VIRTUAL REALITY AS A TOOL FOR VOCATIONAL INTERVENTION: A SYSTEMATIC LITERATURE REVIEW

A Thesis submitted by

Jessica Anne Francis, BApSc (Occupational Therapy)

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ABSTRACT

The right to employment exists as a part of the Universal Declaration of Human Rights, and rightly so, given the enormous benefits of meaningful employment to individuals and society. Traditionally vocational rehabilitation, which can be defined as health intervention focussed at enabling people into employment, , has involved face to face therapy with varied results and costs. However, with the development of technology the exploration of alternative intervention modalities has become a possibility. The development of immersive technologies, such as Virtual Reality (VR), open up the potential for job and functional training in a controlled, gradable and safe environment. This has led to the rapid uptake of VR by industry for work-related training, but with little alignment to academia and evidence-based practice. This systematic literature review aimed to determine whether VR was an effective intervention tool for vocational rehabilitation. Additional goals were to determine the most effective type of VR tool, and the best dosage of intervention for outcomes. Finally, the systematic review set out to determine whether VR vocational interventions were more effective than face to face, or traditional, vocational interventions. Results revealed that VR in the vocational intervention space is in an emerging state, with positive results indicated for eliciting vocational outcomes, including employment outcomes as well as improved self-efficacy outcomes. In addition, the systematic review demonstrated positive outcomes in regard to cognitive function. However, the limited volume and strength of the results indicates that further research is required to determine whether VR is effective as an intervention tool for vocational rehabilitation. Additionally, the recommended type and dosage of VR intervention was unable to be determined due to the heterogeneity across the studies reviewed. Finally, whether VR vocational intervention is more effective than face to face intervention is yet to be seen, with only one study using these conditions as comparators. Overall, the results for VR as a vocational intervention tool shows promise, but definitive answers are yet to be determined with the current volume and quality of evidence available. There is growing enthusiasm within the technological and workplace training industry that VR is the new way forward for work-related training; however, this is yet to coincide with the research and evidence to back these claims.

Keywords: virtual reality, vocational rehabilitation, employment, cognition

CERTIFICATION OF THESIS

This Thesis is entirely the work of Jessica Anne Francis except where otherwise acknowledged. The work is original and has not previously been submitted for any other award, except where acknowledged.

Principal Supervisor: Erich Fein

Associate Supervisor: Neil Martin

Associate Supervisor: Zahra Izadikhah

Student and supervisors' signatures of endorsement are held at the University.

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WORKS RELATED TO MAIN CONTENT

The findings of this research were presented in a conference poster “Virtual Reality as a vocational intervention tool: A systematic literature review” at the Occupational Therapy Australia National Conference, Sydney, June 2021.

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LIST OF ABBREVIATIONS

3D	3- Dimensional
ABS	Australian Bureau of Statistics
AIVTS	Artificial intelligent virtual-reality based training program
AOTA	American Occupational Therapy Association
AR	Augmented Reality
COVID-19	Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) disease
DES	Disability Employment Services
DSM	Diagnostic and Statistical Manual of Mental Disorders
ECT	Electroconvulsive Therapy
HMD	Head Mounted Device
IQ	Intelligence Quotient
JBI	Joanna Briggs Institute
LCD	Liquid Crystal Display
LSAS	Liebowitz Social Anxiety Scale
MR	Mixed Reality
NDIA	National Disability Insurance Agency
NDIS	National Disability Insurance Scheme
PEVTS	Psycho-educational vocational training system
PTSD	Post Traumatic Stress Disorder
RQ1	Research Question 1
RQ2	Research Question 2
RQ3	Research Question 3
RQ4	Research Question 4
SADI	Self-Awareness of Deficit Interview
Sensorimotor Contingencies	SCs
TAM	Technology Acceptance Model
VR	Virtual Reality
VRVTS	Virtual-reality based vocational training system

CHAPTER 1 INTRODUCTION

Employment is a powerful tool for psychosocial wellbeing and for societal participation, it enables people to have choice and control over their lives and roles and is a key moderator in the fight against poverty and social inequity. Employment is a basic human right, and all people, with all abilities should have the right to engage in employment (International Labour Organization, 2015; United Nations, 1948). Vocational intervention programs aim to assist people to return or enter the workforce. To date programs have been delivered face to face by clinicians, with variations in effectiveness and costs. The continued advancements of technology, including immersive technologies such as Virtual Reality (VR) have enabled the exploration of alternate modes of intervention that can be used by clinicians to assist people to improve their work abilities through vocational rehabilitation. The continued exploration of intervention modalities which may have a higher efficacy, and potentially are more cost effective than traditional interventions is driven by evidence-based practice movements and the continually evolving socio-political environment in which health funding is dictated.

The narrative of VR in the workplace started in the fields of aviation, aeronautics, military, and surgical training, in fields where cutting-edge technology is accessible and can provide the competitive edge in the commercial or scientific race across the globe and into space. With the continued improvements in technology comes improvements in accessibility, and hence it is possible to consider the use of VR in these fields and translate this to fields of practice today, such as healthcare and workplaces. The purpose of this research is to understand the existing research in regard to VR as an intervention tool, and address the strengths, limitations and gaps of the extant research. This systematic literature review aims to collate the existing body of research, to understand the effectiveness of VR intervention tools for improving work ability. It is envisioned that this research could form the basis of the development of an evidence-based VR tool for clinicians to use in vocational intervention to assist in improving work abilities, particularly for people with disability.

Employment and Health Outcomes

The benefits of employment are well documented; the overwhelming volume of literature concurs that meaningful employment is linked to increased physical and mental health and wellbeing (Dutta, 2008; Evans, 2000; Modini, 2016; Repetti, 1989). Conversely, it has been shown that long term absence from work, work disability and unemployment each have negative impacts on health and wellbeing (Evans, 2000; The Royal Australasian College of Physicians, 2011). Furthermore, work has been shown to be an effective means of reducing poverty and social exclusion faced by disadvantaged populations in our society (Evans, 2000; Lindsay, 2018; The Royal Australasian College of Physicians, 2011). In addition, article 23 of the Universal Declaration of Human Rights dictates that “Everyone has the right to work, to free choice of employment, to just and favourable conditions of work and to protection against unemployment” (United Nations, 1948) and this right is upheld by the Australian Government to affirm that the right to work is afforded to all people (Australian Human Rights Commission, n.d.).

Unemployment and underemployment can have a significant impact on peoples’ physical and mental health as demonstrated thoroughly in the research, where unemployment has been linked with increased mortality rates, particularly from cardiovascular disease and suicide (Blakely, 2003; Jin, 1995; Shand, 2021; The Royal Australasian College of Physicians, 2011). Additionally, unemployment has been associated with poorer overall health (Mathers, 1998), poorer physical health including increased rates of cardiovascular disease, lung cancer, susceptibility to respiratory infections, poorer mental health (Platt, 1984), somatic complaints, long term illness and disability (The Royal Australasian College of Physicians, 2011). Vocational rehabilitation is an important health intervention to enable people to obtain and maintain employment and hence the rationale for this systematic literature review to explore alternate modalities for intervention.

Labour force statistics from the Australian Bureau of Statistics (ABS) indicate, that as of December 2019, the unemployment rate was 5.4% and the underemployment rate was 8.3% (Australian Bureau of Statistics, 2019). The ABS defines underemployment as those workers who worked less than 35 hours per week but would have preferred to work more hours (Australian Bureau of Statistics, 2011), academic literature defines underemployment as “working in a job that is below the employee’s full working capacity” P.963 (McKee-Ryan, 2011). Following the peak of the COVID-19 pandemic, whilst many countries were still experiencing significant economic and health impacts of the virus, in May 2021, the Australian unemployment rate was 5.1%, decreased from prior to the pandemic, and underemployment decreased to 7.4% (Australian Bureau of Statistics, 2021). The Australian government has confirmed a target unemployment rate within its federal budget released in 2021 of below 5% (Kehoe, 2021). The continued focus on reducing unemployment rates at a state and federal government level signifies the importance of employment within our society, that is well backed by the literature.

Disability in the context of this research is defined as “difficulty in functioning at the body, person, or societal levels, in one of more life domains, as experienced by an individual with a health condition in interaction with contextual factors” p.1220 (Leonardi, 2006). For people with disability the unemployment rates are poorer, with more people with disability experiencing unemployment than those without. As of 2020, people aged between 15 and 64 years old with disability are more likely to be unemployed than those without disability in Australia (Australian Institute of Health and Welfare, 2020). The data suggests that the unemployment rate for people with disability of working age is 10%, which is almost twice of those who do not have a disability at 5.1% (Australian Institute of Health and Welfare, 2020). Furthermore, those people with severe or profound disability are seen to have an unemployment rate of 13% compared with those with other disabilities, whose unemployment rate sits at 9% (Australian Institute of Health and Welfare, 2020). In addition to having a higher rate of unemployment, people with disability were shown to be more likely to be unemployed for longer periods than those without disability (Australian Institute of Health and Welfare, 2020). It is clear from the data that there is potential for improvement in the employment rates for people with disability, and this supports the exploration of effective intervention modalities for vocational intervention.

In Australia, a major reform into disability support and funding was launched in 2013, the National Disability Insurance Scheme (NDIS), and presently supports approximately 500,000 Australians with permanent and significant disability (NDIS, 2021b). A key tenet of the NDIS is that it is an insurance scheme which is defined as "not a welfare system" (NDIS, 2021b) and that it is designed to see people improve over time, and hence it can be assumed that improvements in independence come with a decrease in need for scheme funding. Since 2019 The NDIS has identified employment of participants of the scheme as a significant area for improvement (NDIS, 2019). This reinforces the focus and importance of employment in the lives of all Australians, including those with disability.

The National Disability Insurance Agency (NDIA), who are the agency which implement the NDIS, release a quarterly report which includes scheme outcomes and areas of focus following the completed quarter. The 2020-2021 Quarter 3 report indicated that employment remains a key focus for the agency (National Disability Insurance Agency, 2021). The report stated that overall participation in work for participants of the scheme has been stable, however those who have accessed the scheme for more than 2 years have had only marginal increases in employment (National Disability Insurance Agency, 2021). As of March 31st 2021, 21% of participants aged 15-24 years were engaged in some form of employment and 23% of participants aged 25 years and older were engaged in employment (National Disability Insurance Agency, 2021). Employment rates for participants of the scheme continues to be a key focus of the NDIA, which led to the announcement of a specific Participant Employment Strategy in 2020, aimed toward achieving a target of 30% of participants in paid employment by June 2023 (National Disability Insurance Agency, 2021). The focus on employment of people with disability provides an immense opportunity for vocational intervention modalities to be explored that are effective and accessible, including those such as VR.

Unemployment rates for people with disability across the globe are similarly higher than for people without disability, demonstrating the global nature of this challenge. In the UK, as of December 2020, the unemployment rate for people with disability was 8.4%, compared to 4.6% for people without disability (Powell, 2021). In the USA, statistics were similar, as of December 2020 the unemployment rate for people with disability 12.6%, compared to 7.9% for people without disability (Bureau of Labor Statistics, 2021). Although data is hard to find for global statistics, the United Nations estimates that in developing countries, 80-90% of people with disability of working age are unemployed, and in industrialised countries, 50-70% are unemployed (United Nations, n.d.). This global divide between employment rates for people with disability when compared to those without disability demonstrates the need for an effective and accessible solution to address this inequity in employment outcomes.

It is clear that unemployment rates amongst people with disability are higher than those without (Kalargyrou, 2014; Pavlou, n.d.), but the benefits of employment for people with disability are just as important, including improved health and wellbeing (Modini, 2016; Repetti, 1989), improved quality of life, self-confidence, income (Bush, 2017; Lindsay, 2018) and an increased social network (Dunstan, 2017; Lindsay, 2018). Furthermore, increasing the participation of people with disability in the workplace has been shown to deliver individual, social and economic returns (Business Council of Australia, 2015). Documented benefits of a diverse workforce inclusive of people with disability include increased revenue (Stadtler, 2019), reduced turnover (Australian Network on Disability, 2020; Exceptional Parent Magazine, 2008; Kalargyrou, 2014; Stadtler, 2019; Workplace Initiative by Understood, 2020), increased productivity (Stadtler, 2019; Unger, 2002; Workplace Initiative by Understood, 2020), reduced incidence of workplace injury (Australian Network on Disability, 2020; Workplace Initiative by Understood, 2020), improved customer connection (Australian Network on Disability, 2020; Stadtler, 2019), improved morale and productivity (Australian Network on Disability, 2020; NSW Government, 2020; Unger, 2002; Workplace Initiative by Understood, 2020) and increased problem solving and team work (Exceptional Parent Magazine, 2008; NSW Government, 2020).

Barriers to employment

People with disabilities continue to face significant difficulties in gaining meaningful employment, despite the well-documented benefits of inclusion and diversity for organisations. Social identity theory suggests that a person's sense of who they are is based on their group membership and this is important in creating a sense of belonging (McLeod, 2019; Tajfel, 1979). Research shows that people without disabilities tend to associate with other people without disabilities, which leads to people with disability becoming out-group members, which can create a culture of ignorance, misconception, stereotyping and stigma (Fujimoto, 2014; Kalargyrou, 2014). This is reinforced in the research by Unger, where employers expressed greater concerns over employing people with mental, emotional or communication disabilities than those with physical disabilities as they perceived social skill impairments to be an impediment to team work (Unger, 2002).

Perceived barriers to employing people with disability include a lack of resources and related costs, lack of experience and skills, supervisor concerns managing people's needs (Kalargyrou, 2014), including being fearful of seeming discriminatory, invading the person's privacy by asking about their disability, and not knowing what to ask (Business Council of Australia, 2015). Interestingly, the data demonstrates that these barriers may be less impactful than perceived, for example, the research shows that 56% of workplace accommodations cost nothing (Kalargyrou, 2014). The current research set out to identify whether VR interventions can contribute a solution to these barriers, particularly the barrier expressed around a lack of training, experience, and skills.

Vocational Rehabilitation

Vocational Rehabilitation is defined as "the managed process that provides an appropriate level of assistance, based on assessed needs, necessary to achieve a meaningful and sustainable employment outcome" (para. 1) (Department of Veterans' Affairs, 2016). The purpose of vocational rehabilitation is to assist a person to return to or to enter the workforce. Vocational rehabilitation services may include vocational assessment, guidance, counselling, functional capacity assessments, work experience, vocational training and job seeking assistance (Department of Veterans' Affairs, 2016). There has been increased growth in the delivery of vocational rehabilitation across the globe, due to increasing disability-related expenditure (Matthews, 2010). However the majority of the research into vocational rehabilitation sits within the American context (Matthews, 2010).

In the US, the state-federal rehabilitation service program, which costs $2.5 billion annually, provides a significant portion of vocational rehabilitation services to assist people with disabilities to obtain and retain employment (Dutta, 2008). The positive value of these vocational rehabilitation services has been supported in the literature (Bellini, 1998; Bolton, 2000; Dutta, 2008), with employment rates post intervention found to be approximately 60% (Kaye, 1998; Rosenthal, 2006).

In Australia, there are three key vocational rehabilitation programs for people who are unemployed, have a disability, or are injured at work. These include jobactive (Australian Government, n.d.) and Disability Employment Services (DES), which are the welfare schemes (Department of Social Services, 2019), and a Workers Compensation scheme, for people injured at work (Fair Work Ombudsman, n.d.). From the published information available about these schemes, the application of and access to vocational rehabilitation services is variable and appears to focus on vocational skills such as interview skills, resume development and work-related skills and is delivered in a face-to-face manner by either health professionals such as Rehabilitation Counsellors, Psychologists or Occupational Therapists in the workers compensation sector, or via non-qualified job coaches in the jobactive and DES sectors. The published data into these schemes shows varied effectiveness and relatively high costs associated with the programs (Department of Employment, 2019; Department of Social Services, 2019; State Insurance Regulatory Authority, n.d.). Furthermore, research into vocational rehabilitation in Australia shows inconsistent levels of training in the sector resulting in people with complex needs not consistently receiving the services they require to obtain and maintain employment (Buys, 2014; Matthews, 2010). Research into vocational rehabilitation programs shows that current vocational intervention programs, typically led by a therapist in a face-to-face environment can be costly and time-consuming (Dean, 2015, 2018; Sohn, 2016). Additionally, services that meet the specific needs of people with disability may be limited in availability, effectiveness and involve a high cost (Dutta, 2008; Hendricks, 2010; Humm et al., 2014; Lawer, 2008; Muller, 2003; Rogers, 2006; Sweetland, 2012).

The challenges created by global unemployment rates, particularly for those with disability, coupled with the current state of vocational rehabilitation services create a space for continued improvement in clinical practice. This search for continued improvement provides an opportunity for innovation and the development of a best practice, cost-effective intervention tool, fuelled by advancements in technology, that clinicians could utilise in assisting people to improve their work abilities, which may be the place for VR.

Virtual Reality

The current and future economic pressures on healthcare in addition to the rapid development of technology create opportunity for exploration of technology-enabled alternate modalities of intervention that have the potential to be more cost-effective, more accessible to more people and may off greater efficacy and outcome potential. VR has the potential to be this accessible, cost effective and efficacious modality for intervention.

VR belongs to a group of technologies called immersive technologies; these are technologies that blur the line between the physical and virtual digital worlds and allow a user to experience a sense of immersion (Suh, 2017). Immersive technologies include Augmented Reality (AR), Virtual Reality (VR) and Mixed Realty (MR) (The Franklin Institute, 2020), all of which differ from each other. AR adds digital information to the world that a participant can interact with (Craig, 2013), it is typically experienced using a camera on a smartphone. AR adds to the user's vision, instead of replacing it as VR does, and projects images over the world seen by the user (Greenwald, 2018). AR technology can be seen in examples such as the smart phone game made popular in 2019, Pokémon GO (Niantic Inc., 2021), or the Ikea Place app (Inter IKEA Systems B.V., 2021) offering people the opportunity to place virtual furniture in their rooms. AR can also be seen within healthcare, where AR has been used to project a map of a patient's veins onto their skin, increasing the ease for nurses of finding their correct vein (AccuVein Inc., 2021).

VR by contrast, involves a digitally generated environment which gives the user an impression that they are entirely in that digitally generated environment instead of the real world (Suh, 2017). The user experiences a sense of complete immersion that occludes the physical world (The Franklin Institute, 2020). Immersive VR replaces the real-world sensory information with digital stimuli, including 3D imagery, audio, and often tactile feedback. The goal of immersive environments is to enable the user to experience the digital world as if it were real and produce a sense of presence (Bowman, 2007). VR typically includes a device such as a smartphone or computer, paired with a Head Mounted Device (HMD) (Greenwald, 2018), which fully encloses the participant, such as the HTC Vive (HTC Corporation, n.d.), Google Cardboard (Google LLC, n.d.-a) or Oculus Quest (Facebook Technologies LLC, n.d.-a). In VR, the HMD includes Liquid Crystal Display (LCD) panels and lenses, which completely fill the participant's field of vision and give the impression that the outside world is replaced by a virtual one (Greenwald, 2018). In addition to the HMD or visual input, VR typically involves auditory input and can be experienced with a range of accessories, for example tactile handsets. Examples of VR include Microsoft Flight Simulator, where the participant can experience flying a plane as the pilot (Microsoft, n.d.-a), or Google Earth VR, which allows people to explore the world in an interactive 360 degree manner (Google LLC, n.d.-b).

360-degree video is similar to VR, with the exception that it does not allow for interaction with the digital environment. It typically involves a 360 degree video of an environment, which involves a video recording in all directions at the same time and can be viewed like a panorama in the shape of a sphere (Goodwill Community Foundation, n.d.). An example of a 360-degree video is where a person can take a virtual tour of the pyramids of Egypt, without leaving the comfort of their home.

The final type of immersive technology is described as Mixed Reality (MR), which is a combination of elements of AR and VR in addition to the real world, and also includes digital objects that the user interacts with (The Franklin Institute, 2020). An example of an MR device includes Microsoft's Hololens (Microsoft, n.d.-b), which involves a holographic computer, with lenses over the participant's eyes that project holograms onto the physical surroundings of the person (Academy Xi, n.d.). MR has been used by surgeons in the operating theatre, to enable them to plan and simulate various scenarios in a procedure, using the patient's anatomical imagery (Academy Xi, n.d.). Silverchain, a homecare provider in Western Australia, has used MR technology to project holograms of doctors to provide consults to patients being seen in the community by nurses (McGowan, 2017).

Anecdotally, VR has a reputation of being used for some time in the training of defence force personnel, police, surgeons, train drivers (Fink, 2017) and in aviation training with positive outcomes (Hays, 1992), in addition to numerous uses in healthcare. As such, VR displays positive potential for improving work abilities and hence potential for use as a vocational intervention tool. VR tools have the capacity to create an environment that is immersive, three- dimensional and inclusive of all of the sensory inputs required in the real environment (Man, 2013). Hence, VR has been shown to be well suited to simulate the challenges that people face in the natural environment that are useful for assessment and treatment purposes (Rizzo, 2011). VR researchers have constructed virtual environments including aeroplanes, buildings, battlefields, social settings, fantasy worlds, school rooms, offices, supermarkets, street environments and many more environments to mimic the world to immerse participants and facilitate a therapeutic approach for people with and without disabilities (Rizzo, 2011).

VR has demonstrated a positive transfer effect to real training (Lam, 2004; Riva, 2002; Yip, 2009; Zhang, 2003) and as it is a computer program has the advantage of providing an environment with unlimited repetitions for training (Choi, 2020; Hodges, 2001; Kahan, 2000), sensory modulation, graded complexity and an opportunity for feedback and learning (Choi, 2020; Rizzo, 1997; Standen, 2005; Wilson, 1997), which seems to be the moderating factors in the achievement of outcomes. In addition, VR has the opportunity for gamification, which can be described as adding game-like elements to the program to encourage engagement and fun and can serve to motivate participants to engage with the program (Bryanton, 2006; Choi, 2020; Growth Engineering, 2021; Palaus, 2017). VR also offers a level of inherent safety to the participant and clinician. This level of inherent safety allows participants to engage in potentially dangerous tasks such as navigating an unfamiliar area, engaging in battle, or driving a vehicle from a safe and controllable environment (Jonson, 2021; Maguire, 2006; Plancher, 2012). Finally, VR has the capacity to create a wider range of scenarios than the equivalent real-life training scenarios and therefore may create better outcomes and create cost-savings (Howard, 2017, 2018; Manca, 2013).VR has documented negative effects, primarily cybersickness, which may limit its adoption and effectiveness in the health sector. Cybersickness is classified as a form of motion sickness due to exposure to immersive reality environments, including in VR and AR (Arcioni, 2019; Kim, 2020; Ng, 2020; Weech, 2019). Studies have shown that between 22-80% of participants experienced cybersickness during or after using VR (Cobb, 1999; Curry, 2020; Kim, 2021; Munafo, 2017). Cybersickness may limit participants' willingness to engage with a VR intervention, and may limit compliance with a therapeutic program; and hence may limit the effectiveness or outcomes associated with VR intervention modalities.

VR has been used across many domains of the health spectrum as an intervention tool and as a training tool, and as such, for the purposes of this research, we will categorise health related VR uses as either Health Treatment; which aims to cure or treat a condition, and Adaptive Health; which aims to adapt the person to their situation, which could otherwise be referred to as rehabilitation.

Health Treatment Virtual Reality

Health treatment VR uses VR tools to cure or treat a health condition. VR intervention programs have been demonstrated to be effective in the treatment of several mental health conditions, including phobias, Post Traumatic Stress Disorder (PTSD) and anxiety disorders. There is a significant body of research indicating that VR interventions are effective for the treatment of phobias (Botella, 2000, 2017; North, 1998; Parsons, 2008a, 2009). The research suggests that VR is a useful tool for exposure therapy applied to phobias, due to the controllable nature of the environment, the ability to manipulate and grade exposure to the trigger (Botella, 2017).

The same mechanism used for treating phobias, virtual reality exposure therapy, has been used to also treat PTSD (Difede, 2002; Rothbaum, 2001) and anxiety disorders. Some studies suggest this exposure therapy is preferred to traditional modes of therapy by participants, including one study which found military personnel reported a willingness to use a VR approach in comparison to traditional approaches (Wilson, 2008). Additionally, another study found that from a cohort of students with a fear of spiders, 90% preferred VR exposure to traditional modes (Garcia-Palacios, 2002). The research surrounding anxiety and VR effectiveness includes multiple meta-analyses, demonstrating positive outcomes in reducing anxiety and achieving clinical outcomes (Cardos, 2017; Kampmann, 2016; Opris, 2012). To date, there is limited research that indicates contraindications or limitations in the use of VR explicitly. The limitations detailed within the literature comprise methodological limitations including small sample sizes and study design within the body of research available.

Adaptive Health Virtual Reality

In contrast to health treatment VR, which aims to cure or treat a health condition, adaptive health VR aims to assist a person to adapt to their environment or adapt the environment to the person. VR has been used for rehabilitation programs, particularly for upper and lower limb rehabilitation (Choi, 2020), cognitive rehabilitation (Mekbib, 2020), and pain management (Hoffman, 2011). Within a study looking at rehabilitation for children with brain injury, the VR group showed significantly better improvements in upper limb dexterity, performance in activities of daily living, and forearm supination than the control group (Choi, 2020). In a meta-analysis of 27 studies reviewing upper limb rehabilitation in patients with stroke, Mekbib and colleagues found that the VR intervention groups showed statistically significant improvements in the recovery of upper limb function, activity and participation versus the control groups (Mekbib, 2020). VR has been used for the rehabilitation of neurological disorders and brain injury with positive efficacy (Burge, 2009; Holden, 2005; Merians, 2010; Rose, 1998; Rose, 2005; Yip, 2009). VR has additionally been used for pain management in wound care, to distract the patient with pleasant sights and sounds during the administration of injections and wound care (Hoffman, 2011).

In addition to upper limb rehabilitation, VR has been used in cognitive rehabilitation. Cognition comprises interrelated processes that contribute to task performance, including perceiving, organising, thinking, judging, remembering, attending and problem solving to enable a person to process, learn and generalise (Abreu, 1987; Ranka, 1997). VR intervention programs have demonstrated an overall positive effect on cognitive functional improvements, including problem solving skills (De Luca, 2021; Man, 2013; Parsons, 2008b, 2009; Rizzo, 2006; Rose, 2005), however the research shows mixed results and queries whether cognitive improvements observed are related to cognitive improvements or learning of the tasks applied within the existing studies (Jonson, 2021; Montana, 2019).

Focus and Scope

It was clear from the preliminary search stages of this systematic literature review that the definition of VR lacks consistency across studies (Kardong-Edgren, 2019). Definitions of VR within the literature include “simulations that use a variety of immersion, highly visual, 3D characteristics to replicate real-life situations and/or health care procedures; virtual reality simulation is distinguished from computer-based simulation in that it generally incorporates physical or other interfaces such as a computer keyboard, a mouse, speech and voice recognition, motion sensors, or haptic devices” (p. 40) (Lopreitato, 2016); and “computer-generated simulation of a three-dimensional environment the user is able to view and manipulate or interact with” (p. 315) (Kilmon, 2010). As such, Virtual Reality (VR) for the purposes of this study was defined as requiring a participant to participate in an immersive and interactive 3D virtual environment (D'Cunha, 2019). To be considered immersive and interactive, the tool had to enable the participant to interact with the virtual environment and the participant had to feel like they were present or immersed within the virtual environment.

Immersion has been identified as a key concept in the alternate reality space, including in VR, AR and MR, and is a key reason VR has been chosen for this study. Immersion within the literature has been defined as being “characterised by the sensorimotor contingencies (SCs) that they support” (p. 3550) (Slater, 2009). Sensorimotor contingencies are defined as “actions that consistently result in changes to images (in all sensory modalities) so that perception may be changed meaningfully" (p.3550) (Slater, 2009), for example, bending to see something underneath an object or reaching and grasping an object (Kardong-Edgren, 2019). Immersion exists as a variety of levels of immersion, and higher levels of immersion have been shown to result in a higher level of presence for the participant (Kardong-Edgren, 2019; Witmer, 1998). For the purposes of this study, immersion will refer to the depth to which a participant feels that they are actually present within the virtual environment.

This research will be completed within an Occupational Therapy frame of reference, with a focus on client-centredness aimed at enabling people to participate in the activities of everyday life (World Federation of Occupational Therapy, 2012). Occupational Therapists currently utilise technology in assisting people to adapt to their environment, or adapt their environment to their needs as well as using technology as a tool for improving people's abilities within therapy programs (American Occupational Therapy Association, 2015). Occupational Therapists currently utilise VR technology for stroke and neurological rehabilitation (Wen, 2018); hence it would be viable for Occupational Therapists to utilise VR technology for vocational intervention.

The research on VR is vast and spread across a range of disciplines and fields, with a multitude of aims and outcomes. To assist in categorising the available evidence and themes, aims and outcomes will be categorised into five components of functional performance comprising: Biomechanical function, which refers to the physical structures of the body and their performance, including aspects such as strength, endurance, range of motion and circulation (Ranka, 1997); Cognitive function, which involves processes that contribute to task performance, including perceiving, organising, thinking, judging, remembering, attending and problem solving to enable a person to process, learn and generalise (Abreu, 1987; Ranka, 1997); Sensory-Motor function, which refers to the interpretation of sensory input and the motor responses performed by the body in response to the input, and includes registration and interpretation of auditory, visual, tactile, temperature, movement and smell stimuli (Ranka, 1997); Interpersonal function, which refers to social functions which occur between people such as empathy, communication and relationship building (Ranka, 1997); and Intrapersonal function, which represents psychological processes such as emotions, mood and motivation (Ranka, 1997). These occupational performance components have been utilised from the Occupational Performance Model (Australia), an Occupational Therapy model of human occupation and performance commonly used within the discipline in Australia and globally (Ranka J., 2011).

Research Questions and Objectives

Vocational Rehabilitation is a vital health intervention aimed at assisting people to return to or enter the workforce, with far-reaching social and economic implications, as has been signposted throughout this thesis. Vocational Rehabilitation research shows varied outcomes and costs which vary across regions. The ongoing future need for Vocational Rehabilitation, the continued shift to evidence based practice, tightening funding models, and technological advancements create an opportunity to explore alternate therapeutic modalities that may provide improved outcomes for clients.

The VR research is vast and varied, and so this research project aimed to identify and collate the existing body of research in a coherent format for analysis to guide evidence-based practice for clinicians, consumers, and policymakers. The primary objective of this research was to answer the following key question:

(RQ1): *Is Virtual Reality effective as a tool for vocational intervention?*

This question will be answered by exploring whether Virtual Reality is shown to be used in the research as a tool to improve work ability, as measured by the study, or as a tool that improves function as referenced by the occupational performance component areas. Additional questions that this research will aim to answer include:

(RQ2): *What is the most effective type of Virtual Reality tool for vocational intervention?*

To inform the research team as to whether there is a consensus within the literature as to what type of VR tool, including hardware and/or software, is the most effective to enable the future development of an evidence-based intervention tool. Given the push for evidence-based practice and the socio-political pressures for healthcare to be more cost effective, the research team will explore:

(RQ3): *Is Virtual Reality intervention more effective than face to face vocational intervention programs (including efficacy and cost)?*

This will enable the research team to identify what the evidence suggests is best practice regarding vocational intervention modalities, including from an efficacy and outcomes perspective as well as a cost perspective. The final research question is:

(RQ4): *What is an effective dosage for best outcomes (including frequency, duration, intensity, and co-intervention)?*

This will enable the research team to make suggestions on the intervention dosage that is aligned with best outcomes, to enable clinicians to be informed of the best approaches for client outcomes.

Relevance and Importance

This systematic literature review will provide a synthesis of published peer-reviewed quantitative research focusing on vocational and work-related functional outcomes using VR intervention modalities. The systematic literature review will identify what VR tools have been used, how effective they are at facilitating functional outcomes and whether there is sufficient evidence to propose a best-practice tool for clinicians to use. Presently, the available research is vast, it sits in different fields, including medicine, psychiatry, and rehabilitation, holds different aims and is comprised of varying methodologies, populations, and sample sizes. This variation limits the ability of a clinician, researcher, consumer, or policymaker to extract conclusions around the effectiveness of VR in the vocational intervention field, limiting clinical best practice decision making and potential policymaking or funding decisions. The primary aim of this research project is to collate the existing information and formulate conclusions around what evidence is available and robust, as well as what areas of the research could benefit from additional research. Specifically, this research will look to evaluate the effectiveness, efficacy, and cost benefit of VR as a tool for vocational intervention.

Occupational Therapists currently engage in vocational intervention and rehabilitation programs across a range of sectors, including in primary health settings, rehabilitation centres, home and community services, schools, industry and workplaces (World Federation of Occupational Therapy, 2012). Within practice, a range of evidence-based intervention tools are utilised for therapy to improve client outcomes and achieve their goals. Occupational Therapists commonly work in fields with clients aiming to return to or obtain employment, as well as in work rehabilitation settings. The American Occupational Therapy Association (AOTA) describes work rehabilitation as a "broad term that encompasses many aspects of intervention, all geared toward facilitating participation in work and satisfactory fulfilment of the worker role" (American Occupational Therapy Association, 2017). Occupational Therapists implement interventions aimed at improving peoples' ability for work each and every day, and therefore could benefit from a cost-effective intervention tool with positive efficacy for achieving client outcomes. This study aims to shape, refine, and expand the knowledge base around VR as an intervention tool for vocational rehabilitation, within an occupational therapy framework, and provide a basis for future research into the topic.

CHAPTER 2 METHODOLOGY

This chapter details the methods used to conduct the systematic literature review, including the search strategy, the inclusion and exclusion criteria, the screening process used, the quality appraisal process and the data extraction processes. These processes describe the systematic literature review protocol followed.

Search strategy

A systematic review, according to the Cochrane handbook "uses explicit, systematic methods that are selected with a view to minimizing bias, thus providing more reliable findings from which conclusions can be drawn and decisions made" para. 2 (Higgins, 2019). Systematic reviews follow a structured process, emphasising a consistent and rigorous method to ensure reliable results and are considered the pillar of evidence-based practice in healthcare (Munn, 2018). Furthermore, systematic reviews can be used to confirm whether current practice is based on evidence or to establish the quality of existing evidence to address any uncertainties (Munn, 2018).

The review methodology was adapted from the Joanna Briggs Institute (JBI) guidelines for systematic reviews of effectiveness (Tufanaru, 2020) and the Cochrane Handbook for Systematic Reviews of Interventions (Higgins, 2019). A preliminary search of Cochrane Database of Systematic Reviews, EBSCOhost and Google Scholar was conducted in June 2019, where no existing systematic reviews on the topic were found. In addition to there being no found systematic reviews or meta-analyses, the research was observed to be from a wide range of sources, authors, countries, and professions. For the present study, a systematic literature review methodology was chosen to collate the available evidence to allow for understanding of where the knowledge base exists, the strength of evidence and to understand the associated gaps in the existing research; to enable the research team to address the research questions. Therefore, a systematic literature review was determined to be the most appropriate methodology to achieve these outcomes.

The research team identified and refined the search terms following preliminary searches in databases, with initially proposed search terms excluded or amended based on key terms utilised the in available literature in addition to consultation with a research librarian to formulate the search string.

The search terms used for this research were “Virtual Reality” AND “Employment” OR “Work” OR “Job” OR “Vocational” AND “Intervention” OR “Rehabilitation” OR “Training.” Scholarly databases were selected in consultation with the research team and a research librarian. The following databases were utilised to perform the search (a) EBSCOhost Megafile ultimate including Academic Search Ultimate, AHFS Consumer Medication Information, Anthropology Plus, APA PsycArticles, APA PsycTests, Applied Science & Technology Source Ultimate, Audiobook Collection (EBSCOhost), Australia/New Zealand Reference Centre, Biological Abstracts, Business Source Ultimate, CINAHL with Full Text, Communication Source, eBook Collection (EBSCOhost), EconLit, Education Research Complete, E-Journals, ERIC, GreenFILE, Health Business Elite, Health Source - Consumer Edition, Health Source: Nursing/Academic Edition, Hospitality & Tourism Complete, Humanities Source Ultimate, Index to Legal Periodicals and Books (H.W. Wilson), Library, Information Science & Technology Abstracts, MAS Reference eBook Collection, MAS Ultra - School Edition, MasterFILE Premier, MasterFILE Reference eBook Collection, Mental Measurements Yearbook with Tests in Print, MLA Directory of Periodicals, MLA International Bibliography, Newspaper Source Plus, Newswires, Psychology and Behavioral Sciences Collection, Regional Business News, Religion and Philosophy Collection, Sociology Source Ultimate, SPORTDiscus with Full Text, The Serials Directory and Web News, and (b) Scopus. Google Scholar was searched with the goal of identifying peer-reviewed journal articles that may have been missed in database searches.

Full search strategies for each database including unique search strings, filters/limiters, and number of results found for each string are shown in Appendix A. All searches were conducted on 29 June 2020 by two independent reviewers, with identical results. Citations identified through the searches were exported into EndNote X9 (The EndNote Team, 2013).

Inclusion and Exclusion Criteria and Screening Process

Population

As the topic is an emerging field and nil previous meta-analyses nor systematic literature reviews were identified on the topic, studies involving any cohort of the population were included in the participants of the studies reviewed. Specific considerations included any gender, any age, any level of ability or disability, any diagnosis or lack of diagnosis and any employment status.

Intervention

The research team aimed to answer (RQ2): *what is the most effective VR tool?* As such, it was determined that studies involving intervention programs utilising immersive Virtual Reality technology of any type would be included in the review if the intervention was aimed at improving work ability or abilities aligned the occupational performance component areas of biomechanical function, sensory- motor function, cognitive function, interpersonal function or intrapersonal function.

Comparator

This study included studies that compared the VR intervention to any other intervention, comparison, or control group, including no intervention comparators. The research team were particularly interested in any studies including face to face vocational intervention as a comparator, to address (RQ3): *Is Virtual Reality intervention more effective than face to face vocational intervention programs (including efficacy and cost)?* However, the criterion for inclusion was not limited to comparators involving face to face vocational intervention.

Outcomes

This review considered a broad lens on outcomes, so as not to limit the volume of studies reviewed. The research team were particularly interested in whether studies demonstrated (1) an improvement in vocational function, including measures of employment post program; (2) an improvement in function in the occupational performance component areas; including biomechanical function, cognitive function, sensory- motor function, interpersonal function, and intrapersonal function; or (3) measures of economic data to enable evaluation of the cost effectiveness of the intervention programs.

Inclusion Criteria

In line with the population, intervention, comparator, and outcomes used to shape the search, the research team agreed on the additional inclusion criteria of no language or date restrictions, to ensure no relevant studies were missed on the basis of date or language, due to this being the first review on this topic.

This review considered experimental and quasi-experimental methodological designs, including randomised controlled trials, non-randomised controlled trials and cohort studies, where single groups were measured pre and post intervention. This level of evidence was selected using the Level of Effectiveness Rating Scheme (Ackley, 2008); and represents levels I through IV of evidence including Level I which includes systematic reviews or meta-analyses, Level II which includes randomised controlled trials, Level III which includes controlled trials without randomisation and level IV which includes case-control or cohort studies. Level V, VI and VII which include systematic reviews of descriptive and qualitative studies, single descriptive or qualitative studies and opinion of authorities and/or reports of expert committees were not included due to the nature of the evidence being qualitative or descriptive and the limitations on generalising this type of research.

The research team considered studies that included a fully immersive, interactive VR tool with or without accessories. To be considered immersive and interactive, the tool had to enable the participant to interact with the virtual environment and the participant had to feel like they were present within the virtual environment. The research team initially refined the inclusion criteria to include the use of a head mounted device, which fully encloses the participants, such as the HTC Vive (HTC Corporation, n.d.), Google Cardboard (Google LLC, n.d.-a) or Oculus Quest (Facebook Technologies LLC, n.d.-a). However, due to the limited volume of studies found on the topic which included this hardware, this was removed from the inclusion criteria. The research team note that a sense of immersion can be achieved without the use of these devices, however this presents an opportunity for future research into whether there is a difference in the level of immersion, participant experience or outcomes between varying hardware devices.

Due to the exploratory nature of the study and to answer (RQ4): *What is an effective dosage for best outcomes (including frequency, duration, intensity, and co-intervention)?* The research team included studies with any dosage for the VR intervention, including any frequency, any intensity, any duration, and any co-intervention included within the intervention. The final inclusion criterion included was that the outcomes of the study would not be used as an inclusion criterion.

Exclusion Criteria

There is a range of technology often used interchangeably with VR that do not provide immersive, interactive, and fully virtual experiences for the participant. The research team determined VR as the intervention of focus for this study, and hence additional modes of alternate reality were excluded to prevent contamination of the results of the study and to enable the research questions to be answered in reference to VR. As such, this study excluded studies using Augmented Reality (AR); which merges the real-world environment and enhances it with virtual elements (Carmigniani, 2011). This study additionally excluded studies involving 360 Degree Video; which displays images surrounding a person and does not allow the participant to interact with the elements (Roberts, 2016) and Mixed Reality (MR); which involves a combination of AR and VR (Hughes, 2005). A summary table of the inclusion and exclusion criteria is listed in Appendix B.

Screening

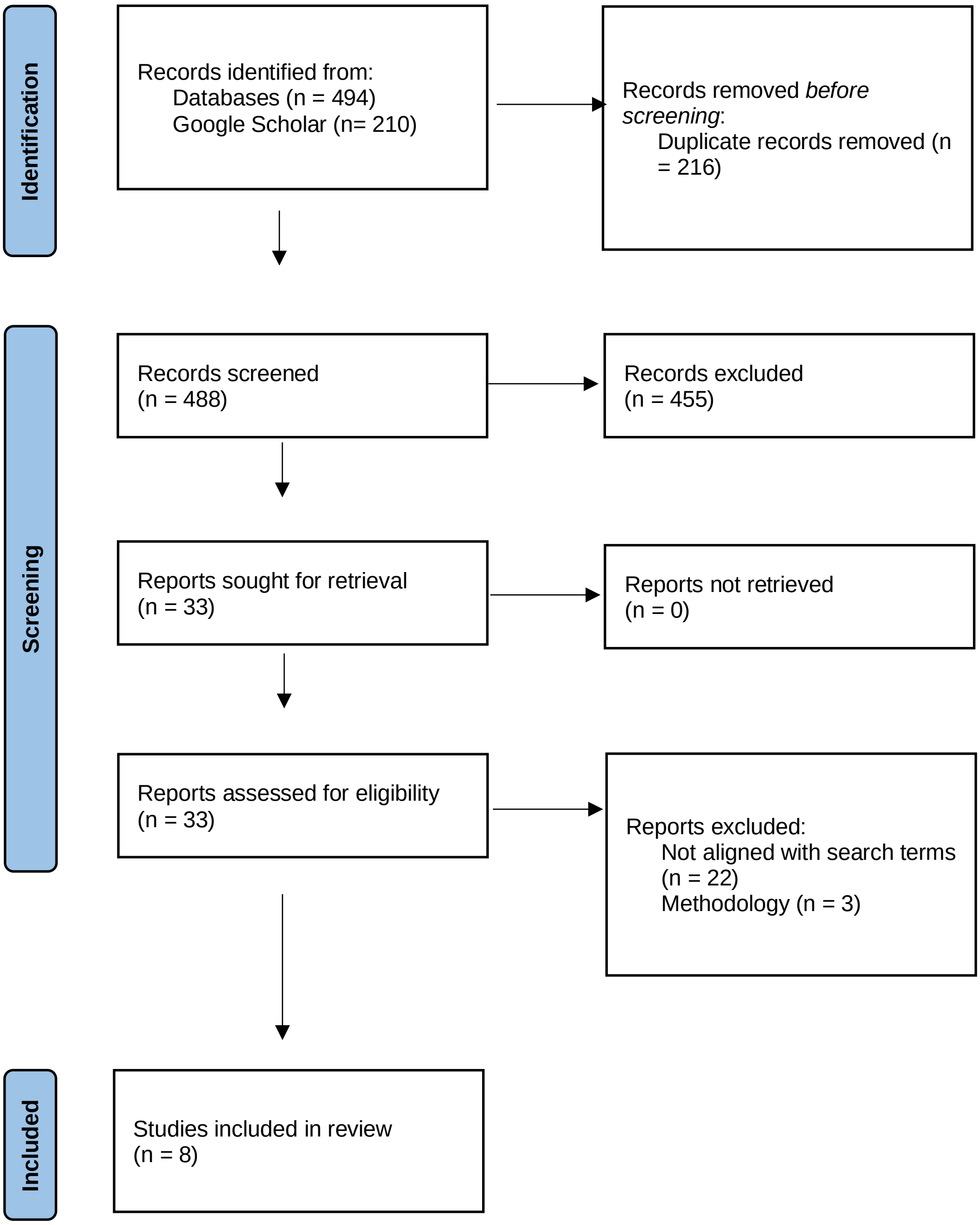
Abstracts and citations were exported to EndNote X9 (The EndNote Team, 2013) and duplicate records were removed by the lead researcher. The research team completed a screen of titles and abstracts and sorted the citations according to inclusion and exclusion criteria into 'Include,' 'Exclude' or 'Questionable' folders within EndNote. The screen was completed by two reviewers simultaneously and a third reviewer gave opinion on any ratings that were not matched by both initial reviewers, resulting in 33 articles remaining. Potentially relevant articles were then retrieved in full and downloaded by the lead researcher.

The research team completed a review of full text articles and assessed these against the inclusion and exclusion criteria by one reviewer and then they were independently assessed by a second reviewer within the research team. The independent review of full text articles was divided between three reviewers within the research team. Differences of opinion between reviewers were resolved through discussion and agreement at each stage, and if required, through escalation to the research team for discussion and unanimous decision making.

Throughout the review, the research team engaged in a reflective process, as is vital for high quality research (Finlay, 1998). The team consistently engaged in re-evaluation of the research process at each stage of the process. As a result of this, the 11 final articles were reviewed by the research team, and a further 3 articles were removed at the quality review stage as the articles did not meet the inclusion criteria for quasi-experimental methodology; leaving a final 8 articles used for the data extraction phase. The search, screening and numbers details are reported below in figure 1, using a PRISMA flow diagram (Page, 2021).

Figure 1

PRISMA Flow Diagram



Quality Appraisal

Eligible studies were critically appraised for methodological quality by the lead researcher and then a second reviewer within the research team for each article. The second, independent review was divided between three members of the research team. Reviewers utilised the Effective Public Healthcare Panacea Project (EPHPP) Quality Assessment Tool for Quantitative studies to appraise the quality of the studies (Thomas, 2014).

The EPHPP was chosen due to its applicability across quantitative design methods and its quality scoring requirements. The EPHPP was able to be used across all methodologies which were included in the study, including experimental and quasi-experimental methodologies. The studies included in the review comprised randomised controlled trials and cohort studies and as such the EPHPP enabled a single tool to be used for the appraisal of all these studies, which enabled the researchers to appraise consistently across all studies included. The EPHPP tool also enables a quality rating to be assigned to each study, including weak, moderate, or strong quality. The EPHPP requires two reviewers to assign a rating and allows for the user to calculate a coefficient of agreement and has been shown to have "fair inter-rater agreement for individual domains" (Armijo-Olivo, 2012). This comprehensive appraisal and scoring of methodological quality were determined by the research team to be valuable to the study and hence the EPHPP was selected as the tool for the quality appraisal.

The EPHPP was completed with two reviewers for each article, with scores for each appraisal documented and collated. The scores were then analysed statistically using IBM SPSS Version 26 (IBM Corp., Released 2019) and a Kappa value determined to represent interrater reliability. Following the determination of the Kappa value, a final quality appraisal rating was assigned for each article by the lead researcher and then conferred and agreed upon by the research team to determine a final score for each article. The final quality ratings can be found in Appendix C. The Kappa value for interrater reliability was determined to be a value of 0.13, which indicates a slight agreement (Landis, 1977) in the rating scores between reviewers and is detailed in Table 1 below. Although agreement was slight, the level of Kappa was acceptable for this study given the low volume of articles assessed. With a higher volume of articles, we would expect Kappa to rise based on the dilution of inter-rater disagreement across more cases.

Table 1

Kappa Scores for Coefficient of Agreement

	Value	Asymptotic Standard Error	Approximate Tb	Approximate Significance
Measure of Agreement Kappa	.13	.13	.97	.33
N of Valid Cases	8			

Note: a. Not assuming the null hypothesis. b. Using the asymptotic standard error assuming the null hypothesis.

Data extraction

A data extraction form was developed by the research team and was based on the research questions, a copy of the data extraction form is in Appendix D. The data extraction form was developed for consistency in the systematic review and involved both numerical, free-text and fixed- text (i.e., yes/ no) fields to simplify the extraction and analysis of the data. A sample of the data extraction form was piloted on 2 studies to ensure that the form was appropriate and included relevant details. Data extraction was completed by the lead researcher into the table in Word (Microsoft, n.d.-c). Data extracted was relevant to the research questions, including authors and year of publication, study design and sample size, type of VR tool and dosage, the occupational performance components featured within the study, the measures used, the key findings of the study, limitations of the study and the directions suggested for future research. A second researcher independently reviewed the data extraction form for accuracy and completeness to reduce the chance of human error in this process. The data from the form was then extracted and collated for thematic analysis performed by the lead researcher. The thematic analysis used within the research was informed by the Reflexive Approach (Braun, 2012) although was not followed explicitly due to the nature of the data extracted from the systematic literature review. The data extracted and thematic analysis will be described in the following chapter.

CHAPTER 3 RESULTS

This chapter will include the findings of the systematic literature review performed to answer the research questions; RQ1: *is VR effective for vocational intervention?* RQ2: *what is the most effective VR tool?* RQ3: *is VR more effective than face to face vocational intervention?* and RQ4: *what is an effective dosage for best outcomes?* This chapter will detail findings in relation to the breadth and quality of the research, the participant cohorts involved, the characteristics of the virtual reality tools utilised for the interventions, the occupational performance components that form the focus and shape the outcomes of the studies as well as the primary findings around cognition and vocational outcomes. The nature of the findings in this research are varied and spread across the research questions. As such, the chapter is structured by theme rather than by research question, with the intent to maximise readability.

Overall Findings

Overall, the findings indicated a wide spread of evidence across different domains, cohorts, and disciplines. The majority of studies comprised Cohort studies, with small sample sizes and varying methodological quality. In addition, the majority of studies involved people with mental health conditions and measured cognitive and intrapersonal function using a large range of clinical outcome measurement tools. The findings indicate potential positive relationships between VR and improved cognitive function and vocational outcomes. The findings leave many opportunities for future research.

Quality Findings

Breadth of Research

As part of identifying and collating the existing evidence base, the research team set out to determine whether there was a geographic centre (e.g., Hong Kong) or professional discipline centre (e.g., psychology) for VR research in vocational rehabilitation. The studies reviewed demonstrated a wide spread of geographic locations for the research as well as a spread across disciplines. Of the final studies reviewed, two articles (Man et al., 2013; Tsang & Man, 2013) were conducted in Hong Kong, China; two were conducted in the United

Kingdom (Brooks et al., 2002; Kwon et al., 2013) and one each in France (Amado et al., 2016), United States of America (Humm et al., 2014), Canada (Rizzuto et al., 2019) and South Korea (Sohn et al., 2016).

The studies reviewed spread across professional disciplines including psychiatry (Amado et al., 2016; Sohn et al., 2016), psychology (Brooks et al., 2002; Man et al., 2013), medicine (Humm et al., 2014; Kwon et al., 2013; Sohn et al., 2016), kinesiology (Rizzuto et al., 2019) and occupational therapy (Tsang & Man, 2013) and were each featured in different journals. This demonstrates the breadth of the existing evidence base and the emerging nature of the evidence, which aligns with the research team's initial observations and rationale for the research questions.

Table 2

Year, Location and Profession of Publication of Studies Reviewed

Author	Title	Year	Journal	Discipline	Geographic Location
Amado et al.	A serious game to improve cognitive functions in schizophrenia: A pilot study.	2016	Frontiers in Psychiatry	Psychiatry	France
Brooks et al.	An evaluation of the efficacy of training people with learning disabilities in a virtual environment.	2002	Disability and Rehabilitation	Psychology	United Kingdom
Humm et al.	Simulated job interview improves skills for adults with serious mental illnesses.	2014	Annual Review of Cybertherapy and Telemedicine	Medicine	United States of America

Table 2

Year, Location and Profession of Publication of Studies Reviewed- Continued from previous page

Author	Title	Year	Journal	Discipline	Geographic Location
Kwon et al.	How level of realism influences anxiety in virtual reality environments for a job interview.	2013	International Journal of Human-Computer Studies	Medicine	United Kingdom
Man et al.	The effectiveness of artificial intelligent 3-D virtual reality vocational problem-solving training in enhancing employment opportunities for people with traumatic brain injury.	2013	Brain Injury	Psychology	Hong Kong, China
Rizzuto et al.	Evaluation of a virtual reality head mounted display as a tool for posture assessment in digital human modelling software.	2019	Applied Ergonomics	Kinesiology	Canada

Table 2

Year, Location and Profession of Publication of Studies Reviewed- Continued from previous page

Author	Title	Year	Journal	Discipline	Geographic Location
Sohn et al.	Developing a virtual reality-based vocational rehabilitation training program for patients with schizophrenia.	2016	Cyberpsychology, Behavior, and Social Networking	Medicine Psychiatry	South Korea
Tsang & Man	A virtual reality-based vocational training system (VRVTS) for people with schizophrenia in vocational rehabilitation.	2013	Schizophrenia Research	Occupational Therapy	Hong Kong, China

Study design, Sample Size and Limitations

The review included studies that comprised experimental or quasi-experimental design, aligning with the levels of evidence level I through level IV (Ackley, 2008). This level of evidence was determined as the most aligned with the research questions and allowed the researchers to identify the effect of the interventions using VR. Quasi-experimental designs were included as these studies were deemed to preserve several of the distinguishing features of experimental design that allow for some level of causal inference.

Sixty two and a half percent of studies reviewed utilised cohort methodology to analyse the impact of the VR intervention using pre and post clinical outcome measure scores (Amado et al., 2016; Brooks et al., 2002; Kwon et al., 2013; Sohn et al., 2016). These studies all identified that the Cohort design of their study was a limitation, as there was no control group to discern whether the effect of the intervention was as described.

The remaining 37.5% studies reviewed comprised Randomised Controlled Trials to analyse the between- group impact of interventions using VR (Humm et al., 2014; Man et al., 2013; Tsang & Man, 2013). The limitations listed for these studies include small sample sizes and the potential for co-interventions to have impacted the results of the studies; indicating further research is required to control for co-interventions and larger sample sizes to measure the effect size more accurately.

Sample sizes varied from 10 (Sohn et al., 2016) up to 96 (Humm et al., 2014) participants within the studies reviewed, indicating small sample sizes which may reduce the visibility of the effect size and limit the generalisations about the results that can be made from the data. All studies reviewed listed small sample size amongst the limitations and indicated further research needs to include larger sample sizes to measure the effectiveness of the intervention more thoroughly, the study design and sample size detail is displayed below in Table 3.

Table 3

Study Design and Sample Sizes

Study detail	Study Design	Sample Size
Amado et al. 2016	Cohort design Assessment completed prior to the VR program (week 0) and after the final session (week 12). Psychiatrist and neuropsychologist raters administered the assessments and were not blind to the assessments.	10
Brooks et al. 2002	Cohort design All participants were pre-tested and re-tested in their training kitchen on 4 food preparation and hazard identification tasks.	24

Table 3

Study Design and Sample Sizes- Continued from previous page

Study detail	Study Design	Sample Size
Humm et al. 2014	Randomised Controlled Trial design Participants from the 3 cohort groups were randomised to a control group or intervention group at a ratio of 1:2.	96
Kwon et al. 2013	Cohort design Pre-test screening prior to intervention and post-test screening following each intervention.	20
Man et al. 2013	Prospective Randomised Controlled Trial design Two groups: intervention group and control group. Pre and post-test assessments were conducted for each group.	40
Rizzuto et al. 2019	Cohort design Measurements were taken during the tasks in addition to pre and post questionnaires.	14
Sohn et al. 2016	Cohort design Baseline and after the 8-week training program assessments conducted.	10
Tsang & Man 2013	Randomised Controlled Trial design Single blinded with assessors blinded to the group assignment. Independent assessors, who were blind to the expected results of the program completed pre and post-test outcome assessments at baseline and post intervention.	75

Demographic Findings

Health Conditions

Given the purpose of the systematic literature review was to identify and collate the existing research, no conditions were placed on the cohort of participants within the studies in the inclusion and exclusion criteria. Within the studies reviewed, there was a wide range of cohorts of participants, from the general healthy population through to people with disability. The majority of studies, 62.5%, involved cohorts of participants with mental health conditions, including participants with Schizophrenia (50%) (Amado et al., 2016; Humm et al., 2014; Sohn et al., 2016; Tsang & Man, 2013), Post Traumatic Stress Disorder (PTSD) (Humm et al., 2014) and Social Anxiety (Kwon et al., 2013). In addition to mental health diagnoses, the remaining studies involved participants with Autism Spectrum Disorder (Humm et al., 2014), Learning Disability (Brooks et al., 2002), Traumatic Brain Injury (Man et al., 2013) and the general, healthy population of university students (Rizzuto et al., 2019) respectively. The participant details are included in Table 4 below.

Table 4

Participant Cohorts for Studies Reviewed

Study detail	Participant Cohort	Exclusion criteria	Inclusion criteria
Amado et al. 2016	Outpatients meeting Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-V) criteria for Schizophrenia or schizoaffective disorders. Institutionalised for several years, coming to day care activity centre several times per week.	Auditory or visual impairment. Mental retardation (IQ <70). Traumatic brain injury. Presence or history of neurological illness. Poor understanding of French or instructions. Concurrent substance abuse or dependence.	Nil listed

Table 4

Participant Cohorts for Studies Reviewed- continued from previous page

Study detail	Participant Cohort	Exclusion criteria	Inclusion criteria
Brooks et al. 2002	Students with learning disabilities. Students were undertaking catering courses at Pinewood School, Ware.	Nil listed	Nil listed
Humm et al. 2014	3 groups of participants: 1) Community dwelling adults with autism spectrum disorder; n= 26. 2) Community dwelling individuals with schizophrenia and other serious mental illnesses (schizophrenia and other) n= 37. 3) Veterans diagnosed with Post Traumatic Stress Disorder (PTSD) who received outpatient care; n= 33. All participants were unemployed at recruitment but were searching for or planning to search for work.	Nil listed	Nil listed

Table 4

Participant Cohorts for Studies Reviewed- continued from previous page

Study detail	Participant Cohort	Exclusion criteria	Inclusion criteria
Kwon et al. 2013	Minimum of moderate symptoms of social anxiety, defined as individuals who scored over 55 on the Liebowitz Social Anxiety Scale (LSAS).	Nil listed	Nil listed
Man et al. 2013	Mild to moderate traumatic brain injury, defined by scores on the Glasgow Coma Scale and length of Loss of Consciousness.	Impaired physical functions inhibiting the operation of keyboard or mouse. Showing lack of awareness deficit (as indicated by Self-awareness of Deficit Interview SADI). Pre-morbid and profound post-morbid mental retardation. Diagnosed with other neurological pathology (epilepsy). Had previous training with similar artificial intelligence programs before.	Aged between 18-55. Passed 3 screening tests (Modified Barthel Index, Mini-mental status examination, and Test of non-verbal intelligence-version 3). Medically stable.

Table 4

Participant Cohorts for Studies Reviewed- continued from previous page

Study detail	Participant Cohort	Exclusion criteria	Inclusion criteria
Rizzuto et al. 2019	Healthy, right-hand dominant volunteers from the university population.	Upper limb musculoskeletal injury within the past year.	Nil listed
Sohn et al. 2016	Diagnosed with schizophrenia using the diagnostic criteria in the Diagnostic and Statistical Manual of Mental Disorders, fourth edition-test revision (DSM IV-TR). 8 participants were diagnosed with paranoid subtype and 2 with undifferentiated subtype.	Physical disabilities that would make it difficult to engage in the program. History of alcohol or substance based within the past month. Intellectual disability. Neurological or developmental disorders.	Between ages 20-55. At least middle school education. Desire for vocational rehabilitation training. Ability to give written informed consent.

Table 4

Participant Cohorts for Studies Reviewed- continued from previous page

Study detail	Participant Cohort	Exclusion criteria	Inclusion criteria
Tsang & Man 2013	Patients with schizophrenia who had been diagnosed in alignment with the Diagnostic and Statistical Manual of Mental Disorders, fourth Edition (DSM-IV). Inpatients who attended a vocational rehabilitation program in the occupational therapy department.	Patients with physical handicaps, for example blindness. Patients who had undergone electroconvulsive therapy (ECT) during the past 12 months. Patients who had an episode of drug abuse during the past 30 days. Patients with a history of mental retardation or other neurological diseases and developmental disabilities.	Patients with diagnosis of schizophrenia. Patients who attended vocational rehabilitation services at the Castle Peak Hospital. Chinese ethnicity of both genders. Aged between 18-55. Able and willing to provide informed consent to participant in the study.

Virtual Reality Type and Dosage

At the outset of the research, the researchers wanted to know what kind of VR would be the most effective, whether there was any evidence to suggest this, and whether the evidence was sufficient to develop a VR tool based on evidence, hence the research questions included RQ2: *what is the most effective type of VR tool?* and RQ4: *what is an effective dosage for best outcomes (including frequency, duration, intensity and co-intervention)?* Across the studies reviewed there was a large variation in type of VR, type of hardware used to run the VR, different virtual environments used to conduct the studies and a large variation in dosage used for the interventions. Dosage has been included in the data for VR characteristics in Table 5 and this data is applicable to all results in Tables 6-9. The dosage findings were variable and with little patterns identified, as such they have been included in Table 5, rather than all results tables to create ease for reading.

Across the eight studies reviewed, there were eight different applications of VR environments. Of the eight studies, five included virtual workplace settings including a commercial kitchen (Brooks et al., 2002), interview settings (Humm et al., 2014; Kwon et al., 2013), clerical workplace (Man et al., 2013) and a virtual shop and store room (Tsang & Man, 2013) and these studies required participants to interact with these environments in the context of employment. Three of the eight studies reviewed included community-based virtual environments and asked participants to interact with those environments in the context of day-to-day living. These virtual environments included a virtual town (Amado et al., 2016), a virtual convenience store and a virtual supermarket (Sohn et al., 2016).

Typically, VR set ups involve the use of a computer that runs VR software comprised of videos or games, paired with a HMD which covers a participants' eyes, headphones and may involve the use of controllers and other accessories that provide tracking or sensory feedback to the participant (Virtual Reality Society, 2017). This level of hardware is required to create the sense of immersion which enables the participant to feel like the virtual world is real (Greenwald, 2018; Virtual Reality Society, 2017). The definition of VR within the research was observed to vary within the preliminary search conducted by the research team, and to this end the researchers set out to confirm if there was an evidence base around the hardware used in the evidence and whether there was evidence suggesting which set up led to the best outcomes.

Of the studies reviewed, 37.5% involved the use of a monitor, joystick, mouse, and keyboard hardware without the use of a headset, headphones or other accessories. Two of the studies reviewed utilised equipment aligning with the researcher expectations, including a HMD in their VR intervention to create a sense of full immersion (Kwon et al., 2013; Rizzuto et al., 2019). Given the positive results across all studies, the question arises whether VR or immersion is required to facilitate a functional outcome, or whether the degree of the outcome is impacted by the VR tool and level of immersion.

The dosage of VR intervention was analysed to determine whether there was an evidence-based recommendation around the frequency and duration of VR intervention for intervention outcomes. Whilst there were positive outcomes associated with many of the studies, there was no pattern observed for frequency nor duration amongst the studies. The majority of studies involved recurring or repeated sessions (Amado et al., 2016; Brooks et al., 2002; Humm et al., 2014; Kwon et al., 2013; Man et al., 2013; Sohn et al., 2016; Tsang & Man, 2013), whereas one study involved a once-off use of the VR intervention tool (Rizzuto et al., 2019). There was no correlation between whether the interventions were recurring or one-off and the outcomes of the studies, with both groups demonstrating outcomes that were positive as well as non-outcomes. Table 5 below details the VR characteristics within each study.

Table 5

Virtual Reality Characteristics

Study	VR Hardware	Virtual Environment (Software)	Dosage
Amado et al. 2016	Joystick Monitor	Virtual town	12 weekly sessions 90 minutes per session
Brooks et al. 2002	Desktop computer Joystick Keyboard Mouse	Virtual kitchen modelled on real training kitchen familiar to participants	3 sessions over 2-3 weeks.
Humm et al. 2014	Monitor Headphones with Microphone	Virtual interview	5 hours of educational training modules to prepare for interviews. Simulation role-play: 10+ hours of practice over 5 visits.
Kwon et al. 2013	4 different levels of immersion: 1) Audio only 2) Laptop screen 3) LCD Television High resolution monitor with headset	Virtual Interview	2 sessions.

Table 5

Virtual Reality Characteristics- continued from previous page

Study	VR Hardware	Virtual Environment (Software)	Dosage
Man et al. 2013	Monitor Joystick Mouse Keyboard	Virtual clerical workplace	20- 25 minute sessions over 12 sessions.
Rizzuto et al. 2019	Oculus Rift headset. Reflective markers on participants hand and headset.	Virtual pointing environment	Once-off 10 minutes of familiarisation in the 3 environments. 5 minute task completion in each environment. 10 minutes break between each environment.
Sohn et al. 2016	3 LCD digital projectors in an immersion room. Microphone Mouse	Virtual convenience store and supermarket	15- 20 minute sessions over 8 weeks.
Tsang & Man 2013	Monitor Joystick Mouse Keyboard	Virtual shop and storeroom	10 sessions over 5 weeks

Occupational Performance Components

Given the nature of the research aims, to collate the existing research, the research team anticipated that a wide spread of evidence across several domains would be identified. As a tool for collating this, five occupational performance component areas were identified to group whole-body function, based on the Occupational Performance Model (Australia) (Ranka J., 2011). The occupational performance component areas used to group the research focus and findings included biomechanical function, cognitive function, sensory-motor function, interpersonal function, and intrapersonal function. As anticipated, there was a spread of focus and findings across the occupational performance component areas, however not in the areas anticipated by the researchers.

All studies reviewed were able to be grouped into the occupational performance component areas, which indicated that there was a focus on health and function throughout the evidence base. 62.5% of studies reviewed demonstrated focus and findings aligned with the cognitive occupational performance component (Amado et al., 2016; Brooks et al., 2002; Man et al., 2013; Sohn et al., 2016; Tsang & Man, 2013); which aligns with the cohort of participants being people with mental health diagnoses, learning disabilities, Autism Spectrum Disorder and Traumatic Brain Injury, all of which typically involve cognitive impairment to some degree.

Secondary to the cognitive occupational performance component was the intrapersonal component (27.5%), which comprises psychological function (Amado et al., 2016; Humm et al., 2014; Kwon et al., 2013). Given most studies focussed on mental health cohorts, it follows that intrapersonal function was one of the commonly reviewed occupational performance components. There was one study (Rizzuto et al., 2019) which focused on the biomechanical occupational performance component, looking at reaching task accuracy and performance in VR compared to real world scenarios. Nil studies reviewed demonstrated a focus or findings consistent with Interpersonal (social function) or Sensory-Motor occupational performance components; despite the researcher's hypothesis that sensory-motor function would be a key moderator in the effectiveness of VR interventions.

Measures

The clinical tools used to measure the intervention outcomes aligned with the occupational performance component groupings. The studies reviewed used a large range of clinical outcome measurement tools for baseline and post intervention measurement of function. Across the studies reviewed there were 46 unique tools used which were utilised by a range of disciplines including psychology, neuropsychology, and occupational therapy. It follows that the largest occupational performance component was observed to be cognition, as the majority of clinical outcome measurement tools were cognition focused (41%). Of the cognition-focused outcome measurement tools, there were three tools used in a repeated fashion across studies, including the Rey-Osterrieth Complex Figure Test (2), Vocational Cognitive Rating Scale (2) and Wisconsin Card Sorting Test (3). Similarly, to occupational performance components, the second highest category of tools were psychological functional measurement tools (30%), followed by a small number to measure biomechanical function aligned with the one study focussing on this occupational performance component, the clinical outcome measurement tools are detailed below in Table 6.

Table 6

Occupational Performance Components

Study	Occupational Performance Component(s)	Clinical Outcome Measurement Tools
Amado et al. 2016	Intrapersonal Cognitive	Brief Psychiatric Rating Scale Global Assessment Functioning Scale Social Autonomy Scale Schizophrenia Questionnaire for Quality of Life Self-Esteem Rating Scale D2 Cancellation Test Weschler Adult Intelligence Scale Grober and Buschke Verbal Learning Test Battery for Assessment of Dysexecutive Syndrome Rey-Osterrieth Complex Figure Test Retrospective and Prospective Memory Virtual Test
Brooks et al. 2002	Cognitive	Scores in task performance
Humm et al. 2014	Intrapersonal	Repeatable Battery for the Assessment of Neuropsychological status Bell-Lysaker Emotion Recognition Task for Social Cognition
Kwon et al. 2013	Intrapersonal	Brief Fear of Negative Evaluation Scale Skin Conductance Pulse Rate Measure of Anxiety in Selection Interviews

Table 6

Occupational Performance Components- continued from previous page

Study	Occupational Performance Component(s)	Clinical Outcome Measurement Tools
Man et al. 2013	Cognitive	Wisconsin Card Sorting Test Tower of London Test Vocational Cognitive Rating Scale Employment Outcomes Modified Barthel Index Mini-Mental Status Examination Test of Non-Verbal Intelligence Self- Efficacy Rating Scale
Rizzuto et al. 2019	Biomechanical	Game Engagement Questionnaire Task Performance/ Error Pointing Velocity Movement Time
Sohn et al. 2016	Cognitive Intrapersonal	Manchester Scale Clinical Global Impression- Severity Clinical Global Impression- Improvement Personal and Social Performance Scale Hamilton Depression Rating Scale Zung Depression Rating Scale Beck Anxiety Inventory Wisconsin Card Sorting Test Rey-Osterrieth Complex Figure Test Auditory Verbal Learning Test (Korean Version)

Table 6

Occupational Performance Components- continued from previous page

Study	Occupational Performance Component(s)	Clinical Outcome Measurement Tools
Tsang & Man 2013	Cognitive	Brief Neuropsychological Cognitive Examination Digital Vigilance Test Rivermead Behavioral Memory Test Wisconsin Card Sorting Test Vocational Cognitive Rating Scale

Outcome Findings

A number of findings were observed within the studies reviewed, and as anticipated the results were spread across a range of disciplines, cohorts and focus areas, limiting the ability for researchers to draw firm conclusions around the evidence base surrounding VR intervention tools. In addition to this, the identified limitations of the studies reviewed, including small sample sizes and potential co-interventions may impact on the generalisations that can be made from the findings. Overall, the findings suggest a positive relationship between VR interventions and improvements in the occupational performance components, with stronger findings in cognition demonstrated.

Cognition

Unsworth (1999) describes cognition as “thinking, remembering, reasoning and making sense of the world around us are fundamental to carrying out everyday living activities” (p. 1). Cognition is comprised of processes that are interrelated for task performance and include the ability of a person to perceive, organise, think, judge, remember, attend, problem solve and manipulate information to allow the person to process information, learn and generalise (Abreu, 1987; Ranka, 1997).

The majority of studies reviewed focused on the cognitive occupational performance component, and 50% of all studies reviewed demonstrated positive findings and improvements in cognitive function after using the VR intervention tool (Amado et al., 2016; Brooks et al., 2002; Man et al., 2013; Sohn et al., 2016; Tsang & Man, 2013). Overall areas of observed improvements in cognition included increased attention, working memory, prospective and retrospective memory, selective and perceived memory function, and general cognitive function.

Improvements in attention, working memory and prospective and retrospective memory were observed by Amado et al. in their study looking at participants navigating a virtual town (Amado et al., 2016). On the other hand, no improvements were observed in planning as a result of using the VR intervention tool (Amado et al., 2016). Man et al. demonstrated that over 12 sessions of VR intervention in a virtual clerical work environment, that there were improvements in selective memory processes and improvement in the perception of memory function amongst participants (Man et al., 2013). Furthermore, Sohn et al. demonstrated using their supermarket and convenience store intervention that delayed recall and memory scores improved significantly following the use of the VR intervention (Sohn et al., 2016). Finally, Tsang and Man demonstrated in their prevocational skills training program that the VR group performed better than the control in overall cognitive function, including their scores on the Wisconsin Card Sorting Test (Tsang & Man, 2013). There was a mix of statistically significant and non-statistically significant outcomes demonstrated in the studies reviewed. Table 7 below details the statistically significant outcomes observed in relation to cognition within the studies reviewed.

Table 7

Statistically Significant Outcomes

Study	Outcome for Cognition	Statistically Significant p<0.5
Amado et al. 2016	Improvement in attention, working memory, prospective and retrospective memory.	Attention, visual scanning, speed processing: Yes for D2 Cancellation Test KL score and GZ-F score, but No for GZ score and F% score. Yes for WAIS-III score. Verbal and visural working memory- Yes for Digit Span for backward span, No for visuo-spatial span subtest or forward span. Verbal learning: No Executive function: No Visuo-spatial organisation: No Retrospective and prospective memory: Yes for 'where' and 'when' but No for 'what'
Man et al. 2013	Improvement in selective memory processes and perception of memory function.	Executive function, planning: TOL test- Yes Attention, Perseverance, abstract thinking and set shifting: WCST- Yes Cognitive impairment in the workplace: VCRS- No

Note: TOL: Tower of London Test; VCRS: Vocational Cognitive Rating Scale; WCST: Wisconsin Card Sorting Test; RCFT: Rey- Osterrieth Complex Figure Test; K-AVLT: Korean Version of the Auditory Verbal Learning Test.

Table 7

Statistically Significant Outcomes- continued from previous page

Study	Outcome for Cognition	Statistically Significant p<0.5
Sohn et al. 2016	Improvement in memory.	Attention, Perseverance, abstract thinking and set shifting: WCST- No Processing: Stroop test- No Immediate recall- Yes Delayed recall- Yes Visualspatial construction and visual memory: RCFT- Yes Auditory verbal learning: 1st and 5th attempts at K-AVLT- Yes
Tsang & Man 2013	VR group performed better than control in cognitive function.	Attention, perseverance, abstract thinking and set shifting: WCST- Yes Cognitive impairment in the workplace: VCRS- Yes

Note: TOL: Tower of London Test; VCRS: Vocational Cognitive Rating Scale; WCST: Wisconsin Card Sorting Test; RCFT: Rey- Osterrieth Complex Figure Test; K-AVLT: Korean Version of the Auditory Verbal Learning Test.

Vocational Outcomes

Vocational Outcomes were a key focus area for the researchers, given the research aim to determine whether VR intervention is an effective tool for vocational rehabilitation. Vocational rehabilitation is defined as "the managed process that provides an appropriate level of assistance, based on assessed needs, necessary to achieve a meaningful and sustainable employment outcome" (Department of Veterans' Affairs, 2016). It was seen through the research that vocational outcome definitions varied.

Throughout the studies reviewed, vocational outcome definitions varied between obtaining employment, to task performance improvements within work or virtual environments and also included self-efficacy in regard to work. Overall, the studies reviewed demonstrated a positive relationship between the VR interventions administered and vocational outcomes. For the purposes of this research, vocational outcomes will be categorised as either (a) employment outcomes; referring to obtaining, maintaining, or increasing level of employment and including task performance; or (b) self-efficacy outcomes; referring to the persons' perceptions of their ability to work.

Vocational Outcomes – Employment

Employment outcomes, for the purposes of this study can be defined as people gaining employment, maintaining employment, or increasing their level of employment. Of the studies reviewed, only 2 studies measured employment outcomes following intervention (Humm et al., 2014; Man et al., 2013). The study by Man et al. demonstrated that following their VR based prevocational skills training program, the VR group performed better than the therapist- led group and had better employment outcomes (Man et al., 2013). The study by Humm et al. demonstrated that, 20 weeks following interview training, the VR group had a higher percentage of participants who had obtained emploument 56.3%, compared with the control group, where 27.2% of participatnts had obtained employment (Humm et al., 2014).

In the study by Man et al. the two groups studied each had 20 participants and outcomes are demonstrated in detail in Table 8 below. AIVTS represents the VR group "Artificial intelligent virtual-relatity based training program" and PEVST represents the therapist-led group "Psycho-educational vocational training system" (Man et al., 2013). It was demonstrated that the VR group had 5% of participants in open employment and 85% unemployed 1 month post intervention; compared to 100% unemployed in the therapist-led group. At 6 months post intervention, the VR group had 25% of participants in open employment and the therapist-led group had 15%. Overall, the VR group showed a reduction in unemployment of 25%, whereas the therapist-led group showed a reduction in unemployment of 20%, demonstrating a positive link between vocational outcomes and the use of the VR intervention. These results were observed to be very encouraging in the viability of VR as an intervention modality.

Table 8

Job Outcomes

Job Status	1 month- AIVTS	1 month-PEVTS	6 months-AIVTS	6 months-PEVTS
Unemployment (searching for job)	17 (85%)	20 (100%)	12 (60%)	16 (80%)
Sheltered workshop	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Supported employment	2 (10%)	0 (0%)	3 (15%)	1 (5%)
Open employment	1 (5%)	0 (0%)	5 (25%)	3 (15%)

Note: AIVTS: Artificial intelligent virtual-reality based training program; PEVTS: Psycho-educational vocational training system.

Work task performance can be aligned with vocational employment outcomes, as employment generally involves performance of tasks and typically better performance of those tasks is related to a more positive work performance. Brooks et al. demonstrated that virtual training in work tasks was as beneficial as real training, and more beneficial than workbook or no training in food preparation tasks, however demonstrated that for hazard identification tasks, all modes of training delivered equal results (Brooks et al., 2002). This demonstrates a potential positive relationship between VR and task performance as a vocational outcome, however the varied results within the study warrant further investigation into the moderating factors in the relationship between VR training and task performance.

In the study by Tsang and Man, they asked participants to complete an on-site test that comprised a questionnaire which assessed the participant's performance in sales-related activities using a 10 point Likert scale to rate their work-related knowledge and skills (Tsang & Man, 2013). The study found significant improvement in scores on the questionnaire in both the VR group and the Therapist-led group compared with the control group. This indicates a potential positive relationship between VR and improved work performance, however warrants further investigation.

Interview performance can also be linked with employment outcomes, as to obtain employment one typically needs to undertake a job interview and generally, the better the performance in an interview, the more likely the person to be succesful in obtaining the role. In their research into job interview performance for people with ASD, Schizophrenia and PTSD, Humm et al. demonstrated that VR intervention provided a significant training effect, with the VR group scoring higher in the role play and self-assessing higher than the control group participants (Humm et al., 2014).

Vocational Outcomes – Self-Efficacy

Self- efficacy refers to an individual's belief in their capacity for behaviours necessary to produce performance (Bandura, 1977, 1986, 1997; Carey, 2009). Self-Efficacy and work-related performance have been shown to be positively correlated (Stajkovic, 1998) and as such, work self-efficacy has emerged as a construct of its own, referring to a persons' key capacities needed to be successful in work (Pepe, 2010). A number of studies reviewed demonstrated a positive relationship between VR intervention and improved self-efficacy.

Amado and colleagues demonstrated that participants showed overall improvements in their level of autonomy and their drive to search for jobs or return to activities within the community following their use of the VR intervention (Amado et al., 2016). Sohn et al. demonstrated improved psychosocial and cognitive function and identified that these improvements could influence real-world vocational performance (Sohn et al., 2016). Tsang and Man demonstrated that participants scored a higher level of self-efficacy after using the VR intervention and had a demonstrated improved work performance (Tsang & Man, 2013). The specific self-efficacy outcomes observed in each study are detailed below in Table 9.

Table 9

Self-Efficacy Outcomes

Study	Self-Efficacy Outcome
Amado et al. 2016	Improved level of autonomy. Improved drive to search for jobs or return to activities within the community.
Humm et al. 2014	Improved self-assessment of performance in interviews.
Man et al. 2013	Positive qualitative data demonstrated potential for improved self-efficacy; however not formally measured.
Sohn et al. 2016	Improved psychosocial and cognitive function which could lead to real-world vocational performance.
Tsang & Man 2013	Improved self-efficacy score for the VR group.

Other Outcomes

Other outcomes were demonstrated in the remaining studies reviewed, however there were not sufficient studies to group these into themes of the research conducted. One study demonstrated that the level of anxiety experienced in a job interview is not correlated to the degree of realism of the characters involved in the virtual environment, however that immersion is the key factor that influences anxiety experienced by the participant (Kwon et al., 2013). This is a relevant finding and may speak to the moderating factors between immersion, VR and participant's experiences that lead to outcomes. This reinforces the importance of immersion in the use of VR intervention tools and warrants further research.

Finally, Rizzuto et al. asked participants to undertake a pointing task within a virtual environment with either auditory or visual stimuli and a real-world envrionment (Rizzuto et al., 2019). They found that participants demonstrated poorer performance in the virtual environment when compared with the real-world envrioment, as measured by velocity and movement time (Rizzuto et al., 2019). The study suggested that there was potential for VR to be more effective with static postures, such as prolonged sitting, instead of dynamic tasks, such as pointing tasks requiring precision.

Overall, the findings of this systematic literature review confirm the wide spread of literature across cohorts, focus areas, professional disciplines and across geographic regions. The studies reviewed demonstrated cohort and randomised controlled trial methodological design, with small sample sizes and varying levels of methodological quality. The studies included a range of participant cohorts, with the majority comprising people with mental health diagnoses.

The studies reviewed indicate positive and promising results that VR may be a viable intervention modality. The systematic literature review found a positive link between VR interventions and vocational outcomes; both direct employment outcomes as well as improvements in self-efficacy relating to work. Furthermore, the studies reviewed indicated positive outcomes to cognitive function following the use of the VR intervention tools. Overall, the results demonstrate positive links emerging between VR and improved work ability, but further research is warranted. The results found in this systematic literature review will be further discussed in the following chapter.

CHAPTER 4 DISCUSSION OF RESULTS

The purpose of the current study was to examine the existing research surrounding VR and its application to vocational intervention, using a systematic literature review, and critically examine the literature. The research team set out to answer the research questions relating to VR as an intervention tool for vocational rehabilitation. The research sits on the frontiers of the topic area which is presently creating a buzz within industry. The level of evidence is emerging, promising and provides the rationale to support the further pursuit of research into the topic.

The systematic literature review aimed to answer the research questions (RQ1): *Is VR effective for vocational intervention?* (RQ2): *What is the most effective VR tool?* (RQ3): *Is VR more effective than face to face vocational interventions?* And (RQ4): *What is an effective dosage for best outcomes?* Following the systematic literature review, based on the methodology explained in previous chapters, the overall findings of the review indicated a wide spread of evidence, with the majority of studies comprising participants with mental health conditions and measured cognitive function and vocational outcomes pre and post intervention with a VR tool. The findings indicate VR intervention may be a viable alternative to face-to-face intervention, however the strength of the evidence is limited at this stage. Due to this limited volume of evidence, a meta-analysis was not completed within this study.

This discussion chapter will include a discussion of the overall results, and the emerging nature of VR intervention tools within the vocational rehabilitation field. In addition, this chapter will discuss the rationale for the key finding of the systematic literature review that the evidence base is thin, before discussing the results of each research question, as this is pertinent to all the research questions. The chapter will explore whether VR is an effective intervention tool (RQ1), and discuss this in regard to vocational outcomes, before discussing each occupational performance component area and the findings relating to these components and in the context of the broader literature. The chapter will then discuss the most effective type of VR (RQ2) and the dosage for intervention (RQ4), before discussing whether VR is more effective than face to face intervention (RQ3). Following the discussion of each research question, this chapter will outline current commercial applications of the research topic, demonstrating the potential for VR and the anecdotal evidence available to support the use of VR as a vocational intervention. Finally, the chapter will be closed out with discussion of the strengths and limitations of the present systematic literature review and the recommendations for future research.

Overall results

The geographic spread of the research reviewed as part of the systematic literature review across Asia, Europe, and North America in addition to the professional discipline spread across psychology, psychiatry, medicine, kinesiology, and occupational therapy suggests that the current state of evidence surrounding VR use in a vocational context is an emerging field. At present, it was observed that the research is in its early stages, as neither a geographic centre (e.g., Hong Kong) nor a professional discipline centre (e.g., psychology) has yet been established. This aligns with the limitations of the studies reviewed, being of smaller sample sizes and study designs comprising cohort design rather the randomised controlled trials; as this indicates the research is in its infancy, rather than established and mature. It is expected that the more mature a topic is within research, the higher levels of evidence would be available as per the evidence hierarchy (Ackley, 2008).

The results of the current systematic literature review demonstrated a promising positive link between VR intervention and the cognitive occupational performance component as well as positive link between VR intervention and improved employment outcomes following vocational intervention. The results observed for the cognitive occupational performance component were spread across a wide range of assessment tools and each study set out to measure different aspects of cognition. This creates difficulty in collating the results and determining the weighting of the outcomes in totality or determining the effectiveness of the interventions on cognition. However, there were some promising outcomes demonstrated in memory, attention, and overall cognitive function.

In respect to the type and dosage of VR, the systematic literature review did not identify a pattern in use of VR systems and hardware, nor in the application of the VR intervention to participants in relation to the outcomes obtained. The definition of VR was also observed to be varied throughout the studies reviewed, which may explain some of the variations in results. In addition, very few of the studies measured or documented that immersion was considered in the development of the VR tool. Given immersion appears to be a key moderator in the participant's experience using VR, and therefore the outcome obtained, this is a key gap in the research that requires further exploration.

Whether VR was more effective than face to face, or therapist-led vocational rehabilitation is yet to be seen. Only one study (Man et al., 2013) measured this within the reviewed studies and they demonstrated a positive link between the VR group and higher employment outcomes when compared with the therapist-lead group. The absence of volume of evidence to answer this research question likely points to the maturity of the research topic, which is evidently in an emerging state.

Challenges to the literature for VR

The body of evidence at this stage is in an emerging state due to a number of factors including the development and accessibility of technology, advances within the discipline, acceptance of VR and digital tools as a therapeutic tool by both clinicians and consumers and the current divergence of the technology and academic fields. This is likely to converge at a key point in the future, likely the next 5 years or so, but contributes to a spread of evidence that at present is not able to confidently inform practice of clinicians, consumers nor policymakers. The literature surrounding the challenges in the adoption of an evidence-based VR intervention tool is detailed below, and although there are presently a number of challenges for such a tool to overcome, it can also be seen that we are approaching the perfect combination of market forces to enable the development to occur. These challenges are discussed prior to discussion of each research question, as they pertain to all the research questions.

The development and accessibility of technology is a key element that has contributed to the findings of this study. Innovative technology developments often take many years to turn from concept to reality and then even longer, often, to become widely used in mainstream applications. This is the case for VR also, with the first head-mounted display prototype developed in 1968 by Ivan Sutherland (Jauregui, 2019). From the 1970s to the 1990s, VR was used mainly for flight simulation and military training purposes (The Franklin Institute, n.d.). The first widespread commercial consumer headsets were released in 1992, and Computer Gaming World Magazine predicted “Affordable VR by 1994” (Engler, 1992), which did not actualise. The first prototype of the Oculus Rift (Facebook Technologies LLC, n.d.-b) was designed in 2010 and had limited function compared to the version we see today in 2021 (Kumparak, 2014). From 2016 to 2021, there were a number of other devices released to the market from HTC, Facebook, Amazon, Apple, Google, Microsoft, Sony and Samsung, with continuous improvements to the technology and the software capabilities. It is reportedly expected that the VR global market will grow to $62.1 billion by 2027 (Jochum, 2021), particularly following the COVID-19 pandemic, that has accelerated technological advancements in the face of social distancing and remote-working requirements.

Improved access to technology is a key challenge that must be overcome in the journey from concept to becoming a mainstream device for any technological innovation. VR is not exempt from this, and as many forms of technology have done, VR has been through a journey to shape its hardware and software to something that can be accessed and used by the general population today and into the future. The first HMD was reportedly so heavy that is had to be suspended from the ceiling (Jauregui, 2019), in contrast, todays’ units weigh approximately 500g (Evans, 2019). In addition to the physical use of the device, the historic cost has been a significantly prohibitive factor for accessibility, with early devices costing in the realm of $100,000 US Dollars (Kumparak, 2014). In contrast, todays Oculus Quest 2, on the higher end of the market, costs $639 Australian Dollars (Facebook Technologies LLC, n.d.-a). With the improved features and access to VR devices, it is likely we will continue to see developments that move further into the mainstream use and subsequently further into healthcare settings. The risk for moving faster and further into the mainstream is that the evidence base to support the safety and efficacy of the VR modalities may not exist, creating difficulties for clinicians, consumers and policymakers in best-practice decision making.

Becoming mainstream is a goal of VR, and all technological innovations; however, with increased accessibility comes the emergence of further challenges. For VR, an emerging challenge is the inclusivity of access for people with disability or unique access requirements. It has been shown that people with a range of disabilities from physical (e.g. Cerebral Palsy) to sensory (e.g. vision impairment) would like to use VR however experience significant accessibility issues due to the difficulties in customising the user experience and the requirement to move particular body parts (Phillips, 2020; The University of Melbourne, n.d.; Wong, 2017). In particular, VR requires the participant's use of vision to navigate virtual environments and also requires a level of cognitive and verbal skill to understand how to use the platform (Jonson, 2021). This presents another reason why the research surrounding vocational intervention using VR may be limited, as not all people undergoing vocational intervention may be able to utilise the VR tools available today. VR accessibility presents a topic that warrants further investigation as the literature continues to grow surrounding the use of VR in the vocational setting.

In addition to the development and access to the hardware of VR, a user needs to access and seamlessly use the software that comprises the virtual world. Typically, VR software comes in the form of a game and is accessed via the internet. Internet speeds and access to the internet have been another limiting factor to the speed of development and adoption of VR historically. In 1993, with the introduction of the internet, dial-up access was limited to a speed of 56Kb per second (Eha, 2013) with modems connected to the internet via phone lines; in contrast, today's internet speed in Australia is 58Mb per second (Pentanet, 2021), which is approximately 1,000 times faster. With the improvement in internet speed comes improved access in higher quality software, as higher resolution software can be streamed or downloaded in a reasonable timeframe compared to years ago. The internet is not used or accessible to all people on earth however, at the start of 2021 there were 4.66 billion active internet users (Kemp, 2021). With a current global population of approximately 7.83 billion people, this equates to approximately 59.5% of the population actively using the internet (Lin, 2021). With the continued improvement in access to the internet and the speed of the internet, it is expected that VR applications will continue to grow and move further into the mainstream.

In addition to access to technology and the seamless of technology, the acceptance of technology in healthcare is another challenge that VR needs to overcome to increase usage and to increase the volume of research available. Acceptance of technology can be reviewed using the technology acceptance model (TAM), which posits that two major factors are involved in user adoption of technology; perceived use of ease and perceived usefulness (Davis, 1989). In addition to usefulness and ease, technology acceptance in healthcare presents with additional challenges, including privacy, discomfort and care personnel concerns (Hirani, 2017). Specific to VR, research suggests that a higher sense of presence is more likely to be accepted by participants (Plotzky, 2021). However, VR has had historic difficulties in its perceived ease of use, requiring equipment that has in the past been heavy, large, and with myriad technical difficulties in its use due to software and internet speeds. VR is currently facing a challenge in proving its usefulness, rather than being perceived as a gimmick. This is part of why the present systematic literature review was conducted and why further research into the evidence base surrounding the use of VR in vocational interventions, and wider healthcare is imperative to its success.

The final challenge facing the VR literature, and probably the most pertinent to this systematic review is the pace of change and limited alignment between the technology and academia sectors. At present, the technology sector is moving at an incredibly fast pace, with health technology start-ups announcing new VR programs almost daily. The challenge in crafting an environment of technology acceptance is creating the evidence base that supports the use of VR interventions, that demonstrates the safety and effectiveness of VR intervention modalities. At present, this is the gap for VR and will become a significant barrier to widespread adoption if not rectified. Academia is thorough, resource heavy and costly, and as a result, slower than technology start-ups. This is backed by the observed small sample sizes within the systematic literature review, likely due to challenges in accessing participants in addition to the time it takes to complete thorough research.

At present, the technology and academic sectors are diverged on the topic of vocational intervention using VR, which may limit the acceptance of the technology by consumers, clinicians and policymakers. If VR is to succeed as an effective tool for vocational intervention, the technology and academic sectors need to converge, and research needs to be conducted to ensure that consumers are receiving evidence-based, effective, and safe healthcare.

So far, the emerging research into VR as a vocational intervention shows promising results, but it is still early days. The evidence suggests that VR tools may be a viable alternative or adjunct to face to face intervention, and the technology sector is producing several products that speak to this in an anecdotal manner; but the convergence of academia and technology is yet to occur sufficiently to provide sound evidence of effectiveness. The remainder of this chapter will explore the research questions of the present systematic literature review, the present-day practical applications of the topic as well as the strengths and limitations of the systematic literature review.

Effectiveness of VR for vocational intervention (RQ1)

Overall, the studies reviewed demonstrate a positive link between VR intervention tools and positive outcomes for participants, ranging from employment outcomes to functional improvements, indicating a potential effectiveness of VR for vocational intervention. The research showed that VR has potential to aid in employment outcomes for participants as well as improve self-efficacy. Furthermore, the research showed VR interventions were positively linked with cognitive and intrapersonal performance, however demonstrated negative correlation with biomechanical performance and showed gaps in interpersonal and sensory-motor performance. Much of these findings correlate with the findings from the wider body of research into VR interventions within other settings, such as neurological and psychological rehabilitation. The research question (RQ1) will be discussed in reference to each aspect of effectiveness reviewed as part of the systematic literature review, including vocational outcomes and each of the occupational performance components; including cognitive, biomechanical, sensory-motor, interpersonal and intrapersonal components

Vocational Outcomes

Vocational outcomes, for the purpose of this systematic literature review have been split between (1) employment outcomes; to obtain, maintain or increase the level of employment, including task performance and (2) self-efficacy outcomes; to increase the participant's perception of their abilities toward work. The studies reviewed demonstrated positive links in both employment outcomes and self-efficacy, however with a greater volume of evidence supporting the positive link with self-efficacy than employment outcomes.

Direct employment outcomes were measured by only two studies within the selection (Humm et al., 2014; Man et al., 2013). Within the study by Man et al. they followed participants for a period of 6 months after the intervention for both the VR group and the control group; and at 1-, 3- and 6-month intervals, the VR group demonstrated higher employment outcomes. In the study by Humm et al. they followed participants for a period of 20 weeks following intervention for both the VR group and control group, and the VR group demonstrated higher employment rates than the control (Humm et al., 2014). No other studies sought to measure employment outcomes within the studies reviewed. Demonstrating a link with employment outcomes can be challenging due to multifactorial nature of finding employment that involves myriad of factors not related to the intervention, for example the labour market position, economic factors, and social factors. There is limited wider research to support or refute the findings in regard to employment outcomes, which is the key finding of this study.

The quality of work task performance was assessed by a further two studies (Brooks et al., 2002; Tsang & Man, 2013) and in this review, demonstrated mixed findings. Brooks et al. had participants conduct two tasks and showed that VR training was better than workbook or no training, and equally beneficial as real training in one of the tasks. In the second task, safety and hazard identification, all training methods delivered an equal result (Brooks et al., 2002). Further research in this area would be beneficial, particularly as this is where a number of industry applications of the topic are focussed. Work task performance has been the focus of research for many years in the academic fields within medicine, military and Aeronautics and have displayed mixed results similar to the present systematic review.

Surgical simulation training using VR has been implemented within orthopaedics due to the need for a greater volume of experience for training junior surgeons (Parham, 2019). However the evidence for VR and its clinical efficacy is mixed (Camp, 2018; Frank, 2018). The VR simulators within a surgical environment has been shown to enable the participants to learn and practice arthroscopic skills within a risk-free environment, with no risk of patient harm, and the VR environment enables the provision of immediate feedback to participants. The existing challenge for the medical profession is that a recent meta-analysis and systematic review demonstrated that performance within the simulators was successful in improving performance within the simulators, and that skills gained within the simulator training are not perfectly transferrable to a clinical setting (Frank, 2018). The evidence suggested that highly-specific skills may have a high degree of transferability to a clinical setting (Frank, 2018; Hamstra, 2006; Matsumoto, 2002), but more global skills face greater challenges with transferability (Frank, 2018). These findings, although far more mature and of a greater volume, align with the findings of our study; that VR appears to have a positive impact on task performance, however, further investigation is required into the mechanism and generalisation ability of these intervention modalities.

VR use within aviation and aeronautics suggests positive outcomes for simulating dangerous or challenging work tasks. Within the aviation industry, VR technology was envisioned as an alternative to flight simulators due to VR's relative flexibility, mobility and size compared to flight simulators (Moroney, 2009; Oberhauser, 2018). VR simulators have indeed been shown to be a viable tool for use in training pilots in flying (Oberhauser, 2018) and are widely used within the sector. NASA, the National Aeronautics and Space Administration in the US, has long been considered as the original and an early adopter of

VR for various training simulations run for astronauts. VR has been used by NASA to successfully operate remotely controlled robotic mechanisms (Nguyen, 2001) and for enhancing the training of astronauts and ground-based personnel, for example training for completing repairs and maintenance on the Hubble Space Telescope (Loftin, 1994). Although VR is and has been used in industry for some time, the evidence for its efficacy is still inconclusive, which aligns with the findings of this systematic literature review.

In addition to task performance, interview performance is an important aspect of employment, as it is a precursor to obtaining employment. Within the studies reviewed, one demonstrated improved interview performance as a result of using a VR interview program compared to the control groups (Humm et al., 2014). The results of this study align with the results of a randomised controlled trial by Smith et al. which demonstrated that their VR job interview training program was efficacious for improving job interview skills for people with schizophrenia and that those participants had greater chances of being employed at the 6-month follow up (Smith, 2015). Furthermore, these results align with preliminary research using VR interview programs with veterans with PTSD which indicated positive outcomes (M. J. Smith, Boteler Humm, L., Fleming, M.F., Jordan, N., Wright, M.A., Ginger, E.J., Wright, K., Olsen, D., Bell, M.D., 2014).

The mechanism by which VR interview training achieves positive outcomes for participants is an area where further research is warranted. The VR interview appears to be advantageous in its' capacity to teach, reinforce and refresh interview skills (Humm et al., 2014; M. Smith, Ginger, E., Wright, K., Wright, M., Taylor, J., Humm, L., Olsen, D., Bell, M., Fleming, M., 2014), which aligns with the broader research on VR, suggesting its repeatable, controllable nature coupled with the ability to provide real-time feedback is the key to outcomes.

In addition to employment outcomes, task performance and interview performance, vocational outcomes can be measured by improvements to an individual's self-efficacy in relation to work. Work self-efficacy refers to a person's belief in their capacity to be successful in work performance (Pepe, 2010) and work self-efficacy has been demonstrated within a number of the studies reviewed to be positively linked with VR interventions

(Amado et al., 2016; Humm et al., 2014; Sohn et al., 2016; Tsang & Man, 2013). The nature of VR lends itself to improving self-efficacy as it enables participants to repeat tasks and gain real-time feedback to obtain a level of mastery over the task they are completing (Humm et al., 2014). This finding links to the broader research base across VR intervention tools for interviews (Crawford, 2018; M. Smith, Ginger, E., Wright, K., Wright, M., Taylor, J., Humm, L., Olsen, D., Bell, M., Fleming, M., 2014; M. J. Smith, Boteler Humm, L., Fleming, M.F., Jordan, N., Wright, M.A., Ginger, E.J., Wright, K., Olsen, D., Bell, M.D., 2014; Smith, 2015). These studies have cited feedback from participants including that the technique was worthwhile and appropriate (Crawford, 2018), participants saw the benefits of ongoing feedback and were enthusiastic (Bell, 2011) and that it was easy to use and helpful (Smith, 2015).

The wider research into VR and self-efficacy suggests a positive relationship more broadly. In a study examining student teachers, the VR learning environment was positively linked with increased self-efficacy, increased innovative behaviours and increased creativity (Nissim, 2017). In another study examining self-efficacy with negotiation skills, the VR system significantly improved the participants' knowledge of negotiation and increased their self-efficacy and self-motivation (Ding, 2020). This was further supported by a study looking at play rehabilitation for children with cerebral palsy, which demonstrated a positive relationship between the VR intervention with increased self-efficacy (Reid, 2009).

Moreover, VR was also shown to improve self-efficacy in claustrophobic situations during intervention with participants for claustrophobic fear and these results were maintained at a 3 month follow up post intervention (Botella, 2000). It appears that VR is positively linked with increased self-efficacy, the moderators in this relationship may include the ability to provide feedback and repeat tasks within the VR program, however further research is warranted to explore the relationship between work self-efficacy and VR intervention further in addition to linking this with employment outcomes.

As this is the first systematic literature review on this topic, it is important to not only explore the vocational outcomes as an indicator of the effectiveness of VR intervention modalities, but to also explore the occupational performance component outcomes, which all comprise vocational function. The following section of this chapter will discuss the findings in relation to each of the occupational performance component areas, including cognitive function, intrapersonal function, biomechanical function, interpersonal function, and sensory-motor function.

Cognitive Occupational Performance Component

Cognition comprises interrelated processes that contribute to task performance, including perceiving, organising, thinking, judging, remembering, attending and problem solving to enable a person to process, learn and generalise (Abreu, 1987; Ranka, 1997). Cognition is a key functional performance component for engaging successfully in tasks within employment. Problem solving, attention, memory, creative thinking, critical thinking, organising, planning and time management, for example, are all elements of performing a job (Job Access, 2018) and deficits in these areas of function may create difficulties for a person in performing the requirements of the job. This systematic literature review observed a positive relationship between VR intervention and improved cognition, with some mixed results, which aligns with the wider research into cognitive rehabilitation using VR which has demonstrated positive outcomes, with mixed results.

The majority of studies reviewed within this systematic review focused on the cognitive occupational performance component, and 50% of the overall studies demonstrated positive findings and improvements in cognitive function following use of the VR intervention tool (Amado et al., 2016; Brooks et al., 2002; Man et al., 2013; Sohn et al., 2016; Tsang, 2013). Overall, the results showed improvements in attention, working memory, prospective and retrospective memory, selective and perceived memory function as well as general cognitive function. These findings suggest that virtual environments may create increased cognitive performance and as a result, that VR vocational intervention may be positively linked with improving cognitive function in regard to the workplace. However, the small sample sizes observed, and the methodological challenges warrant further investigation as to whether the VR intervention was the moderating factor in the improvements observed in the participants.

The findings of this research are aligned with the wider VR body of research, specifically in the fields of cognitive rehabilitation. A systematic literature review looking at cognitive rehabilitation using VR by Montana et al. found varied results in regard to VR as an intervention tool for cognitive rehabilitation (Montana, 2019). This systematic review found that the existing body of literature demonstrates a positive relationship between VR and spatial memory. However, they also noted that some of the studies reviewed may indicate a learning effect rather than a direct improvement in spatial memory function and this warrants further investigation (Montana, 2019). Importantly, this review suggested that the dosage of the VR intervention is a key moderator in the results of the studies, indicating success relied on the overall duration of the training, the frequency, the intensity of each session and the time elapsed since the injury or illness which caused the impairment in memory (Montana, 2019); which aligns with RQ4 of the present systematic review.

Another study demonstrated similar mixed results in relation to VR and spatial memory rehabilitation (Jonson, 2021), as did a case-study looking at cognitive function with an individual with ASD- Level 3, which demonstrated improvements in attention, visual search, scanning and visuo-spatial skills (De Luca, 2021). It can be seen that the evidence for VR intervention to create cognitive functional improvements shows promise, however further evidence, larger samples and alternate study designs, including randomised controlled trials, is required to further analyse this relationship.

Intrapersonal Occupational Performance Component

The intrapersonal occupational performance component refers to "the operation and interaction of and between internal psychological processes used during task performance" Para. 16 (Ranka, 1997). The intrapersonal component can include elements such as emotions, mood, affect, self-esteem, satisfaction and motivation (Ranka, 1997). Intrapersonal function is vital for work performance as it represents a person's ability to maintain themselves and their presence to the tasks within a workplace, for example to have the motivation to complete tasks and the skills to self-regulate their emotions to participate in a time-pressured environment.

The studies reviewed focused predominantly on people with mental health conditions (62.5%), including participants with Schizophrenia, PTSD, and Social Anxiety. Despite the majority of studies focusing on people with mental health diagnoses, the focus of the outcomes of these studies was not aligned with this, with only one study focusing on the participant's levels of anxiety during a job interview (Kwon et al., 2013). In addition, two studies stated generalised improvements in psychosocial function based on baseline neuropsychological testing pre and post intervention (Amado et al., 2016; Sohn, 2016). The limited results in improvements in intrapersonal performance is likely linked to the primary diagnosis studied being Schizophrenia, which is generally considered a lifelong condition with limited prognosis for improvements (Harvard Health, 2019).

There is a body of research surrounding VR interventions for intrapersonal function, specifically surrounding anxiety management and phobia treatment. VR has been shown to create virtual environments that enable logistically appropriate exposure therapy to be carried out with participants (Lindner, 2021). This may be one of the reasons why the primary cohort of the studies reviewed in this systematic literature review were participants with mental health diagnoses. There are volumes of evidence for VR exposure therapy for anxiety disorders in the way of systematic reviews and meta-analyses (Botella, 2017; Carl, 2019; Fodor, 2018; Lindner, 2021; Opris, 2012); however, similarly to the existing study, these meta-analyses have raised questions around sample size and methodological protocol, highlighting the need for further research (Lanier, 2019; Lindner, 2021; Page, 2016).

Biomechanical Occupational Performance Component

The biomechanical occupational performance component refers to the physical structures of the body and their performance in tasks (Ranka, 1997). The biomechanical component includes aspects of performance such as joint range of motion, overall endurance, muscle strength, circulation and the elimination of body waste (Ranka, 1997). The biomechanical occupational performance component is related to employment in the physical completion of work tasks, involved in almost all employment situations in some form or other. One of the studies within this study focused on biomechanical performance

(Rizzuto et al., 2019) and demonstrated that the VR group showed poorer performance in a pointing task, as measured by movement time and velocity, than the control group. This study suggested potential for VR in more static postures and their analysis, rather than dynamic tasks and suggested further research be conducted.

In contrast, there is a significant body of research surrounding upper limb rehabilitation and rehabilitation following stroke. In a study looking at VR interventions for upper limb rehabilitation, they found similar results to Rizzuto et al. for a reaching task, in that the virtual group had less smooth reaches with a longer time to peak velocity than the control group (Demers, 2021). Alternatively, within a study looking at rehabilitation for children with brain injury, the VR group showed significantly better improvements in upper limb dexterity, performance in activities of daily living, and forearm supination (Choi, 2020). In a meta-analysis of 27 studies reviewing upper limb rehabilitation in patients with stroke, Mekbib and colleagues found that the VR intervention groups showed statistically significant improvements in the recovery of upper limb function, activity and participation versus the control groups (Mekbib, 2020). These results suggest, again, a mix of outcomes associated with the VR interventions although suggest a positive correlation between biomechanical function and VR interventions.

Interpersonal Occupational Performance Component

Interpersonal function refers to the social interaction functions which occur between a person and others. The interpersonal occupational performance component includes aspects of performance such as empathy, communication and building and maintaining relationships (Ranka, 1997). Interpersonal function is required in all workplaces to some degree, even work roles which require limited social contact with others require a person to engage in a job interview or interact with a supervisor or manager.

None of the studies included focused on or measured interpersonal outcomes directly, one study reviewed interview performance for people with ASD, Schizophrenia and PTSD (Humm et al., 2014), however this study measured task performance in the interview tasks presented to participants. Although improved task performance in an interview could be linked with improved social skills, it is not a direct link and cannot be generalised. The broader research demonstrated that there are varied definitions and methods of measuring social functioning (Burns, 2007) and as such, for the purpose of this study, task performance has been viewed as a separate outcome from interpersonal function and is discussed in the vocational outcomes section of this chapter.

There is some evidence to suggest that VR intervention tools are positively linked with improved interpersonal outcomes, defined within the literature as social skills. A meta-analysis looking at VR programs for social skill development showed that the VR programs performed better than alternatives for improving social skills (Howard, 2020). Interestingly, this meta-analysis also found a number of counter-intuitive findings, including that gamified programs produced slightly worse outcomes than non-gamified programs; and programs using head-mounted displays with greater immersion produced slightly worse outcomes than non-immersive displays (Howard, 2020). These findings again suggest further research into the moderating factors of VR interventions is required to understand the mechanism for functional improvements.

Sensory-Motor Occupational Performance Component

The sensory-motor performance component refers to the interpretation of sensory input and the motor responses performed by the body in response to the input (Ranka, 1997). Characteristics of sensory-motor performance may involve appropriate motor responses to sensory input, registration of sensory stimuli, and coordination and may involve a persons' interpretation of auditory, visual, taste, tactile, temperature, movement and smell stimuli (Ranka, 1997). Although sensory-motor performance is not a direct task that is performed within a workplace, appropriate processing and response to sensory stimuli is required for optimal performance. For example, a person may need to hear and interpret auditory stimuli including a fire alarm, which may be particularly challenging in loud or busy environments for someone with sensory processing difficulties.

Given VR's ability to control, grade and manipulate sensory input for a participant, it was hypothesised by the research team that sensory-motor performance would be a key outcome or moderator in VR modalities. Whilst VR demonstrated positive outcomes for participants, sensory-motor function was not a key area of focus nor measurement in the studies reviewed. This may relate to the difficult nature of measuring sensory-motor function, which is generally a subjective experience of a participant.

The wider research is also lean on sensory-motor outcomes using VR interventions, focusing mostly on participants' experience of cybersickness as a function of sensory- motor function (Arcioni, 2019; Commins, 2019; Kim, 2020; Ng, 2020; Weech, 2019). One study into vestibular rehabilitation in older adults with cognitive impairment using VR demonstrated significant improvement in postural control and vestibular-ocular reflex and suggested that VR may be a safe option for these participants (Micarelli, 2019). An additional study was found detailing a preliminary exploration of visual and touch processing assessments using VR for adolescents with ASD, they found that the VR system may have better assessment sensitivity than traditional questionnaires used to assess sensory processing (Koirala, 2021). This is a significant gap in the research as sensory-motor function may be the key moderator in achieving outcomes through VR; due to the very nature of VR being a sensory experience. It is recommended that further research into sensory-motor function be conducted to explore this relationship further.

Type of VR (RQ2) and Dosage of Intervention (RQ4)

The research team set out to determine the most effective type of VR (RQ2) and the most effective dosage of intervention (RQ4), however no definitive conclusions in regard to either research question were able to be drawn due to the heterogeneity within the research. The studies reviewed included a wide range of VR hardware and software arrangements, and all studies varied in terms of frequency, intensity, and recurrence of intervention participation. The heterogeneity of the studies reviewed means that the research team are unable to draw conclusions around this yet. These findings align with findings from various meta-analyses into the use of VR across several health contexts (Howard, 2017, 2020; Montana, 2019).

The research team set out to collate evidence that would enable the development of an evidence-based vocational intervention VR tool, however due to the emerging nature of the field, this is not yet achievable. Accessible VR headsets have been in the market for approximately 10 years and their technological development in this time has been immense and dynamic. In addition to this, the evidence reviewed demonstrates initial phase research, including scoping reviews and case cohort designed studies, indicating an emerging nature of the research. It is anticipated that, with further development of technology, and maturity within the professional disciplines (e.g., occupational therapy and psychology) and academia, the body of evidence from which to draw conclusions will rapidly expand over the next 5 years.

Is VR more effective than face to face vocational interventions? (RQ3)

Whether VR intervention is more effective than face to face, or therapist led vocational intervention is yet to be seen, due to the emerging nature of the research topic. One of the studies reviewed addressed this question directly, by having a VR group and a control group led by a therapist for traditional psycho-educational vocational intervention. They demonstrated that the VR group had significantly better employment outcomes at 1-, 3- and 6-month intervals following the intervention program (Man et al., 2013). At this stage, the research demonstrates a potential positive link between VR vocational intervention and vocational outcomes, as well as a positive potential for VR to be more effective than face to face intervention programs, although further research is required. No wider research was found on this topic by the research team, indicating an area for future research focus.

Practical Applications

Although the research is inconclusive on the effectiveness of VR tools for vocational intervention in isolation, it is clear that industry sees VR as an exciting opportunity. There are several organisations pushing forward with VR innovations focused on training and upskilling the workforce. At this stage, the technology sector is moving at a fast pace ahead of academia and as such the research evidence for VR interventions is limited. The research questions that the team set out to answer require the convergence of the technology and academic sectors and is likely to expand rapidly over the next 5 years. Some examples of companies with VR innovations aligned with the research topic are detailed below.

VirtualSpeech are using VR to teach people soft skills for the workplace, including skills for networking, dealing with the media and speaking in meetings and conferences (VirtualSpeech Ltd., 2021). Strivr are working with organisations such as Walmart, Fidelity, Verizon, and jetBlue to create VR training for their workforces including health and safety training, operational efficiency training, customer service and soft skills training and sports training for athletes (Strivr Labs Inc., 2021). BP and Igloo Vision have partnered to develop training for employees in start-up and emergency exit procedures on their oil refinery in England to reduce the probability of employees making errors in the real environment which could be fatal (Igloo Vision, n.d.). The Children's Hospital in Los Angeles have created a training program for doctors on how to treat children in emergencies, specifically for infants who have had a seizure or are in anaphylactic shock (Takahashi, 2017).

The US Military uses the Virtual Squad Training System as part of their military training, which immerses soldiers into simulated combat situations to enable learning by practical experience, without the fatal risks associated with real-life combat situations (Judson, 2019). DHL and Immerse built a VR platform to train and promote safe, efficient unit load device stacking, which was used to improve efficiency and safety in warehousing operations (Graham, 2020; VirtualSpeech Ltd., 2021). Next World is providing off-the-shelf VR learning experiences including manual handling, hazard identification, excavator safety, fire hazards, fire extinguisher skills, working at heights, confined space entry and chainsaw safety training for employers in Australia (Next World Enterprises, n.d.). Finally, Vantari VR have developed immersive VR training for medicine and surgical procedures training for doctors and surgeons (Vantari Pty Ltd, n.d.).

There are many more examples of real-life applications of the research topic currently happening across the world, but currently the link with research evidence is lacking. This is where this systematic literature review contributes to the technology, health, and academia sectors, by identifying the need for convergence between the sectors to create a product that is evidence-based, safe and has a demonstrated effectiveness for client outcomes for vocational rehabilitation. At present, in Australia, we have the market forces present to drive this convergence with national healthcare workforce shortages creating pressure on access to services (Harrington, n.d.), booming client populations in aged care and disability (Australian Institute of Health and Welfare, 2018; Harrington, n.d.; NDIS, 2020) requiring more care from less workers and legislative reform and scheme sustainability under the microscope (NDIS, 2021a; Skatssoon, 2021) which may potentially reduce funding availability; all in conjunction with better technology, faster internet and generational change and acceptance of technology. It is likely that further partnerships will continue to emerge in this space and thus will ensure that proper evaluation of the VR tools take place, which will contribute to the development of the evidence base over time.

Strengths and Limitations of the Review Process

A strength of this systematic literature review is that the research team followed a methodical, reflective process, guided by the principles in the Cochrane Handbook for Systematic Reviews (Higgins, 2019) and the JBI Guidelines for systematic reviews for effectiveness (Tufanaru, 2017). Another strength is the methodology chosen to conduct the research, being a systematic review. A systematic literature review is advantageous as it limits bias and allows the research team to identify accurate, reliable conclusions that can be provided to consumers, clinicians and policymakers in regards to healthcare (Gopalakrishnan, 2013). Systematic literature reviews have also been shown to improve generalisability of results and have been shown to increase the accuracy of results (Gopalakrishnan, 2013; Greenhalgh, 1997).

The review included articles of all languages and years, ensuring the largest sample of studies that may be relevant were included. In addition, the quality appraisal process was a strength of this systematic literature review. The quality appraisal process was completed by two independent reviewers, with a coefficient of agreement calculated and a final score determined by agreement from the research team. The databases used to complete the search associated with this systematic review were high quality, academic databases, including EBSCOHost and Scopus.

This review could have been strengthened by using additional academic and grey literature databases to determine whether there were any additional studies that could have been included. As a limitation of this research was the reduced volume of available research, with limited data with which to complete a meta-analysis of the results. The reduced body of research demonstrated the research gap and hence the importance of the topic and this research within the wider body of knowledge. However, due to the limited volume of research available, the research team had to make adaptations to the initial inclusion criterion around the use of HMDs and this may have impacted the outcomes observed within studies.

Furthermore, systematic literature reviews have a potential weakness in the presence of publication bias within the reviews (Gopalakrishnan, 2013). Publication bias includes the findings of more positive outcomes than alternate outcomes in studies due to a bias in publishing positive outcomes over negative (Gopalakrishnan, 2013; Song, 2013). To avoid publication bias, this systematic review removed outcomes from the search terms, and included searches of the grey literature. However, as demonstrated in the literature, it is difficult to know whether all unpublished studies have been discovered (Song, 2013).

Finally, the quality appraisal coefficient of agreement data indicated a slight agreement in quality ratings between reviewers, indicating a degree of potential inconsistency in the quality appraisal process. The Kappa value calculated was 0.13, indicating a slight agreement between reviewers. However, due to the low number of articles included in the systematic literature review, it was determined that this level of Kappa was acceptable. It was acknowledged by the research team, that with a higher number of articles included within the review, we would expect Kappa to rise based on the dilution of inter-rater disagreement across more studies.

Recommendations for Future Research

The overall findings of the study indicate that VR interventions may be effective for vocational intervention and improving people's ability for work; but the evidence base is limited by small sample sizes, methodological quality, and the maturity of the topic. At this stage, the evidence for VR as a vocational intervention tool is in an emerging stage and it is anticipated that with the further development of technology, the technology and academic sectors will converge to produce a greater volume of evidence to review the efficacy of such a tool. Future research should focus on larger sample sizes, methodological quality, consolidating the definitions used for VR and immersion, the moderating factors in the relationship between VR and outcomes, the accessibility of VR and further focus on sensory-motor outcomes and the relationship sensory-motor function plays in VR interventions.

Future research should focus on improving methodological quality, including larger sample sizes, randomised controlled trial design with blinding, and controlling for any potential co-interventions that may impact on the outcomes. The current body of research comprises majority cohort study design with small sample sizes, limiting the ability to generalise the findings or to identify the effect size of the interventions on the participant cohorts. It is therefore recommended that further studies be conducted with larger sample sizes, and greater methodological quality, including randomised controlled trial design with blinding. It is recommended that greater descriptions within the studies around the VR tools that they have used and how they have determined the level of immersion is considered, as this is presently limited. Improving methodological quality will enable the findings of the research to be more readily generalised, enabling thematic analysis and informing clinical decision making.

As an element of methodological quality, the definitions surrounding VR must be consolidated. At present, the definitions of VR, immersion, presence and how these are measured varies greatly across the research and industry. Studies reviewed do not necessarily detail how they concluded that their hardware constituted VR, nor do they detail how they have considered or factored in the level of immersion for the participant. Given the importance of immersion and presence, it follows that future studies consider immersion, the level of immersion and how this impacts their choice of hardware and software. Without consistency in the definitions and concepts of VR and immersion, generalised and robust results will continue to elude researchers and VR may remain on the outskirts of technology, as a video-gaming tool or gimmick. Furthermore, once the definitions are consolidated, it would be beneficial for future research to focus on the moderating factor of immersion and the mechanism around how immersion impacts on functional outcomes for participants, including whether improvements can be attributed to learning effect or to functional improvements and whether these can be translated to the real world.

Future research needs to consider and explore further into sensory-motor function and VR accessibility. Given VR is a predominantly sensory experience, it follows that sensory-motor outcomes are explored as a potential outcome of using VR interventions. Additionally, the mechanism of sensory-motor function should be further explored in how it plays a role in facilitating the functional outcomes observed as a result of using VR intervention modalities. Finally, in addition to sensory-motor function, further consideration needs to be given to the accessibility of VR, particularly for people with disabilities and to the elimination of accessibility being a prohibitive factor in the access to VR interventions.

Conclusion

The research team set out to answer research questions including (RQ1): *Is Virtual Reality effective as a tool for vocational intervention?* (RQ2): *What is the most effective type of Virtual Reality tool?*; (RQ3): *Is Virtual Reality intervention more effective than face to face vocational intervention programs (including efficacy and cost)?* And (RQ4): *What is an effective dosage for best outcomes (including frequency, duration, intensity, and co-intervention)?* The research team set these research questions in an effort to collate and analyse the existing body of literature examining the use of VR as an intervention tool for improving work abilities. Overall results demonstrate a positive potential for VR to be an effective tool for vocational rehabilitation, however the evidence is in an emerging state.

The outcomes of the systematic literature review demonstrated positive links between VR interventions and improvements in cognitive function, intrapersonal function, and vocational outcomes by way of both employment outcomes and improvements in self-efficacy in relation to work. However, the findings were limited by small sample sizes and methodological quality, which has led to a difficulty in providing generalisations of results and indicating the emerging nature of the topic at present.

Employment is a powerful tool for health and wellbeing of individuals and society and constitutes a basic human right (International Labour Organization, 2015; United Nations, 1948). The continued advancements of technology, including immersive technologies enable researchers and clinicians to seek alternate modes of intervention in a process of continual improvement. VR may provide a viable, effective improvement to vocational rehabilitation and hence its powerful potential should be further investigated.

Future research should focus on larger sample sizes and higher level evidence methodologies, such as randomised controlled trials (Ackley, 2008), to allow for generalisations of the findings and for the analysis of between-group findings between VR interventions and control groups. Future research should consider a consolidated definition of VR and of immersion and explore the moderating factors in the relationship between VR, immersion, and functional outcomes. Furthermore, future research should consider the accessibility of VR, and how the limitations in accessing VR may limit the scope for VR interventions in the future. Finally, future research should review the relationship between sensory-motor function and VR and how sensory-motor function plays a moderating role in the outcomes obtained using VR interventions.

It is clear that there is significant industry excitement around the potential for VR in the work ability and work training space, with numerous emerging technology companies offering VR training for the workplace and this number expanding rapidly by the day. The anecdotal reports from these companies suggest positive outcomes have been seen in relation to their products; however, the academic rigour behind these tools, programs and innovations is at present lacking and therein lies the opportunity for academia and technology.

The continued focus on VR in the technology, healthcare and academic sectors is rapidly expanding; and currently expanding in alternate directions. To create the body of evidence required to inform practice for clinicians and funding decisions for policymakers, the technology and academic sectors need to converge into the same direction for focus. At present, in Australia, we have the market forces present to catalyst this convergence; with workforce shortages, booming client populations and a focus on reigning in expanding healthcare related costs presenting significant challenges to technology, healthcare and academia over the next 5-10 years.

This systematic literature review has made contributions to the field by providing insights into the existing body of literature surrounding VR and vocational intervention. We have provided the evidence of the existing gap in the research and provided linkages between real-world practical applications and the current academic state of play; creating an exciting opportunity for academia and industry to come together to realise the vision of using VR as a tool to improve peoples' abilities for work.

It is clear that there is both value and opportunity in the vocational intervention and work training space for technological innovations. It is clear that we need more consistent, more accessible and more efficient intervention modalities to improve peoples' work abilities. It is clear that industry sees VR as the next frontier in workplace training. It is clear that further industry and academic partnerships will emerge to build the evidence base for VR modalities. It is becoming clear that VR is primed to step into the innovative spotlight over the coming years as a tool to enable people to engage in work.

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i.amado@ch-sainte-anne.fr

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APPENDIX A

Search String

Database and search strings	Search terms	Field(s) searched	Database filters/ limiters
EBSCOhost Megafile ultimate Academic Search Ultimate, AHFS Consumer Medication Information, Anthropology Plus, APA PsycArticles, APA PsycInfo, APA PsycTests, Applied Science & Technology Source Ultimate, Audiobook Collection (EBSCOhost), Australia/New Zealand Reference Centre, Biological Abstracts, Business Source Ultimate, CINAHL with Full Text, Communication Source, eBook Collection (EBSCOhost), EconLit, Education Research Complete, E-Journals, ERIC, GreenFILE, Health Business Elite, Health Source - Consumer Edition, Health Source: Nursing/Academic Edition, Hospitality & Tourism Complete, Humanities Source Ultimate, Index to Legal Periodicals and Books (H.W. Wilson), Library, Information Science & Technology Abstracts, MAS Reference eBook Collection, MAS Ultra - School Edition, MasterFILE Premier, MasterFILE Reference eBook Collection, Mental Measurements Yearbook with Tests in Print, MLA Directory of Periodicals, MLA International Bibliography, Newspaper Source Plus, Newswires, Psychology and Behavioral Sciences Collection, Regional Business News, Religion and Philosophy Collection, Sociology Source Ultimate, SPORTDiscus with Full Text, The Serials Directory, Web News	virtual reality AND (employment OR work OR job OR Vocational) AND (intervention OR rehabilitation OR training)	Title, Subject Terms, Abstract, All Text	Limiters - Hidden NetLibrary Holdings Expanders - Apply equivalent subjects Narrow by Methodology: - empirical study Search modes - Boolean/Phrase

Search String- continued from previous page

Database and search strings	Search terms	Field(s) searched	Database filters/ limiters
Scopus	("virtual reality" AND "employment" OR "work" OR "job" OR "vocational" AND "intervention" OR "rehabilitation" OR "training")	Article Title, Abstract, Keywords	Subject Area: Health Professions Keyword: Virtual Reality

APPENDIX B

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
1. No language restrictions	1. Technology not considered fully immersive and interactive virtual reality, including: a) Augmented Reality intervention tools b) 360-degree video intervention tools c) Mixed reality intervention tools (defined as a combination of AR, VR, and other alternatives)
2. No date restrictions	
3. Study design: experimental or quasi-experimental design	
4. Study must include fully immersive, interactive virtual reality tool and may include use of or no use of accessories.	
5. Study virtual reality tool measurements: any frequency, any intensity, any duration, and any co-intervention included.	
6. Outcomes of a study will not be used as a criterion for inclusion.	

APPENDIX C

Final quality appraisal ratings

Author	Title	Final rating
Amado et al. 2016	A serious game to improve cognitive functions in schizophrenia: A pilot study.	Moderate
Brooks et al. 2002	An evaluation of the efficacy of training people with learning disabilities in a virtual environment.	Moderate
Humm et al. 2014	Simulated job interview improves skills for adults with serious mental illnesses.	Moderate
Man et al. 2013	The effectiveness of artificial intelligent 3-D virtual reality vocational problem-solving training in enhancing employment opportunities for people with traumatic brain injury.	Moderate
Tsang & Man 2013	A virtual reality-based vocational training system (VRVTS) for people with schizophrenia in vocational rehabilitation.	Strong
Sohn et al. 2016	Developing a virtual reality-based vocational rehabilitation training program for patients with schizophrenia.	Strong
Kwon et al. 2013	How level of realism influences anxiety in virtual reality environments for a job interview.	Weak
Rizzuto et al. 2019	Evaluation of a virtual reality head mounted display as a tool for posture assessment in digital human modelling software.	Weak

APPENDIX D

Data Extraction Table

Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
Amado, I. et al. 2016	Virtual town, created by Laboratory of Memory and Cognition at Paris Descartes University. Used joystick in virtual 3D town. 12x 90min weekly sessions.	Intrapersonal Cognitive	Sample of 10 outpatients meeting DSM-5 criteria for schizophrenia or schizoaffective disorder. (2 dropped out, 1 refused post testing, only 6 performed game assessment). Cohort Study- Pre and post test scores compared.	Brief Psychiatric Rating Scale (BPRS) Global assessment functioning scale (GAF) Social Autonomy Scale (EAS) Schizophrenia questionnaire for quality of life (S-QOL) Self-Esteem rating scale (SERS) D2 cancellation test (attention, visual scanning, speed processing) Wechsler Adult Intelligence Scale (WAIS-III) Grober and Buschke verbal learning test Battery for assessment of dysexecutive syndrome (BADS) Rey-Osterrieth Complex Figure Test (RCFT)- Visuo spatial	Clinically significant improvement in BPRS and GAF. Significant improvement EAS. No difference for S-QOL, Insight short form questionnaire, SERS. Attention, visual scanning and speed processing: D2 cancelation test significantly improved, improvement in WAIS domain score. Verbal and visual working memory: WAIS digit span had significant improvement. No significant difference for visuo-spatial subtest or forward span, but significant difference for backward span. Verbal learning: no change. Executive function: no change. Visuo-spatial organisation: no significant difference. Retrospective and prospective memory: significant difference for	Mod.	Small sample size. Non-parallel versions of some assessments. Participants had diverse treatment.	Include more flexibility into VR program. Include different areas and routes. Develop complexity of scripts and interactive avatars. Introduce public transportation and unpredictable events.

				Retrospective and prospective memory virtual test	retrospective test with binding apprehension for where and when, no significant different for what. Qualitative results: 6/6 felt better organisation. 3/6 improved planning. 2/6 better enrichment of relatedness. 4/6 increased self-confidence. 5/6 more awareness of difficulties. 3/6 a better rhythm in life. 4/6 noticed effort to search for work or training. 3/8 requested more therapy. Overall mentioned having done more concrete things with less stress. 1 /6 went to an employment agency searching for a job. 3/6 aimed to return to work or being training. Benefits to: attention, working memory, prospective and retrospective memory. No improvement: planning. Clinical and functional overall improvement with increased autonomy, increased drive to search for jobs or return to			

					activities within the community.			
Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
Brooks, D. et al. 2002	Virtual kitchen, modelled on a real kitchen familiar to the participants. Constructed by Third Dimensions Ltd using Superscape VRT software. Using a desktop computer, analogue joystick or keyboard direction keys and a mouse. 3 sessions over a 2- or 3-week period.	Cognitive	24 students with learning disabilities. Cohort pre and post-test.	Scores in food preparation tasks pre, post and improvement scores. Scores in hazard recognition tasks pre, post and improvement scores.	Participants enjoyed the VR kitchen. All participants were able to use the virtual environment without assistance by the end of the 3 sessions. No effect on familiarity scores. Significant difference between the training conditions. Virtual training showed more improvement than no training and workbook training (significant difference). No significant difference between real training and virtual training. Virtual training was as beneficial as real training and more beneficial than workbook and no training for food preparation tasks. Virtual, real and workbook training were found to be	Mod.	Real training tasks used simulations of real food preparation (due to resourcing real food), potentially limiting motivation of participants.	Further research into the transference between virtual and real training environments.

Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
					equally beneficial in the hazard identification task.			
Humm, L.B. et al. 2014	VR role-play using PeopleSim technology. Job interview training with Molly Porter. 5 hours of educational training modules. Simulation role-play 10+ hours of practice that provides a different experience each time, provided over 5 visits. Video, voice recognition and non-branching logic.	Intrapersonal	Randomised control trial 3 groups of Participants from varying cohorts (26, 37, 22 participants). All Participants were put into 2 groups- control or Molly interview. 96 Unemployed adults With ASD n=26 With schizophrenia n= 37 With PTSD n=33.	Demographics. Vocational history. Baseline RBANS- repeatable battery for the assessment of neuropsychological status. Baseline BLERT- bell-lysaker emotion recognition task for social cognition.	Role play scores improved significantly for Molly group. Post intervention self-confidence was significant in the molly group. Reports from 27 participants contacted 20 weeks post intervention indicated that of 16 from Molly group, 9 had obtained work 56.3%; whilst 3 of 11 27.2% from the control group had obtained work. Simulation provided a highly significant training effect, with experimental group participants scoring better in the role play interviews and self-assessing higher than control group participants.	Mod.	Small sample size. Small post-intervention follow up sample size.	Larger sample size. Possibility for measuring work self-efficacy.

	Database of more than 1000 questions ad 2000 possible learner responses. Learners receive nonverbal cues. Feedback is provided at the end.							
Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
Kwon, J.H. et al. 2013 Experiment 2	4 different levels of immersion: Audio only- SONY MDR-NC60. 14-inch laptop screen ACER. 42-inch LCD TV SONY. High resolution HMD NVIS nVisor SX	Intrapersonal	Participants had at least moderate symptoms of social anxiety, scores over 55 on the LSAS. 20 participants Divided into 4 groups matched for ethnic background and severity of social	Compare user's anxiety responses with varying levels of immersion for VR interview. Baseline BFNE scale pre-intervention (brief fear of negative evaluation). Skin conductance and pulse rate was tracked.	Participants in the HMD and head tracker had the highest presence scores, followed by LCD screen, laptop then audio. Difference in MASI score between the 4 conditions was significant. LCD and HMD provoked similar level of anxiety. No significance in interaction effect of presence and type of VR interview for MASI and Pulse rate.	Weak	Small sample size. Study design. Results difficult to generalise.	Potential for VR to assist with therapy for anxiety provoking situations.

	including head tracker Polhemus 6DOF-Motion Tracker. Interview asked 7 interview questions out of 12 in random sequence.		anxiety symptoms. 2x virtual job interview exposures at different immersive levels with 1 week interval between sessions. Cohort design.	MASI was measured with self-report of state anxiety (measure of anxiety in selection interviews).	Suggests level of anxiety is not influenced by sense of presence when undertaking a VR job interview. Sense of anxiety is less correlated to the graphical realism in the VR environment. Some degree of immersion is needed to maintain anxiety levels over the course of VR exposure.			
Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
Man, D.W.K. et al. 2013	Clerical work. 12 session modules across both AIVST and PEVST. In AIVST 12 sessions of 20-25 minutes. Monitor, mouse, keyboard.	Cognitive	Randomised controlled trial comparing a 12 session VR training system (AIVRTS) compared with structured and content similar conventional psycho-educational vocational training programme (PEVTS).	Problem solving (Wisconsin Card Sorting Test WCST) and Tower of London Test (TOL) and Vocational Cognitive Rating Scale (VCRS) Employment outcomes 1, 3 and 6 month follow ups on employment outcomes were performed. Modified Barthel.	AIVTS group performed better than the PEVTS group in WCST. Statistically significant difference in vocational outcomes for both groups- no difference between groups. Suggested positive impact on problem solving and vocational outcomes. AIVRS showed better performance than PEVTS for cognitive function. There is efficacy in improving work performance by	Mod.	Comprehensive relationship between variables unable to be confirmed- maybe due to local labour market. Small sample size. Potential additional intervention	Larger sample size.

			Participants- mild to moderate TBI (Glasgow Coma Scale GCS) and length of loss of consciousness (LOS). 40 participants (20 in each group).	Mini mental status examination. Test of nonverbal intelligence (TONI-II). Winconsin Card sorting test WCST. Tower of London test TOL. Vocational cognitive rating scale (VCRS). Employment outcomes. 10 item self-efficacy scale. 10 item onsite test.	conducting problem solving training within a work context and through an innovative model. Improvement in selective memory processes and perception of memory function were found. VR group performed better than the therapist led group with better vocational outcomes.		had been provided to participants prior to participation in study. Difficult to determine intensity of training and whether it was sufficient.	
Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
Rizzuto, M.A. et al. 2019	Real-world apparatus was developed and them replicated in VR. Head mounted device was used - Oculus Rift 2 with 14 reflective markers on the headset	Biomechanical	14 Right-hand dominant volunteers from the university population. Cohort design.	Target errors. Joint angles. Pointing velocity.	Game engagement questionnaire (GEQ) psychometric evaluation of the participants familiarity and level of engagement playing video games. Significant differences in target error, but not joint angle. Pointing velocity was slower and target error greater in virtual conditions.	Mod.	Limited task- pointing task aimed to simulate reaching in the workplace. Limited generalisation to tasks requiring manipulation or precision.	Review environment variability (real vs virtual) further and the inter-subject variability to validate the apparatus. Use VR for static postures rather than dynamic.

	and the participant's hand. Used Siemens PLM Software for VR model. Participants undertook 10min of familiarisation in each of the 3 environments (real, VR with auditory stimulus, VR with visual stimulus). 10min break between each environment.				Target error in virtual was 2x greater than the real environment- concerns around efficacy for tasks requiring precision. VR seems to have good efficacy for static postures. Greater target error in virtual compared to real environment. Peak pointing velocity was slower and movement time longer during virtual conditions.			
Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating (Weak, Mod., Strong)	Limitations	Directions for Future Research
Sohn, B.K. et al. 2016	VR environments for convenience	Cognitive	Participants with schizophrenia using the	Clinical symptoms- Manchester Scale, Clinical Global Impression-Severity,	9 total participants finished. No statistically significant change of WCST and Stroop Test.	Mod.	Small sample size.	More realistic characters and places.

	store and market environments. Were provided general training then given either convenience store or supermarket scenarios to complete. Convenience store took 20min, supermarket 15min. Participants performed activity each week for 8 weeks. Used 3x LCD digital projectors in an immersion room at the medical centre.		outpatient clinic. 10 patients were selected to participate. Cohort design	Clinical Global Impression-Improvement, Personal and Social Performance Scale and Hamilton Depression Rating Scale, Zung Depression Rating Scale and Beck Anxiety Inventory Cognitive functions- Wisconsin Card Sorting Test, Stroop Test, Rey-Osterrieth Complex Figure Test, Korean Version of the Auditory Verbal Learning Test	Memory scores and delayed recall of the RCFT and 1^{st} and 5^{th} attempt of the K-AVLT increased significantly. VR may improve general psychosocial function and memory, potentially influencing real world vocational performance.		Short program duration. No control groups.	More diverse jobs and experiences. Modifications to level of difficult tailored to cognitive function and severity of symptoms.
Authors/Year	VR Type & Dosage	Occupational Performance Component	Study Design / Sample	Measures	Key Findings	Quality Rating	Limitations	Directions for Future Research

						(Weak, Mod., Strong)		
Tsang, M.M.Y. & Man, D.W.K. 2013	All Participants attended 3hr of prevocational skills training. Monitor, joystick, mouse, keyboard.	Cognitive	Single blind RCT. Participants were patients with schizophrenia. Put into 3 groups: Vocational training group, therapist administered group an conventional group. 75 participants.	Brief neuropsychological cognitive examination. Digital vigilance test. Rivermead behavioural memory test. Wisconsin card sorting test. Vocational cognitive rating scale. Self-designed checklist for knowledge and skills in performing sales related activities. Self-efficacy in performing sales related activities. Global cognitive function- BCNE. Specific cognitive function- attention DVT, Memory- RBMT, executive function- ECST Cognitive function in the workplace- VCRS.	Significant interaction effect of group over time in DVT-time, RBMT, WCST-percentage of error, WCST percentage of conceptual level response. No significant group difference found regarding DVT time. Significant difference between groups for WCST-percentage of error and WCST-percentage of conceptual level response VRG showed better performance in the WCST percentage of error and WCST conceptual level response. Marginally significant interaction effect of group over time for WCST and VCRS No significant interaction effect of group of time was found for the BNCE VRG and TAG showed significantly better improvements in the on-site test than the CG.	Strong	Small sample size. Small to medium effect size may be obscured, secondary to limited power.	Larger sample sizes for greater generalisation. Increased training hours. Used outside schizophrenia cohort.

				Subjects' knowledge of skills and self-efficacy.	Significant difference across time intervals across all groups for self-efficacy score. Only VRG showed a significantly better improvement in self efficacy than CG. VR group performed better than others in cognitive function, had a better self-efficacy score and better work performance.			

Appendix E

Figure 2

EPHPP Quality Appraisal Checklist

QUALITY ASSESSMENT TOOL FOR QUANTITATIVE STUDIES

EPHPP
Effective Public Health Practice Project

COMPONENT RATINGS

A) SELECTION BIAS

(Q1) Are the individuals selected to participate in the study likely to be representative of the target population?
1 Very likely
2 Somewhat likely
3 Not likely
4 Can't tell

(Q2) What percentage of selected individuals agreed to participate?
1 80 - 100% agreement
2 60 – 79% agreement
3 less than 60% agreement
4 Not applicable
5 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

B) STUDY DESIGN

Indicate the study design
1 Randomized controlled trial
2 Controlled clinical trial
3 Cohort analytic (two group pre + post)
4 Case-control
5 Cohort (one group pre + post (before and after))
6 Interrupted time series
7 Other specify ______________________
8 Can't tell

Was the study described as randomized? If NO, go to Component C.
No Yes

If Yes, was the method of randomization described? (See dictionary)
No Yes

If Yes, was the method appropriate? (See dictionary)
No Yes

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

Figure 2

EPHPP Quality Appraisal Checklist- continued from previous page

C) CONFOUNDERS

(Q1) Were there important differences between groups prior to the intervention?

1 Yes
2 No
3 Can't tell

The following are examples of confounders:

1 Race
2 Sex
3 Marital status/family
4 Age
5 SES (income or class)
6 Education
7 Health status
8 Pre-intervention score on outcome measure

(Q2) If yes, indicate the percentage of relevant confounders that were controlled (either in the design (e.g. stratification, matching) or analysis)?

1 80 – 100% (most)
2 60 – 79% (some)
3 Less than 60% (few or none)
4 Can't Tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

D) BLINDING

(Q1) Was (were) the outcome assessor(s) aware of the intervention or exposure status of participants?

1 Yes
2 No
3 Can't tell

(Q2) Were the study participants aware of the research question?

1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

E) DATA COLLECTION METHODS

(Q1) Were data collection tools shown to be valid?

1 Yes
2 No
3 Can't tell

(Q2) Were data collection tools shown to be reliable?

1 Yes
2 No
3 Can't tell

RATE THIS SECTION	STRONG	MODERATE	WEAK
See dictionary	1	2	3

Figure 2

EPHPP Quality Appraisal Checklist- continued from previous page

F) WITHDRAWALS AND DROP-OUTS

(Q1) Were withdrawals and drop-outs reported in terms of numbers and/or reasons per group?

1 Yes
2 No
3 Can't tell
4 Not Applicable (i.e. one time surveys or interviews)

(Q2) Indicate the percentage of participants completing the study. (If the percentage differs by groups, record the lowest).

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell
5 Not Applicable (i.e. Retrospective case-control)

RATE THIS SECTION	STRONG	MODERATE	WEAK	
See dictionary	1	2	3	Not Applicable

G) INTERVENTION INTEGRITY

(Q1) What percentage of participants received the allocated intervention or exposure of interest?

1 80 -100%
2 60 - 79%
3 less than 60%
4 Can't tell

(Q2) Was the consistency of the intervention measured?

1 Yes
2 No
3 Can't tell

(Q3) Is it likely that subjects received an unintended intervention (contamination or co-intervention) that may influence the results?

4 Yes
5 No
6 Can't tell

H) ANALYSES

(Q1) Indicate the unit of allocation (circle one)

community organization/institution practice/office individual

(Q2) Indicate the unit of analysis (circle one)

community organization/institution practice/office individual

(Q3) Are the statistical methods appropriate for the study design?

1 Yes
2 No
3 Can't tell

(Q4) Is the analysis performed by intervention allocation status (i.e. intention to treat) rather than the actual intervention received?

1 Yes
2 No
3 Can't tell

Figure 2

EPHPP Quality Appraisal Checklist- continued from previous page

GLOBAL RATING

COMPONENT RATINGS

Please transcribe the information from the gray boxes on pages 1-4 onto this page. See dictionary on how to rate this section.

A	**SELECTION BIAS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
B	**STUDY DESIGN**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
C	**CONFOUNDERS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
D	**BLINDING**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
E	**DATA COLLECTION METHOD**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	
F	**WITHDRAWALS AND DROPOUTS**	**STRONG**	**MODERATE**	**WEAK**	
		1	2	3	Not Applicable

GLOBAL RATING FOR THIS PAPER (circle one):

1 STRONG (no WEAK ratings)
2 MODERATE (one WEAK rating)
3 WEAK (two or more WEAK ratings)

With both reviewers discussing the ratings:

Is there a discrepancy between the two reviewers with respect to the component (A-F) ratings?

No Yes

If yes, indicate the reason for the discrepancy

1 Oversight
2 Differences in interpretation of criteria
3 Differences in interpretation of study

Final decision of both reviewers (circle one):

1 STRONG
2 MODERATE
3 WEAK