Research Article

ISSN 2641-4333

Neurology - Research & Surgery

# Bringing the Virtual to Reality- How Virtual Reality Can Enhance People's Health and Social Lives

**Eddie John Paul Fisher*, Yorkys Santana González and Alicia de la Caridad Martínez Tena**

*Faculty of Social Sciences, Universidad de Oriente, Santiago de Cuba, Cuba.*

***Correspondence:**
Eddie John Paul Fisher, 8 Kendal, Swindon, Wiltshire, SN5 8HW, United Kingdom, Tel: 44-179-349-0423.

**Received:** 30 may 2019; **Accepted:** 26 June 2019

**Citation:** Eddie John Paul Fisher, Yorkys Santana González, Alicia de la Caridad Martínez Tena. Bringing the Virtual to Reality- How Virtual Reality Can Enhance People's Health and Social Lives. Neurol Res Surg. 2019; 2(1): 1-10.

## ABSTRACT

*The application of Virtual Reality (VR) has an increasing capacity to simulate everyday environments. It provides multimodal sensory stimulations that have the ability to influence the human brain to correct neurological and cognitive rehabilitation/behavioral disorders. The purpose of this research is to determine how Virtual Reality (VR) could aid the quest to eliminate or reduce mental disorders/the effects of brain injuries. The outcome suggests that appropriate applications of VR can lead the human brain to improve/reverse neurological activities that lead to mental disorders such as dementia, Alzheimer's and brain injuries caused by accident or strokes. Cognitive rehabilitation and behavioral therapists would benefit from the application of VR to improve the therapeutic experiences of brain injury or anxiety disorder patients. The coming together of involved parties such as individuals, society, manufacturers of VR technology, neurosurgeons, neurologists and social psychology are paramount to the success of this considered approach to eliminate/reduce various types of mental disorders.*

## Keywords

Virtual, Augmented and Mixed Realities, Social Psychology, Cognitive Rehabilitation/Behavioral Therapy, Neurology, Mental Disorders.

## Introduction

There is an improved understanding of how the human brain works. It appears that scientists have learned more about the human brain over the last decade than they have done over centuries. This is due to fast-paced increases in neurological and behavioral research, combined with improved research methodologies. With increases in technological capabilities in areas such as virtual (VR), augmented (AR) and mixed realities (MR), it appears possible to combine these for the benefit of mankind, in many areas of human life such as surgical, medical, behavioral, automotive and educational. For example, recent experiments with infra-red laser stimulation of parts of the human brain such as the pre-frontal cortex have shown that both short-term and long-term memory can be influenced positively. New VR technology allows people to take this further by focusing on making the human brain believe that dormant or unused neurological connections can be vitalized/revitalized. The researchers' focus was on an approach that was based on a combination of what was already known about the subject matter under investigation (a priori) and the practical experiences of research participants (a posteriori). It focused on applying VR in its various forms such as augmented and mixed to improve people's social lives in a number of areas (A-C) considered to be of initial priority, using a cognitive rehabilitation/behavior approach together with a transfer of learning results:

**A:** Mental Disorders- Dementia, Alzheimer's, Creutzfeldt-Jacob, Autism

**B:** Behavioral-Drug and Alcohol Abuse, Artificial Limbs, Automotive Responses, Attitude and Behavior and Personal Issues, Anxiety Disorders

**C:** Social and Work-Images of loved ones during periods of absence, Self-confidence and Personal Psychology People Skills

Virtual environments present new opportunities to conduct social research [1]. Researchers are able to influence and alter the

experiences of research participants. It is possible to immerse people into new worlds, engage people in actions previously obstructed by physical or ethical limitations. For example, it is possible to study, examine and evaluate the behavior of research participants when assigned with opposite-sex avatars (female=empathizing, male=systemizing behaviors/approaches), consistent with the social representation of their own gender. With an improved understanding of how the human brain works, and with increases in technological capabilities in areas such as virtual, augmented and mixed realities (VR), it appears possible to combine the two for the benefits of mankind. In the context of this research, social psychology is defined as being part of psychology that focuses on how social phenomena influence people and how people generally interact with each other. How people see themselves in relation to the rest of the world is paramount to how human beings make choices, their behavior and beliefs. Another interpretation of VR, considered for this research, is that of the Foundry Vision-mongers Organization [2], a visual effects software company: 'Virtual Reality is the umbrella term for all immersive experiences, which could be created using purely real-world content, purely synthetic content or a hybrid of both' In this context, it is suggested that two more kinds of 'reality' should be considered: Augmented Reality (AR) and Mixed Reality (MR).

| Mental Illness | Feedback Loop 1 | Feedback Loop 2 | Brain Region Affected |
|---|---|---|---|
| Paranoia | Receiving a threat | Discounting threats | Amygdala, prefrontal lobe |
| Schizophrenia | Creating voices | Discounting voices | Left temporal lobe, anterior cingulate cortex |
| Bipolar Disorder | Optimism | Pessimism | Left/right hemisphere |
| Obsessive Compulsive Disorder (OCD) | Anxiety | Satisfaction | Orbitofrontal cortex, caudate nucleus, cingulate cortex |

**Table 1:** Shows the details of the relationship between all three considered non-real realities.

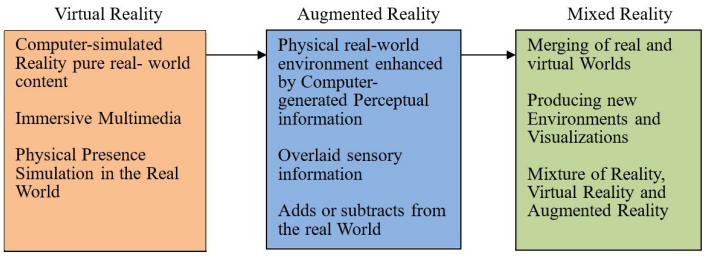


**Figure 1:** The Relationships between Virtual, Augmented and Mixed Realities.

This research investigates potential problem areas associated with regular exposure to VR applications, what the affects these have on people and what can be done to overcome these. The researchers suggest that people of all ages and both sexes will benefit from appropriate applications of the VR technology to boost the quality of their personal lives. The researchers have adopted the concept of additive manufacturing (aerospace industry) for the context of this research and suggest that only appropriate levels of VR are applied to influence the human brain to either rejuvenate existing neurons or create new ones. Section 1.2 presents the literature review; Section 1.3 discusses the knowledge gap and Section 1.4 lists the main research questions/hypotheses. This is followed by Methodology and Results (outcomes of face to face interviews and ranking of the considered application/solutions). Discussion and Conclusions form the final two Sections.

## Literature Review

### Films

Film: Glass (Universal Pictures), released in the US on 18 January 2019: the main character of the film, Kevin Wendell Crumb, suffers from dissociative identity disorder and has 24 different personalities within him known as The Horde. Over the course of the film Kevin is able to inhabit each different identity with a high level of authenticity and a deeply unsettling edge. 'His mind is host to 24 warring personalities, some of whom are lethal. Three of those split personalities, "Dennis", "Patricia" and "Hedwig", eventually stage a coup to release "The Beast", a further persona that gives Kevin superhuman abilities and murderous rage. The Beast's agenda is to rid the world of the "Untouched": people who have never known suffering. Those who have had a harder time, according to his philosophy, are the "Pure" who will inherit the Earth' (www.empireonline.com), 2019). Kevin's psychiatrist, Dr Ellie Staple, specializes in delusions of grandeur, with particular emphasis on patients who think they are superhuman. At one point during the film she states that a collection of personalities is the 'total utilization of the human brain power capacity'. This is an interesting notion and the researchers will discuss in Section 4-Discussion if VR should play a role to improve cognitive rehabilitation therapy covered in this paper, through the creation of virtual personalities.

Film: The Titan (Voltage Pictures/Automatik Entertainment, The Post Republic, Nostromo Pictures), released 30 April 2018, UK: This film presents a provocative approach to engage in radical genetic transformation to alter the human DNA in order to save humanity. In the year 2048, Earth is overpopulated and it appears that there is a necessity to consider a new home for humanity. Titan is considered suitable but due to its environmental conditions would require some serious human adaptations in order to survive in areas such as vision (low level light) and staying under water for extended periods of time. Climate on Titan includes wind and rain and thus creates surface features close to planet Earth. In order to achieve essential mutations to get the human being (Homo Titanians) ready for Titan, human DNA is infused with animal DNA to create the necessary adaptations such as night vision, running faster over prolonged periods of time and being able to remain under water much longer. No appropriate concern is given to these evolutionary experiments with regard to side effects: hair and skin loss/mutations and sensory changes such as low-level light vision and low frequency communications, resulting in unexpected changes to the normal human rational behavior patterns.

Film: Ready Player One (Warner Bros. Pictures, released March 2018, UK): This film is set in the year 2015. Much of mankind

uses a virtual reality software known as OASIS to escape the desolation of reality/life in the real world. A hidden game within the OASIS software promises the winner total control over the OASIS. It appears that the lack of human interactions leads to people becoming obsessed with the virtual world. Avatars (image of person in the virtual world) replace actual people. The OASIS has become a replacement for real life living. It appears that most human interactions have been suspended. Emotions, feelings and perceptions have been replaced by VR interactions. The very essence of what makes human beings 'human' has been replaced by a convenient alternative to experience the real ups and downs of life. Knowledge, skills, and experiences of real-life events appear to have disappeared, taken over by all matters VR. People appear to be distracted from solving their real-life issues by a VR domination that cancels all things human. There are no real feelings for real people. The real world is much slower than VR. People who are primarily in that environment ultimately lose their sense of reality, for example, in terms of speed and realistic limitations. The human brain drives human behavior and it is not clear in how far VR influences the brain and what potential consequences are.

## Literature

According to Rubin [3], VR has grown over recent years to become the biggest technological innovation. VR is already deployed in everyday life in areas such as entertainment, travel, education and real estate but also in the medical profession. Rubin suggests that the human brain can be fooled by virtual experiences 'that it triggers the body to respond as though the experience were real' (page 4). Associated reactions such as emotional, cognitive and psychological, in the virtual world, appear to change human beings and their brains in fundamental ways. For example, if people's senses can be manipulated to perceive and behave in the virtual world just like the real world, then it is possible to trick or overrule the rational human brain, too. This is the cognitive con referred to as 'presence'. Presence can affect emotional and physical responses and as such people's memory, in particular the explicit memory called episodic (experience-based). Clinical research in Germany (2017) considers that VR has the 'ability to deliver perfectly tuned simulations of real-life experiences' (page 140), thus 'VR could induce reactions and memories indistinguishable from real-life memories' (page 140). This appears to validate, subject to clarification, that VR could be used in an area such as mnemonics (study and development of systems in order to improve and assist the memory). Rubin argues that the more people work with VR, the stronger their memory becomes. Quoting the work of four researchers from the US (2010), Rubin reports that their application of an experiential research design to elicit evidence of what creates presence in VR users, concludes that five categories create this user experience: sensory (visual and haptic/sense of touch), cognitive (mental engagement), affective (emotional response), active (empathy) and relational (social aspects). Lanier [4] suggests that VR is a means of creating complete illusions giving the impressions that people actually are in different places. This can take the form of, for example, appearing to be in a non-human body or being in a totally different environment. The application of VR environments helps researchers, too, to understand better what a human being actually is in terms of cognition and perception. According to Lanier, based on many years of pushing the transformative power of modern technology to its limits, VR is 'The substitution of the interface between a person and the physical environment with an interface to a simulated environment' (page 47). It appears that some VR fanatics suggest that VR will eventually overtake the human nervous system and that there should then be no further necessity to improve VR any further. Lanier refutes such notion. The human nervous system is far superior than any VR system can ever be. It benefits from hundreds of millions of years of evolution and is designed to 'tune itself to the quantum limit of reality in special cases already' (page 49). The knowledge human beings already have about their bodies and physical reality surpasses what VR can ever have. It appears and is suggested that VR cannot fool the human brain indefinitely. Human cognition is in motion and is likely to overtake any progress in VR over time. Lanier argues that the human nervous system is holistic whereas VR makes the brain believe, for a while, that the virtual world is real. VR is the technology that exposes people to themselves. It is a kind of proof that people are real. Olson [5] considers that with the help of VR, people can get much closer to their own mind as they have ever done before. To achieve equilibrium and to endure success, Nash & Stevenson [5] suggest that people should aim for sustainable, enduring success throughout their lives, across the following four main spheres of self, family, work and community: Happiness-Achievement-Legacy-Significance. People who regularly review their goals and adjust their habits, appear to be making better progress. It is all about doing rather than talking:

cue → routine/habit → reward [7]

Positive mental attitudes and habits lead to a more fulfilling life. The human brain can be trained and therefore re-shaped irrespective of age. Efforts to change the way people think is similar to physical exercise to improve the body. VR has the true potential to help people create new positive habits and improve ways of thinking and being (based on the research conducted by Seligman et al. [8]. Eschen et al. [9] report that recent technological advances in areas such as VR and Augmented Reality (AR) have led to potential increases in areas such as employee training, remote aviation maintenance or inspection and assembly processes [10-12]. AV and VR form part of Mixed Reality (MR). MR combines the physical with the digital world and sits between the extremes of real world and virtual world (Figure 2).

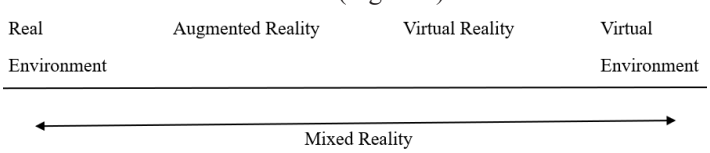


**Figure 2:** Mixed Reality Continuum [9].

Kaku [13] suggests that the human brain/mind is still one of the greatest and most mysterious forces in the world. It appears that the introduction of a variety of advanced brain scanning machines

such as magnetic resonance imaging (MRI), electroencephalogram (EEG) and deep brain stimulation (DBS), has transformed neuroscience significantly. More is known today about the human brain than in all previous times in the history of mankind. The human mind is at the forefront and no longer considered out of reach.

Applying, for example, MRI scans, it is possible to read thoughts circulating in the brain. Less-able people such as paralyzed patients, with the help of an inserted chip in their brains, can surf the web, read and write messages, control their wheelchair, operate household appliances and manipulate mechanical arms. Such patients can almost function in the same way as a more-able person can. Kaku quotes the work of neurosurgeon Dr Wilder G. Penfield (1891-1976) who discovered in the 1930s that electrical pathways connected the brain to the body and that by stimulating parts of the temporal lobe, patients experienced the revival of long-forgotten memories as if they had just happened. MRI scans have also provided new evidence of cognitive impairment of mental diseases such as Alzheimer's, Parkinson's and schizophrenia. Another tool, originally used by Dr Penfield in a crude form, is known as deep brain stimulation (DBS).

It can be used to treat mental disorders mentioned earlier. Kaku concludes that, based on the contemporary views of neurologists, 'What is missing, they pointed out, is the middle ground, where most of the interesting brain activity takes place. It is in this middle ground, involving the pathways of thousands to millions of neurons, that there are huge gaps in our understanding of mental disease and behavior' (page 251). Kaku suggests to find the origins of certain mental disorders as it appears that many of these are caused by misconnection at molecular/cellular level. 'The world of the future will be the world of the mind' (page 320).

According to some research conducted by Blissing et al. [14], the performance and behavior of MR and VR systems are almost exclusively determined by the display techniques used to present the computer-generated graphics. There are a number of display techniques that can be applied to create images for AR, MR and VR. One option appears to be the use of a head-mounted display (HMD) to present visual cues to users, deploying either an optical see-through HMD [15], a video see-through HMD [16] or an opaque HMD for pure virtual worlds [17].

Blissing et al. suggest that the main challenge for future VR, AR and MR systems are in the areas of latency and improved tracking. A major priority must be to reduce the visual latency to remedy the misalignment between real and virtual objects. Pulijala et al. [18] report that the purpose of their trial was to establish what effect the use of VR surgery would have on the self-confidence and knowledge of surgical residents. The study group participants showed substantial perceived self-confidence levels compared to a non-VR group. The conclusion from this trial purports that Immersed VR (iVR) experiences enhance knowledge and self-confidence of the surgical residents. Ip et al. [19] argue that, for example, shortfalls in social-emotional reciprocity (one of the diagnostic criteria of Autism Spectrum Disorder (ASD), prevents children from responding appropriately so they can adjust themselves in different social situations. The outcome of their study demonstrates that it is possible to use VR for the training of children with ASD. It appears that it is feasible to improve social skills, emotional expressions and regulation of autistic children through appropriate VR training. Turner & Casey [20] report that the application of VR in psychological interventions has only been on the increase recently [21,22]. It appears that significant advantages have been achieved in areas such as computer graphics, speed and processing power and head-mounted displays (HMD).

It is possible to engage in psychological and behavioral change in new and creative ways. Applying actions similar to face to face interviewing, VR can be used (and tailor-made) to identify a number of different psychological disorders and behavioral issues. Although research results have been promising, more research is suggested necessary to generalize whether findings can be generalized to VR interventions. Hesse et al. [23] consider that the application of psychological therapies such as cognitive behavioral therapy (CBT) in VR environments can help people with abnormal thinking and perceptions (psychotic disorders). VR, in this context, provides a computer-controlled environment and immerses participants' senses by a head-mounted display (HMD) and headphones. A so-called head-tracker simulates head movements within an HMD egocentric view. Complex, for example, social scenarios, can be presented in a controlled way. VR allows for avatars to be used to whose behavior can be controlled down to minute details. It is thus possible to induce social interactions with maximum therapeutic benefits. Foreman & Pollard [24] report that the main focus of cognitive therapy is how information is processed by the human brain, how this information is then processed and stored, and how the human brain integrates new information with existing. Cognitive therapy is concerned with gaining a much better understanding how the human brain thinks. People's behavior and emotions are driven by their perceptions of what is happening around them. It is possible to apply this knowledge for the benefit of people with psychological disorders who require treatment. The interaction of thoughts, emotions, behaviors and physical states appear to be the cause and reason why cognitive difficulties are maintained by the human brain. Cognitive behavioral therapy is considered to be particularly effective for mental health issues such as anxiety, depression, phobias and post-traumatic stress. Foreman and Pollard argue that an antecedent or trigger event generates an emotional reaction. This is based on people's beliefs and leads to an evaluation of the event and any potential causes or meaning. The final stage is the consequence of how people view the event and this leads to their emotional or behavioral reaction to it (Table 2).

| The ABC of… | CBT |
|---|---|
| Antecedent | Trigger event or occurrence which appears to lead to an emotional reaction |
| Beliefs | Beliefs, thoughts and interpretation or evaluation of that event and its possible causes or meaning |
| Consequences | Consequences of that way of viewing the event-people's emotional or behavioral reaction to it |

**Table 2:** The ABC of CBT (adopted from Foreman & Pollard, [24]).

## Knowledge Gap

The literature review from this current research has confirmed that there is a potential to engage VR technology to develop solutions to reduce or eliminate brain injuries, for example, following an accident, and mental disorders such as dementia, Alzheimer's, Creutzfeldt-Jacob and autism. The outcome of the literature review has been valuable but not conclusive on its own how to achieve this ambition. Insights regarding the application of VR from contemporary psychology students, both at practical and theoretical level, provided valuable suggestions about the future role of VR and how this technology could be applied to improve people's mental health. Practical insights from cognitive rehabilitation therapists provided additional contributions to identify how appropriate applications of VR could ameliorate, for example, traumatic brain injuries.

## Main Research Questions/Hypotheses

The main questions for this research are:

1. What is the definition of Virtual Reality (VR) in the context of this research?
2. What are the potential and realistic areas VR can be applied in to enhance people's lives, in accordance with the research limitations of this research?
3. Can VR systems be modified to meet the individual needs of people as one size does not appear to fit all? How flexible are VR systems?
4. What are the practical implications from the outcome of this research at global level, in the area of mnemonics?
5. Does a potential gap exist between what can be achieved in reality and in non-reality environments to improve people's social lives?
6. Does VR facilitate social interaction? What are the benefits?

The following hypotheses were constructed:

**H1:** VR technology can be applied and used by people of all ages and both sexes. Age and gender are not affected by this nor does this produce any short- or long-term adverse side effects.

**H2:** Neurological changes to the human brain as a direct result of exposure to VR are permanent. The activation of new brain cells and any regeneration of existing cells is lasting.

**H3:** VR memory experiences do positively affect the brain's episodic memory. Perfectly tuned VR simulations based on real-life experiences can induce reactions and memories in the human brain that can, ultimately, lead to reductions/eliminations of mental disorders and improve brain injury behavior/rehabilitation therapy.

# Research Methodology

## Method

The researchers considered that a critical text interpretation approach (a priori) and the collection of primary research data originating from face to face interviews, within a constructivist interpretivist research paradigm, was most appropriate. The aim was to uncover what was already known about the subject matter under investigation and to capture the contemporary thoughts and opinions of research participants. It was of paramount importance to the researchers to get close to the subject matter under investigation within the characteristics of what they considered to be a socially constructed world.

A related applied representation of the experiences and choices of practitioners allowed for the inclusion of the practical real-life experiences (a posteriori) of the interviewees. It appears that this strengthened the a priori outcomes from the literature review by presenting new thinking into the subject matter under investigation. Face to face interviews formed an important part of this investigation to bring theory (literature review) and practice (face to face interviews) closer together and to answer the questions and hypotheses from Section 1.4.

Table 3 is a summary of the questions asked during the face to face interviews with the research participants from the 'Escola Superior Politécnica do Bié, Provincia Bié, Angola. All participating students were students of Psychology, including studies in Social Psychology during years 2 and 3. All answers were recorded in writing or electronically where possible. Students provided their full approval including the use of first names in Section 3.1. 20 undergraduate students were interviewed during March 2019. Of these 6 were female (30%) and 14 were male (70%). Their age ranged from 19 to 33 years. 8 were undergraduate psychology students in their second year (40%) and 12 (60%) in their final year. All students had extensive experience in the areas of psychology/social psychology and their own work experiences. They provided valuable insights for this research. Cognitive Rehabilitation Therapists (CRT) from Headway, Swindon, UK, participated in this research.

The center provides a safe and relaxed environment for adults who have experienced a brain injury. The application of CRT will enhance the competence of experiencing real life situations and allowing individuals to increase their self-esteem and self-confidence. Their ongoing aim is to enable and support people to reach their potential through the use of CRT. Interviewees had many years of practical CRT application between them and held recognized certificates in CRT. Table 4 shows a summary of the questions asked during the face to face interviews.

| |
|---|
| How can Virtual Reality (VR) help people to improve their social lives? |
| What are the potential and realistic areas VR can be applied in to enhance people's lives, in accordance with the research limitations of this research? |
| Can VR systems be modified to meet the individual needs of people as one size does not appear to fit all? How flexible are VR systems? |
| What are the practical implications from the outcome of this research at global level, in the area of mnemonics? |
| Does a potential gap exist between what can be achieved in reality and in non-reality environments to improve people's social lives? |
| Does VR facilitate social interaction? What are the benefits? |

**Table 3:** Face to Face Interview Questionnaire for Student Participants.

| |
|---|
| Can regular/extended exposure to VR positively influence the human brain to activate dormant/or create new neurological connections, to aid reversion of mental disorders such as dementia and Alzheimer's? |
| Considering VR, medicines and infra-red laser stimulation: which of these is most likely to succeed, with the least potential side-effects (short, medium and long term)? |
| What are your personal views on using VR in your area of expertise, including any ethical/moral implications? |

**Table 4:** Face to Face Interview Questionnaire for Cognitive Rehabilitation Therapy Participants.

### Data Collection and Interpretation

The researchers considered two approaches to obtain and collect appropriate research data to answer the research questions and hypotheses from Section 1.4: a literature review (Section 1.2) and face to face interviews (Section 3), within the context of a philosophical study of experience and consciousness and an associated constructivist interpretivist research approach. The results from each of the applied research approaches contributed to answer the main questions and to confirm the hypotheses from Section 1.4. The findings from each of the research approaches focused on an evidential analysis and interpretation of the collected research data. These were enriched by the current view contributions from the interviewees and enabled a balanced view to be presented. A consistent and methodical approach was applied to conduct all interviews. The researchers ensured that sufficient supportive evidential data was generated by the interview participants, leading to increased data reliability and validity.

## Results

Face to Face Interviews with Students

### How can Virtual Reality (VR) help people to improve their social lives?

'Virtual Reality (VR) is made up of a group of technological systems that have been implemented to aid knowledge sharing through non-real environments for the benefit of modern society and its optimum functioning' (Celso, Ermes, Antonio and Albertina). 'VR can allow us to interact with people who are not with us, and it provides a means of quick access to life-like training, for example' (Modest, Count, Nelsa, Dominich and Mario). 'It is about understanding how people live and communicate in our current world and then applying this knowledge to create a virtual environment to improve it' (Januario, Assuncao and Laurinda).

### What are the potential and realistic areas VR can be applied in to enhance people's lives, in accordance with the research limitations of this research?

'VR can be applied in all areas of society, and of course, academia, medics and technology' (Ermes, Amadeu and Samuel).

'It should be developed and applied in three areas: education (improve learning and increase knowledge), at work (to improve productivity) and society (improve people's relationships in different socio-cultural contexts and general well-being such as health)' (Filipe, Antonia, Mario, Ernesto, Paulo, Joao and Olivio).

'I am concerned about information security and how this could be misused by Governments to exercise more control over people' (Celso).

### Can VR systems be modified to meet the individual needs of people as one size does not appear to fit all? How flexible are VR systems?

'VR's main area of contribution is in science. Science affects all our lives and this is where I see VR will make, over time, significant differences to how people live, work and think' (Count). 'VR systems need to be modified to be fast, cheap and easily accessible by all people world-wide, including free access to treat mental disorders to improve people's social lives'(Ermes, Amadeu, Count, Januario, Laurinda and Paulo). 'From a security and safety point of view, VR systems must be made secure to safeguard personal information and data. This includes medical records of patients, for example, where VR is applied to treat mental disorders' (Celso, Nelsa and Albertina).

### What are the practical implications from the outcome of this research at global level, in the area of mnemonics?

'VR can make a big difference to assist and improve with the future memory development in human beings' (Amadeu, Filipe, Ernesto and Olivio). 'It can help people to become more misinformed and thus help human beings' societal developments' (Count, Modest, Samuel, Mario and Joao). 'VR can become a threat to people and societies they live in due to indoctrination of people through deliberate misrepresentation of facts' (Celso, Nelsa, Januario and Antonia).

### Does a potential gap exist between what can be achieved in reality and in non-reality environments to improve people's social lives?

'In VR, knowledge can be shared with a much bigger audience in terms of content and group size, including so-called hidden knowledge' (Amadeu and Dominich). 'The difference is that in reality we can improve the lives of people only at the real level. At VR level, this would always be very subjective due to the nature of the non-real environments' (Ermes, Count, Celso, Filipe and Januario). 'In reality, individuals live with their feet on the ground and in line with accepted social norms. In VR, people can create things without thinking too much about the social consequences' (Assuncao, Antonia, Laurinda and Olivio).

### Does VR facilitate social interaction? What are the benefits?

'VR certainly facilitates social interaction through much faster communications and increased levels of sharing new knowledge' (Antonio, Count, Nelsa, Paulo and Olivio). 'The exchange of experience for me is of paramount importance. This is driven by the ability of VR to allow us to visit places we could never visit in reality du to physical limitations' (Amadeu, Ermes, Modest and Dominich). 'VR enables us to improve the society we live in. We can increase our knowledge of social habits and customs of people much quicker and better, thus allowing us to improve the societies we live in' (Filipe, Assuncao, Laurinda, Ernesto and Joao).

Face to Face Interviews with Cognitive Rehabilitation Therapists

**Can regular/extended exposure to VR positively influence the human brain to activate dormant/or create new neurological connections, to aid reversion of mental disorders such as dementia and Alzheimer's?**

'Yes, I believe that some regular exposure to VR can influence the human brain, over time, into thinking that some neurological connections could actually work well again. I am not sure if this could, ultimately, act as a prevention to cure mental disorders. I think that it is possible that a damaged human brain would benefit from VR. The application of re-learning through practice could be greatly enhanced by applying VR technology. For example, people who suffer from physical/speech deficiencies following an accident or stroke, could benefit from VR as this technology would allow for faster incremental rates of change (the first two years after an incident are crucial for the recovery process)' (Sonja). 'Cognitive Rehabilitation Therapy would benefit from a VR application trial, say, something like four weeks, conducting a variety of exercises depending on the level of brain injury. This could be done in addition to or in parallel with current therapy practices such as mirror therapy (box with two mirrors that supports therapists, for example, to improve movement of limbs after a stroke). In addition, VR could be used at patients' homes to increase so-called feel-good-factors. This is particularly useful to help people regain social abilities and even bring back old memories with the help of VR. Peoples' confidence in going out such as shopping could also be improved by creating virtual shops similar to the ones near peoples' homes' (Jane). 'It's about bringing the real world to theory, too, so it can work for the benefit of both!' (Sonja; Jane).

**Considering VR, medicines and infra-red laser stimulation: which of these is most likely to succeed, with the least potential side-effects (short, medium and long term)?**

'Looking at the various approaches, it appears that VR is probably the safest method. The use of a VR headset creates virtual images only and this appears to be relatively safe for use into tricking the human brain to believe, for example, that certain neurons are still ready to function' (Sonja). 'I prefer VR to other interventions such as medicine or infra-red laser stimulation, as there is less control over any potential consequences' (Jane). 'There is a high level of risk when applying something like infra-red laser stimulation. Whilst it appears that this method produces some beneficial effects in areas such as memory and mood, it also has the capability to augment the functioning of neurons in such a way that these become uncontrolled and perhaps this will lead to irreversible consequences we can then not correct' (Sonja; Jane).'Taking both advantages and disadvantages of each approach into consideration, I am still not sure whether VR is too realistic or perhaps too pretty? This also raises the question whether real life is not good enough' (Sonja; Jane).

**What are your personal views on using VR in your area of expertise, including any ethical/moral implications?**

'The use and application of VR in the area of human brain intervention needs to be carefully controlled and regulated. People are unique and perhaps this status should not be changed. People are vulnerable, particularly after a brain injury. They are more likely to become more out of touch with reality and any inappropriate application of VR could make things worse for them' (Sonja). 'Misuse of trust springs to mind. Like any other software application, VR can be misused by others to gain the trust of vulnerable people and this could lead to serious invasions of privacy. Software safeguards would be needed to combat hacking opportunities' (Jane). 'VR could be used in Cognitive Rehabilitation Therapy in a generic format first, perhaps tailor-made to suit the needs of individuals as best as possible. An initial safe environment would be of paramount importance' (Sonja; Jane). 'Programs could be written to address specific issues people have in areas such as emotions and personalities, using real life experiences to give this some real authenticity' (Jane). 'VR has the potential to underpin cognitive rehabilitation therapy in a very positive way. The two are complementary. VR would allow for the introduction of lots more areas relevant to rehabilitation in a more realistic way. Typical areas can include people's interests and hobbies' (Sonja).' In summary, the application of VR within the area of cognitive rehabilitation would make a substantial difference to the effective treatment of people with brain injuries. Funding will be needed to purchase the relevant equipment and software plus ongoing maintenance. VR treatments should be free for patients irrespective of their social backgrounds' (Sonja; Jane).

| Area of Decline | VR Applications | Ranking |
|---|---|---|
| Dementia/ Alzheimer's/ Creutzfeldt-Jacob/Autism | Combine MRI, VR and DBS technologies to identify and correct cognitive impairments | Considered important by the literature review |
| | Improve social skills, emotional expressions and regulation of autistic children through appropriate VR training | Identified by all parties as being important * |
| Behaviour | Link opto-genetics to VR to improve and control long and short term behavior | Identified by all parties as being important * |
| Limb Movement Disorders/ Artificial Limbs | Retrain the nervous system (motor learning) to improve arm/leg movements via the muscles following spinal cord injuries | Considered important by the literature review |
| | Provide the human brain with motor learning capabilities, for the operation of exoskeletons, to enable people who are totally paralyzed to lead normal lives | Considered important by the literature review |
| Attitudes | To improve social skills, emotional expressions and psychological disorders through the appropriate application of immersed VR-based training | Identified by all parties as being important * |
| Cognitive Rehabilitation Therapy (CRT)/ Cognitive Behavior Therapy (CBT) | Link VR to CRT to create social environments, for example, in a controlled way, to assist people with abnormal thinking and perceptions (psychotic disorders) | Identified by all parties as being important * |
| | Provide re-learning applications through practice, to improve the mental well after accident injuries | |

**Table 5:** Application and Ranking of Considered Solutions. *=Literature

Review and Face to Face Interviews.

## Discussion

It appears that VR has an inherent potential to become the new and safe means of eliminating, or at least reducing, known mental disorders such as dementia and Alzheimer's. This technology would be of equal benefit to cognitive rehabilitation/behavior patients (discussed below).

Contrary to current and considered interventions to cure the mentioned mental disorders, namely infra-red laser stimulation of the pre-frontal cortex, blending of human DNA with animal DNA or prescribing so-called Alzheimer's drugs, VR has a number of distinct advantages over these current approaches. Applications are considered to be safe and it is possible to reverse treatment effects. Interventions are not physical as is the case with infra-red laser treatment and there appear to be no side effects as is the case with so-called Alzheimer's drugs (such as loss of appetite, tiredness or loss of sleep).

All known alternative treatments to reduce or eliminate mental disorders carry side effects and risks that could ultimately lead to some genetic disorders, particularly where the mixing/blending of DNA is concerned. Mixing of human and animal DNA carries some ethical considerations that should be taken into account before such practices are applied. For example, blending human with animal DNA that has prevented animals from developing diseases such as Alzheimer's and Dementia as they aged, carries unknown risks and side effects. Research would need to be conducted to confirm/deny such evidence before proceeding to controlled experiments with human volunteers. VR technology, basic during its early development and infancy phases, has seen substantial transformations over recent years, leading to permutation opportunities in areas such as augmented and mixed VR. Many parts of human life already benefit from VR including medical applications in areas such as dentistry, pain management and haptic surgery (using the senses of touch and motion).

Applying VR to eliminate or reduce mental disorders such as Dementia, Alzheimer's, Creutzfeldt-Jacob and autism appears to be a natural, safe and ethically-acceptable progression to improve the social lives of people affected by these disorders. The human brain can be stimulated to reinstate dormant neurons, to create new neurological connections and to improve 'faulty' or 'misguided' neural connections that lead to improved signal connections and reductions in neuro-degeneration. VR provides people who experienced brain injuries or loss of limbs/feelings in limbs a far greater user experience than, for example, psychiatric treatments. VR offers a much higher level of realism and can transfer results to the real world with ease.

In this respect, VR can be applied to a wider range of disorders including fear conditions, anxiety disorders and brain injuries. Cognitive rehabilitation and behavior therapists would be able to create, much more realistically, small doses of, for example, fear environments or objects. Over time, increased anxiety-provoking environments can be created to guide patients towards taking control of their fears and anxieties. It is possible for VR to enhance an existing cognitive rehabilitation therapy known as the mirror box application (reduction of phantom limb pain/inability to move by engaging the symmetric limb).

Currently, sensorimotor signals from the functioning side of the brain are engaged rather than the disordered signals of the malfunctioning/amputated limb. VR can correct this by focusing, for example, on the limb stump, making sure that the correct side of the brain receives movement feedback. The visual side of the brain will be forced into thinking that a virtual link exists, thus improving its perception that both limbs are functioning properly. The application of the various forms of VR carry some legal and ethical considerations and issues. IP rights are considered the most important legal issues associated with the use of VR.

For example, does the creation of a virtual restaurant such as Burger King violate the trademark registration in a virtual world? It is necessary to consider any potential harm one user of VR technology can cause to another user, for example, by getting close to them in the virtual world and potentially causing real harm in the real world as a direct result of the interaction.

There are also potential privacy and security issues such as: What personal data will be collected during VR applications? Could the application, unintentionally, create dangerous situations for users? It appears that there are no solutions in place today but that future incidents may drive the need for solutions when the societal need for these has been recognized. Another ethical consideration relates to the creation of multiple personalities in order to improve cognitive rehabilitation/behavior therapy, for example, by creating multiple personalities within accident brain injury patients to help them regenerate their self-confidence levels. There appears to be insufficient evidence whether such an approach could become acceptable to enhance the cognitive rehabilitation of brain injury patients. VR technology needs to be available to people of all walks of life irrespective of their social status.

Generally, the cost of VR technology has come down substantially. This is reflected in its use in industries other than the traditional association with gaming. Soon the daily use of VR will cost no more than prescribing medicine but with the added value that VR fixes the root causes and not just the symptoms, leading to both short- and long-term permanent remedies without, it appears, any known side effects. For example, Nursing Homes and brain injury rehabilitation centers would benefit from having access to VR technology to help mental, brain injury and neuro-motive disorder patients more effectively. Social Psychology needs to respond proactively to these technological advancements and play a far greater role driving through the application of VR to improve the social lives of people who suffer from the aforementioned mental disorders. The three hypotheses of this research are supported by strength of evidence from the literature review and face to face interviews (Table 6).

| Hypothesis | Related Question (s) | Results |
|---|---|---|
| **H1:** VR technology can be applied and used by people of all ages and both sexes. Age and gender are not affected by this nor does this produce any short- or long-term adverse side effects. | 1. What is the definition of Virtual Reality (VR) in the context of this research?<br>2. What are the potential and realistic areas VR can be applied in to enhance people's lives, in accordance with the research limitations of this research?<br>3. Can VR systems be modified to meet the individual needs of people as one size does not appear to fit all? How flexible are VR systems?<br>5. Does a potential gap exist between what can be achieved in reality and in non-reality environments to improve people's social lives?<br>6. Does VR facilitate social interaction? What are the benefits? | The evaluation of the literature concluded that VR technology can be used by people irrespective of their age, gender or sex. The face to face interviews concluded that VR applications need to be 'tailor made' to suit the needs of individuals, for example, in areas such as mental disorders and cognitive rehabilitation therapy. The literature review provided conclusive evidence that the application of VR does not carry any short- or long-term side effects, as no physical, surgical or medicinal interventions are applied. Hesse et al. (2017) suggest that further research should be conducted to give these claims more purport. |
| **H2:** Neurological changes to the human brain as a direct result of exposure to VR are permanent. The activation of new brain cells and any regeneration of existing cells is lasting. | 2. What are the potential and realistic areas VR can be applied in to enhance people's lives, in accordance with the research limitations of this research?<br>3. Can VR systems be modified to meet the individual needs of people as one size does not appear to fit all? How flexible are VR systems? | The literature review was positively conclusive and provided sufficient valid and reliable evidence that suggests that the application of VR leads to permanent neurological changes. It appears that regeneration is possible by developing and applying a VR program that has the capability to achieve a neurological return to a previous state. |
| **H3:** VR memory experiences do positively affect the brain's episodic (personal experience) memory. Perfectly tuned VR simulations based on real-life experiences can induce reactions and memories in the human brain that can, ultimately, lead to reductions/eliminations of mental disorders and improve brain injury rehabilitation therapy. | 2. What are the potential and realistic areas VR can be applied in to enhance people's lives, in accordance with the research limitations of this research?<br>4. What are the practical implications from the outcome of this research at global level, in the area of mnemonics?<br>5. Does a potential gap exist between what can be achieved in reality and in non-reality environments to improve people's social lives? | The literature provided conclusive evidence that VR-deployed and applied memory improvement interventions in the area of autobiographical events lead to increases in the human brain's ability to collect and retain:<br>1. Personal experiences<br>2. Facts about the world around people including general knowledge<br>People who experienced brain injuries would benefit from this VR application. They would be able to travel back in time to re-experience past events. It is possible to relearn old cognitive skills or to learn new ones to compensate for lost ones. |

**Table 6:** Hypotheses and Questions: Summary of Results.

## Conclusion

It is possible to make VR, in its various forms, become the de facto standard for the short- and long-term cure or management of mental disorders and brain injuries. Virtual Reality is a fast-paced and dynamic technology that has the capacity and capability to be engaged in lieu of other existing applications such as medicine or infra-red laser stimulation that appear to carry undesirable side effects. A considerable amount of effort is required by a number of parties such as social psychology and society to make this happen. It is imperative that these parties act in the best interest of others and with only one aim: to improve the health and social lives of people irrespective of the societal standing and social background of these. Putting people's needs before profit approach is of paramount importance.

Social Psychology needs to facilitate the coming together of VR technology, mental disorders/brain injuries and people to ensure those in need receive the treatment they deserve to improve their mental disorder conditions. Society in itself, with the help and support from social psychology, needs to consider to adopt VR as a means to eliminate or improve mental disorders and to improve brain injury recovery. This means that an education programme needs to be developed and rolled out by social psychology, in conjunction with the manufacturers of VR, to bring this technology not only into people's homes, in an informed and positive way, but also to extend its use and application into institutions such as specialist mental health centers, nursing homes, learning disabilities day centers and brain injury rehabilitation centers.

Manufacturers have a social responsibility to reduce the production and maintenance costs of the VR technology so that this technology becomes more affordable over time. It appears that there are currently no Intellectual Property (IP) issues associated with the use of VR, for example, in medical applications such as brain injury rehabilitation (creating virtual environments that use real set ups such as known restaurants and shops). The legal profession needs to conduct some extensive research/audits to ascertain facts about potential VR claims in areas such as IP and personal injury, in readiness for potential increased use of VR technology in the medical areas suggested by this research.

More research is suggested necessary to investigate and confirm whether any regular application and exposure to VR has any side effects and potential negative consequences to sufferers of mental disorders. Further research is necessary to gain a better understanding of how practising neurosurgeons and neurologists view the potential application of VR to eliminate/reduce mental disorders and brain injuries. Capturing the views, knowledge and practical experiences of subject matter experts would provide valuable insights of how this could be achieved with the use of VR technology. The researchers confirm that the research questions from Section 1.4 have been answered and that the hypotheses from Section 1.4 hold true.

## Acknowledgments

The corresponding author wishes to thank the Escola Superior Politécnica do Bié, Provincia Bié, Angola for providing access

to interview students from the Faculty of Psychology outside of formal teaching hours to assist with the completion of this research. Special thanks go to Jane Weston and Sonja de Blaquire from Headway in Swindon for providing valuable insights how VR could benefit their specialist area of Cognitive Rehabilitation Therapy (CRT).

## References

1. Martens AL, Grover CA, Saucier DA, et al. An examination of gender differences versus similarities in a virtual world, Computers in Human Behavior. 2018; 84: 404-409.
2. Foundry Vision-mongers Organization, Virtual Reality, accessed on 6 May 2018.
3. Rubin P. Future Presence-How Virtual Reality is Changing Human Connection, Intimacy, And the Limits of Ordinary Life, Harper One. 2018.
4. Lanier J. Dawn of The New Everything-A Journey Through Virtual Reality, The Bodley Head, London. 2017.
5. Olson DA. Success-The Psychology of Achievement, Dorlin Kindersley Ltd, Penguin Random House. 2017.
6. Nash L, Stevenson H. Success That Lasts, Harvard Business Review, February. 2004; 102-109.
7. Fisher E, Santana González Y. Actions Speak Louder than Words: Stop Talking-Do! The role of Social Psychology to turn Talkers into Doers to Nourish Organizational Behavior, Business and Economic Research. Macro Think Institute. 2018; 8: 25-44.
8. Seligman M E P, Steen T A, Park N, et al. Positive Psychology Progress, American Psychologist. 2005; 60: 410-421.
9. Eschen H, Koetter T, Rodeck R, et al. Augmented and Virtual Reality for Inspection and Maintenance Processes in the Aviation Industry, Procedia Manufacturing. 2018; 19: 156-163.
10. Bacim F, Ragan E, Scerbo S, et al. The effect of display fidelity, visual complexity, and task scope on special understanding of 3 d graphs, Proceedings of Graphics Interface. 2013; 25-32.
11. Bischoff R, Kazi A. Perspectives on augmented reality based human-robot interaction with industrial robots, IEEE/RSJ Int. Conference on Intelligent Robots and Systems (IROS). 2004.
12. Chong J, Ong SK, Nee A, et al. Robot programming using augmented reality: An interactive method for planning collision-free paths Robotics and Computer-integrated Manufacturing. 2009; 25: 689-701.
13. Kaku M. The Future Mind-The Scientific Quest to Understand, Enhance and Empower the Mind, Penguin Books. 2014.
14. Blissing, B, Bruzelius F, Eriksson O. Driver behavior in mixed and virtual reality-A comparative study, Transportation Research Part F. 2017.
15. Bock T, Maurer M, Faerber G. Validation of the Vehicle in the Loop (VIL)-A milestone for the simulation of driver assistance systems, In Proceedings of the 2007 IEEE intelligent vehicles symposium. Istanbul, Turkey: IEEE. 2007; 219-224.
16. Berg G, Millhoff T, Faerber B. Vehicle in the Loop-Zurueck zur erweiterten Realitaet mittels video-see-through. Fahrer im 21. Jahrhundert. 2013; 2205: 225-236.
17. Karl I, Berg G, Ruger F, et al. Driving behaviour and simulator sickness while driving the vehicle in the loop: Validation of the longitudinal driving behaviour, IEEE Intelligent Transportation Systems Magazine. 2013; 5: 42-57.
18. Pulijala Y, Ma M, Pears, et al. Effectiveness Immersive Virtual Reality in Surgical Training-A Randomized Control Trial, Journal of Oral Maxillofac Surg. 2018; 76: 1065-1072.
19. Ip HHS, Wong SWL, Chan, et al. Enhance emotional and social adaptation skills for children with autism spectrum disorder: A virtual reality enable approach, Computers and Education. 2018; 117: 1-15.
20. Turner W A, Casey LM. Outcomes associated with virtual reality in psychological interventions: where are we now? Clinical Psychology Review. 2014; 34: 634-644.
21. Gorini A, Riva C. Virtual Reality in anxiety disorders: the past and the future. 2008; 8: 215-233.
22. Repetto C, Riva G. From virtual reality to inter-reality in the treatment of anxiety disorders, Neuropsychiatry. 2011; 1: 31-43.
23. Hesse K, Schroeder PA, Scheeff J, et al. Experimental variation of social stress in virtual reality-Feasibility and first results in patients with psychotic disorders. J Behav Ther & Exp Psychiat. 2017; 56: 129-136.
24. Foreman EI, Pollard C. CBT-Cognitive Behavioural Therapy, Icon Books Ltd. 2016.