteristics of the participants in mind". As a wellbeing intervention, Tyack *et al.* (2015) developed an Android tablet-based 'art viewing' app, designed for people with dementia and their informal caregivers view together.

### **Study designs**

Table 2 gives information about the design of each study, a MMAT (Pluye *et al.*, 2011) score and the checklist applied. MMAT scores are provided with a brief explanation of why the study received its score. The score is a rough appraisal of a study's methodological quality, and does not measure reporting quality. For qualitative and quantitative studies, the percentage of criteria met is stated. For mixed-methods studies, the overall score cannot exceed the lowest score of a component, so if one part received 100% but the other 25%, the overall score would

be 25%. This means it would be possible for a study to have a strong quantitative section and a weaker qualitative section, or vice-versa, but the overall score would be low, suggesting the study might be less valuable. The MMAT is still under development and is necessarily reductive, making it unable to capture study nuances. It was used for this review because it can be applied to the full range of study types and give comparable ratings for each.

Alm *et al.* (2009) reviewed three interventions (including CIRCA, comprehensively reviewed in Astell *et al.*, 2010, and thus not included here). It is worth noting that both Alm *et al.*, studies included research also written up by Astell *et al.*, (2006; 2010) for different journals, aimed at different groups of readers, which scored more highly on the MMAT.

## **Outcomes – People with dementia**

### ***Mood and mental health (including behavioural evidence of mood changes)***

Table 2 contains psychological impact findings, and some are explored in more depth in this section. Alm *et al.* (2009) measured significant increases in the amount of time people with dementia spent using ExPress Play between the first and third sessions ( $t(M = 25, df = 24) = -2.89, p=0.008$ ), in the number of finger movements made during subsequent sessions, and in the range of musical moods selected to play. This was interpreted as evidence that learning had occurred. In addition, 21 out of the 25 users said they enjoyed their first session, rising to 24 in the final session and after the final session, 22 indicated they would like to use it again.

In a study using the Picture Gramophone, Topo *et al.* (2004) found a significant positive correlation ( $r_s = .46, p < .05$ ) between age and impact on mood,

suggesting older users more often benefited from PG than younger ones. One case example in the paper concerns a woman who was described as depressed and staff reported that she had “cheered up with PG use”. Another user reported, “It is inspiring and takes my depression away.”

Hofmann *et al.* (1996) found no significant impact on depressive symptoms as measured by the Montgomery–Åsberg Depression Rating Scale (Montgomery & Åsberg, 1979) or on quality of life, measured by the interview for deterioration in daily living activities in dementia (Teunisse & Derix, 1991, as cited in Hofmann *et al.*, 1996, p. 494). The decision to use the trainers to administer the scales, however, raises the risk of unintended bias. One participant was able to find their way to a location with ICT training, but unable to find their way back, which was part of the training protocol. Another participant reported that ICT was, “Quite different from the feeling of getting worse in every other aspect of life” (p. 500). In a later study, Hofmann *et al.* (2003) found that the training seemed to lead to an average one point improvement on the mini mental state examination (MMSE; Folstein *et al.*, 1975), which was significant ( $F(2,23) = 8.47, p < .008$ ). It was also reported that people with dementia expressed the highest level of liking the training of the three groups who trialled ICT.

Mood and engagement scores were highest for iPad activities, compared with traditional ones (Leng *et al.*, 2014). The mood and engagement scores for cooking were significantly less than for both iPad sessions, suggesting that iPad-based activities were more beneficial for mood and engagement than cooking. A wider range of behaviours (six compared to two) were recorded with iPads use compared to cooking and craft work. It is worth noting that categories such as “reminiscence life review” and “being engaged (watching)” were only reported for iPad activities;

perhaps different recipes or craft activities could have prompted these behaviours. Nevertheless, with a wider range of observed behaviours, perhaps there are more possible ways to become engaged with iPad activities, and greater engagement could mean more chances for improvement in mood.

Whilst art therapists were unsure if they or their clients were satisfied with ePAD, people with dementia reported high levels of satisfaction with the intervention and its novelty (Leuty *et al.*, 2013). Some users were reported to engage in reminiscence as a result of using ePAD: an unexpected finding. Median responses from people with dementia suggested that they were happy with ePAD, enjoyed using it, were satisfied with the art created and that creating art was fun. One user stated, "It's miles ahead of anything I've ever seen to give you an ability to do something."

Whilst AP@LZ was not found to have a significant impact on the mood measures used by Imbeault *et al.* (2013), one of the participants' carers observed that his ability to perform the tasks supported by AP@LZ improved, as opposed to his functioning in other areas which continued to deteriorate. This suggests that AP@LZ helped to maintain user independence and engagement in daily activities.

One study (Tyack *et al.*, 2015) found that user-reported wellbeing tended to increase at the end of art-viewing sessions, and that the wellbeing benefits seemed to increase as people completed more sessions. This raises the issue about the optimal length of time, within sessions and longitudinally, for tablet-related activities.

### ***Social life and quality of interaction***



Alm *et al.* (2004, 2007, 2009) observed, that the balance of conversations seemed to be more equal when using their prototype cognitive prosthesis and its successor CIRCA: facilitators did not predominate. One informal carer stated, "I have never had such a good reaction from Jim before". These shifts sound beneficial for the people with dementia. When using CIRCA, Astell *et al.*, (2008) also noted shifts in behaviour, with people with dementia initiating significantly more interactions (RCT phase  $p < .0005$ ; within subjects phase  $p < 0.05$ ) and making significantly more decisions (RCT phase  $p < .001$ ; within subjects phase  $p < 0.005$ ), suggesting more engagement and stimulation. Engagement benefits of CIRCA (Astell *et al.*, 2010) included significantly more choices being offered to people with dementia by caregivers ( $t(10) = 5.9$ ,  $p < .0005$ ) and their subsequently making more choices ( $t(10) = 3.617$ ,  $p < .005$ ) than during TRAD. More joint laughter was recorded when people were using CIRCA.

It was suggested that laughing together was a sign of enjoyment, whereas separate laughter indicated discomfort. This was corroborated by observations that solitary laughter tended to occur when the person with dementia was lost for words, perhaps in an effort to manage uncomfortable feelings. Astell *et al.* (2010) analysed eye gaze and found that gaze patterns were significantly altered with CIRCA compared to TRAD, with a lot more attention being paid to the stimuli during CIRCA by both people with dementia and informal carers during CIRCA sessions. They suggested that since eye gaze is thought to be a reflection of engagement and comfort, dyads were better at establishing joint attention during CIRCA sessions, facilitating more equal interactions. Carers were also observed to point a lot more during CIRCA sessions, and parallels could be drawn with research showing that mothers tend to point to cue their infants into attending to a point of shared focus to

scaffold interactions (Pratt *et al.*, 1988), suggesting higher quality of interaction was taking place. A systematic review of attachment in people with dementia and their caregivers (Nelis *et al.*, 2013) found that insecure attachment styles link with neuropsychiatric difficulties, and that attachment security also impacts on caregiver health. Interventions that promote attachment-enhancing behaviour are thus of great potential benefit within care dyads.

Tablet use, with interesting and engaging apps, can lift an individual's mood along with the people around them. For example, a user with dementia expressed, "enthusiasm about the Picture Gramophone [which spread] to the others. They all had a good time." (Topo *et al.*, 2004). Likewise, Tyack *et al.* (2015) found that art-viewing sessions had changed the way family members spent time together, with some reporting improvements in their relationships and wider social impacts, such as people with dementia enthusiastically showing the tablet's app to others. Participants who sought and received support from family members, such as grandchildren, said that highly valuable interactions ensued (Lim *et al.*, 2013). This suggests that well designed and intuitive touchscreens can be learned by relative novices, increasing the possibility of bringing people from different generations closer together by providing mutually enjoyable shared activities.

### ***Sense of mastery***

Some studies reported on participants' engagement with and mastery of the intervention. Imbeault *et al.* (2013) reported that one of their participants was "proud" to use AP@LZ, and that his wife noticed that he seemed to feel more empowered by it. As participants gained experience, their usage frequency of the devices tended to increase. Tyack *et al.* (2015) found that one pair reported feeling "proud" to have the

app, another participant reported feeling good to be able to use the app, and a person with dementia reported that using the app increased their confidence in their cognitive abilities. Two pairs relayed success stories in relation to overcoming difficulties using the app. Hofmann *et al.* (1996) found that following training, participants' performance on ICT improved, with fewer mistakes, less time needed, and less advice needed. This pattern was also observed by Hofmann *et al.* in 2003, as well as an increase in the rate of correct answers. The group with dementias was also found to improve significantly more than the other groups in their level of mistakes ( $F(4,15) = 2.95, p < .044$ ). Lim *et al.* (2013) reported that 48 percent of people with dementia said the iPad was moderately or extremely intuitive to use, despite under ten percent initially saying that they were confident using computers and technology. Topo *et al.* (2004) reported that one client initially said she would be unable to use the PG, but she spontaneously started touching the screen and interacting with the device. At a social event, people with dementia used the PG independently to choose songs to dance to.

## **Outcomes – Informal carers**

### ***Burden***

Various studies reported an impact on the stress or burden of informal carers. Imbeault *et al.* (2013) reported that AP@LZ reduced informal carer stress as carers felt reassured that the people they cared for would be able to contact them if necessary. The Carer Burden Inventory (Hébert *et al.*, 1993) indicated a trend towards increased burden over time in both cases, but without controls it is not possible to discern whether this increase might have been altered by AP@LZ. One

carer indicated she felt less burdened in relation to medication, as the reminder system prompted her spouse.

Carers reportedly enjoyed access to the video facility in PAL4-dementia (Nijhof *et al.*, 2013), and whilst the intervention did not reduce carer burden, it was suggested that it might over a longer timeframe. Since Lim *et al.* (2013) reported that 90 percent of participants with dementia could use iPads independently, this might provide activities they could do whilst informal carers did other things, potentially reducing burden. Meiland *et al.*, (2012) found no impact of CDN on carer burden, but the system was unstable and carers found this frustrating. They suggested that with more development the CDN might be more beneficial for users.

### ***Other areas***

Other impacts included carers finding out new information about those they cared for (Alm *et al.*, 2004) which might enrich their relationship and provide new conversation topics or activities. Astell *et al.* (2010) observed that carers sang ( $z = 2.33$ ,  $p < 0.05$ ) and moved to music more ( $t(10) = 2.39$ ,  $p < .05$ ) during CIRCA sessions. Thus, touchscreen based interventions can have impacts on both members of care dyads, which could support both members' wellbeing. Tyack *et al.* (2015) described one caregiver describing her spouse being more able to express his feelings following art-viewing, and this making her feel more able to support him.

### **Important aspects of interventions**

#### ***User interface***

Interface factors relate to the "aesthetic-usability" effect (Norman, 2002), which can be neatly summed up in his phrase, "aesthetics matter: attractive things work better". Alm (2007) elaborated that the aesthetic-usability effect related to how

an appealing application interface seemed to invite users to engage with their intervention, whereas less aesthetically-pleasing designs might not have done. They concluded that aesthetic design is therefore a crucial feature of their system. Several studies underlined the importance of simple interfaces. Table 2 contains details aspects of the interfaces reported to be important.

A system of guidance built into the interface was recommended. Leuty *et al.* (2012) and Riley *et al.* (2009) suggested prompting users was important, although Riley *et al.* cautioned that written prompts needed to be clear, otherwise they could be confusing. Alm *et al.* (2009) found continual feedback was important, which comprised encouragement when people experienced difficulty, and praise of successes. They also found that making the next step as obvious as possible was key, via interface behaviour or targeted prompts.

An error-free experience seems to be beneficial. Alm *et al.* (2004; 2007) and Astell *et al.* (2008; 2010) based their error-free interface on the “hypermedia effect” (McKerlie and Preece, 1992). This is a structure similar to the world-wide-web, where items are interconnected, without dead-ends, so that wherever the user may find themselves is fine, and it does not matter if they lose track of where they are. It also facilitates the interlinking of different media types, allowing the user to jump between them easily, hopefully enlivening the experience. Further information on user interface priorities, including strategies for prompting has been reported in detail by Jodrell and Astell, (2016).

### **Hardware**

Users with little prior experience of computer-use tended to adapt to their touchscreen interface more easily Nijhof *et al.* (2013), whilst those with prior

computer experience tended to request keyboards and mice to facilitate their interactions. This phenomenon was linked with the “technology generation” theory (Docampo Rama *et al.*, 2001) which suggests that experiences with technology in the first 25 years of life are more persistent than later ones. Leuty *et al.* (2012) discovered adjustability of the easel-mounted screen was important, only discovering this after they had been forced to fix the screen in place. Topo *et al.* (2004) found that ensuring uniformity of touchscreen sensitivity across devices was crucial, as there were noticeable differences between devices that sometimes compromised usability.

### ***Content and personalisation***

CIRCA’s photo and music content were generally appreciated more than videos (Alm *et al.*, 2007). Incorporating personalised reminiscence media, such as family photographs, was trialled. Unfortunately, this could lead to distress, “often to the point of tears”. People with dementia and informal carers found failures to remember events or people upsetting and this feature was abandoned. The researchers instead focussed on accumulating sufficient generic information that could be randomised, so that potentially upsetting personal details were unnecessary. With this approach, the presented material led some people to engage in reminiscences that even their informal carers did not know about.

Other researchers found personalisation in different, less intimate ways to be helpful. Topo *et al.* (2004) found individualising music to users’ preferences beneficial. Leng *et al.* (2014) and Lim *et al.* (2013) both suggested tailoring iPad activities to individual preferences was helpful, but did not elaborate on how this was achieved. Tyack *et al.* (2015) found that 10 participant interviews contained

suggested improvements, including having more images, recording favourite images, and a zoom facility. Nijhof *et al.* (2013) found the practical step of ensuring the ringtone of the system was different to users' own ringtones was important.

The importance of elements of challenge or skill-mastery was raised by Alm *et al.* (2009) and Hofmann *et al.* (2003). Alm *et al.* identified that there should be a goal to games, otherwise people tend not to engage. Hofmann *et al.* suggested that it is more beneficial for people with dementia to try and exercise complex cognitive skills as opposed to basic ones, suggesting that specifically targeted interventions had limited subjective wellbeing benefits.

### ***Procedural***

Hofmann *et al.* (1996, 2003) suggested that touchscreen interventions automatically enhance the learning stage as motor action is necessary as well as mental effort. Motor and implicit procedural memory systems tend to be relatively preserved as dementia progresses (Eslinger and Damasio, 1986), and motor action during learning has been shown to have a positive impact on recall for people with dementia (Karlsson *et al.*, 1989). Imbeault *et al.*, (2013) employed an "errorless learning" method for their intervention (Laffan *et al.*, 2010). This approach limits the possibility of experiencing making errors, and is thus thought to enhance the learning process. This was augmented by a phase dedicated to "teaching transfer", where the learned skills were consolidated via their employment in day-to-day events in line with a "three stage approach" to learning (Sohlberg and Mateer, 1989). Imbeault *et al.* found that it took about five months for participants to integrate AP@LZ into their daily lives.

Including potential users from the start of the development process was found to be useful by Meiland *et al.* (2012) and Tyack *et al.* (2015). Nijhof *et al.* (2013) stated that they did not do this, and that this may have contributed to the lack of user-friendliness of their system, with no users describing it as “intuitive”. They did provide support with their intervention, and this was adopted by users and reported to be helpful. Alm *et al.* (2004) found that the cognitive prosthesis could be employed with little preparation on the part of the staff, which seemed to increase the chance of its being used.

### ***Progression of dementia***

Various studies found the stage of dementia progression to be an important factor. Imbeault *et al.* (2013) found that of their two participants, the one at an earlier stage of dementia learned much faster. Lim *et al.* (2013) suggested that iPad activities were more helpful for people at earlier stages of dementia, and recommended matching activities to the skill level of each user. Nijhof *et al.* (2013) reported that informal carers said they thought that the people they cared for would have learned to use PAL4-dementia more easily earlier in the progression of their dementias. They caution that the introduction of such a device earlier on might have been experienced as upsetting or stigmatising for people with dementia.

## **Discussion**

This review has explored the diverse range of touchscreen based interventions for people with dementia that have been cited in published research. The diversity of the interventions is complemented by the relative qualities of the published papers. This diversity results from studies by researchers from different professional backgrounds, and in journals targeted at different audiences. The



exploratory nature of the research and variety of target readerships often also led to idiosyncratic approaches to research and reporting. The robustness varied, and sample sizes tended to be small, therefore conclusions should be cautiously interpreted. Ethics and consent were often not clearly reported, and this is crucial in an area involving vulnerable people often with limited capacity to consent.

A limitation of this review is the somewhat reductive nature of MMAT (Pluye et al., 2011) used to assess the methodological quality of the studies. Whilst its applicability to both mixed-methods and purely qualitative or quantitative papers is helpfully versatile, its scoring system can give a low score to useful research, particularly so with qualitative studies. This is an issue common to assessment tools however, and is a drawback of their necessary standardisation. Reviewing studies with diverse designs allows facilitates richness of information, but it is difficult to come to definitive conclusions. It is worth noting that with the MMAT it is important to have a second rater in order to increase validity.

Whilst research has looked at the feasibility of touchscreen-based interventions, it is apparent that touchscreens are usable by those with dementia, and when well-designed they can be used with little training, particularly at the earlier stages of dementia. As technology advances, hardware-related issues that arose in early studies such as inconsistent screen sensitivities are likely to diminish. These factors will hopefully allow more consideration to be given to the wellbeing outcomes of the interventions. According to this review, touchscreen based interventions can confer a wide range of benefits to the wellbeing of people with dementia in relation to their mood and mental health, their social lives and quality of interaction and their sense of mastery. Touchscreen interventions can also benefit the wellbeing of informal carers in relation to their sense of burden, as well as enhancing the quality

of their relationships and time spent with the people they care for. This effect might help to sustain informal caregiving relationships for longer. Touchscreens may therefore be an intervention strategy that could help people with dementia to be supported by their informal caregivers to remain in their homes for longer, as suggested by Smith and Mountain (2012).

McKechnie *et al.* (2014) recommended mixed-methods approaches for early-stage explorations of computer-based support in their review, and mixed-methods studies (Alm *et al.*, 2007; 2009; Imbeault *et al.*, 2013; Leuty *et al.*, 2013; Meiland *et al.*, 2012; Nijhof *et al.*, 2013; Topo *et al.*, 2004; Tyack *et al.*, 2016) have been useful in gathering rich information about user-experience as well as data about the outcomes of the interventions in this review. In line with the findings of Godwin *et al.* (2013) the studies reviewed here tended to report improvements in their users, but intervention delivery and outcome measurement were inconsistent.

In relation to the potential for interventions to support or undermine the personhood (Kitwood, 1997) of the users, on balance it seems that when used with appropriate planning and support, touchscreen interventions are able to support the personhood of people with dementia in various ways. These include the ability to engage in meaningful activities not directly linked to being people with dementia, sharing social interactions with others, and mastering new skills independently.

Key aspects of the interventions' interfaces were shown to be related to the interface being simple, intuitive, aesthetically pleasing, error free and providing guidance to the user. Important procedural aspects included provision of support, including potential users in the development process from the beginning, an errorless learning method for training, requiring motor-action during training and the

ability to use the intervention with little preparation. Important aspects of content included tailoring content to the user where appropriate and an element of challenge, which might mean exercising complex cognitive skills rather than simpler ones. It was interesting to note that attempts to include personalised biographical material could prove to be upsetting for users, so this should be avoided in favour of more generic material that could allow people more choice about the focus of their reminiscences. Hardware considerations included ergonomics, screen quality, consistency and a conspicuous location. The progress of users' dementia was also highlighted as a key aspect in several studies. Studies tended to report that introduction of interventions earlier in the progress of users' dementia facilitated uptake. It would be helpful to explore whether interventions could be designed to dynamically adapt to the ability level of the user.

### **Recommendations for future research**

Future research can strengthen and build on the foundation established so far in a range of ways:

- In order to improve the evidence base, research should be conducted with larger sample sizes and more rigorous methodological approaches. This could include the establishment of consensus on how wellbeing is to be measured (Camic, Hulbert & Kimmel, 2017), and adherence to reporting standards.
- Mixed-methods research would allow more in-depth information about the user experience to be collected, especially in exploratory studies. It would be important to pay attention to the process of integration of quantitative and qualitative findings.

- Longer-term and longitudinal interventions could explore the effect of stage of dementia on the effectiveness of the interventions.
- Standardised hardware platforms such as specific models of tablet could be used in order to allow easy replication of research in other locations. This could also facilitate the exploration of impact across settings, such as at home, in daycare and in residential settings.
- Interventions that have been found to be useful in other areas, as Tyack et al. did with previous art-based interventions (e.g. Camic *et al.*, 2013; Eekelaar *et al.*, 2012; Rhoads, 2009) could be adapted for delivery via touchscreen devices, and their effectiveness explored.

### **Clinical implications**

A range of clinical implications can be cautiously suggested as a result of this review:

- Touchscreen apps should be considered by family members, charity programme staff and older age clinicians working with people with dementia and their informal and professional carers, as opportunities to support wellbeing by providing a platform that allows people with dementia to be more equal partners in social interactions as well as providing opportunities for new learning and independent pastimes.
- In considering touchscreen technologies, clinicians and others should consider challenging prevailing beliefs that people with dementia are unable to use touchscreen technologies.
- People are more likely to be able to engage with touchscreen technology if they are initially offered them earlier on in the progression of dementia, along with appropriate support as they learn to use them.

- Touchscreen-based activities should be considered to help people interact across generations, potentially reducing their sense of isolation and social exclusion.

**Conflict of Interest:** None

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### Figures / Tables

Table 1

*Search terms and results from databases (search completed)*

<b>Database</b>	<b>PsycInfo</b>	<b>ASSIA</b>	<b>Medline</b>	<b>Cinahl</b>	<b>Cochrane</b>
<b>Search 1</b>	("dement*" OR "Alzheimer*")				
<b>Results</b>	75 697	6 893	166 374	15 311	8 847
<b>Search 2</b>	("touch screen*" OR "touchscreen*" OR "touch-screen*" OR "iPad*" OR "Android*" OR "tablet*" OR "haptic*")				
<b>Results</b>	5 681	621	47 958	510	463
<b>Search 3</b>	(Search 1) AND (Search 2)				
<b>Results</b>	101	4	227	44	81

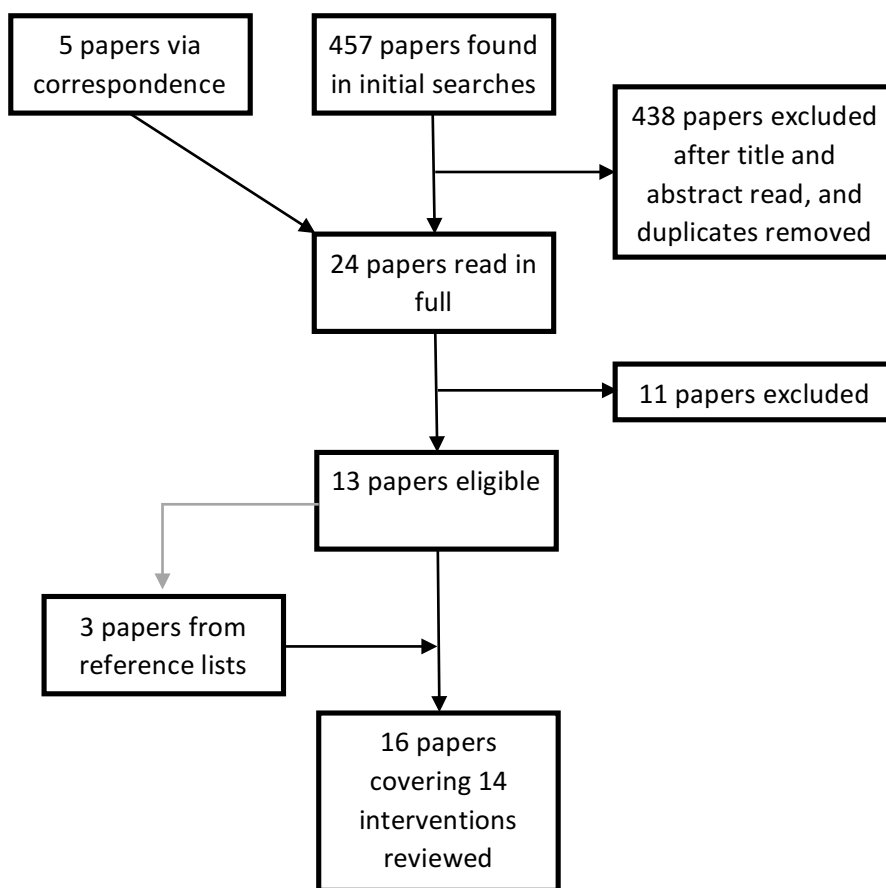


Figure 1. *Flow diagram of article selection process.*

Table 2

*Study characteristics*

<b>Authors, date</b>	<b>Participants</b>	<b>Aim</b>	<b>Touchscreen Intervention</b>	<b>Design (MMAT appraisal)</b>	<b>Measures</b>	<b>Psychological impact finding(s)</b>	<b>Important aspects of intervention</b>
<b>Alm et al. (2004)</b>  <b>Phase 1</b>	6 PWD – 3 male, 3 female. Mean age 74.3 (range 57-95), MMSE scores 10-25, mean 15.6. 6 carers – 3 informal, 3 formal.	Pilot study, to test the feasibility of PWD using the technology.	“Cognitive prosthesis”. LCD touch pad – sound, videos and photos	System evaluation – exploration of user experience and carers’ views.	Structured interviews with PWD. Self-report questions and Likert scales with carers.	“All participants liked”.  Care staff said prompting meant PWD interacted more than usual.	Hypermedia - no penalty on “losing the place” Not reliant on short-term memory Simple presentation All found touchscreen ‘easy’.
<b>Phase 2</b>	9 PWD – 4 male, 4 female (sic). Aged 65-95, mean 83. MMSE range 8-22, mean 16. 9 professional care staff across 5 day centres.	Prototype evaluation to explore: 1. Interest and involvement of PWD. 2. Impact on care staff enjoyment in keeping company with PWD.	Refined version of cognitive prosthesis, with sections on entertainment, recreation and local Dundee life.	Qualitative exploration of clients’ views  ( <i>qualitative checklist: 25% researcher position, ethics, analysis and consideration around integration unclear</i> )	Evaluation questionnaires with PWD and staff.	All PWD and staff said they enjoyed, and named aspects they liked. PWD named stimuli they had liked the best. Staff believed PWD learned new things, put focus of attention back	PWD expressed desire for stimuli with personal relevance.  Staff able to use system with little preparation.



Authors, date	Participants	Aim	Touchscreen Intervention	Design (MMAT appraisal)	Measures	Psychological impact finding(s)	Important aspects of intervention
						on PWD, and remembered things. Better quality time together.	
<b>Alm et al. (2007)</b>	40 PWD, 30 informal carers.	Initial prototyping with a number of potential interfaces	CIRCA (Computer Interactive Reminiscence & Conversation Aid) – evolution of cognitive prosthesis	Informal evaluation – demonstrations of different interfaces across settings.  <i>(prototyping phase excluded from MMAT appraisal for not having explicit methodology)</i>	Unclear, but apparently observation of PWD in care homes and conversations with their carers.	PWD “interested and motivated”.  Videos only engaging when resonated with PWD.  Greater PWD engagement reported even when carers using CIRCA.	Hypermedia structure Simple interface, muted colours. No need to duplicate paper scrapbook look. Touchscreen essential. Photos & music appreciated more than videos. Animations of music players helpful.
<b>Phase 1</b>							
<b>Phase 2</b>	18 PWD – 13 female. “Moderately to seriously affected.”	To compare impact on interactions between PWD and carers when using CIRCA vs traditional	CIRCA	Between participants - random assignment to CIRCA or TRAD  <i>(mixed methods)</i>	Sessions videoed. CIRCA logs scrutinised. Coding of interactions: - PWD choosing	Changes in interaction pattern: PWD offered more choice with CIRCA (U=1.50, p<.001), and made more	Attempts to integrate personal information were distressing when PWD could not recall family

Authors, date	Participants	Aim	Touchscreen Intervention	Design (MMAT appraisal)	Measures	Psychological impact finding(s)	Important aspects of intervention
		reminiscence (TRAD)		<i>checklist: 25% - allocation and data completeness unclear, integration consideration unclear</i>	- Caregiver prompting - Memories, humour, laughter or movement	choice (U=2.00, p<.001) More choice led to PWD sharing more reminiscences (r=.40, p<.05). Conversations more equally balanced with CIRCA. "It takes you back and refreshes your memory."	members: personal material not needed as generic material can provoke recall.  "Aesthetic usability effect" meant software was usable.
<b>Alm et al. (2009)</b>  <b>Phase 1 – Interactive entertainment</b>	Initially 5 PWD, 3 male, 2 female. Eventually 12 PWD – 7 female, 5 male	Investigate ways an interactive entertainment system for PWD could engage & prompt them to use it unaided	3D virtual environments, activities and games	Qualitative exploration of clients' views  <i>(qualitative checklist: 25% researcher position, ethics &amp; analysis unclear)</i>	Interviews and observations	Individual: "appeared to enjoy" 3/5 tried independent use. "Wonderful". "I'd be there all day." "Lovely." In groups : "lots of comments and cheering at ... success"	Engaging, "attractive" and colourful interface which promises enjoyment Clear goals Challenge and skill mastery Continual feedback – encouragement and praise
<b>Phase 2 – Being</b>	25 PWD	To devise technology which could	ExPress Play Chord-based music creator.	Mixed methods	Video of sessions, asking	Sig increase in duration of music playing	Unclear

Authors, date	Participants	Aim	Touchscreen Intervention	Design (MMAT appraisal)	Measures	Psychological impact finding(s)	Important aspects of intervention
<b>musically creative</b>		help a PWD to carry out a satisfying creative activity.		<i>(qualitative checklist: 25% researcher position, ethics &amp; analysis unclear)</i>	participants about their experiences and device activity logs	in 3 <sup>rd</sup> session. More finger movements & choices. Learning took place? Ppts tended to want to keep playing.	
<b>Astell et al. (2008)</b>	18 PWD, 13 female. Mean age 82 years. (Same as Alm et al., 2007 phase 2 above).	To examine utility of CIRCA as a communication prosthesis for PWD	CIRCA PWD used with professional care staff in pairs.	Between participants RCT. CIRCA vs. traditional reminiscence (REM)	Incidences of PWD initiating topics and making decisions were recorded, as well as aspects of caregiver interactions. Interview data reviewed for feedback from PWD about their experiences.	In both studies: PWD initiation much higher with CIRCA. PWD also made more decisions about what they wanted to do. All PWD said they enjoyed. Staff said CIRCA was easier and less burdensome. CIRCA restores PWD's status as equal conversation partners.	Reduces "working memory load" of conversation for PWD. Hypermedia + touchscreen → good flexibility for PWD. CIRCA helps conversation partners too.
<b>Study 1</b>							
<b>Study 2</b>	11 PWD, 6 female. Mean age 83.54 years. (Same as Astell et al., 2010 below).	To examine utility of CIRCA as a communication prosthesis for PWD	CIRCA PWD used with professional care staff in pairs.	Within participants CIRCA vs. REM  <i>(Quantitative checklists : 75% as allocation concealment, if possible, was unclear)</i>			
<b>Astell et al. (2010)</b>	11 PWD, 6 female, who	To explore changes in	CIRCA	Repeated measures.	Wellbeing	Verbal	Hypermedia allows PWD to

<b>Authors, date</b>	<b>Participants</b>	<b>Aim</b>	<b>Touchscreen Intervention</b>	<b>Design (MMAT appraisal)</b>	<b>Measures</b>	<b>Psychological impact finding(s)</b>	<b>Important aspects of intervention</b>
	met criteria for “probable Alzheimer’s disease”. Recruited from day care and residential settings. Age 65-95 (mean 83.54). Mean 10.2 years of education. MMSE scores 9-23, mean 15.9. 11 professional care staff.	verbal and nonverbal aspects of caregiver and caree communication when using CIRCA as opposed to TRAD.		CIRCA vs. TRAD  <i>(Qualitative checklist 100% well-designed study, with accounting for position of researchers, ethical considerations and consent).</i>	Verbal measures coded online and from video recording.  Nonverbal measures from coded sections of video recordings e.g. gaze, moving and singing.	-PWD sang significantly more when using CIRCA (t(10) = 2.191, p < .05). -more choices offered to PWD with CIRCA -PWD made more choices with CIRCA -less initiation of interactions by PWD in TRAD Nonverbal -More joint laughter -Interaction easier to sustain -Status hierarchy redressed? -More shared activity	talk about topics that might not arise in traditional sessions.  PWD have more choice and control with CIRCA.  Improvements in staff satisfaction could feed back into relationship with PWD.
<b>Hofmann et al. (1996)</b>	10 PWD, 6 female, mean age 69, mean MMSE 19.4 (SD 4.0).	To evaluate effectiveness of interactive computer-based	ICT – interactive simulation of either local and social	Repeated quantitative measures.	Performance on tasks, and psychometric scales.	Performance on all task measures improved. Psychometric	Some trained skills stayed improved – motoric and implicit memory

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		cognitive training (ICT)	environment or town and social competence tasks	<i>(Quantitative checklist: 100%)</i>	Anecdotal info from carers.	measures not valid and no significant differences. Carers suggested people's abilities improved in real life.	might be preserved.  Motor action during learning leads to improved cued recall.
<b>Hofmann et al. (2003)</b>	9 PWD, 9 people with <i>depression</i> , MMSE 19.6 ±5.8 10 controls, age & sex matched	To evaluate effectiveness of interactive computer-based cognitive training (ICT)	ICT – an interactive simulation of the process of going shopping. 5 different programs.	Three experimental groups. Case-control design. Repeated quantitative measures  <i>(Quantitative checklist: 100%)</i>	Quantitative - Training effectiveness - MMSE scores - Self-ratings of ICT impact	PWD – less errors. MMSE improved. Self-reported positive effect of training. All participants reported liking ICT.	Ergonomics - comfort via the easy-to-handle touchscreen function and desktops showing familiar items from the participants' environment. Exercising complex cognitive skills, not simple.
<b>Imbeault et al. (2013)</b>	2 PWD – both male, aged 71 and 80, each with an informal carer	See if PWD could use AP@LZ. Explore impact on memory.	AP@LZ (agenda personnalisé pour des personnes avec maladie d'Alzheimer)	2 single 'ABA' case studies, mixed methods  <i>(mixed methods checklist: 25%)</i>	Neuropsych tests, performance measures, depression measure,	Could learn to use. Preserved ability on supported tasks. No significant	Errorless learning style Three-step learning Stage of dementia

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		Explore impact on carer burden.		<i>- tiny sample, qualitative analysis unclear, integration consideration unclear)</i>	burden measure.	impact on depression or burden.	Over five months needed to integrate AP@LZ in to daily life.
<b>Leng et al. (2014)</b>	6 PWD with similar attributes at Singaporean day centre.	Investigate whether iPad apps could promote wellbeing like other meaningful activities	iPad apps “chosen with the characteristics of the PWD in mind”	Group sequential quasi-experimental design. Repeated measures of PWD using iPad vs Cooking vs Craft work.  <i>Quantitative checklist : 100% - but small sample)</i>	Dementia care mapping	iPad activities promoted wellbeing and engagement. Wider range of behaviours with iPad.	Detailed planning and approach. Tailoring activities.
<b>Leuty et al. (2013)</b>	6 PWD – art therapist (AT) dyads	Investigate 1. Usability for ATs 2. Usability for PWD 3. Improvements	Prototype ePad (Engaging Platform for Art Development) – artificially intelligent touchscreen	Pragmatic mixed methods concurrent nested.  <i>(Mixed methods checklist: 75% as whilst both</i>	Mainly usability, but discussion includes psychological outcomes	PWD were “excited” by ePad, but frustrated by counterintuitive parts.	Improve intuitiveness – ATs did not like some aspects like simulated brush “running dry”. Using bar to set brush

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				<i>qualitative and quantitative components met all criteria, integration consideration was unclear)</i>			size potentially confusing. Prompting. Ergonomics – screen position.
<b>Lim et al. (2013)</b>	21 PWD (early stage) – carer dyads. Early-stage dementia. Living privately. Informal carer.	Explore usability of tablets by PWD	iPads with chosen apps.	7-day in-home pilot study.  <i>(Quantitative checklist: 100%)</i>	Quantitative questionnaires with PWD and FC.	50% could use independently – suggested would reduce carer burden.	Case-by-case consideration of aptness. Simple interface. More helpful earlier in dementia.
<b>Meiland et al. (2012)</b>	Test 1 - 16 PWD and their carers Test 2 - 14 PWD and their carers Test 3 - 12 PWD and their carers	Explore usability (tests 1-3) and effectiveness (test 3 only) of COGKNOW Day Navigator.	COGKNOW Day Navigator (CDN) – prototype ‘daily life support’	3 mixed methods field tests.  <i>(Mixed methods checklist: 50% - quantitative components of this study met MMAT criteria, but it was not stated whether qualitative components and integration</i>	Semi-structured interviews, and outcome measures.	No effect from practical intervention. No effect on burden / autonomy.	Adaptations suggested such as including PWDs and ICs from beginning of development.

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<b>Nijhof et al. (2013)</b>	16 PWD and family carers. 11 professionals.	Study advantages & disadvantages of system from PWD, IC and professional perspectives.	PAL4 Dementia: Daily organiser, "PAL4 features", webcam	Mixed methods – qualitative interviews, logs, group meetings  <i>(Mixed methods checklist: 75% as integration consideration unclear)</i>	Wellbeing and other measures	PWD seen laughing, stimulated, ++QOL, ++ independence Caregivers could speak remotely → ++ QoL	System in conspicuous place. Simpler games better. Trouble-shooting service. Language of programs. All options visible on main screen. Photos of contacts.
<b>Riley et al. (2009)</b>	3 pilots – only 3 <sup>rd</sup> with PWD (10)	Provide and assess novel activity – creation of music	Evolution of CIRCA – ExPress Play. Chord-based music creator.	Pilot studies building to 3 <sup>rd</sup> with PWD.  <i>(Qualitative checklist: 25% as analysis and researcher position unclear)</i>	Observation and discussions.	All "appeared to enjoy". Laughing. When carer present, more conversation when PWD or carers using. PWD avoided low-mood music.	Ergonomics – accidental button pushing Prompting system



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<b>Topo et al. (2004)</b>	28 PWD at five daycare centres in Ireland, Norway, UK.	Part of ENABLE project which aims to find solutions to aid people living at home. This research was to assess usability and impact of jukebox-type program, and to find associations with wellbeing of participants.	The Picture Gramophone (PG) – a jukebox-type application which allows people to listen to music	Mixed methods pre-post and case studies.  <i>(Mixed methods checklist: 75% as researchers' consideration of their impact unclear).</i>	Staff ratings of PWD PG usage. Staff ratings of health-related QoL measures. Staff ratings of sociability. Interviews with PWD after 2 weeks about their experiences with PG. Case studies.	52% had prob using. 91% benefited. 74% +ve mood impact. 70% +ve impact on social interaction	- Issues with touchscreen sensitivity – needs to be consistent. - Screen text should be as large as possible. - Stimuli (music) individualised to user beneficial - No intrusive error messages
<b>Tyack et al. (2015)</b>	12 PWD and their informal caregivers	Explore the impact of viewing visual art on a tablet-style computer on subjective wellbeing for PWD and their informal caregivers	Art Viewer app – allows people to view art	Mixed methods quasi-experimental repeated measures and qualitative interviews  <i>(Mixed methods checklist: 75% as integration consideration unclear)</i>	Wellbeing visual analogue scales and thematically-analysed interviews.	Improvement in quantitative wellbeing increased in size with subsequent sessions.  Qualitative – benefits in mental stimulation and mood (11 pairs), and relationships. 5	Ease of use of hardware – screen visibility and sensitivity, and ease of charging

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						pairs reported increased activity levels.	