Differentiated Reality: Building Empathy through XR Scenarios and Experience-Design – Richard Lachman

ABSTRACT

The emerging field of Empathic Computing (Cai, 2006) is a branch of Computer Science and Human-Computer Interaction (HCI) that explores how software techniques influence shared understanding and empathy in users. The goal of this HCI project is to influence empathic understanding in users through real-time cross-reality (XR) interactions with other users, trainers, and scenarios, leading to changes in user-behaviour. Specific applications we explore include simulations of physiological invisible disabilities (vision impairment, auditory impairment) for care-givers, co-workers, and pre-exposure training of patients with long-term degenerative conditions; and XR de-escalation and mental-health crisis-response training for law-enforcement officers based on empathy and a simulation of perception/difficulties. Virtual Reality has been well studied for its' contributions to medical training simulations (Cook et al, 2011), and, to a lesser extent, as way to build empathy among care-givers (Yee and Bialenson, 2006). Similarly, while Augmented and Mixed Reality (AR/XR) techniques represent an active area of research in medical training and treatment for professionals (Brydges et al, 2015), there are far fewer examples of using the technology as a pre-exposure training and empathy-building tool (Billinghurst, 2014; Piumsomboon, 2017) for those at risk for developing symptoms in the future. And while simulations are used in XR training to mimic the real world, the use of scenarios and serious-game designs to script experiences and emotional arcs in these utility-based contexts is less well explored. Our aim is to directly impact EDI issues in the workplace and in society by investigating the gap between policy, empathy, and action in users. Our XR experiences seek to change user-behaviour in dealing with the Canadian Charter of Rights and Freecoms-protected groups of the mental- and physically disabled through technologically-mediated scenario design.

In this program of research, we will integrate technologies (AR headsets, eye-trackers, facial performance-capture), with scenarios and interaction design to develop experiences that create measurable behaviour-change in users. We will develop real-time filters to mimic physiological conditions (for example, glaucoma, cataracts, macular degeneration, colour blindness) and auditory/mental disorders (ex: tinnitus, loss of fidelity, sensory overload, loss of frequency-response at higher ranges). We will create XR scenarios and game-like experiences that force users to interact with the world and with trained interactors in-game, to train them in different ways of perceiving and engaging with challenges. The combination of Tangible and Embodied Interaction (TEI), Empathic Computing, and Cross Reality (XR) grounds physical and social interactions in a world filtered to alter human perceptions/capabilities rather than enhance them.

Research Objectives

The purpose of this research program is to investigate the use of XR to simulate the effects of physiological and perceptual difference, for the purposes of increasing empathy in a variety of user-domains: care-givers, patients with degenerative conditions, law-enforcement/institutional staff, and others. We will then conduct studies exploring how these experiences impact the future behaviours of the users

1. To determine which XR techniques (visual filters, real-time shaders, real-time audio processing, facial performance capture) simulate specific user-experiences

2. To formulate a series of exercises and scenarios that use principles of game design, psychology, theatre, and social dynamics to create high-impact user experiences based around these core XR techniques
3. To develop tools for assessing the impact of these experiences on user-behaviours in the short- and medium-term

Motivation
Similarly, our motivation for this research aligns into three streams:

1. Growing empathy is useful for individuals who may benefit from visualizing their future states. Soutscheck (2018) describes situations in which we need to develop an awareness of our future self in order to exercise self-control. An awareness of what a sensory impression or embodied interaction might feel like could lead to earlier interventions, or awareness of changes in one's own health status. An empathic understanding of one's own future state may motivate changes in one's lifestyle. Finally, growing empathy may also be useful for caregivers or family members who will have long-term involvement with patients suffering from diminished physical or sensory capabilities.
2. As with studies exploring VR, XR should be explored as a tool for increasing empathy among users. By linking digital content with a tangible and embodied experience, there may be potential for increasing the relevance of the experience to a user's own daily life. This ecological validity of the experience may lead to stronger changes in empathy, presence, and impact.
3. Social experiences and game design techniques can be used to further increase the ecological validity and impact of XR experiences on users.

Background and Literature Review
Immersion in extended realities

Immersion is often described as the goal of high quality XR experiences, and can include the following categories: *Strategic Immersion* – planning for future results instead of the current situation makes the participant more able to suspend disbelief, and makes them more forgiving of shortcomings in rendering, representation, and fidelity (Murray, 1998; Isbister, 2017); *Tangible Immersion* – including physical and tactile senses in the experience (Papagiannis, 2017); *Spatial Immersion* – controlling and designing the quality of the virtual and physical space created around the participant (Isbister, 2017); *Social and Emotional Immersion* – multi-user interaction, competition, and cooperation can engage users more strongly and emotionally (Billinghurst & Thomas, 2011; Papagiannis, 2017; Isbister, 2017).

Empathy
Despite the rich literature on empathy, researchers don't agree on a unified definition (Bohart & Greenberg, 1997; Batson, 2009). Rumble et al. (2009) argues that empathy is influenced by two conditions: Perceiving individuals who are struggling; and imagining their emotions, circumstances and struggle. Meeting these conditions would increase empathy; and in turn, it is suggested, increase positive (generous) behaviors (Batson, 1991; Batson et al., 1996; Batson, Early, & Salvarani. 1997). Simulation, in many forms, is used to train medical professionals to build empathy (Bearman, 2015). Preliminary research argues that cross reality platforms have

facilitated an increase in empathy when used for news storytelling (Archer & Finger, 2018), in games (Kor et al, 2016), and can reduce stigma around disease (Silva et al, 2017). Chris Milk (2015) controversially proposed VR as the ultimate Empathy Machine, referring to a technological and content-based approach to represent someone else's emotional experience (Myers, 2017). In this context, virtual reality content attempts to let the user embody someone else's experiences as a means of creating empathy. Piumsomboon (2017) defines a range of experiences for cross reality to build empathy between users, ranging from shared heart-rates to shared visual fields.

Serious games

This term is used to describe games that educate, train and inform (Michael & Chen, 2006). The serious games approach adds elements that, we suggest, could further add to the empathetic impact of the experience. Serious games design should balance the challenges against the participants' abilities, and researchers have suggested that specific serious games interventions show signs of increasing personal and social learning and ethics (Pereiraa et al., 2012).

EDI and Physiological Symptoms

It's important to note that some disability advocates are outspoken in their critique of VR or AR as empathy-building technology (Nario-Redmond et al 2017). In particular, conditions such as dyslexia are multi-dimensional neurodevelopmental conditions, with vastly different psychological experiences from one person to the next. We will therefore focus on physiological differences wherever our simulations are to mimic experiences for end-users. In experiences based on mental differences, we will have experienced XR trainers perform actions derived from and designed by people with lived-experience, with users/trainees interacting from their own point of view. We will avoid situations where a user is assumed to completely understand mental and emotional differences based on short XR experiences as a best practice, and we will also focus on tangible behavioural changes in users to be measured in the short- and medium-term.

Our goal is to directly impact EDI issues in society by building empathy and skills that lead to tangible behavioural change. Some pioneering Mixed Reality researchers such as Steve Mann implemented limitations, rather than augmentations, for their senses, based on the technological capabilities of their systems (eg: reflecting visuals along X/Y axes; freeze-framing still images) (Mann 1997). Think-Aloud (TAP) protocols (Jääskeläinen, 2002) will allow us to design our visual and auditory filters driven not by technological possibilities, but by human lived-experience. Under the protocols, users describe out loud their experience of user-interfaces, allowing real-time conversations to hone and modify the experiences. We will work with specific patients within our EDI-identified groups to tune and refine the software filters to match their experience, creating (and, eventually, aggregating) experience-profiles for different members of society. The filters will be coded to support this kind of refining and alteration quickly and easily during the TAP process.

Example 1 : Physiological Conditions

There are a wide range of visual and auditory symptoms which can be simulated in an augmented-reality headset, including, but in not limited to, the following:

> **Cataract**: Cataract is a clouding of the eye lens which leads to a decrease in vision. Cataracts often develop slowly and can affect one or both eyes. It is characterized by: Foggy or cloudy

vision; Blurry vision; Dull colour perception.
Macular Degeneration: represented as a large spot in the centre of one's field of vision.
Glaucoma: commonly, referred to as tunnel vision. In some cases, the patient sees a sharp centre with blurry corners
Hearing impairment and reduction in fidelity
Tinnitus: a condition that causes a continuous sense of ringing in the ears.
Noise: It has been reported that some people experience noises and radio-like distortion.

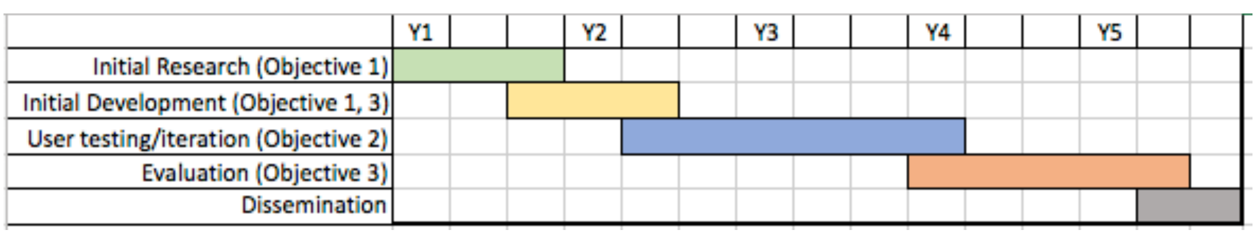
Related work includes A Walk through Dementia (2018) is a virtual reality experience developed by Alzheimer's Research UK that combines 3D models and 360 filmed content, experienced through Google Cardboard. The scenario is pre-recorded and interactions are pre-determined. Virtual Dementia Tour (2010) is a non-technology based twelve minutes tour, developed by Second Wind Dreams protected by patent. Virtual Dementia Experience (2013) is a VR scenario that allows limited user-interaction in a fixed 3D virtual environment, and bills itself as a pioneer in the field of 'empathic education'. Virtual Dementia Tour (n.d.) is a physical-only experience which doesn't use any headset technology. Users don bulky gloves, plastic goggles to limit their view of the world, wear headphones playing back noise, and have their movement limited by stones placed in their shoes.

Example 2: De-escalation Training
Our example explores two over-arching research questions: is VR a viable platform for scenario-based police training in violence de-escalation and mental health crisis response? Do VR-based approaches offer benefits in scalability, cost, and utility compared to existing training methodologies? We intend to tackle these research questions by developing live training scenarios and replicates these scenarios in a VR platform. In partnership with existing collaborators including the Durham Region Police Board and researchers at Ryerson University, Simon Fraser, and University of Victoria, we will apply empathy-based VR/XR scenario-training in this domain. Related work has been done on the need for de-escalation and empathy-based training for law-enforcement (Anderson et al 2017; Boyce et al 2012; Brink et al 2011), and on VR/XR in situational-awareness and law-enforcement training (Carlson & Caporusso 2018; Davies 2015; Sharma et al 2017; Hughes et al 2016). This project is an opportunity to blend the two bodies of work using XR scenario-based training. Original contributions will include partnerships with sociology/criminology, scenario-design that involves people with lived experience of the conditions being modeled, and operational concerns around cost/scale/portability that can move ideas into practice.

Implementation and Feasibility
These projects will primarily built on the Vive Pro Eye platform, using the passthrough cameras the SRWorks SDK, and the built-in eye-tracking capabilities of that system. On release of the new hardware, projects will also incorporate the HoloLens 2. Visual filters will mainly be built in the Unreal engine, with some simpler prototyping and smaller-scale projects built in Unity. Integrated with Windows machines running our software will be biometric tracking tools.

Methodology
We will use a mixed-method approach, primarily based around an iterative techniques in human-centered design. By involving users in every step and at every iteration, we will gradually refine our software, hardware, and experimental protocols to maximize impact towards our goals. We will use the following stages iterated each year, for a total of five times over the life-cycle of the project:

Initial Research: research will be conducted into literature, with a focus on researcher-investigations and personal patient-descriptions and documentation of the visual and auditory effects under study. The team will also recruit users to act as our think-aloud-protocol team, describing their own experiences in order to help us "tune" the filters to simulate lived experience.
Initial Development: The initial software prototypes will be re-engineered to support tuning/real-time adjustment, and to implement filters that more closely match the research. The system will also be designed with reusability and modularity in mind, to develop the project as an ongoing project which can be added to as the research progresses.
User testing/Iteration: We will use our recruited participants as well as general users in order to refine both the verisimilitude of the experience and the immersive nature of the activities. All elements of the simulation will be designed, including the physical space, the order of events, the instructions, and the nature of the social interactions, in addition to the software/hardware. Principles of experience design as well as the above cited elements of immersion will be included in our testing and refinement process.
Evaluation: We will formally test and document user-experiences when completed projects are produced, using semi-structured interviews.
Dissemination: This work will be presented at conferences (such as CHI, CHI.Play, TEI (Tangible, Embedded, and Embodied Interactions) and the Symposium on Virtual Reality, as well as through journal publications.



Impact
This research offers to deepen our investigation of Human Computer Interaction (HCI) in the sub-domains of Tangible Embodied Interaction (TEI) and Empathic Computing. By conducting basic research in how XR techniques can integrate with human sensory experiences, we can ground future applications that explore building empathy between groups of users. We can also develop a basic understanding of how to use XR technologies to impact our own behavior, understanding, and decision-making about our future selves. As Canadians continue to integrate cross reality technologies into applications ranging across medical, educational, industrial and entertainment industries, a solid understanding of the basic mechanisms of human experience becomes of primary importance to the field of computer science.

Richard Lachman - References

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