Final Report

Time-Travelling with Technology (TTT): Applying and Evaluating Behavioural and Psychosocial Benefits of Liquid Galaxy-Based Reminiscence Therapy for People with Dementia

Dementia Centre for Research Collaboration

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Translating dementia research into practice

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Acknowledgements Residents and families, Nursing and Care Staff at BaptistCare Yallambi, Walldock, and The Gracewood; Dementia Collaborative Research Centres (DCRC); Andrew Leahy, Karen Watson, Daniel Piepers, Janice Stokes, Jan Martin, Caroline Gray, Donna Francis, Rhonda Brooker, Anthony Tucker, Simone Pardea, End Point, Google.

This project has been funded by the Dementia Centre for Research Collaboration as part of an Australian Government Initiative.

Disclaimer

The views expressed in this work are the views of its author/s and not necessarily those of the Australian Government.

Acronyms

LG: Liquid Galaxy
M: Mean
MMSE: Mini Mental State Examination
n: Sample size
NPI: Neuropsychiatric Inventory
p: Probability
QoL: Quality of Life
RAO: Residential Activity Officer
RT: Reminiscence Therapy
SD: Standard deviation
TTT: Time Travelling with Technology

Introduction

Aims

The aim of this applied research project is to investigate the feasibility and effectiveness of new technology – Google Liquid Galaxy and web resources – as an improved intervention for reducing the behavioural and psychological symptoms of people with dementia.

Imagine Lorraine and Karl flying, taking their carers and family members to the suburbs where they grew up. The group is seated in front of 5 large “Liquid Galaxy” screens displaying Google maps. Karl’s granddaughter navigates, zooming over Sydney, arriving at Camperdown. Lorraine talks animatedly about her 15 years growing up there. Group members ask questions, suggest landmarks, chat, reflect, remember. Lorraine and Karl’s feelings of anxiety, evident minutes before, have disappeared. Everyone is absorbed. Time travelling. Reminiscing. Next stop, Karl’s hometown, Vienna.

Reminiscence Therapy (RT) refers to vocal or silent recall of life events, activities and experiences often using personal triggers such as photographs, music or objects (Subramaniam & Woods, 2012). It is a means to talk about or share memories and, in turn, promotes communication, reduces social isolation, improves mood and sense of self-worth, and sustains relationships with loved ones. RT can be used with people with varying levels of cognition including those unable to verbalise (Lazar, Thompson, & Demiris, 2014).

Realistic dynamic 2D and 3D visual environments offer new possibilities to intensify the experience and effectiveness of RT. Memory aids such as photos and objects rely on materials being available with contextual information that connects them with care recipients. Music can be used as a trigger but may not suit everyone and relies on adequate levels of hearing and attention. Photographs are static and discrete. Wrap-around screens that display photographic, life-size or hyper real software-rendered images, by contrast, are navigable through space and time, eliciting a sense of agency, envelopment and continuity.

The *Time Travelling with Technology* (TTT) project tested these assumptions. It brought together the established principles and effectiveness of RT with new visual and readily available hardware and software. While studies are beginning to emerge of the use of technology in RT, few studies have adequate statistical power and rigorous evaluation (Lazar et al., 2014) and none combine RT and Liquid Galaxy technology (Google, 2017). We implemented and evaluated the impact of RT and dynamic visual technology on behavioural and psychological symptoms of dementia. The new collaboration with Baptist Care enabled applied research by installing the technology at Baptist Care, evaluating the intervention and identifying key variables that optimize RT success. The **research questions** were: 1) Is Liquid Galaxy an effective and practical RT medium for people with dementia in aged care? and 2) Does the immersive nature of a Liquid Galaxy system surpass less-immersive technology-based RT?

Hypotheses

1. If Liquid Galaxy is an effective and practical RT medium for people with dementia in aged care then participants attend multiple sessions over a period of weeks;
2. If Liquid Galaxy is an effective and practical RT medium for people with dementia in aged care then participants engage visually, verbally and emotionally with RT content; and
3. If Liquid Galaxy (LG) immersive technology intensifies and enhances RT, then RT with immersive compared with less-immersive technology-based RT reduces behavioural and psychological symptoms of dementia, specifically, reducing anxiety and irritability, improving mood, quantity and quality of communication.

Background and Significance

One of the expected consequences of the continued growth and ageing of Australia's population is a substantial increase in the number of people with dementia over time (Australian Institute of Health and Welfare [AIHW], 2012). Currently, there are more than 353,800 Australians living with dementia, with approximately one new case every 6 minutes (Economics Australia, 2009). By 2050, the Australian Institute of Health and Welfare projections suggest that around 7.5 million people in Australia will be aged 65 and over, with the expected number of people with dementia to almost triple to about 900,000 (AIHW, 2012).

Dementia is marked by a slow, progressive and generally irreversible loss of cognitive abilities, such as loss of memory, language, perception, personality, judgment, and problem solving (AIHW, 2012; Lazar et al., 2014). As the disease progresses, non-cognitive and behavioural problems (e.g., mood disturbances, personality changes, agitation, aggression, pacing) become evident (Forester & Oxman, 2003). The behavioural and functional problems that accompany dementia can contribute to reduced physical activities and mental wellbeing, impair social or occupational functions, and negatively impact on quality of life (Huang et al., 2015; Cotelli, Manenti, & Zanetti, 2012). As a result of these alarming projections and the progress of the disease, an important concern is the development and evaluation of effective therapeutic interventions to improve both the associated symptoms and long-term quality of life (QoL) of people living with dementia.

Although pharmacological treatments are widely used, especially for functional impairments in people with dementia, it is recognised that they have limited effectiveness and are associated with important adverse effects (e.g., increased risk of cerebrovascular adverse events and metabolic syndrome; Backhouse, Killett, Penhale, Burns, & Gray, 2014; Huang et al., 2015; Woods et al., 2009) . In view of this, there is increasing interest and more attention focused on psychosocial interventions, which have been recognised to be as effective as pharmacological therapies, as well as preferable in some contexts (for instance, when potential undesirable side effects are a concern; Cotelli et al., 2012; Woods et al., 2009). Importantly, psychosocial interventions have the potential to promote wellbeing and improve the QoL of people with dementia and their caregivers (Cotelli et al., 2012).

One psychosocial intervention that has attracted research and clinical attention is Reminiscence Therapy (Cotelli et al., 2012). It typically involves the discussion of past activities, life events and experiences (in group meetings or individual sessions) often assisted by a range of memory triggers such as videos, music, photographs, familiar objects, life story books (Miller, 2009; Subramaniam & Woods, 2012; Woods et al., 2012; Woods, Spector, Jones, Orrell, & Davies, 2005; Yasuda, Kuwabara, Kuwahara, Abe, & Tetsutani, 2009). This therapy is based on the fact that long-term memory is usually preserved in people with dementia (O'Rourke, Tobin, O'Callaghan, Sowman, & Collins, 2011) so they are encouraged to talk and reflect about memories from earlier in life to improve communication and mood, and foster their sense of self (Miller, 2009). RT is a valuable approach to encourage interaction and wellbeing in those with dementia (O'Rourke et al., 2014).

Recently, RT has expanded beyond the tangible and traditional. There is growing evidence that the use of technologies to support and facilitate RT may boost effective intervention (Subramaniam & Woods, 2012). Increased social interactions and communication among participants with dementia were reported in a study comparing the use of multi-media 'touch-screen' with traditional RT (Astell et al., 2015). Yasuda et al. highlighted the effectiveness of personalised reminiscence photo videos for individuals with dementia (Yasuda et al., 2009). Moreover, the use of the internet-based video sharing website, 'YouTube', has been suggested a feasible means for increasing sense of wellbeing and mood in a group context of people with dementia (O'Rourke et al., 2014).

A recent systematic review examining current evidence on the use of information and communication technology in conducting RT reported the potential uses and challenges of technology in people with dementia. Engaging multimedia reminiscence materials may promote social interactions, create opportunities for people with dementia to take ownership of conversations and reduce barriers due to motor deficits in people with dementia. However, due to the limited body of well-conducted studies with appropriate sample size and clear methodologies, as well as the high variability in technologies used across the studies, the authors recommended that larger studies investigate whether the use of technology in RT has a positive effect on people with dementia (Lazar et al., 2014).

On the basis of the paucity of robust data demonstrating therapeutic impact of the use of information and communication technology in conducting RT, we propose a feasibility study using RT aided by LG monitors arranged in an arc around the person to expand the evidence base use of this medium for people with dementia in residential aged care. While cost of the technology is presently high, Moore's Law tells us that computer power doubles, and the cost halves, every two years.

Research Method – Round 1

Participants

Thirty-three residents with differing stages of dementia or cognitive impairment were recruited from a residential Baptist Care facility for a six week study called Time Travelling with Technology. Signed consent was obtained from each resident and / or their primary carer prior to their participation in the study. Residents were randomly placed in either a high-tech immersive intervention condition (n = 16; 11 female; M age = 83.06 years; M MMSE = 13.94), where they were exposed to highly immersive and dynamic triggers for reminiscence, or a less immersive, but still technology-based control group (*n* = 17; 9 female; *M* age = 81.06 years; *M* MMSE = 14.06) where they were exposed to less immersive and static, visual triggers for reminiscence.

Apparatus and Design

Google Earth and Google Street View locations were used as triggers for reminiscence and were displayed using Liquid Galaxy technology. The Liquid Galaxy System was set up in the resident lounge at the aged care facility and consisted of five 55 inch LCD screens that were navigated from a touch screen pedestal and Space Navigator (3Dconnexion, 2017). The screens and pedestal were connected via a network of computers. Figures 1-2 illustrate the set-up.

The five screens were mounted on stands in portrait orientation at eye level and arranged in a 120 degree arc. Brackets were used to hold the screens in place once they were configured. Buttons on the touch screen pedestal were used to switch between separate Google Earth and Street View locations. The touch screen was also used to switch to nearby locations in Street View through tapping on the Google Map interface. The Space Navigator was used to move around the Google Earth environment. In Google Street View the Space Navigator was used to pan the image left and right in each panoramic scene. The buttons on the Space Navigator were used for moving backwards and forwards in the Street View environment. Panning the image up and down was not possible in Street View due to restrictions in the software.

Figure 1. Five-screen (high-immersion and dynamic) Google Liquid Galaxy set-up at Yallambi.

Figure 2. Low immersion Liquid Galaxy monitors displaying a static landmark from StreetView.

We were interested in whether the large scale visual immersion and dynamic aspects of the technology used for recollection would influence the effectiveness of reminiscence therapy sessions. We tested this by manipulating two important features of the TTT experience for high-immersion and low-immersion conditions in the experiment. First, in the high-immersion condition, locations were displayed across all five LCD screens, while in the low-immersion condition this imagery was restricted to the central three screens. This meant that the display arc was approximately 120 degrees for the high-immersion condition and 70 degrees for the low-immersion condition. Second, the high-immersion condition was dynamic while the low-immersion condition was static. For low-immersion, Google Earth and Street View sessions displayed single static images of each location. Only the touch-screen buttons on the pedestal were used to switch between locations and the dynamic 3D mouse and Street View map capabilities of the pedestal were not used. Conversely, the visual display in the high-immersion condition was dynamic. In Google Earth sessions, the high-immersion display moved around familiar landmarks, showing locations from varying distances and viewpoints. In high-immersion, residents were also “teleported” to other locations of interest. In Street View sessions, residents in the high-immersion condition travelled around their immediate environment, panning left and right in each panoramic scene, roaming up and down streets and around other environments such as shops, malls and famous landmarks. It was also possible to switch between and explore other Street View locations in the high-immersion condition.

Sessions were filmed on two tripod mounted video cameras with Rode external microphones. The first camera was positioned below the central LCD screen facing the residents and filmed the faces of all residents in frontal view. A second video camera, which was positioned off to one side of the Liquid Galaxy display, filmed both the resident’s faces (in profile view) and partial imagery from the display. The first camera was the primary point of reference for video coding while the second camera was used as a backup if the faces of residents on the main camera became momentarily occluded or moved off camera. The second camera was also useful in establishing which landmarks were being visited at any particular point during the session as well as when locations switched.

Stimuli

Google Earth and Street View Locations included previous home and family addresses, favourite holiday and recreational locations, places of work, schools, famous landmarks and other places of personal interest. Places that residents had not previously seen but wished to visit were also included in this list. Prior to the first week of testing a list of suitable locations was obtained for each resident by the session facilitator. Locations were provided by either the residents themselves or by family or care staff. A list was also kept of the locations specified by residents, family and care staff both during and after each therapy session and many of these locations were visited in future Google Earth or Street View sessions.

For the first three weeks of testing, suitable aerial viewpoints of each location were found using Google Earth. These locations were place-marked and then saved as keyhole mark-up language (KML) files which contained geographical information about the selected viewpoint; its longitude and latitude as well as its heading, tilt and range relative to the target of interest. The Google Earth imagery associated with these coordinates served as the starting point for navigation in the high-immersion condition and as static images used in the low-immersion condition. Placemarks were entered into the Liquid Galaxy system by adding them as bookmarks to an online content management system that could be accessed on site.

For the second half of the TTT program (i.e., weeks 3 to 6), suitable images of locations were found using Google Street View. Two important pieces of information were needed for each location: a panorama ID, which specifies the panoramic image needed from Street View, and a compass heading, which specifies the viewable portion of the panoramic image. Street View location information was saved in the form of a JavaScript object notation (JSON) file and transferred to the Liquid Galaxy system. Viewable portions of Street View imagery served as the starting point for navigation in the high-immersion condition and as the static images used in the low-immersion condition.

Measures

A test battery consisting of the Mini-Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975), Neuropsychiatric Inventory - Nursing Home Version (NPI-NH; Cummings et al., 1994; Wood et al., 2000) and Quality of Life-AD (QoL-AD; Logsdon, Gibbons, McCurry, & Teri, 1999; 2002) was used to assess the cognitive functioning, psychopathology and quality of life of the residents participating in TTT. The NPI-NH and QoL-AD were administered both pre- and post-test while the MMSE was administered once prior to testing.

The MMSE (Folstein et al., 1975) is a widely used measure of cognitive impairment that is often used to screen for dementia (see Mitchell, 2009; Tombaugh & McIntyre, 1992 for reviews). It contains a series of questions that target cognitive abilities such as orientation, memory recall, arithmetic and language ability. Collectively the questions are worth a total of 30 points and the test takes approximately 10 to 15 minutes to complete. Different score ranges on the MMSE have also been reported to align well with Clinical Dementia Rating (CDR) categories (Hughes et al., 1982) suggesting that scores on the MMSE may also be a useful indicator of the stage or severity of dementia (Perneczky et al., 2006). According to Perneczky and colleagues a MMSE score of: 21-25 indicates mild dementia; 11-20 indicates moderate dementia, and; 0-10 indicates severe dementia in accordance with how these stages are characterised in the CDR.

The NPI-NH (Cummings et al., 1994; Wood et al., 2000) measures for the presence, frequency, severity and occupational disruptiveness of ten behaviours that indicate the psychological state of the resident under evaluation as well as their eating and night-time behaviours. The ten behavioural domains are delusion, hallucination, agitation and aggression, depression, anxiety, euphoria, apathy, disinhibition, irritability and aberrant (repetitive and apparently non-purposeful) motor behaviour. The NPI-NH takes the form of a structured interview that is given to nursing staff who have spent considerable time with the resident under evaluation. The frequency of behaviour is rated on a four point scale ranging from rarely (less than once a week) to very often (continuously) while severity is rated on a three point scale ranging from mild (where the behaviour is either non-harmful and/or relatively easy to change) to severe (where the behaviour is stressful and/or nearly impossible to change). Domain scores are obtained by multiplying the frequency score by the severity score and total NPI-NH scores are obtained by adding together domain scores for the first ten behaviours. Eating and night-time behaviour domain scores can also be added to the total NPI-NH scores if they are considered to be important to the research area.

The Quality of Life- AD (QoL-AD; Logsdon, Gibbons, McCurry, & Teri, 1999; 2002) is a 13 item measure which can take the form of a questionnaire (for caregivers) and interview (for residents). The QoL-AD focuses on 13 quality of life domains: physical health, energy, mood, living situation, memory, family (or extended family), marriage (or close relationships), friends, money, the ability to do chores and fun things and, the self and life as a whole. Domains are rated by residents and / or caregivers on a scale of 1 (Poor) to 4 (Excellent). Domain scores are then added to produce a total QoL-AD score ranging from 13 to 52.

Procedure

Prior to the commencement of TTT the session facilitator (who was also a Registered Nurse) provided pre-trial training in the administration of the NPI-NH for nursing staff and in the administration of the QoL-AD for Residential Activity Officers (RAO's). Training was provided to one or two staff members at a time to accommodate their busy work schedules and the training session took approximately 15 minutes to complete. RAO's were given one week to complete the questionnaire version of the QoL-AD for each of the residents under their care both prior to and at the completion of the TTT reminiscence therapy sessions. They were instructed to report on each resident's quality of life in the two weeks prior to filling out the form. This meant that at the completion of testing RAO's were reporting on the quality of life behaviours exhibited by residents in the final two weeks of testing. Nurses followed the same time course in their administration of the NPI-NH reporting instead on the psychopathology of the residents under their care. The MMSE was administered to residents by the facilitator to obtain baseline cognitive levels for group allocation prior to resident participation.

TTT reminiscence therapy sessions ran over the course of a 6 week period. Residents attended one half hour session each week which was always scheduled on the same day and at the same time so that it could be incorporated as part of the resident's weekly routine. Attempts were made prior to the commencement of TTT to ensure that the scheduled days and times for sessions did not clash with other social activities that took place at the facility. Prior to each reminiscence therapy session two members of the research team previewed the locations for each resident to ensure that there were no issues with the alignment and visibility of landmarks on screen. This was particularly important in the low-immersion condition as relevant sections of a panoramic image could not be rotated to once the image was shown to this group. In preparation for low-immersion condition sessions, the power supply to the two outside screens was cut prior to residents entering the room. In preparation for high-immersion condition sessions, power was restored to all five LCD screens.

Residents were assisted from their living quarters to the resident lounge under the supervision of either the facilitator or care staff (nurses or RAO's) employed by the facility. Residents were seated approximately 2 metres from Liquid Galaxy display in comfortable seating or wheelchairs. This distance ensured all group members could be seen in the video recordings and also provided sufficient movement space for the session facilitator, who usually sat on the floor between the residents and the screens. Small adjustments were made in viewing distance to accommodate different group sizes. In cases where family or care staff attended all or part of a reminiscence therapy session they were encouraged to sit behind the residents so that the residents participating in the study could be positioned as close as possible to the Liquid Galaxy display while still being visible on camera. At least two other researchers were present for most of the therapy sessions. One researcher stood at the pedestal and 'drove' the technology, navigating around the Google Earth and Street View environments during high-tech sessions and switching between location images in the low-tech sessions. The other researcher was responsible for overseeing the smooth operation of the Liquid Galaxy technology and kept a log of additional locations that were mentioned by residents and their visitors during the session.

The facilitator began each TTT session by greeting the residents and giving them an overview of what the focus of the session would be. Following this, locations for each resident were displayed one at a time. The facilitator conversed with each resident about their specific locations and encouraged them to share any recollections with the group. Other residents, staff, visitors and researchers in the room were also welcome to take part in the conversation. The session concluded with a debrief and a preview of what the focus would be for the following weeks session. Residents were also encouraged to share other locations they would like to visit in future sessions.

Locations were visited in Google Earth during the first 3 weeks of testing and in Google Street View during the last 3 weeks of testing. The first Google Earth session was used to establish a baseline and focused almost exclusively on famous landmarks in and around Sydney CBD. In consecutive weeks, the Google Earth focus gradually became more global. The second Earth session focused primarily on locations within Australia while the third session focused primarily on other countries around the world that had been visited. Google Street View sessions followed a similar trajectory. Starting with Australian landmarks and working up to a more global focus.

Results – Round 1

Of the 33 residents initially recruited for the study, 24 fulfilled the minimum three session attendance criteria for inclusion in the final analysis. Of the 9 residents that were excluded, 4 only attended the first RT session while the remaining 5 did not attend any sessions. The remaining 24 residents attended between 3 to 6 therapy sessions, supporting Hypothesis 1, and were distributed relatively evenly between the high-immersion (*n* = 11; 8 female; *M* age = 81.09 years) and the low-immersion (*n* = 13; 6 female; *M* age = 80 years) conditions. Baseline comparisons revealed similar MMSE scores for residents in the high-immersion (*M* = 13.55, *SD* = 5.54) and low-immersion (*M* = 15.23, *SD* = 5.93) conditions, $t(22) = 0.72$, $p = .482$. Residents also attended a similar number of reminiscence therapy sessions in the high-immersion (*M* = 4.73, *SD* = 1.19) and low-immersion (*M* = 5.08, *SD* = 1.12) conditions, $t(22) = 0.74$, $p = .466$. A total of 43 sessions were carried out over the course of six weeks with between 1 to 4 residents from the same group attending each session (*M* group size = 2.83, *SD* = 0.40). An additional high-immersion session was run in the first week but discontinued from the second week onwards due to the drop in attendance. Mean group size was calculated on a week by week basis and factors in the size of the additional high-immersion session.

Behavioural and Psychosocial Symptoms

To investigate Hypothesis 2 that the high-immersion RT intervention would have an effect on behavioural and psychosocial symptoms of dementia compared with low-immersion RT, *t*-tests were conducted separately for high- and low-immersion conditions with respect to pre-intervention versus post-intervention scores on i) the QoL; and ii) NPI. Paired samples *t*-tests showed no difference between pre- versus post-intervention scores on the QoL scale in either the high-immersion (p=.90) or low-immersion (p=.83) condition. In support of Hypothesis 2, there was a significant reduction in NPI scores from pre-intervention (*M*=31.64, *SD*=19.11) to post-intervention (*M*=24.27, *SD*=11.98) for participants in the high-immersion condition, $t(10)=2.27$, $p=.046$, but not in the low-immersion condition (p=.70). A strong contributor to the significant result is a reduction from pre- to post-intervention in irritability in the high-immersion condition.

Qualitative Comments from Family and Lifestyle Coordinators

Qualitative data, gathered during Week 3, suggested general enthusiasm for technology-infused RT. For example, one family member commented: “Thank you so much for doing this; he loves it; he thinks it’s amazing how you have all the big screens and take him to places he knows”. A Lifestyle Coordinator in the high-care part of the facility commented: ‘It’s lovely wonderful for the residents. You know, the other day I was wheeling a resident back from a session that is usually quite withdrawn and she said, ‘Oh no take me down to the dining room I feel like chatting after that’”; “Yesterday not one remembered”; “Lana [names have been changed], when her daughter came, she recounted the whole journey for her. She said, ‘I have been to a beautiful place’’’; “Cathy love’s it, enjoys it, remembers it”. Another Coordinator from low-care area said: “It’s good; they’re always looking forward to it, it’s great. It gives excitement. Archie, Bernadette, Bob, Jack, Cyril and his wife (Claudia) are all overwhelmed”. A third Coordinator noted that “Betty, in the moment, she likes it while it’s happening and then forgets”. Comments from a Coordinator in the Memory Support Unit included: “Abby loves it. Just to get a smile out of her you’re doing well… because she has very… [points to her face demonstrating flat affect]. Coming back in the bus yesterday, as we were pulling back up to the unit she said ‘that was really good’.” “They really like coming… when I say they’re coming. They don’t remember once they are back.” “Paul remembers. He is speaking more about his mum. She passed away last year.” “Matthew remembers. When I ask him about the sessions, he says, ‘Oh yeah’. He really enjoys the sessions”. “Panos’s memory comes and goes; sometimes he will remember the sessions.” “Vera is talking about her son more”. “Friedrich remembered me when I entered the facility, voiced that he was looking forward to this week’s session.”

Participant Engagement – Approach to Coding Video

Video coding schemes in the area of dementia research commonly include checklists of behaviours designed to measure engagement, levels of agitation and emotional responses (Cruz, Marques, Barbosa, Figueirdo, & Sousa, 2013; Jones, Sung, & Moyle, 2015; Kolanowski, Litaker, Buettner, Moeller, & Costa, 2011). The video coding framework used in the current study was similar to that proposed by Jones and colleagues (2015), grouping engagement behaviours on the basis of whether they were largely emotional, verbal, visual or physical in nature and including a separate category for behaviours indicative of agitation. Indicators of ‘collective engagement’ (interaction with others in the group) were not coded separately but instead collapsed across the other engagement categories (e.g. including a ‘prompted by other residents’ indicator in the verbal engagement category). Also, the use of hand gestures such as pointing replaced the handling of stimuli as an indicator of physical engagement. Some of the engagement indicators used by Cruz and colleagues (2013) were also included in the current video coding framework (e.g. head nodding / shaking as a sign of physical engagement). Table 1 provides an overview of the engagement behaviours that were coded for.

Video coding was carried out for all 6 sessions. Coding for each session was restricted to 5 minutes of video footage for each resident in the group. The 5 minute coding segment selected for each resident started just prior to them being prompted to respond to (or making their first unprompted speech in response to) a newly displayed location. Each 5 minute segment was broken down into ten 30-second intervals. Whenever an engagement behaviour was presented / observed during a 30-second interval this was coded with a ‘1’ while if there was no evidence of that behaviour during the interval then the cell was left blank. This meant that scores could range from 0-10 for each indicator. Behaviours only needed to be presented briefly during an interval in order to be coded. For example, if a resident only responded ‘yes’ to a question posed by the facilitator once during a 30-second interval and said nothing else during this time, then they were coded as having made a facilitator prompted verbal response during the interval. While this measure was not as precise as measuring the exact frequency and duration of engagement behaviours, it provided a more time efficient and objective means of analysing a large amount of video data.

Table 1. The engagement behaviour framework and focus indicators used for video coding in TTT.

Engagement Framework	Indicator	Indicator Description
Emotional Engagement	Smile	Upward curve of mouth indicating pleasure or amusement
	Laugh	Produces positive sound while smiling (e.g. laugh, giggle)
	Sing [a]	Produces musical sound (e.g. sings, hums, whistles)
	Sadness [a]	Shows evidence of sadness (e.g. crying, sighing)
	Other [a]	Displays other emotional response (e.g. anger, fear)
	Missing[a]	Emotion information missing because face cannot be seen
Verbal Engagement	Participant Speech	Overall use of speech
	Unprompted Speech	Speech not specifically prompted by a question
	Facilitator [b] Prompted	Speech directly in response to a facilitator's question
	Resident Prompted [a]	Speech directly in response to a resident's question
	Visitor Prompted [a]	Speech directly in response to a visitors' question
Visual Engagement	Look at Screen	Looks at the Liquid Galaxy display
	Look at Facilitator [b]	Looks at facilitators or researchers
	Look at Resident	Looks at other residents
	Look at Visitor	Looks at care staff or other visitors
	Look Elsewhere	Off-task looking behaviour (e.g. looking at hands or floor)
	Eyes Closed [a]	Eyes closed for more than a second (blinking not counted)
	Unavailable [a]	Eye information missing because face is not visible
Physical Engagement	Hand Gestures	Hand / arm motions used for interaction (e.g. pointing)
	Nod / Shake Head	Head rotations indicating agreement or disagreement
	Closer to Screen	Decrease distance to stimulus (e.g. approaching, leaning)
Agitation	Restless / Repetitive Motion [a]	Motion unsettled, repetitive and non-purposeful
	Aggression / Frustration [a]	Speaks or acts aggressively towards others

Descriptions are provided for each behaviour.
[a] These indicators were not included in the final analyses because they rarely occurred, were prone to baseline effects and failed to meet normality assumptions for either group of residents.
[b] Other researchers in the room were also defined as facilitators during coding

Engagement Results

There was a main effect of verbal engagement, $F(1, 22) = 93.37$, $p < .001$, partial $\eta^2 = .81$, showing that overall participants engaged in more facilitator prompted (M = 8.15, SD = 1.39) than unprompted speech (M = 4.00, SD = 2.57). Interestingly while the main effect of condition did not reach significance (p = .999), there was a significant two-way interaction between verbal engagement and condition, suggesting that there was a difference between-groups in the size of the gap between facilitator prompted and unprompted speech. To explore this effect further difference scores were first calculated for each resident by subtracting their unprompted speech interval scores from their facilitator prompted speech interval scores. These difference scores were then entered into an independent samples *t*-test. Results revealed that there were significant differences in the size of the gap between facilitator-prompted and unprompted speech between condition, with the high-immersion condition showing a considerably larger difference (M = 5.28, SD = 2.30) in the number of intervals where engaged in facilitator-prompted as opposed to unprompted speech than those in the low-immersion condition (M = 3.20, SD = 2.01), see Figure 3. Simple between-group comparisons for each verbal engagement type reveal that this reduction in the gap for the low-immersion condition can be more readily attributed to a decrease in facilitator prompted speech, $t(22) = -1.94$, $p = .065$, than an increase in unprompted speech, $t(22) = .989$, p = .334

What might we attribute this to? One possibility is that while the high-immersion condition might be more engaging, it may also be more distracting. The facilitator needs to bring resident attention back on task by prompting them, leading to an increase in facilitator prompted speech in this condition.

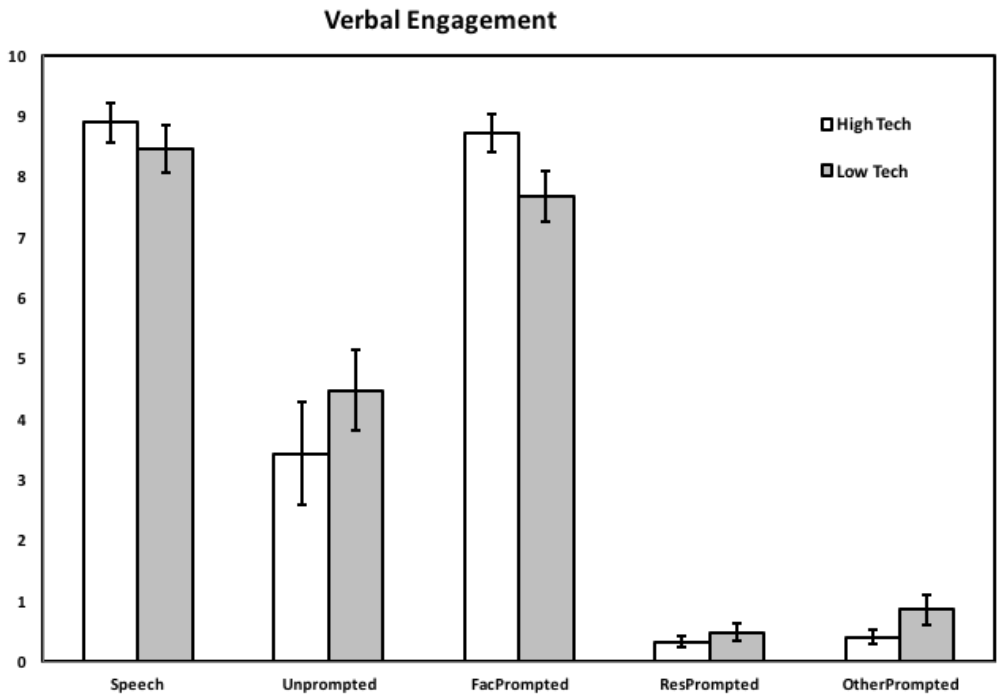

Figure 3. There was significantly more facilitator-prompted verbal engagement in the high-immersion versus low-immersion condition.

There was a main effect of visual engagement, $F(4, 88) = 254.21$, $p < .001$, partial $\eta^2 = .92$, revealing that across conditions participants spent significantly more 30 second intervals looking at the screen ($M = 8.29$, $SD = 1.36$) and facilitator ($M = 8.26$, $SD = 1.06$) than they spent looking at residents ($M = 1.21$, $SD = 1.12$), others ($M = 0.81$, $SD = 0.83$) or elsewhere ($M = 1.50$, $SD = 1.43$) in the room (all *p*s < .001; see Table 1). The main effect of condition approached significance, $F(1, 22) = 3.94$, $p = .06$, partial $\eta^2 = .15$, suggesting that the analysed visual behaviours were more evident in the low-immersion condition than they were in the high-immersion condition. However, the main effects were of limited interest as there was also a two-way interaction (a disordinal one) between visual engagement and condition, $F(4, 88) = 2.75$, $p = .033$, partial $\eta^2 = .11$, suggesting that there were significant between-group differences for one or more of the visual engagement indicators. A series of five independent samples *t*-tests revealed that the low-immersion condition spent significantly more time looking elsewhere in the room than in the high-immersion condition, $t(22) = -2.94$, $p = .008$, suggesting a higher overall level of visual disengagement for the former group (Figure 4). There were no between-group differences in the mean number of intervals looking at the screen, $t(22) = 1.06$, $p = .300$, facilitator, $t(22) = 0.71$, $p = .484$, residents, $t(22) = -1.25$, $p = .226$, or others in the room, $t(22) = -1.00$, $p = .326$.

Table 2. Mean number of 30 second intervals containing each type of visual engagement indicator for the high-immersion and low-immersion conditions (SD in parentheses).

Technology Condition	*Looking at Screen*	*Looking at Facilitator*	*Looking at Residents*	*Looking at Others*	*Looking Elsewhere*	*Eyes Closed*	*Eye Gaze Unavailable*
High-Immersion	8.61 (1.10)	8.42 (0.77)	0.90 (0.70)	0.63 (0.59)	0.69 (0.68)	0.10 (0.24)	0.27 (0.65)
Low-Immersion	8.02 (1.55)	8.11 (1.26)	1.47 (1.35)	0.97 (0.99)	2.18 (1.56)	0.51 (0.95)	0.27 (0.35)

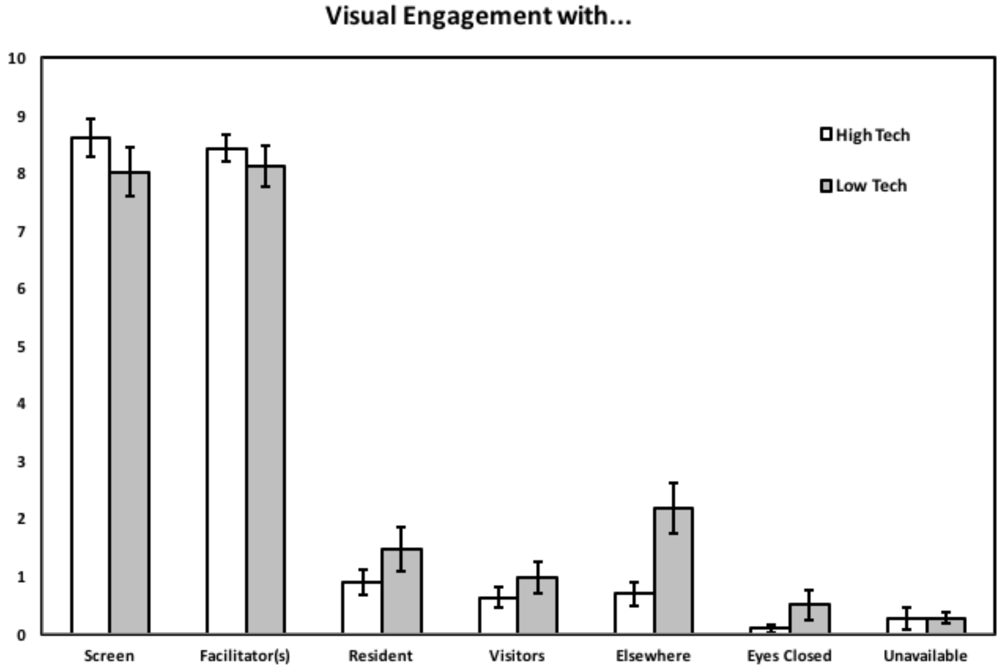

Figure 4. Significantly more looking elsewhere than the screens in the low-immersion versus high-immersion condition suggests less visual engagement in the low immersion RT.

Three other motoric engagement behaviours that were coded for were the use of hand gestures, nodding or shaking of the head and leaning towards, moving (or being moved) closer to the screen. The mean number of thirty second intervals during which each of these behaviours was observed can be seen in Table 3.

Table 3. Mean number of 30 second intervals containing each type of other engagement behaviour for the high-tech and low-tech groups (SD in parentheses).

Technology Condition	*Hand Gestures*	*Shaking / Nodding Head*	*Closer to Screen*
High-immersion	4.12 (2.74)	3.97 (2.66)	2.25 (0.97)
Low-immersion	5.26 (3.36)	3.08 (1.91)	1.36 (1.45)

These Engagement behaviours were entered into a 2 (technology group) x 3 (Other Engagement) mixed ANOVA. Sphericity assumptions were not met for other engagement or the two-way interaction. There was a main effect of other engagement, $F(1.42, 31.22) = 10.30$, $p = .001$, partial $\eta^2 = .32$ (with a Greenhouse-Geisser correction), revealing that across conditions participants spent significantly more 30 second intervals using hand gestures ($M = 4.73$, $SD = 3.08$) and nodding or shaking their heads ($M = 3.49$, $SD = 2.27$) than they spent positioned closer to the screen ($M = 1.77$, $SD = 1.30$; both $ps < .005$). The main effect of condition was not significant, $F(1, 22) = 0.12$, $p = .732$, partial $\eta^2 < .01$, suggesting that collectively these other behaviours occurred in a similar number of intervals in the high- and low-immersion conditions. The two-way interaction between other engagement and condition was also not significant, $F(1.42, 31.22) = 1.67$, $p = .208$, partial $\eta^2 = .07$, suggesting that there was no difference in the pattern of change between-groups for the three other engagement behaviours.

Round 2 – Rationale and Results

Round 2 was conducted to collect further data to increase sample size and strengthen statistical power. It followed a similar protocol to Round 1 but was conducted at a new BaptistCare facility, The Gracewood in Kellyville, Sydney. A number of participants had been relocated from the Yallambi and Waldock Carlingford facility to the new building and 13 of these residents volunteered to participate in another six-week program of TTT. Statistical power was improved by using a repeated measures design with careful counterbalancing of residents who would participate in Round 2 of the study. That is, residents previously in the high-immersive condition were allocated in Round 2 to the less-immersive control condition, and vice versa. Importantly, there was a six month separation between conducting Round 1 and Round 2 of the experiment.

The data summarised here come from a sample of 27 participants with 13 participants completing both Rounds 1 and 2. Descriptive statistics are shown in Table 4.

Table 4. Round 2 descriptive statistics.

Technology Condition	*MMSE*	*Sessions*	*Prior TTT*
High-immersion	14.13(6.24)	4.93 (0.96)	0.53(0.52)
Low-immersion	12.25 (5.38)	4.08(1.08)	0.42 (.52)

Residents in the low-immersion condition in Round 2 attended significantly fewer sessions than those in high immersion condition when they fulfilled the 3 session minimum criteria, $t(25)=2.16$, $p=.041$. There was no significant difference in mean MMSE scores or ratio of residents with Prior TTT experience.

A 2x2 within groups ANOVA including round (first round of TTT vs second round of TTT) and time (pre-test vs post-intervention) was carried out to assess the overall effectiveness of TTT in reducing total NPI-NH scores focusing on the 13 residents who completed two rounds of TTT. We were particularly interested in whether participating in TTT over a longer time period lead to an overall greater reduction in the frequency and severity of neuropsychiatric symptomology as it is assessed by the NPI-NH.

There was a main effect of NPI round, $F(1, 12) = 10.18$, $p=.008$, partial $\eta^2 = 46$, suggesting that overall total NPI-NH scores were lower during the second round of TTT ($M = 17.23$, $SD = 11.83$) than they were during the first round ($M = 24.27$, $SD = 13.76$). There was also a main effect of NPI time, $F(1, 12) = 8.57$, $p = .013$, partial $\eta^2 = 42$, suggesting that across rounds total NPI-NH scores were higher at baseline ($M = 24.54$, $SD = 15.72$) than they were post-intervention ($M = 16.96$, $SD = 9.70$). Most importantly, the interaction between NPI Round and NPI time was also significant, $F(1, 12) = 7.84$, $p = .016$, partial $\eta^2 = 40$, suggesting that the reduction in total NPI-NH scores was larger during one of the rounds. To investigate this interaction two paired samples t-test were carried out comparing pre- and post-intervention total NPI scores between Round 1 and Round 2 of TTT. While NPI scores did not change significantly for these participants during Round 1 of TTT, $t(12) = 0.52$, $p = .615$, there was a significant reduction in total NPI during Round 2, $t(12) = 3.81$, $p = .003$. Together these results suggest that TTT is most effective in reducing the frequency and severity of the problematic behaviours assessed by the NPI-NH when it is repeated at a later period of time. The ordinal nature of the relationship between round and time can be seen in Figure 5. To assess whether a reduction in total NPI was also observed for residents who only participated in the second round of testing a paired samples *t*-test was also carried out comparing pre- and post-intervention NPI scores for this group. A reduction in total NPI scores was not found, $t(12) = 1.55$, $p = .147$, further supporting the conclusion that the repetition of TTT is associated with reducing the problematic behaviours targeted by this inventory. There was no main effect of condition on the NPI in the repeated measures analysis.

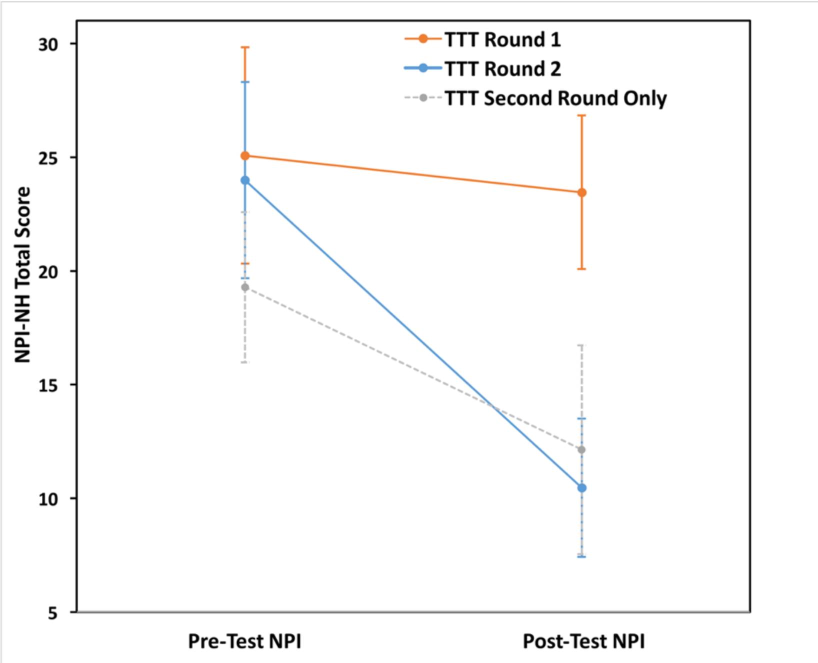

Figure 5. Round 2 mean NPI pre- and post-test scores.

A 2x2 within groups ANOVA including round (first round of TTT vs second round of TTT) and time (pre-test vs post-intervention) was carried out to assess the overall impact of TTT on total Quality of Life (QoL) scores focusing on the 13 residents who completed two rounds of TTT. There was a main effect of QoL round, $F(1, 12) = 41.07$, $p < .001$, partial $\eta^2 = .77$, suggesting that the quality of life experienced by residents was lower during the second round of TTT ($M = 26.39$, $SD = 3.90$) than it was during the first round ($M = 30.92$, $SD = 3.89$). The main effect of QoL time, $F(1, 12) = 1.03$, $p = .331$, partial $\eta^2 = .08$, and the interaction between QoL Round and QoL time, $F(1, 12) = 4.27$, $p = .061$, partial $\eta^2 = .26$, were not significant.

A 2 x 2 x (2) mixed ANOVA including two between-groups variables [Condition (High-immersion vs Low-immersion) and Prior TTT experience (Yes vs No)] and one within-groups variable [QoL testing time (baseline vs post-intervention)] was carried out using the Total Quality of Life scores from Round 2. Contrary to the null findings found for Quality of Life in Round 1, there was a main effect of QoL time, $F(1, 22) = 17.55$, $p < .001$, partial $\eta^2 = .44$, showing an overall reduction in quality of life scores between the onset ($M = 29.04$, $SD = 3.55$) and completion ($M = 26.23$, $SD = 4.98$) of the second round of TTT, a main effect of condition, $F(1, 22) = 10.91$, $p = .003$, partial $\eta^2 = .33$, suggesting overall higher quality of life for residents in the high-immersion ($M = 29.29$, $SD = 2.91$) compared to those in the low-immersion condition ($M = 25.71$, $SD = 3.84$) and a main effect of Prior TTT, $F(1, 22) = 6.49$, $p = .018$, partial $\eta^2 = .23$, suggesting overall lower quality of life scores for residents with prior TTT experience ($M = 26.38$, $SD = 3.90$) compared to those who were participating in TTT for the first time ($M = 28.88$, $SD = 3.32$). Most importantly the interaction between QoL time and condition reached significance, $F(1, 22) = 14.18$, $p = .001$, partial $\eta^2 = .39$, suggesting there was a difference in the extent to which quality of life scores were reduced for residents in the high- and low-immersion conditions during the second round of TTT. To investigate this interaction further, paired samples *t*-tests were carried out separately for the high- and low-immersion conditions comparing total quality of life at baseline and post-intervention. While the low-immersion condition showed a significant decline in total quality of life scores, $t(11) = 5.29$, $p < .001$, the high-immersion condition did not, $t(11) = 0.50$, $p = .625$, Figure 6.

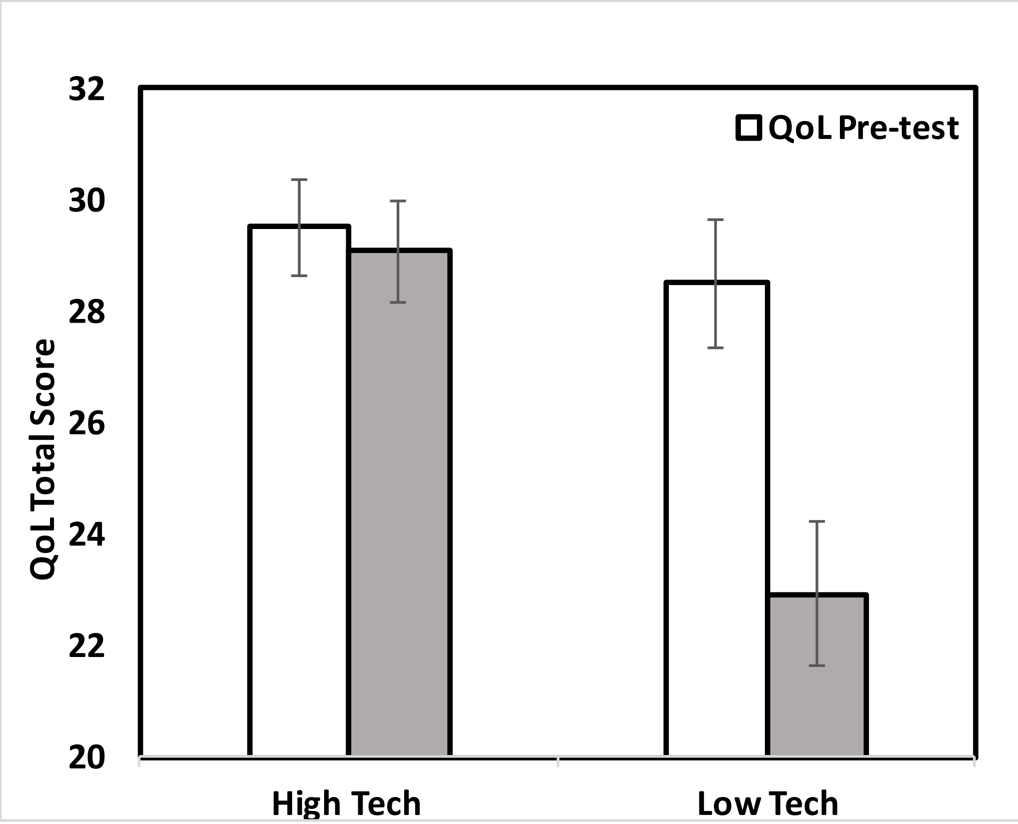

Figure 6. Round 2 mean QoL scores.

Conclusions

Reminiscence therapy using Google Liquid technology was demonstrated to be feasible in a residential aged care facility. The majority of residents consented, completed between 3 to 6 of the scheduled 6 weekly sessions. During the study, the non-technical aspects of the sessions were facilitated by a registered nurse with experience in dementia who was part of the research team. However, lifestyle or other activity personal experienced in reminiscence therapy and working with people with dementia would also be suitable facilitators of the group. In current format, a technical person or person trained with the software was required to navigate the system. Future installations, drawing on more conventional methods of navigation such as a tablet would enable existing nursing or lifestyle staff to facilitate both from a technical and therapeutic aspect.

In the present experiment as the research team were not familiar with the residents and their families there was a time intensive set up period where life histories were sought and residents and families interviewed for suitable landmarks. Other RT sessions use generic objects and do not tailor the sessions to the individual. While the technology can be generic as it was in the first week (Sydney landmarks), a richer RT experience is possible by tailoring the sessions to the individual. The technology because it enables specific landmarks (actual house the person was in born in etc) quickly engages the participant.

Results from both the high and low immersion conditions in Round 1 of the experiment did not show a statistically significant increase in quality of life using the QoL-AD measure. In Round 2, with greater statistical power (repeated measures and counterbalanced conditions), the high-immersion condition maintained QoL from pre- to post-intervention whereas mean QoL decreased significantly in the low-immersion condition from pre- to post. While power was greater, the decrease may be associated with i) lower NPI at baseline in the low immersion group relative to the high immersion condition; and ii) the low-immersion group attending fewer TTT sessions. Round 2 was conducted 6 months after Round 1 and many of the return participants in Round 2 showed some deterioration possibly associated with the relocation of the facility and/or progression of the disease.

In Round 1 of the experiment, there was a significant decrease for the high-immersion condition on the NPI, particularly with regard to irritability. In Round 2, a significant decrease from pre- to post-intervention on the NPI-NH was observed, regardless of condition. However, this was evident only in data recorded from residents who had participated in both rounds of TTT, i.e., two sessions of the 6 week program. This is notable for two reasons. First, the effect does not appear to dissipate over time and second may even suggest opportunity for longer program benefits.

Qualitative comments gathered from staff and family midway through Round 1 provide some insight into the experiences of participants. From the research team's perspective, the participants entered the designated room each week with anticipation. The sessions were fun and engaging, even those residents with limited verbal ability appeared to understand the excitement and fun of using the LG technology to go to places not visited for many years or for some participants places only ever on a postcard or a pin on a map. Participants able to verbally engage had opportunities for friendships and banter that developed between the team and the participants.

The engagement of participants in both conditions was also evident in results of the video analysis. Greater visual engagement with the screen and the facilitators rather than between participants may be related to the level of cognitive ability or other sensory deficits (hearing/vision) that inhibits group dynamics. The immersive and novelty of the large screen set up may also have contributed to this type of interaction. RT conducted in a small group where participants may be sharing objectives or viewing photographs in closer proximity may facilitate participant to participant engagement. While not specifically quantified in the analysis, where participant to participant interaction did occur the groups were lively, fun and participants did not want the sessions to come to a close. Overall, the sense of agency that the person had being engaged with the technology (high- and low-immersion), locations and their memory of significant life events in conjunction with the engagement with the research team and others in the group created a social and stimulating experience. Generic as well as specific landmarks generated interest and opportunity for engagement.

Participation for some as evidenced by the feedback from staff and family, provided opportunity to open conversations about significant events. For others, there was a sense of anticipation each week, something in the schedule to look forward to. There was potentially a reduction in some participants' social isolation by meeting regularly with research team and connecting to the broader outside world both through technology but also the relationships formed.

The experiment was designed to be delivered over a period of six weeks, to build rapport with the research team and participants, between residents for those who did not have existing relationships and acclimatise participants to the technology. The research team arbitrarily set the minimum exposure for analysis as three of the six week planned intervention. The research team, felt that the six week program was adequate and that while this could be repeated a structured format which included themed weeks over this time was in keeping with RT techniques. Due to the immersive nature of the technology and the range of associative memories of differing valence, a single session and dose is not currently recommended. Interestingly, a longer time-course of sessions, i.e., Rounds 1 and 2, appears to maintain interest and produce positive results. It is noteworthy that the two rounds were not continuous but separated by six months.

RT is designed to evoke memories. In any RT it is important for facilitators to be sensitive to past life experiences where negative or painful experiences may be triggered. This is particularly relevant for people who have experienced known trauma such as refugees, those exposed to war or abuse. Knowledge of this may be limited for some participants. Protocols for debriefing and counselling should be available.

The current study indicates that the use of Liquid Galaxy technology is feasible but should be further investigated prior to routinely being adopted by aged care services. At present, ideal group size appears to be 3 participants. This ensures that sessions are not onerously long and that each participant has enough individualised content to remain engaged. Larger groups, where cognitive or sensory deficits are minimal may be possible. Care would need to be taken to ensure the groups were well matched with regard to life history and prior introductory activities to encourage group dynamics may facilitate greater participant to participant engagement. The use of goggles, which are based on an individual immersion may be a viable option. Feasibility of use of goggles for virtual reality is currently being explored elsewhere.

Recommendations

While Liquid Galaxy technology in high or low immersion has been demonstrated to be feasible to use for people with severe, moderate and mild dementia a number of issues limit widespread implementation at present. These include:

1. Current need for technical support for the multiscreen installation and navigation;
2. Understanding the mechanism for engagement through space and time using technology; and
3. Exploration of the addition of sound (street scapes/scenes, genre, era or emotive).

Liquid Galaxy technology has not been previously used for people with dementia or in aged care services. While the current project was exploratory and labour intensive for research staff, technological modifications identified as part of the study would reduce the need for research and technical support. These include: 1) training of lifestyle coordinators in an adapted technological interface (tablets); and 2) use of existing large screens in facilities alleviating installation and programmed synchronisation of multiscreen setup. Both these options should be investigated for feasibility and efficacy.

Budget

DCRC Funding for project	
Salaries RA-1 – Computer Science (HEW 5/4) $50.38 ph + 16.5% on-costs x 314 hours RA-2 – Health Psych/Nursing (HEW 5/4) $50.38 ph + 16.5% on-costs x 361 hours	 $18,429 $21,188
Other Google Liquid Galaxy system (50% cost) Hand-held tablet control Van rental for equipment transport Consumables incl. equipment adjustment RA-1,2 travel to site (14 weeks, 4 days per week) Gift vouchers for participation, $30 ea x 70	 $5,000 $500 $500 $250 $2,000 $2,100
Total DCRC Funding Requested	**$49,917**
Non-DCRC Funding for project	
Salaries (itemised)	
Other (itemised) Google Liquid Galaxy system (50% cost from School of Computing, Engineering & Mathematics (SCEM), WSU) Laptop for RA2 – MARCS Institute School/Institute Overhead Contribution (15%) WSU Commercial Development Fund Contribution (REDI) (5%)	 $5,000 $2,500 $7,488 $2,496
Total non-DCRC Funding	**$17,484**

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Video Overview

3 mins: https://www.youtube.com/watch?v=GjXz0sHdUf4

1 min: https://www.youtube.com/watch?v=YK8NF4-vgaI