Project Summary: Virtual Resilience for Understanding Trauma and Utilizing Regulation to Envision Success (VR-FUTURES)

1. Introduction

Since the 1960s, the United States has spent trillions on a complicated array of federal and state-level programs to address the many social problems that maintain and perpetuate the cycle of intergenerational poverty, particularly in urban communities of color. Unfortunately, these efforts have failed to stem rising income inequality and achievement gaps that fall heavily along racial and socioeconomic lines; a crisis that the COVID pandemic has deepened even further in the last year, as vulnerable children were left without critical resources provided by schools unable to operate in-person. This compounded an already-traumatic experience for youth dealing with the ongoing, chronic stress of a global pandemic and economic crisis – one that caused countless many to lose loved ones, sources of income, and disrupted the learning and development of an entire generation.

A pressing question to explore as we rebuild from COVID is how to mitigate the enormous toll the pandemic and economic downturn have taken on some of the most vulnerable in our society: adolescents whose intellectual, social, and emotional growth and development have been profoundly affected by trauma, caused either directly by COVID or the wide range of other Adverse Childhood Experiences (ACEs) common to many underserved communities in the United States. One answer may be found through the VR-FUTURES project: Virtual Resilience for Understanding Trauma and Utilizing Regulation to Envision Success.

2. Project Description

VR-FUTURES is a collaborative research endeavor between Purdue University Northwest, the University of Southern California, and the Shepherd Community Center in Indianapolis that seeks to develop an effective VR-assisted treatment program for adolescents dealing with chronic trauma (particularly in economically distressed areas). VR-FUTURES aims to create and study an immersive, VR social and emotional learning program designed to help adolescents visualize and design possible futures for themselves, while retraining maladaptive and self-defeating mental attitudes, emotional dysregulation, and faulty beliefs brought on through various ACEs. The end goal of the project is to establish concept validity for an innovative way to improve health, educational, and economic outcomes in a large, underserved segment of the US population.

VR-FUTURES will provide a library of VR content to help participants as they explore and build in a virtual world what life could look like in the future in the real world and deliver educational and training content needed to pursue their goals. By building on the existing literature establishing the effectiveness of VR-assisted treatment in combat veterans with PTSD, the project will leverage VR/AR technology coupled with expertise in developmental, counseling, and neuropsychology, as well as education.

3. Executive Summary

Children who grow up in poverty are far more likely to experience trauma such as violence and sexual abuse and less likely to overcome their adversity (Pinderhughes et.al. 2015). Virtual Reality (VR) and related technologies have already been shown to be successful to help treat post-traumatic stress for veterans (Rizzo et.al. 2017). This program will examine whether a modified, trauma-informed approach can achieve similar success with traumatized children. VR and related technologies will be combined with learning and counseling opportunities designed to help learners recover from trauma and conceptualize a reality for themselves beyond their current life circumstances. The program will include tools aimed at improving children's resiliency while developing skills that empower them to pursue paths out of poverty toward a brighter future.

The program will combine a virtual reality life game embedded with academic learning supports, integrated social and emotional learning activities, and support for families affected by trauma. The program will help children learn to cope and recover, developing the resiliency that allows them to move beyond their trauma and uncover their interests which can be tied to career pursuits, allowing them to envision possibilities for their future. The game will include embedded Social and Emotional Learning (SEL), executive functioning (e.g. delay of gratification), and practical information about life options including education and career paths. While in the game, participants will interact with virtual characters (controlled by a trained counselor) and experience a narrative that depicts the stories of virtual characters who have experienced various types of trauma. Through this experience, participants will learn to tell their own story, developing coping strategies that help to mitigate the effects of stress and continue their stories into a future of possibilities. The game will also train participants to be peer mentors for one another.

Developed at Purdue University Northwest's Center for Innovation through Visualization and Simulation (CIVS), School of Education and Counseling, and Department of Psychology, in collaboration with the University of Southern California's Institute for Creative Technologies (ICT), and additional content experts and consultants, this program is designed to be scalable, with strong potential for future commercialization. The technology components of the program will be mobile, traveling to partnering locations for treatment such as community centers, schools, and other youth-serving organizations. The core VR will be developed in Year 1 allowing enrollment of initial participants and will continue to grow in capabilities and implementation during years 2 through 4. A comprehensive outcome assessment plan has been developed to identify and track the core intervention domains and their individual and collective efficacy.

4. *Project Scope of Work and Evaluation Measures*

This project will include development and implementation of a virtual reality life game, as well as a wide variety of real-world counseling and support activities. The game will focus on helping children recover and increase resiliency and posttraumatic growth from traumatic experiences, see beyond their current life circumstances, and expand and visualize possibilities for their future. The real-world counseling and support activities will complement in-game activities to address participants' academic, social, and emotional learning needs as well as support and tools for families to use at home. Such a comprehensive program complements the use of technology (i.e., AR, VR, etc.) with responsive and nurturing activities and real-time support from trained professionals. The program leverages the powerful intersection of technology and human interactions to foster development in all domains – academic, social and emotional.

A three-year longitudinal study will be conducted in three regions - northwest Indiana, the eastside of Indianapolis, and south-central Los Angeles: all areas with large, diverse populations with many low-income residents. A small sample of participants will be recruited in Year 2 for focus groups, beta-testing, and a feasibility pilot program. A larger research sample from each project region will be recruited in Year 3 for the 2-year study, and a comprehensive battery of empirically validated assessment measures will be used to evaluate changes in subjects' trauma-related symptoms, executive functioning, psychosocial maturity, future orientation, emotion regulation, overall psychological and behavioral, and posttraumatic growth.

5. *Work Plan*

The work will be carried out in three main segments: 1) Design/Evaluation, 2) VR Development, 3) Implementation, Counseling, and Support. Design/Evaluation will be carried out by the PI and Co-PI, research team, and other outside collaborators. The group will create a design document covering the core VR activities, narrative storylines, challenges, and all of the various skill-building and in-game activities. All VR activities will be designed to align with the real-world counseling and support activities. The group will continually evaluate and revise the design as the program is implemented with more participants.

6. *Expected Outcomes*

- The program will help children increase resilience and self-efficacy following trauma and gain skills to maximize their likelihood of economic mobility and professional success.
- The program is expected to improve emotion regulation, executive function, posttraumatic growth, and future orientation, and decrease trauma-related symptoms and psychological and behavioral problems for participants in the Chicago/NWI, Los Angeles, and Indianapolis areas.
- The program is expected to prove the benefit of a VR + Support approach for helping children improve outcomes following trauma exposure.

7. *Resources Required*

$5-6 million over four years.

8. *Research Team*

- **Co-PIs**: Chenn Zhou, PhD, Director of the Center for Innovation through Visualization and Simulation, and Jack Moreland, Sr. Research Scientist (CIVS), Purdue University Northwest
- Anne Gregory, PhD, Director of the School of Education & Counseling, Purdue University Northwest
- Mary Jane Eisenhauer, EdD, Professor of Counseling & Education, Director of Strosacker Early Learning Fellows Program, Purdue University Northwest
- Randy Hill, PhD, Executive Director of the Institute for Creative Technologies, University of Southern California
- Albert "Skip" Rizzo, PhD, Research Professor and Director of Medical VR at ICT, University of Southern California
- Bill Swartout, PhD, Research Professor and Chief Technology Officer at ICT, University of Southern California
- Amanda Zelechoski, JD, PhD, Assoc. Professor of Psychology, Director of Trauma-Informed Care Program, Valparaiso University
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9. *Organizer Contact Information*

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Virtual reality (VR) and Virtual Human (VH) Technology-based Solutions to Address the Needs of At- Risk Youth Due to Adverse Childhood Events

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Revolutionary Developments in Clinical Use of Virtual Reality and Virtual Human Technologies

Virtual reality (VR) and Virtual Human (VH) technologies (all referred to here as VR) offer new opportunities for clinical research, assessment, and intervention. Since the mid-1990s, VR-based testing, training, and treatment approaches have been developed by clinicians and researchers that would be difficult, if not impossible, to deliver using traditional methods. During this time, a large and evolving scientific literature has emerged regarding the outcomes and effects from the use of what we now refer to as C*linical VR* applications targeting cognitive, psychological, motor, and functional impairments across a wide range of clinical health conditions. This work has focused on PTSD, Anxiety Disorders, Depression, Emotional Regulation, Substance Use/addiction, Functional skill training, TBI, Autism, ADHD, Alzheimer's disease, stroke and many other clinical conditions and wellness targets.

As the technology has evolved since the 1990's, a determined and expanding group of researchers and clinicians increasingly recognized awareness of the unique match between VR assets and the needs of various clinical application areas. This recognition of the potential impact of VR technology has led to many clinical and research targets where VR can add value relative to traditional assessment and intervention methods. A short list of the areas where Clinical VR has been usefully applied includes fear reduction in persons with specific phobias (Morina et al., 2015; Opris et al., 2012; Parsons and Rizzo, 2008; Powers and Emmelkamp, 2008), treatment for posttraumatic stress disorder (Beidel et al., 2017, 2019; Botella et al., 2015; Difede et al., 2007, 2014, 2019; Loucks et al., 2019; Maples-Keller et al., 2017; Rizzo et al., 2010, 2013, 2018; Rothbaum et al., 2001, 2014), cue-exposure for addiction and relapse prevention (Bordnick et al., 2019; Hone-Blanchet et al., 2014; Yoon et al., 2014), depression (Falconer, et al., 2016), and paranoid delusions (Freeman et al., 2016). VR has documented evidence in support of its use for discomfort reduction in cancer patients undergoing chemotherapy (Schneider et al., 2010), acute pain reduction during wound care and physical therapy with burn patients (Hoffman et al., 2006, 2019), in other painful procedures (Gold et al., 2006; Mosadeghi et al., 2016), and body image disturbances in patients with eating disorders (Riva, 2019). Cognitive research using VR has produced promising results when applied to navigation and spatial training in children and adults with motor impairments (John et al., 2017), functional skill training and motor rehabilitation in patients with central nervous system dysfunction (e.g., stroke, traumatic brain injury (TBI), spinal cord injury (SCI), cerebral palsy, multiple sclerosis, etc.) (Deutsch & McCoy, 2017; Howard, 2017; Klamroth-Marganska et al., 2014; Koenig et al., 2012ab; Lange et al., 2012; Merians et al., 2010), and for the assessment and rehabilitation of attention, memory, spatial skills, and other cognitive functions in both clinical and unimpaired populations (Bogdanova, Yee, Ho, & Cicerone, 2016; Matheis et al., 2007; Parsons, et al., 2009, 2019; Pugnetti et al., 1995; Rizzo, 1994; Rizzo et al., 2006; Valladares-Rodriguez et al., 2016).

To do this, Clinical VR scientists have constructed virtual airplanes, skyscrapers, spiders, battlefields, social settings, beaches, fantasy worlds, and the mundane (but highly relevant) functional environments of the schoolroom, office, home, street, and supermarket. In essence, VR environments mimicking real or imagined worlds can be applied to engage users in simulations that support the aims and mechanics of a specific clinical assessment or therapeutic approach. As a result, there is a growing consensus that VR has now emerged as a promising tool in many domains of research (Bohil et al., 2011; Larson et al., 2014) and clinical care (Rizzo et al., 2017; Freeman et al., 2016; Lange et al., 2012; Goldman-Sachs, 2016; Norcross et al., 2013).

Moreover, recent work has involved the creation of artificially intelligent virtual human (VH) characters that allow users to engage in credible clinical interactions. VHs have shown documented effectiveness in the role of patients that novice clinicians can use to practice skills required for challenging diagnostic interviews (Talbot & Rizzo, 2019; Reger et al. in press) and for creating online virtual human healthcare guides (Rizzo et al., 2018), and clinical

interviewers with automated sensing of facial, gestural, and vocal behaviors useful for inferring the state of the user interacting with these virtual human entities (Rizzo et al., 2016). As well, this area has advanced dramatically with the continuing advances in the underlying enabling technologies for creating and delivering VR applications (e.g., computational speed, computer graphics, panoramic video, audio/visual/haptic displays, natural user interfaces, tracking sensors, speech and language processing, artificial intelligence, virtual human agents, authoring software, etc.) that have resulted in widespread availability of advanced VR tech delivery systems as consumer products, sometimes at a very low cost. Therefore, when one studies the scientific literature, examines the evolving state of the technology, and observes the growing enthusiasm for VR in the popular culture, it is hard to deny that Clinical VR is ready for Primetime! This bodes well for developing compelling VR and VH applications designed to engage children in simulations that can help them overcome the enduring negative psychological and emotional consequences of *Adverse Childhood Experiences (ACE)*.

Early Childhood Trauma Interventions to address Adverse Childhood Experiences (ACE)

Treating trauma due to ACE in children naturally takes a different form than with adults, but the same theoretical basis of trauma-focused and supportive cognitive behavioral therapy still underlies and informs that delivery in whatever form (barring other intervening co-morbidities). These approaches, that leverage existing innovative technologic advances made at the USC ICT, can be transitioned for use with children who have suffered from ACE and include:

• **Teaching children stress management and relaxation skills** to help them cope with unpleasant feelings and physical sensations about the trauma. This is similar to adult therapy where deep breathing and other stress reduction methods are taught to trauma patients as skills that can be applied if the going gets rough. These skills also provide users with an active coping tool to provide an emotional safe harbor that can help them learn that they do, in fact, have some level of control of their emotional experience. Existing VR applications in this area, originally designed for adults can be adapted for children dealing with ACE. Moreover, these therapeutic applications can be widely distributed via lower cost personal standalone VR platforms. Such VR display systems don't require a tethered computer, with all the graphic and interaction processing taking place onboard the device. 5G cloud-computing promises to advance this capability by offloading much of the real time simulation processing to remote servers that will offer up large libraries of Clinical VR scenarios designed to meet the varied needs of children with diverse ACE experiences. This provides the capacity to promote children's access to mental health and wellness applications designed to deliver preventative and healing strategies in the home. This can be seen most readily in the adoption of home-based VR to promote meditation, mindfulness, and relaxation. VR can add value in these areas by providing children with the opportunity to be psychologically transported to compelling, highly realistic, and sometimes hyper-idyllic settings that encourage engagement with stress-reducing activities. This is important since children experiencing high stress or anxiety may not have the awareness or patience to practice these strategies on their own or in tradition treatment to the degree where they may experience a reduction in aversive internal states. For example, learning the "skill" of achieving a "mindful" state typically requires multiple sessions before the user perceives a rewarding change in their mental/emotional experience. Implementing these strategies in a VR context designed to appeal to and engage users (e.g., underwater, lush terrestrial spaces, surreal fantasy worlds) removed from their everyday surroundings may serve to encourage the amount of practice required to achieve the benefits of a calm state. These apps may also be especially appealing to children who have been isolated in their home for extended periods during the COVID-19 crisis.

The market already provides many options for users wanting to explore these approaches (cf. AppliedVR, Tripp, Magic Horizons, MetaMedical, Guided Meditation VR) with some offerings also integrating binaural beat audio stimulation, transcranial magnetic stimulation, and varied forms of bio/neurofeedback integration, believed to enhance relaxing brain states. Recent research in this domain has been encouraging (Seabrook et al., 2018). ICT has relationships with, and the capability to partner with the groups who have created these existing applications for their modification to address the needs of children suffering from the enduring negative effects of ACE.

• **Engaging Children with Web and Mobile delivery of mental health content and services enabled with autonomous Virtual Human (VH) agents to help them engage with tools designed to address their needs.**

In 2010, the Defense Center of Excellence supported our effort to create an online Virtual Human (VH) agent application, referred to as SimCoach. The system was designed to support the efforts of Service Members, Veterans, and their families to find online mental healthcare information and to get advice about PTSD and other wounds of war. The aim was to have a safe and anonymous place where users could interact with an engaging VH agent (SimCoach) designed to promote access to relevant healthcare information in a fashion aimed at reducing

stigma and other barriers to care. Interaction with this natural language-enabled VH was not viewed as a replacement for good clinical care provided by a live provider, but rather as an accessible and natural interface for engaging users with healthcare content who might not otherwise seek formal in-person help (Swartout et al., 2013; Rizzo et al., 2015). The goal was to motivate users to take the first step and seek information, answer some light assessment screening questions posed in conversation with the SimCoach VH, and then based on that interaction receive advice regarding mental healthcare options. Since that time, the system architecture has been evolved and applied to other healthcare use-cases with different challenges. The most recent iteration of the SimCoach approach is now called the Virtual Wellness Assistant (VWA) or *Ask Ari*. This system is currently being tested as a general health and wellness application for the entire student/faculty population at the University of Southern California (approximately 72k potential users). The SimCoach architecture that underlies the VWA provides general content including screening questionnaires, topical information, psychoeducational material, and self-help activities. Moreover, numerous modules have been built that provide guidance on a range of Cognitive Behavioral Therapy (CBT) strategies that lend themselves to highly structured and manualized delivery (e.g., relaxation, stress management, problem-solving skills, understanding and coping with anxiety, depression and loneliness, mindfulness, substance use self-monitoring, sleep hygiene, emotional regulation, assertiveness, relationship issues, etc.). For the current project, this modular content will be re-structured to provide additional childhood ACE-relevant content embedded within a web-based application designed to support users access to well-vetted and relevant mental health and wellness interactive content and activities.

To enhance access to these interactive VH-enabled activities to children on devices they are comfortable with, the above content can be delivered on a mobile device platform. In view of the widespread penetration of mobile technology in everyday life, we have begun development of a SimCoach-type mobile application, capable of running on an IPhone or Android device, referred to as the Mobile Wellness Assistant (MWA) (Mozgai et al., 2020). This prototype effort was originally designed to improve service member access to relevant wellness and healthcare content. The project commenced in 2019 when we began the design and development of a mobile SimCoach, within the structure of the US Army's *Ready and Resilient (R2) Performance Triad* (e.g., Sleep, Nutrition, Activity) (U.S. Army, 2018). The R2 resilience program has developed a wide array of well-vetted content, but relies on text-based manuals and have even "copied" the manual into a mobile app that is actually less usable than the paper manual. It is our hypothesis that engagement with and benefit from the current R2 text-heavy format would be amplified with a VH interactive interface and this type of content could be modified for use by children. The MWA delivers health interventions (e.g., educational exercises, physical challenges, and performance feedback) matched to the individual user via novel adaptive logic-based algorithms while employing various behavior change techniques (e.g., goal setting, barrier identification, rewards, modeling, etc.). A VH coach leads all interactions including the first time user experience and the brief daily sessions. All interactions were specifically designed to engage and motivate the child while continuously collecting data on their cognitive, emotional, and physical fitness. This multi-component application is integrated and deployed on an iPhone and Apple Watch prototype; a civilian version is currently in-development and a child-relevant application is possible. Moreover, the combination of Performance Triad content with our web-based VWA content described above would provide access to a more comprehensive body of diverse resources for promoting and maintaining mental health and wellness during and in the aftermath of an ACE. Thus, in the current project, the modular content from the VWA would be integrated with the Performance Triad content and then made deliverable via a SimCoach VH in the form of the Mobile Wellness Assistant application to promote children's and adolescent's access and engagement with self-care mental health and wellness resources.

- **Using "exposure strategies," or talking about the ACE and related feelings at a pace comfortable for children**. These strategies have two core objectives:

  - **Creating a coherent "narrative" or story of what happened**. It is often a difficult process for children to reach the point where they are able to tell the story of a traumatic event, but when they are ready, the telling enables them to master painful feelings about the event and to resolve the impact the event has on their life. Again, whether in a relevant context or with a "safe" conversational VH agent (in or out of context), getting the narrative out is key.
  - **Correcting untrue or distorted ideas about what happened and why**. Children sometimes think something they did or didn't do may have caused the trauma, or that if only they had acted a certain way, a traumatic experience might have turned out differently. This is rarely true, and getting the story right helps a child stop prolonging the traumatic stress by punishing him- or herself. This is the part where a well-trained clinician is essential. The skills for effectively challenging cognitive distortions and replacing them with appropriate reframes is as much art as science. Experiential learning activities in VR or with

VH's may be useful vehicles for activating the emotions that are derived from cognitive distortions and directly addressing them in the actual virtual representation of the context.

The USC-ICT has a long-term, internationally respected, and theoretically-informed history of applying Virtual Reality (VR) clinically is in the area of preventing, assessing, and treating Posttraumatic Stress Disorder (PTSD). This commenced with a project focused on the treatment of combat-related PTSD in 2004 via the delivery of the evidence-based intervention referred to as prolonged exposure within highly customizable VR simulations of trauma relevant content. The system, now referred to as BRAVEMIND, has been distributed to over 100 clinical sites across three iterations and now includes civilian content relevant to treating PTSD due to sexual trauma. The efficacy of the system and approach has been documented over the years (Beidel et al., 2017, 2019; Loucks et al., 2019; Rizzo et al., 2018) and in late 2019, the current iteration BRAVEMIND was updated to run on newly available, higher fidelity, yet less expensive equipment (Oculus, VIVE, Samsung MR HMDs). While reducing system costs, the new version has significantly amplified capability, including enhanced usability, stereoscopic rendering, wider field of view, higher resolution, and better user comfort in the operation of the headset. We propose to create a VR exposure therapy system to address the mental health needs of children who exhibit PTSD-related symptoms relevant to their ACE exposure. As with persons with PTSD due to combat- or sexual-trauma related trauma, we see ACE as being responsible for producing a significant number of children who are plagued with symptoms of avoidance, hyper arousal, intrusive thoughts, nightmares, flashbacks, and other alterations of mood and cognition. Careful pacing in BRAVEMIND-like simulations is just one method for fostering the gradual **creation of a coherent narrative of a child's ACE experience** that can then be used by clinicians to **correct untrue or distorted ideas about what happened and why.**

An ACE-relevant BRAVEMIND VR exposure therapy system could be rapidly developed and made available as an in-office treatment approach for children with significant residual impairments relevant to fear, anxiety, and loss. The translation of our existing VR PTSD Exposure Therapy systems to treat ACE-related childhood trauma is hypothesized to have a significant positive impact on the mental health of children. For children who are not ready for a VR therapeutic experience with the realism of a BRAVEMIND approach, a virtual narrative play therapy approach could be implemented as an initial step in a trauma-focused approach. This can take the form of an existing Virtual Sand Tray application. The system virtualizes the original physical version of this play therapy approach to really good effect and may be an effective non-threatening activity for naturally pulling some of the implicit elements of the trauma narrative out of the child at a pace that they completely control within a play activity. A unified toolkit integrating BRAVEMIND type functionality with both exposure and relaxation training, supported by engaging, safe conversational VH agents, and a Sand Tray segment for basic story construction within a play context would provide a holy trinity of components for use with this population. Everything proposed here is technically and clinically feasible with the expertise and existing level of Clinical VR development at the USC-ICT. All of what is proposed is also supported by clinically-informed scientific research.

In summary, VR Exposure Therapy can be seen as one part of a multi-component solution that can be customized around the needs and capabilities of the child. This can be integrated with an interactive dialog component with a safe VH agent that could be usefully embedded within BRAVEMIND contexts (or for warm-up interactions outside the virtual context, initially). The integration of conversational VH characters as described above is hypothesized to provide yet another potent option in this evidence-based process for treating the residual PTS effects due to ACE. Successful mental health treatment in this area will improve childhood functioning and it is an ethical imperative to reduce the enduring pain and suffering in these groups. Moreover, such successful early childhood intervention/treatment will reduce the larger, long term economic costs that have been documented to occur when untreated PTSD becomes a chronic condition (Bilmes, 2007, 2013).