

# Reality Recalled: Elders, Memory and VR

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**Abstract—** *Reality Recalled* explores memory, embodiment, and social interactions of elders and others with digital media experiences and VR. We advocate for a holistic view of the term ‘virtual’ in its conceptual categorization within technology, and make a case for enlarging the audiences and extending the benefits of virtualized realities. In our methods, we argue that design and research decisions should be predicated on inclusivity, usability and the pursuit of pleasurable collaborative meaning making. When human interaction takes place in ‘real’ and virtualized space, the mind is the ultimate virtual playground and memory acts as its controller. Through our research designs and testing with digital media projects, VR, and our current and prospective prototypes, we demonstrate the generation of new conceptual lenses, technological forms and experiences that may enrich the lives of elders, with potential benefits for other communities of participants.

**Keywords—** *affect, Alzheimer’s, dementia, elders, gesture, memory, mobile technology, Virtual Reality.*

## I. VIRTUAL REALITY AND INCLUSIVITY

Virtual Reality is a compelling technology that provides a uniquely immersive, visual and audible experience. While the iconic VR systems, such as head-mounted displays that offer immersive 3D experiences are not new, they are gaining in popular usage due to the support of technology titans Google, Facebook’s Oculus, HTC Vive, Samsung, Sony Interactive Entertainment, and STARVR, all members of the recently formulated and pervasive Global Virtual Reality Association (or GVRA).

These industry leaders in technology, gaming and digital entertainment are targeting predominantly young male audiences, who are interested in Virtual and Augmented Realities and their potential for gaming. However, according to the Entertainment Software Association (ESA) 2015 *Report on Sales, Demographics and Usage Data* [1] the average American game player is 35 years old, with a demographic audience of 56% male players and 44% female players, and an older audience of female players who are on average aged 43. [1]

Bypassing these audiences of women, middle aged people, and the elderly represents an opportunity not taken, and prevents these populations from realizing the hidden potentials of this new

technology, while denying the benefits it may bring to a wider audience. It also overlooks a number of important and potentially beneficial avenues for diversifying technological development and age and gender-related content development. This is more than a marketing or profitability issue, it is a fundamental issue of inclusivity.

VR/AR applications, especially those employing the standard head-mounted displays, present physical barriers and social implications. From the size of one’s head to whether or not one wears glasses, to general mobility issues and tolerance of VR’s nausea inducing capabilities, the uniqueness of people’s bodies and physical abilities varies as much as do their responses to technological inputs and encumbrances.

From a social context, inclusion within the variety of content available for diverse audiences is a challenge that must be met by wider adoption of the technology and the form by diverse creators and producers. VR/AR applications in its current, market form is also a relatively solitary, non-inclusive experience. These rather limiting and exclusionary parameters have so far defined much of the form and content of the medium, although not all, as we shall attempt to illustrate.

These two factors—the physical and the social—are important for all users, but critical to elders, who are more likely to face physical challenges and social isolation after retirement. With an aging population, there is an increasing need for facilities, activities, and technologies that support and enrich the experiences of seniors. Digital media applications and VR and other digital experiences that foster mental acuity, cognition, and physical and emotional health are in increasing demand, and of interest and potential benefit to all members of society.

## II. NEW TECHNOLOGIES, POTENTIAL HEALTH BENEFITS

Dementia is a neurodegenerative disease that results in impaired memory, cognition, resulting in negative behaviours world-views and outcomes for patients and their carers and family members. Forty-seven million people in the world live with dementia (World Alzheimer Report, 2016) [2] of which 60%–80% are cases of Alzheimer’s Disease (AD). AD is

influenced by both genetic and environmental factors. Aging is the strongest known risk factor known for AD. The symptoms for the disease gradually increase over a number of years. AD has no cure however some treatments are available for its symptoms, and there are many activities that can promote new learning and self-actualisation in patients with memory loss.

Studies have shown possible physical health benefits for the elderly using digital technologies. Contrary to the stereotype that elders have difficulty using digital technologies, Lim et al. found older adults can use technologies such as tablet computers and smartphones effectively [3] In addition, Hsu et al. have shown that specific exposure to earlier-year (historical) media and virtual events which either replicate or imitate media from a patient's earlier life experiences, can enhance recall and may also have rejuvenating health effects. [4]

The role of VR for the elderly's memory, cognition, and affect remains less studied. Miller et al. report that "fourteen studies investigating the effects of VR/gaming system use by healthy older adults and people with neurological conditions on activity limitations, body functions and physical impairments and cognitive and emotional well-being met the selection criteria. Study quality ratings were low and, therefore, evidence was not strong enough to conclude that interventions were effective." [5] In addition, "existing evidence to support the feasibility and effectiveness VR/gaming systems use by older adults at home to enable physical activity to address impairments, activity limitations and participation is weak". [5]

This is discouraging, but it is open to review and re-evaluation, particularly if we take the position that memory activates a metaphorical virtual reality which is open to all users, with the benefit of not requiring clumsy and cumbersome and socially isolating VR headset equipment.

Our hypothesis, working with members of this cohort that are in the very early stages of the onset of Alzheimer's-like memory loss and other forms of memory loss, is that calling upon memory, recall and conversation about pleasant family events can provide enriching and positive conversations and activities.

The technological and conversational aspects of these activities may have positive effects on memory scaffolding and more generally, on elder's feelings of ability, while mastering new skills, and hence, self-affirmation. In addition, the technologies we have developed with the *Postcard Memories* application may positively trigger memories of shared family events, with benefits for communication with carers and family members who may also participate in these interactions.

With the *CBC Newsworld Holodeck* we have created a large multi-screen application (involving 12-24 screens) which

gives participants access to an enormous corpus of date specific news media from the CBC, Canada's national broadcaster. This project is multidisciplinary in nature, involving interaction design, mobile technologies, natural language processing, video search, big data visualization, quantified self-actualisation, gerontology, and psychology.

The project employs multiple prior developments including the "Postcard Memories" application developed by Ladly et al. [6]; the CBC Newsworld Project co-developed by Ladly and Penn [7]; Penn's research in natural language processing at the University of Toronto; and Rudzicz's research in speech-language pathology, and rehabilitation at SPOClab (TRI) [8]. The digitized collection of 24-hour *CBC Newsworld* videos spans 25-years (1989-2014) and resides in Penn's U of T lab where it has been digitized and segmented for browsing, information seeking and sharing and review for numerous applications, including incorporation into the *CBC Newsworld Holodeck* project.

Our research is posited on the assumption that researchers can better understand and actualize the benefits of AR/VR technologies, collaborative digital artifact creation and new media review, by studying its positive effects on memory. By studying and working with elder patients (some with memory loss of the Alzheimer's type), using Virtual Reality and/or Augmented Reality and other digital technologies and applications, we may open up new audiences and new possibilities for their use.

For this reason, we advocate that these technologies must become more available and more accessible to researchers in this realm, and to senior populations at large, their carers, and caring institutions.

### III. TOWARDS INCLUSIVE VIRTUAL CATEGORIZATIONS

Head Mounted Displays in Context:

In this paper, we contextualize our research in the virtual realm and advocate for a holistic view of the term 'virtual' in its conceptual categorization within technology, with the goals of inclusivity and interdisciplinary collaboration. Our researchers suggest that there is important overlap when employing interrelated technologies in a variety of ways, each contributing unique and valuable insights to various facets of participant experience. In this section, our research is positioned in relation to head mounted displays (HMDs) and controllers, especially regarding accessibility related challenges and the potential for shared and collaborative interactive experiences.

Over the past six months our research assistants have been actively pursuing interface and virtual object designs using conventional VR HMD technology. Assembling a high-end workstation with an Oculus Rift with dual sensors and touch controllers, utilizing the *Unreal Engine* software, we have

undertaken a broad scan of VR HMD development as well as current commercial offerings across various content platforms. The following are some relevant takeaways emerging from these initial forays.

Over the past two years, both *Unreal* and *Unity* developers have released dedicated VR editors within their engines [9], [10]. These editors allow the manipulation of objects (x/y/z coordinates, scale, rotation etc.) inside the headset, making VR development more intuitive than it has been in the past. Despite these remarkable advancements however, there are still steep learning curves involved, requiring developers to be relatively competent in programming with one of these game engines.

In addition to these highly complex established game engines, there are more accessible browser based tools that simulate the virtual point of view on a standard flat monitor. (*Vizor* has developed the *Patches* tool [11], featuring an interface simple enough for even a novice to begin creating content.) Despite these powerful tools, it can be difficult to navigate compatibility of the content creation and delivery platforms and these tools, while development remains relatively inaccessible to those with limited 3D development skills.

A number of networked applications enable multiple users to connect in virtual space. These application range from sculpting in VR (*Oculus Medium*) [12], to the ‘Second Life-like’ *Alt Space* [13] and to multi-person team sporting activities like the zero-gravity space frisbee game *Echo Arena* [14]. These experiences, while novel and intriguing are also lacking in important ways. Participation is limited as only those who have access to the equipment can participate, and elders and others who do not fit the medium’s demographic are unlikely to be equipped with premium VR equipment.

Most importantly, there is a level of anonymity in virtual gaming afforded by avatars and chosen user names—meaning it is quite common to come into contact with strangers who act in inappropriate ways in virtual gaming arenas. Our research assistant’s experiences in *Echo Arena*, for example, have included sexual gestures and language on the part of strangers that in ‘real life’ would clearly qualify as sexual harassment. It is well known that online video games can be the source of racist, homophobic and sexist language, but in an immersive environment that simulates physical presence, these types of behaviors can be all the more intimidating [15].

Other practical considerations are the time it takes to learn new tools and their complexity. The *Oculus* touch controllers for example, feature gesture tracking, a small joystick, and a half dozen buttons operated with the thumb, middle and index fingers, with these buttons generally having different functions on both the right and left hand units. This complexity and the need for fine manual dexterity may be especially relevant to research involving VR and elders, especially those suffering

neurodegenerative diseases like Alzheimer’s and Parkinson’s Disease [17].

Unless and until these challenges and disparities of audience interaction and opportunity are resolved, with methods like ‘sensitive user design’ and mass adoption of HMD technologies that lower costs and barriers to entry, our researchers will continue to work in simulated virtual environments, using screen-based interactions with conventional displays employing installation, mobile and tablet technologies.

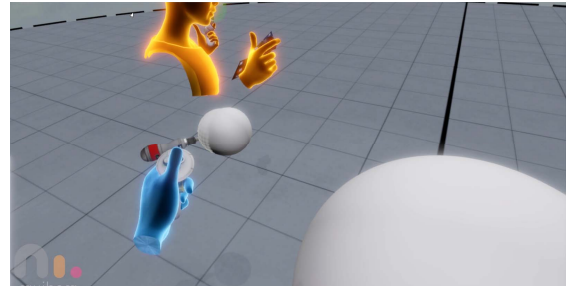


Figure 1: A screen capture of our researcher using the *Oculus Medium* VR application for sculpting and building virtual environments in real time. [12]

### III. RATIONALE AND RESEARCH QUESTIONS

With an aging population, there is an increasing need for facilities, activities and technologies that support and enrich the experiences of seniors. Environments that foster mental acuity, cognition, and physical health are in increasing demand. In multiple studies, it has been established that environmental cues that signal age priming result in increased (or decreased) capacities in respondents and can be used to prime improved health and capacity [4].

Specific exposures to new media as well as earlier-year (historical) media can have rejuvenating health effects with outcomes discernable via interview and psychometric assessment. [4] Given the potential benefits of digital technologies for seniors, including enhancing their peer and family relationships, we seek a deeper understanding of the health, cognitive and social benefits of exposure to digital media, Virtual Reality and Augmented Reality media data, especially if this is related in some way to tangible, real-world experiences and artifacts.

We can better understand and actualize the benefits of collaborative digital/physical artifact creation and review, as well as the benefits of forms of augmented and virtual realities, by emphasizing geriatric patients (some with memory loss of the Alzheimer’s type), and creating applications that are accessible to the geriatric population at large.

In the Visual Analytics Lab at OCAD University in Toronto, and in collaboration with research partners at the

University of Toronto (U of T) and the Toronto Rehabilitation Institute (TRI), we have been exploring the possibility of improving memory, cognition, and meaningful human interaction for the elderly, their carers and family members, through the development and user testing of innovative digital media applications.

Our research questions explore:

- 1) How might a multimodal, personalized digital media application with embodied, social interaction create a virtual reality to enhance social connection and improve memory recall?
- 2) How can we build user interfaces that optimally support seniors' comprehension, use, browsing, and interaction?
- 3) How can effective 2D-3D aesthetic visualizations be created to give non-expert users a sense of a personal relationship with the data?
- 4) Can such new media and VR/AR applications assist elders by enhancing memory, affect, and other cognitive abilities? Can we produce feelings of pleasure and delight in our elder audiences?

To date, our experimental digital media applications have used various modalities of interaction and types of multimedia content to explore the potential of digital mediation of memory, sociality, and embodiment to create a sense of recalled and virtualized realities.

In this paper, we present our lab's research with two digital media applications and their resulting analyses, which address our research questions and explore the intersections of memory, aging, sociality, and virtualized realities. We begin by discussing (A) *Postcard Memories*, a networked, tablet application that facilitates creative, interactive sharing of family memories. We then examine (B) the *CBC Newsworld Holodeck*, a gesture-based, immersive simulated Virtual Reality experience using a large digital audio-video dual-wall, multi-screen installation.

Through our user studies and participant observations, we have found that an internalized virtual reality is created in users, and this has cognitive and affective benefits, particularly in elders with memory loss. The analysis of the results from a user study with the *Postcard Memories* application suggests that our application improved connection between family members, friends, and caregivers by 1 point on a 5-point Likert scale. Elder participants agreed that the applications helped them to recall personal stories, which also enabled them to communicate more openly with carers and family members. Participant observation studies of the *CBC Newsworld Holodeck* installation have similarly found an improvement in users' social interactivity and memory recall.

Participants have also reported feelings of increased self-actualisation, while others have displayed increased conversational opportunities and interest, all the while

engaging with their partner/carers in interactive activities of playfulness, memory, recall, and delight.

#### IV. METHODOLOGIES

Since both of the project's inceptions we have applied 'iterative design' methods to interface design and to programming images and text with audio and video in innovative ways. In the *Postcard Memories* application (A), we have worked with participant's personal images as well as audio and video from the *CBC Newsworld* corpus. We have also worked with date-specific news video footage and video transcripts in order to design a touch-screen experience and an interactive gesture-based immersive installation. These processes allow use of participant's personal data in the form of images and video, and video from the *CBC Newsworld* corpus in innovative ways.

We have also studied the benefits of incorporating the news video corpus into the *Postcard Memories* application and its efficacy in the context of healthfully changing aging cues, with improved cognitive and socialization effects for elders, using the 'user-sensitive inclusive design' methodology.

##### A) *Postcard Memories*

*Postcard Memories* is a touch screen tablet application designed and developed in the Visual Analytics Lab, for people with mild memory loss, and those who are diagnosed with Early Stage Dementia (ESD), their carers and family members. This research aims to create a social space for elders to interact with their friends, family members, and caregivers.

The tablet application enables users to create and send digital postcards that combine their personal photographs and short texts, with selected audio and video (Figure 2). The application was built using HTML5, CSS and JavaScript. PHP enabled interaction between the user-end application and backend MySQL database.

Researchers implemented a user-centered design and iterative learning approach in this research project. The social communication architectural design of the *Postcard Memories* application enables participants to create and send postcards from one user (initiator) to many users (group members).

Visual Analytics Lab Researchers conducted two separate user studies with participants recruited at OCAD University and the Toronto Rehabilitation Institute. The application was preloaded with personal photos supplied by the participants prior to the testing session. Three researchers and the principal investigator of the project were responsible for recording, observation, providing technical support, and guiding the participants throughout the session.

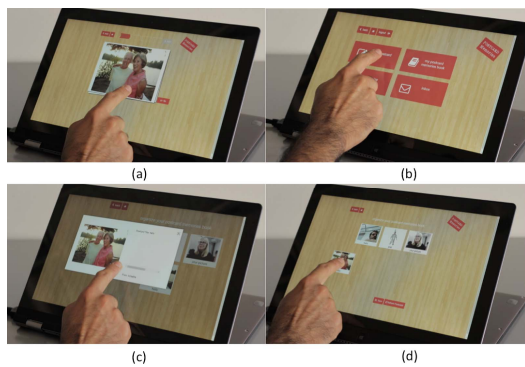


Figure 2: *Postcard Memories* tablet application. (a) Creating and sending a postcard. (b) Main menu screen view. (c) View send/receive postcard screen view. (d) Organize postcards screen view.

Participant out-patients at TRI and their carers/family members were guided and observed in using the application, while their interactions with the application and with each other were video recorded. Participants were then interviewed, and given a pre- and post-testing self-administered de-briefing questionnaire.

We applied the ‘think aloud’ testing method during the user test sessions, in which we asked participants to describe their experience and understanding of the steps and activities in which they were participating, inviting verbal observations and feedback at all stages. Participants were asked to describe their interactions, outcomes, and difficulties with the application.

Numerous spontaneous interactions and personal narratives emerged during the testing sessions, which were of about one hour in length. The semi-structured interviews were undertaken, and then transcribed and coded.

Throughout, we were mindful of our research questions regarding multimodal, personalized digital media applications and embodied social interactions, and how we might create a virtual reality to enhance social connection and improve memory recall. We were also keen to understand if we had designed our user interfaces to optimally support seniors’ comprehension, use, browsing, and interaction.

### B) *CBC Newsworld Holodeck*

In this research project, we developed an interface for visualization and sonification of large portions of the *CBC Newsworld* corpus. This enormous, noisy corpus is a collection of digitized 24-hour newscast videos covering the last 24 years of *Newsworld* output.

Our primary research goal was to answer our research question on how effective 2D-3D aesthetic and/or numeric visualizations can be created to give non-expert users a sense of a personal relationship with the data. A secondary goal was to enable spoken phrase and keyword browsing, information

seeking, search and display and segment review within this corpus. In addition to providing a platform to perform exploratory research and develop and test new visualization / video retrieval technologies, this project was an initiative to preserve the cultural news heritage of Canada.

We designed and developed two application versions; 1) employing an immersive, gestural modality and 2) employing a tablet touch screen interface. Both versions simultaneously showcase twelve different newscasts broadcasted by *CBC Newsworld* on January 1, 1993 (see Figures 3 and 4). The application design allows participants to navigate with a gestural or touchscreen interface through the videos showcased, to select one video at a time that they wish to view partially or in its entirety. This is followed by interactive browsing through the timeline of the video by selecting pertinent keywords that appear on the screen.



Figure 3: *CBC Newsworld Holodeck*—gestural dual-wall interface installation version.

#### 1) *Gestural interface*

The two-screen, gestural interaction version was developed with our industry partner *GestureTek*, through their video tracking technologies, using the *GestureTek Video Gesture Analysis and Control* software, which helped us to create the potential for human interaction with our massive video data corpus. Microsoft’s motion sensing input device *Kinect* performs hand-tracking (Figure 3) using the *GestureTek* interaction software. The application is able to recognize up, down, top, hand motions that enable users to navigate the screen. A swipe movement allows users to go back to the main screen, while the selection of an individual video or keyword can be done by hovering one’s hand over the element on the screen. We built the backend to house and run the multiple video screen feeds using the open source IDE computer tool *Code Blocks*.

#### 2) *Touch screen interface*

The touch screen version of the application was developed as web-application using HTML5, CSS, and JavaScript. This version is able to recognize tap for an audio selection on the main screen and keyword selection on the video player screen,

double tap for video selection on the main screen and a conventional swipe action to go back to the main screen (Figure 4).

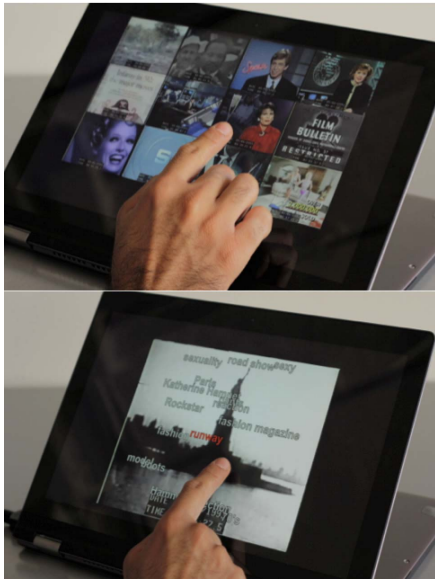


Figure 4: CBC Newsworld Holodeck touch screen tablet version. Top image: main screen view. Bottom image: video player screen view.

We have showcased our *CBC Newsworld Holodeck* as a gestural dual-wall installation, at various research and cultural events, including at the International Symposium of Electronic Art, at Zayed University, in Dubai, United Arab Emirates (2014) and at Toronto’s massive all night open air Interactive Art event, *Nuit Blanche* (2015). These events enabled us to demonstrate, observe participant interactions, and record feedback from an audience of over 2000 people. We then analysed the interactions of our users, who included artists, audio/visual editors, academics researchers, business entrepreneurs, and the general public of all ages, including our target audience of seniors and their family members.

## V. FINDINGS

### 1) *Postcard Memories Methods and Analysis*

The combined analysis from two studies based on the transcribed interviews, researcher observations, and self-administered questionnaires, revealed that the *Postcard Memories* application improved connection between family members, friends, and caregivers by 1 point on a 5 point Likert scale.

In the first stage of testing, the research team worked with a control group of elders and their partners who had not experienced significant memory loss of any type. In the second and third rounds of testing, the research team worked with a target group of volunteer participants who were outpatients at TRI, and who had been diagnosed with early

stages of the onset of Alzheimer’s-like memory loss. These patients were accompanied by their carers and partners, also members of the target audience.

The average age of 9 participants from the first phase of study was 32 (standard deviation=16; average age excluding outlier age of 69 was 26 with standard deviation of 6). The second phase of analysis was performed with 4 participants in pairs of two with one participant diagnosed with early stage dementia (ESD) while the other represented friend/family member/caregiver (equal contributor in the analysis). The average age of participants in second phase was 70.25 (standard deviation= 3.3) (see Figure 5).

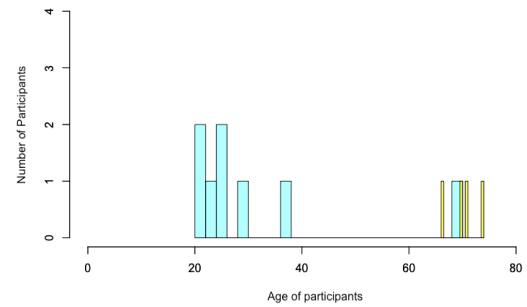


Figure 5: Distribution of age of participants from two phases of testing sessions. (Blue bars: First session; Yellow bars: Second Session).

The participants in both the control group and second and third target groups agreed that the application helped them to recall stories and family events, which also enabled them to share these memories with their carers and partner family members. In all groups, the *Postcard Memories* application and its interactions also seemed to enable opportunities for open communication, discussion, and sharing of related memories and events.

Based on the self-administered questionnaire, we concluded that adding media (audio/video) was most enjoyed by younger participants. However, elders (from phase 2 of the study) enjoyed viewing digital postcards more than creating or sending a new postcard (Figure 6). The observations from the interview and testing session supports the above statements. The ability to send videos/audio clips as attachments was described as “fascinating” by younger participants. Viewing the digital postcards triggered storytelling and memory sharing among the elderly testing audience, both amongst each other and with the researchers, which was considered by the participants to be an intensely “meaningful” activity.

In addition, the self-administered questionnaire revealed that the elderly participants (in phase 2) strongly suggested that the application helped them to recall stories (0.88 on 5-point Likert scale) as compared to younger participants (in phase 1) (2.75 on 5-point Likert scale). Also, the elderly participants “felt more like dancing or singing when they heard a song or watched a video” (1.13 on 5-point Likert scale) as compared to the younger participants (3.13 on 5-

point Likert scale). We had elderly participants dancing and singing in our lab! As the goal of imparting an experience of ‘delight’ was one of our research questions, the researchers in the Visual Analytics Lab found this to be a highly significant and delightful result!

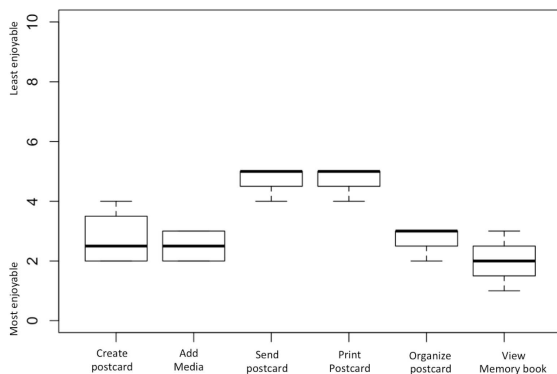


Figure 6: Ranking of application features based on questionnaire results.

Within the media sections, personal photographs (pre-loaded into the application) were voted most enjoyable to attach to the digital postcard. The next enjoyable feature was the ability to attach live pictures taken in the lab via the application. This was followed by attaching video and audio (popular music), which were equally weighted as activities.

In phase 2 study, the participants with ESD found using the application more challenging than their partner participants of a similar age. We observed that typing text on the touchpad was challenging for the elder participants with memory loss, which perhaps can be resolved with speech to text translating software being incorporated into the program.

Positive qualitative results allowed us to answer our 4<sup>th</sup> research question regarding the ways that new media and VR/AR applications could assist elders by enhancing memory, affect, and other cognitive abilities. We had wondered if we could produce feelings of pleasure and delight in our elder audiences. The overall experience was considered to be enjoyable and delightful by our elder audiences in all three studies, another unexpected win for our research goals!

## 2) CBC Newsworld Holodeck

Our primary research question was borne out by our qualitative participant observations of a very large (2000+) number of users, answering our questions about whether effective 2D-3D aesthetic visualizations could be created to give non-expert users a sense of a relationship with the data. Based on the analysis of participant observations made during testing sessions and large public installations of our *CBC Newsworld Holodeck* we concluded that the overall experience was personally enjoyable and informative, not only for participants engaged in direct interaction with the installation,

but also for audience members watching participants interacting with the installation.

The power of the concept of using gestural hand movements made the video interaction experience more interactive and engaging. Some participants reported a ‘Matrix-like’ impression, after the 1999 science fiction film of the same name, directed by the Wachowskis and starring Keanu Reeves as a computer hacker who interacts with gesture-driven banks of 3-D and hologram-like data.

The gestural movements of selection and navigation between videos and keywords was found to be relatively easy to understand and execute, with audience members just needing a brief interactive demo from one of our researchers, or with brief observation of another audience member interacting with the installation.

The *Kinect* motion detector occasionally required adjustment, according to the varying heights of participants. With few exceptions, we found the interaction paradigm to be for the most part intuitive and enjoyable for our participants of all ages. (We recorded interactions with participants aged between 5 years and 75+ years, although most participants in our *Nuit Blanche* audience were aged between 18 and 60.)

The content of the video news media was less well acknowledged compared to the modes of interaction and selection. However, we observed that users were interested in learning about how the selected day looked, what the zeitgeist revealed of fashion and grooming choices, rather than what exactly happened on the day. (This was a significant day, the 1st January 1993, when Czechoslovakia was dissolved to become two countries, Slovakia and the Czech Republic.)

For example, the advertisement video for the ‘Easy-Glider’ exercise machine, with model Vanna White resplendent in hot pink leotard, had a disproportionately large number of views. The discussions among the participants and audience on this video consisted mainly on comments on the model’s appearance more than that on the video content or the meaning or concept of the advertisement. Moreover, the videos showcasing fashion and cultural themes registered high numbers of views and resulting discussions.

Participants of the *Nuit Blanche* experience and other presentations proposed various suggestions and expressed high interest in using the technology and engaging with the conceptual idea of video browsing, search and display in an immersive virtual environment such as the *Holodeck*.

For example, in a brainstorming session with Dr. Sara Diamond (President and Provost of OCAD University) and Mr. Howard Eng (CEO, Greater Toronto Airport Authority) and the lab team, we generated ideas of using the *CBC Newsworld Holodeck* gestural application approach to showcase date-related events in Canadian history.

Moreover, video editors who participated in the demonstrations suggested that our gestural paradigms and technologies may have high potential in building audio/visual editing tools and software.

Still others appreciated the opportunity to browse video by keywords, which take participants directly to the keyword point in the video. This novel form of video browsing is achieved via the output of video transcripts, using natural language processing technologies.

## VI. CONCLUSIONS

Immersive virtual and simulated virtual environments give researchers the opportunity to study how individuals with memory loss and dementia may interact with new and novel environments. Our research involves making technology decisions that can facilitate interaction while creating minimal distress, focusing on elder and other participants while supporting their cognitive resources. [16]

Virtual reality and simulated virtual reality technologies also offer the potential to replicate physical environments, and the social interactions that may occur within them. According to researchers Garcia et al. “The objectives here may be to understand how to better design physical spaces or modify social environments for better quality of life.” [16] Further research in this area will help develop a better understanding of how persons with memory loss can influence their environments—and how they, their carers, and their caring institutions may operate in the environments that affect them.

In the Visual Analytics Lab, our design and research decisions are predicated on inclusivity and usability, and the pursuit of pleasurable collaborative meaning-making, in which human interaction takes place in ‘real’ and virtual space, where the mind is the ultimate virtual playground and memory acts as its controller.

Our efforts have yielded delightful results and valuable insights. Within these parameters, we have employed multimodal, personalized digital media applications with embodied, social interaction to create virtual realities that may enhance social connection and improve memory recall. We have built user interfaces that support seniors’ comprehension and adoption, assisting them to build their social interactions, technological competencies, and feelings of self-hood.

Our researchers have created and demonstrated 2D and real and simulated 3D aesthetic visualizations to give non-expert users a sense of relationship with the data we are displaying. And we have created new media and applications of simulated virtual realities which may assist elders by enhancing memory, affect, and other cognitive abilities.

In pursuit of these goals our researchers will continue using ‘iterative design’ methods with cycles of designing, testing,

and editing; and ‘user-sensitive inclusive design’ methods including the ‘think out loud’ method of user testing, as these methods have provided us with appropriate tools for inclusive audiences, shedding light on the potential of elders to learn and enjoy new technologies and technologically mediated virtual experiences.

Finally, and to our own surprise, we have produced playful responses and feelings of pleasure and delight in our younger and elder audiences, giving us momentum and motivation to continue our research.

## ACKNOWLEDGMENTS

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