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Exploring Possibilities: Virtual Reality in Nursing Research

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Abstract

This paper describes the use of virtual reality (VR) as a method of measurement in nursing research. VR refers to the use of computerized displays to display a life-like environment in which the user interacts. Although many disciplines are beginning to use VR environments in research, nursing has yet to embrace this technology. Nursing, as a profession which values the interaction between the environment, individual, and health, can benefit from the use of VR in research. Establishing reliability and validity of the VR tool selected for research is important and requires special consideration. VR testing can produce side effects, such as vertigo and discomfort, which must be anticipated in the research protocol.

Exploring Possibilities: Virtual Reality in Nursing Research

The student nurse looks at the electrocardiogram (EKG), and notes regular sinus rhythm with an occasional premature ventricular beat. After putting oxygen on the patient and adjusting the rate, she asks the patient how much chest pain he is experiencing on a 1 – 10 scale. The patient reports back that his pain is a “5” and radiating down his left arm. Suddenly, the EKG alarm sounds, and the student looks up at the monitor and notes with alarm that it shows ventricular fibrillation. The patient’s wife cries out, “What is happening?” as the student quickly pushes the code button and prepares to defibrillate. A team of medical and nursing professionals rushes into the room (McUsic, 2008).

This scenario is an example of one that student nurses in virtual clinical experiences may have since the advent of this technology in higher education. Educators in many disciplines have quickly recognized the value and flexibility of the virtual world in preparing professionals, especially in the health fields. More recently, the benefits of virtual reality have been recognized beyond education into the research realm. Virtual reality (VR) presents a plethora of opportunities to study human behaviors, knowledge, and skills, and it has the potential to allow researchers to examine these factors in safe, yet realistic environments.

Nursing, as a discipline, is intimately concerned with the interaction between the person, environment and health (i.e. Dodd et al., 2001). In the current strategic plan for the National Institute on Nursing Research (NINR), there are four strategies that are identified for the advancement of nursing science. These include “integrating biology and behavior, designing and using new technology, developing new tools, and preparing the next generation of nurse scientists” (NINR, 2006, p. 3). The use of VR in research has the promise of helping nurse scientists meet these challenges. VR environments are ideally suited to the measurement of

many variables of interest to nurses, such as complex cognitive, social, and psychomotor variables. VR is an excellent medium in which to observe interactions of individuals and groups within experimental contexts.

Despite the opportunities that it affords, VR has rarely been used in nursing research as a tool for measurement. Yet, VR is being embraced by other disciplines as a powerful tool for measuring complex variables. This paper will give an overview of the use of VR in healthcare and research, and give an exemplar of the use of VR in nursing research.

Brief History of Virtual Reality in Nursing and Healthcare

Fifteen years ago, Phillips (1993) wrote an editorial in which he predicted that VR would dramatically influence people's lives and as such, play a major role in nursing research. Since then, VR has been rapidly embraced by many individuals and groups, for uses such as video games, driving assessment, and even to augment healthcare delivery. Many health care professionals use traditional computer displays to provide VR environments as instructional methodologies (Martin, Phillip, & Thomas, 2002). VR programs have been used to train providers for laparoscopic surgery (Seymour, Gallagher, Roman, Obrien, & Andersen, 2002) and intravenous catheter insertion (Martin, Chantal, & Thomas, 2002). In addition, VR programs are increasingly being used more and more as a therapy for disorders, such as rehabilitation after stroke (Zhang et al., 2003), and treatment for anxiety (Paul, 2005) and phobias (Gregg & Tarrier, 2007). In nursing, VR is being investigated as a method for providing pain and symptom management interventions, with positive findings of the utility of VR in reducing symptoms (Wint, Eshelman, Steele, & Guzzetta, 2002).

The benefits of VR extend beyond education and health care treatment into the research realm. VR is frequently used in other disciplines to analyze cognitive abilities such as

navigation, learning and memory, and spatial learning (i.e. Livingstone & Skelton, 2007; Newman et al., 2007; Spiers & Maguire, 2007). Using experimental designs in which subjects are exposed to different VR conditions, scientists have been able to show the impact of these environmental conditions on behavior and cognitive functioning. Additionally, scientists have been able to relate behavior to brain function using movement through VR during functional magnetic resonance imaging (fMRI) (Janzen, Wagensveld, & van Turenout, 2007; Jordan, Schadow, Wuestenberg, Heinze, & Jäncke, 2004; Parslow et al., 2004). This technology has given invaluable knowledge regarding brain – environment interactions, and fascinating insight into how the brain responds to different environmental conditions and cognitive demands.

Types of Virtual Reality

VR is a general term that refers to a type of technology that includes computerized displays that depict three dimensional environments in which individuals can interact (Gregg & Tarrier, 2007; University of Michigan, n.d.; Zhang et al., 2003). Much of VR technology allows for an interaction between the user's movement and a simulated computerized environment such that head, eye, or joystick motion causes a change in the virtual world seen. Based on the type of technology used, the user can either visualize or actually participate in a simulated activity. Most importantly, VR ideally provides a sense of presence, which is a sense of being within the VR environment rather than observing it from the outside (Lobard & Ditton, 1997; Zhang et al., 2003). VR can be displayed using a variety of technologies, including simple desktop programs, head-mounted displays, special rooms with projected scenes (CAVE) and other devices that allow for multi-sensory input, including motion, sound, and touch. VR is sometimes classified as immersive or non-immersive (Table).

Immersive VR Displays. Immersive VR environments are those that are more life-like and have a high degree of presence (Pausch, Proffitt, & Williams, 1997). Examples of immersive types of VR include head mounted display (HMD) and CAVE environments. A HMD is a device that looks like goggles. Within the lenses, a computer generates a scene to both pupils. Head tracking information is communicated back to the computer, so that the image changes depending upon the direction in which the individual is looking. This allows individuals to visually explore a virtual world, and to have control over the direction in which they are looking. Objects appear life-like and three dimensional (Biocca & Delaney, 1995). Another popular immersive VR environment is the CAVE (Figure 1), which is displayed in a cubic room in which a computer projects images to the walls and ceiling. The user wears lightweight goggles that give information back to the computer regarding head or eye position. The user can walk through the computerized environment within the limits of the room. This type of immersive VR allows for movement and interaction within a lifelike simulated environment (Sherman & Craig, 2003).

Less Immersive VR Displays. There are less immersive types of VR platforms used such as those that are displayed on desktop computers or on movie screens. These VR programs typically allow the user to visually move about the virtual world using a movement device such as a joystick or mouse. Although much less sophisticated and life-like than immersive VR, these programs can still allow for user interaction with a three-dimensional environment (University of Michigan, 2008; Sherman & Craig, 2003). Examples of common VR environments that many people use from their own computers are computer games that depict virtual worlds such as Second Life (n.d.). In this program, individuals move about a complex virtual world with a joystick, and interact with other characters and have simulated experiences of their choosing.

The advantage to these types of less-immersive VR is that they are affordable, easily available, and more accessible to many researchers.

Why use VR and not the real world?

There are major benefits to using VR in research. In experimental studies, testing performance within a VR environment allows for each study participant to have exactly the same testing conditions. For example, Smith-Coggins et al. (2006) examined the impact of napping on the performance of physicians and nurses who worked the night shift in the emergency department. The performance measures in this study included two types of VR simulation, including a VR catheter (IV) insertion simulator, which measured the speed and ability of each subject in intravenous catheter insertion, and a VR driving simulator. The use of VR simulated tests allowed for exact performance measures. Each subject received exactly the same condition for both experiments, which would not be possible in real life or even with the use of mannequins. Although the researchers used other scales in this study, the use of a VR psychomotor assessment tool (IV simulation and driving) added credibility to their findings that naps improved performance of the subjects.

The study above also exemplifies another benefit of VR research, which is the ability to measure variables that would be difficult to measure in real life due to safety concerns. The design of a study using real IV insertion and driving would be difficult to justify in terms of risk of injury to the patient and the subject. Yet, both of these variables are important functional indicators that can easily be measured in VR.

Another benefit of using VR as a research tool is the ability to obtain exact measures of a performance criterion along with qualitative observational data on performance. For example, Kurtz, Baker, Pearlson and Astur (2007) compared the performance of individuals with

schizophrenia to controls in the administration of three prescribed medications. Subjects had to read the prescription, note the time, and obtain the correct dosage out of a medication cabinet in a VR apartment. Measurements included the location of the individual in the apartment at specified times; differences between the prescribed dosage and the dosage of medication taken; and errors in the type of medication taken. Performance was measured by the computer program itself and by direct observation of the performance of the subjects in the given task. Thus, the VR environment in this study allowed for a strong experimental design which employed a mixed methods approach.

Sample VR Research Application: A Study on Wayfinding

In all types of measurement in research, it is necessary to ascertain that tools are valid and reliable measures of the construct of interest (Polit & Beck, 2008). In virtual reality, there are special considerations due to the type of technology used. In this next section, we will explain how we developed and used a VR tool to examine the influence of certain types of environmental cues on wayfinding ability in older adults. Wayfinding, which is the ability to find one's way in the world (Passini, Rainville, & Marchand, 1998), often becomes impaired by aging due to changes in cognitive, sensory and motor abilities (Webber & Charlton, 2001). Our research seeks to determine how to improve environments, using certain configurations of environmental landmarks or cues to enhance wayfinding and hopefully increase independence.

To start, it is important to consider why VR was chosen as a tool for measurement. As with many cognitive processes, measuring wayfinding is a difficult task. People tend to be poor evaluators of their own spatial abilities (Skelton, Bukach, Laurance & Jacobs, 2000; Vecchi, Albertin, & Cornoldi, 1999), which may limit the usability of self report. As such, most wayfinding research has been done using very small samples in real world environments using a

case study approach (Passini, Pigot, Rainville, & Tetreault, 2000; Rainville et al., 2005). Yet, testing wayfinding ability in the real world poses many problems for researchers. In real world environments it is difficult to isolate the effects of the independent variables on the dependent variables of interest, since many known and unknown confounding variables exist. Real environments have many factors that are impossible to control such as lighting, noise, and distractions. Additionally, repeating the same conditions in the real world may be difficult, if not impossible, to provide the exact same testing conditions for multiple subjects. Finally, real world environments pose safety problems for some groups of older adults, as they may have problems walking in unfamiliar locations.

Thus, a testing environment that had ultimate control over extraneous variables was an important consideration. We also desired a prospective design in which we could manipulate variables and measure the effect of other covariates. VR would allow us to test each subject in the exact same conditions. We could expose subjects to different testing conditions to determine the effect of independent variables on the dependent variables of interest. Additionally, VR would allow the subjects, which were older adults, to navigate safely within a virtual world.

Another important consideration in our selection of testing modality was the congruence of our tool to the theoretical basis of our study, which was based on cognitive mapping theory. The cognitive map theory proposes that as individuals learn environments they ultimately create mental images (cognitive maps) based on the spatial relationships among environmental cues. The ability to create cognitive maps is based on many brain structures, but specifically involves the hippocampal formation of the medial temporal lobe of the brain, which is known to be essential for spatial memory (Allen, 1999; Livingstone & Skelton, 2007; O'Keefe & Nadel, 1978; Pearce, Roberts, & Good, 1998; Skelton et al., 2000). Evidence suggests that cognitive

mapping may decline with aging, thus causing wayfinding problems, due to changes within the hippocampus (Laurance et al., 2002; Moffat & Resnick, 2002). Thus, VR would be ideally suited for testing cognitive mapping, as it allowed for manipulation of cues (landmarks) and could test the ability to learn environments based on the cues in the environment.

We used the CG Arena (University of Arizona, n.d.), a desktop virtual reality system, to measure the effects of salient (distinctive) and stable cues on wayfinding performance in healthy younger and older women. We were able to analyze learning trends based on repeated exposures to the cue conditions. Finally, we included other covariates in our analysis that were collected in baseline, such as working memory and socialization. This research has paved the way for more work, with the goal of making physical environments more supportive for older adults in terms of wayfinding (Davis, Therrien, & West, 2008).

Establishing Reliability. A major strength of VR testing is that the computerized nature of the test can allow for exact measurement, thus strengthening the possibility of having a reliable tool. In addition, VR testing, as compared to real world testing, can eliminate or control for outside influences. When VR tasks are done carefully, each participant can receive the same conditions. When protocols are strictly adhered to, subjects can have equivalent instructions for the study, practice time, rest time, and testing conditions (i.e., lighting, noise, etc.).

However, there are still times when that reliability can be problematic in VR. For example, if the protocols for explaining the study and practicing the computerized tests differ between participants, there can be variations in scores not attributable to the concept being measured. With this in mind, it is very important that the protocols are specific and the data collectors are highly skilled and properly trained. Those administering the tests should be monitored periodically as to their adherence to the protocol. Finally, one of the most

challenging aspects of VR is the fact that it involves a computer and other technical equipment, which may break down or “glitch”, causing an unintentional loss of data. Researchers must be prepared to provide required technical support and data collectors must be adequately trained in order to collect reliable data when using this sophisticated technology.

In our wayfinding study, we established several procedures to ascertain that we had reliable measures. Initially, we knew that testing older adults in VR could be challenging, especially in the use of a joystick. We conducted a pilot study to determine the feasibility of using the program we selected, and to determine the appropriate method of moving about the VR environment for older persons. This was very informative, and saved us from making mistakes in our initial study design. For example, we found that the older persons were much more comfortable using a joystick taped to a table than holding it in their lap (Figure 2). We found that it was necessary to allow time for practice. We added a joystick test to make sure that each subject had sufficient control of the joystick and understanding of the objectives of the test.

In our current wayfinding study which builds on the previous study, we have a detailed protocol for the data collectors, including a DVD that explains how to administer the test to the participants. The data collectors receive individual training, and then they are paired with an experienced person until they are independent. We review the data collection frequently to make sure the protocol was adhered to accurately.

When using computers, there is always a concern about losing data, either due to computer malfunction or user error. We have found it necessary to frequently check our computers and equipment to make sure all was in working order and that our data was being recorded appropriately. Our data was automatically recorded by the computer and saved into a data file, which allowed us to collect a great deal of data on each person’s testing session. The

data collectors were taught to back up the data onto a portable jump drive, which served as additional back-up in case of computer malfunction. The data was saved onto a network drive at the end of each week. The researcher went through each file to make sure it was labeled correctly (with the correct group and participant number) and saved accordingly. Although we have an occasional computer malfunction, the protocols and training have resulted in very little lost data.

Thus, establishing reliability when using VR is much like establishing reliability for any instrument. VR tests must be used properly, by trained individuals, and clear procedures must be established to maintain data integrity. Finally, the researcher must ascertain adherence to the protocols throughout the research study.

Validity of the VR Program. A strength of VR is that it can be developed or modified based on the conceptual framework used in the study and the variables of interest. However, this often means that validity will need to be established by the researcher. The use of multiple measures to establish concurrent validity is often appropriate while the instrument is being developed and initially used. Standard methods to establish validity are necessary when using new tools, including VR, for the first time.

In our wayfinding study, as stated earlier, we selected the CG arena because it was congruent with our conceptual framework of cognitive mapping. Additionally, since cognitive mapping is proposed to be a cognitive function that is mediated by the hippocampal (HPC) formation and other brain structures, studies that showed HPC and parahippocampal involvement using fMRI during testing in the CG Arena or other similar VR programs gave evidence for further validity (Parslow et al., 2004; Stern et al., 1996). Construct validity was ascertained by the ability of the CG Arena and programs like it to show differences in wayfinding for groups of

individuals with HPC damage (Skelton et al., 2000; Thomas, Hsu, Laurance, Nadel, & Jacobs, 2001), and in young versus old individuals (Laurance et al., 2002). Thus, programs like the CG Arena that used a personal computer with joystick or mouse control through a virtual environment already had established validity in relation to our theoretical framework and concept of interest prior to our use.

Although it is true that a simulated environment is not the real world, it is important to note that VR, like most research tools, measures a manifestation of the real concept of interest. The VR environment measures an operational definition of a concept of interest – in our case, wayfinding. Thus, even though VR often may appear to be real, it is virtual – meaning “almost the same” as the real world (Arnold & Farrell, 2000, p. 658). As with all instruments, the evidence that gives credence and generalizability to work done in VR (and all research) is the validity testing of the instrument.

One factor related to the amount of “life-likeness” experienced by the user is presence. VR presence can be influenced by many factors, such as the amount of immersion in the VR environment (i.e. CAVE versus computer screen and joystick), the quality of the VR program, and the amount of user control in the VR environment (Schuemie, van der Straaten, Krijn, & van der Mast, 2001). In our study, we used a less immersive type of platform (Table) based on the resources we had available, and to decrease the side effects that the older adults may experience.

There are some legitimate reasons to use or not use VR as a testing method, based on the validity of the tool. Each VR test must be chosen carefully and evaluated as to its relevance and ability to measure the construct of interest in the selected population sample. Issues such as validity in testing people with cognitive impairments, mobility problems, in young or old age, and those with cultural differences should be considered when selecting a tool.

Side Effects Associated with VR

One realistic concern with the use of VR is the safety of those who participate. It is known that a large portion (up to 80%) of VR users experience VR induced symptoms (Sharples, Cobb, Moody, & Wilson, 2007; Zhang et al., 2003). Most symptoms are mild; however, up to 5% of individuals may withdraw from a study due to symptoms. Thus, anticipating this effect is necessary in the design and implementation of a VR study.

Simulation Sickness. The most common side effect associated with VR is simulation sickness. Common symptoms include nausea and vertigo. Simulation sickness is thought to be primarily due to the mismatch between the sensory information perceived visually versus that which is experienced by the vestibular system. For example, some participants may be asked to move through virtual space using a joystick. Even though they experience movement visually, the vestibular system is stationary. This may cause symptoms of motion sickness, including nausea and vertigo. Most of the time, these symptoms are minor and fleeting, and resolve quickly as the person adapts to the VR. However, some individuals complain of severe nausea or vertigo and must be withdrawn from the study (Cobb, Nichols, Ramsey, & Wilson, 1999; Seymour et al., 2002; Sharples et al., 2007; Stanney & Kennedy, 1997).

There is some evidence that motion sickness may be influenced by the type of VR device used. One study showed that individuals were more likely to have symptoms if they used a head mounted display (HMD) versus a desktop or projection type of VR. The desktop VR was least likely to cause motion sickness overall. In addition, they found that subjects who did not move themselves (i.e., they were passively moved) throughout the virtual environment were more likely to have motion sickness than those who had control of their motion through the space via joystick or mouse (Sharples et al., 2007).

In our wayfinding study, we were very concerned about the potential of motion sickness, especially in the elderly subjects. After examining and testing several types of VR devices, we selected desktop VR based on this concern as it has the least potential for causing motion sickness. Although a more immersive VR environment would be more life-like, the trade off would be more likelihood of motion sickness. Since our subject population is older, we had major concerns about vertigo since it could lead to falls or injury.

In addition to the type of VR selected, we had protocols to protect individuals from motion sickness. For example, in the initial subject interview, if potential subjects reported past problems with severe motion sickness or vertigo, they were not included in the study. Further, the research protocol stated that if any subject complained of motion sickness during testing, the testing should be immediately terminated. In our experience, individuals who have motion sickness upon initial exposure to the VR often gets worse after longer exposure. Luckily, we have had very few individuals who needed to withdraw due to motion sickness. This was likely due to the careful screening of participants, the type of program that used, and the fact that the participants had full control of their own motion through the VR space. We noted that the few subjects who did withdraw due to motion sickness recovered shortly after stopping the test (within approximately 30 minutes) and did not complain of further problems.

Physical Discomfort. Another concern with the use of VR is the potential for physical discomfort during testing. Wearing HMD, sitting at a computer, using a joystick, or looking at a computer screen requires different physical abilities (Cobb et al., 1999). Thus, inclusion and exclusion criteria must be carefully thought out in order to avoid causing undue physical discomfort. In our study, for example, we included a joystick test as an inclusion criterion in the study. Subjects were taught how to use the joystick and given time to practice in the CG arena.

Then, they had to demonstrate sufficient psychomotor ability to manipulate the joystick by reaching a visible platform within 30 seconds. This had the advantage of making sure the individuals could use the joystick, as well as determining if manipulating the joystick was too difficult for individuals (i.e., in case of severe arthritis). Other types of VR require close attention to the physical demands of the test, so that individuals do not suffer unnecessary discomforts.

Virtual Reality: Future Research

VR is a technology that is particularly suited for the integration of biology and behavior. For example, scientists are beginning to have a better understanding of how areas within the brain activate in response to certain stimuli and under certain conditions. This type of knowledge can be used to test the effects of interventions on behavior. For example, there is a great deal of evidence that certain treatments for illness, such as cancer, cause an excessive demand on the cognitive ability of attention (Cimprich & Ronis, 2003). Directed attention is difficult to measure using pen and paper tests. However, VR tests have been developed that assess attentional ability in a ecological and functional way (Lengenfelder, Schultheis, Al-Shihabi, Mourant, & DeLuca, 2002). In addition, there are nursing theories and studies that address methods to reduce attentional fatigue. Studies that link brain areas that are activated during the use or overuse of attention, along with VR tests on the use of attention, can give valuable insight into nursing interventions to reduce attentional fatigue.

Our understanding of the ways in which our biological nature influences decision making is also ideally suited for testing in VR. VR can be used to examine individuals' knowledge and decision making in regard to making health related choices. For example, different strategies for teaching clients with diabetes could be evaluated using VR. Simulated tasks, such as

administering medication, choosing foods from a grocery store or kitchen, preparing foods, documenting blood sugars, and determining activity level, could be measured to determine if individuals fully understand how to manage their illness. In fact, VR is currently being used in some settings to evaluate individuals' ability to perform certain activities of daily living (ADLs) after brain injury (Zhang et al., 2003). Similarly, VR can be used to assess the impact of specified nursing interventions on performance of ADL's after illness or other health event.

In understanding health related decision making, nurse researchers have also examined the effects of social networks and motivation (Logsdon, Hertweck, Ziegler, & Pinto-Foltz, 2008; Meadows-Oliver, 2005). These characteristics are ideally suited to examination in VR worlds. For example, Bainbridge (2007) described the ability of VR programs that are available on the internet (i.e., Second Life) to examine the complex interactions that occur between people and communities. These types of interactive communities that are available to people throughout the world have interesting potential for exploring how cultural, political, individual, and community characteristics impact health related behaviors.

. Another area of research of interest to nurses that lends itself to VR is the study of nurses themselves. The ways that different conditions (i.e., stress, fatigue, client characteristics, demands) affect nursing decision making is of great interest to nursing researchers, as this type of knowledge can affect the health and safety of both nurses and clients (Rogers, Hwang, Scott, Aiken, & Dinges, 2004). VR is a unique way to measure the cognitive and psychomotor performance of nurses under certain conditions, as well as their decision making ability. This type of testing is ideal, because it does not rely on self-report, and also does not compromise client safety by measurement in a real world setting.

Clearly, the NINR's strategy to develop new tools and design new technology opens the door for VR. Although there are VR programs already developed and being used in many areas of science, there are very few that have been used in nursing scientific studies. The development, testing, and establishment of these tools are needed in key areas of nursing research.

VR is a technology that is beginning to become a part of the health care world, from teaching procedures to nurses and physicians to relieving patients' pain during procedures. Nursing research, with its emphasis on client, environment, individual, and health, is ideally suited to the use of VR as a way to measure these complex variables and their interactions. As we prepare for the next generation of nursing research, new tools need to be developed that encompass the expanse of scientific knowledge that is being developed and applied. The use of VR along with other scientific methods encourages interdisciplinary collaboration, as we seek to translate knowledge into practice.

References

- Allen, G. L. (1999). Spatial abilities, cognitive maps, and wayfinding: Bases for individual differences in spatial cognition and behavior. In R. G. Golledge (Ed.), *Wayfinding Behavior: Cognitive Mapping and Other Spatial Processes*. Baltimore: The Johns Hopkins University Press.
- Arnold, P., & Farrell, M. (2000). Embodiment and spatial behavior in virtual environments: Comments on Durlach et al. *Presence*, 12(6), 658-662.
- Bainbridge, W. (2007). The scientific research potential of virtual worlds. *Science Progress*, 317, 472-476.
- Biocca, F., & Delaney, B. (1995). Immersive virtual reality technology. In F. Biocca & M. Levy (Eds.), *Communication in the Age of Virtual Reality* (pp. 57-126). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Cimprich, B., & Ronis, D. (2003). An environmental intervention to restore attention in women with newly diagnosed breast cancer. *Cancer Nursing*, 26, 284-292.
- Cobb, S. V. G., Nichols, S., Ramsey, A., & Wilson, J. R. (1999). Virtual Reality-Induced Symptoms and Effects (VRISE). *Presence: Teleoperators & Virtual Environments*, 8(2), 169-186.
- Davis, R., Therrien, B., & West, B. (2008). Cue conditions and wayfinding in younger and older women. *Research in Gerontological Nursing*, 2(4), 252-263.
- Dodd, M., Janson, S., Facione, N., Faucett, J., Froelicher, E., Humphreys, J., et al. (2001). Advancing the science of symptom management. *Journal of Advanced Nursing*, 33(5), 668-676.

- Gregg, L., & Tarrier, N. (2007). Virtual reality in mental health. *Social Psychiatry and Psychiatric Epidemiology*, 42, 343-354.
- Janzen, G., Wagensveld, B., & van Turenout, M. (2007). Neural representation of navigational relevance is rapidly induced and long lasting. *Cereb Cortex*, 17(4), 975-981.
- Jordan, K., Schadow, J., Wuestenberg, T., Heinze, H.-J., & Jäncke, L. (2004). Different cortical activations for subjects using allocentric or egocentric strategies in a virtual navigation task. *Neuroreport: For Rapid Communication of Neuroscience Research*, 15(1), 135-140.
- Kurtz, M. M., Baker, E., Pearlson, G. D., & Astur, R. S. (2007). A virtual reality apartment as a measure of medication management skills in patients with schizophrenia: A pilot study. *Schizophrenia Bulletin*, 33(5), 1162-1170.
- Laurance, H. E., Thomas, K. G. F., Newman, M. C., Kaszniak, A. W., Nadel, L., & Jacobs, W. J. (2002). Older adults map novel environments but do not place learn: Findings from a computerized spatial task. *Aging, Neuropsychology, & Cognition*, 9(2), 85-97.
- Lengenfelder, J., Schultheis, M. T., Al-Shihabi, T., Mourant, R., & DeLuca, J. (2002). Divided attention and driving: A pilot study using virtual reality technology. *Journal of Head Trauma Rehabilitation*, 17(1), 26-37.
- Livingstone, S. A., & Skelton, R. W. (2007). Virtual environment navigation tasks and the assessment of cognitive deficits in individuals with brain injury. *Behav Brain Res*, 185(1), 21-31.
- Lobard, M., & Ditton, T. (1997). At the heart of it all: The concept of presence. *Presence: Teleoperators and Virtual Environments*, 10, 282-297.

- Logsdon, C., Hertweck, P., Ziegler, C., & Pinto-Foltz, M. (2008). Testing a bioecological model to examine social support in postpartum adolescents. *Journal of Nursing Scholarship*, 40(2), 116.
- Martin, A. R., Chantal, L. R., & Thomas, M. K. (2002). Evaluation of the educational effectiveness of a virtual reality intravenous insertion simulator. *Academic Emergency Medicine*, 9(11), 1319.
- Martin, R., Phillip, H., & Thomas, K. (2002). Virtual reality and simulation: Training the future emergency physician. *Academic Emergency Medicine*, 9(1), 78.
- Meadows-Oliver, M. (2005). Social support among homeless and housed mothers: An integrative review. *Journal of Psychosocial Nursing & Mental Health Services*, 43(2), 40.
- McUsic, T. (August 11, 2008). Second life: 3-D ER simulator challenges Tacoma Community College nursing students. *Nursing Spectrum*. Retrieved January 10, 2009, from Nurse World.com website
<http://include.nurse.com/apps/pbcs.dll/article?AID=/20080811/NW02/108110084>
- Moffat, S., & Resnick, S. (2002). Effects of age on virtual environment place navigation and allocentric cognitive mapping. *Behavioral Neuroscience*, 116(5), 851-859.
- National Institute of Nursing Research (NINR). (2006). *NINR Strategic Plan*. Retrieved July 30, 2008. from <http://www.ninr.nih.gov/NR/rdonlyres/54FB62BD-21F5-4F84-BFEF-19A71D2AA46F/0/StrategicStrategies.pdf>
- Newman, E. L., Caplan, J. B., Kirschen, M. P., Korolev, I. O., Sekuler, R., & Kahana, M. J. (2007). Learning your way around town: how virtual taxicab drivers learn to use both layout and landmark information. *Cognition*, 104(2), 231-253.
- O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map*. Oxford: Clarendon Press.

- Parslow, D. M., Rose, D., Brooks, B., Fleminger, S., Gray, J. A., Giampietro, V., et al. (2004). Allocentric spatial memory activation of the hippocampal formation measured with fMRI. *Neuropsychology*, 18(3), 450-461.
- Passini, R., Pigot, H., Rainville, C., & Tetreault, M. (2000). Wayfinding in a nursing home for advanced dementia of the alzheimer's type. *Environment and Behavior*, 32(5), 684-710.
- Passini, R., Rainville, C., & Marchand, N. (1998). Wayfinding and dementia: Some research findings and a new look at design. *Journal of Architectural and Planning Research*, 15(2), 133-151.
- Paul, E. R. (2005). Virtual reality therapy for anxiety disorders: Advances in evaluation and treatment. *The American Journal of Psychiatry*, 162(9), 1772.
- Pausch, R., Proffitt, D., & Williams, G. (1997). *Quantifying immersion in virtual reality*. Paper presented at the Proceedings of the 24th annual conference on Computer graphics and interactive techniques
- Pearce, J. M., Roberts, A. D., & Good, M. (1998). Hippocampal lesions disrupt navigation based on cognitive maps but not heading vectors. *Nature*, 396(6706), 75-77.
- Phillips, J. R. (1993). Virtual reality: A new vista for nurse researchers? *Nursing Science Quarterly*, 6(1), 5-7.
- Polit, D., & Beck, C. (2008). *Nursing Research: Generating and Assessing Evidence for Nursing Practice* (8th ed.). Philadelphia: Lippincott Williams & Wilkins.
- Rainville, C., Joubert, S., Felician, O., Chabanne, V., Ceccaldi, M., & Peruch, P. (2005). Wayfinding in familiar and unfamiliar environments in a case of progressive topographical agnosia. *Neurocase*, 11(5), 297-309.

- Reznek, M., Harter, P., & Krummel, T. (2002). Virtual reality and simulation: Training the future emergency physician. *Academic Emergency Medicine*, 9(1), 78-87.
- Rogers, A., Hwang, W., Scott, L., Aiken, L., & Dinges, D. (2004). The working hours of hospital staff nurses and patient safety. *Health Affairs*, 23(4), 202.
- Schuemie, M. J., van der Straaten, P., Krijn, M., & van der Mast, C. A. P. G. (2001). Research on presence in virtual reality: A survey. *CyberPsychology & Behavior*, 4(2), 183-201.
- Second Life (n.d.). *Second Life: Your World, Your Imagination*. Retrieved 11-13-09, from <http://secondlife.com/whatis/>
- Seymour, N., Gallagher, A., Roman, S., Obrien, M., Vipin, B., & Andersen, D. (2002). Virtual reality training improves operating room performance: Results of a randomized, double-blinded study. *Annals of Surgery*, 236(4), 458-464.
- Sharples, S., Cobb, S., Moody, A., & Wilson, J. (2007). Virtual reality induced symptoms and effects (VRISE): Comparison of head mounted display (HMD), desktop and projection display systems. *Displays*, 29, 58-69.
- Sherman, W., & Craig, A. (2003). *Understanding Virtual Reality*. San Francisco: Elsevier Science.
- Skelton, R., Bukach, C., Laurance, H., Thomas, K., & Jacobs, J. (2000). Humans with tramatic brain injuries show place-learning deficits in computer-generated virtual space. *Journal of Clinical and Experimental Neuropsychology*, 22(2), 157-175.
- Smith-Coggins, R., Howard, S., Mac, D., Wang, C., Kwan, S., Rosekind, M., Sowb, Y., Balise, R., Levis, J. & Gaba, D.. (2006). Improving alertness and performance in emergency department physicians and nurses: The use of planned naps. *Annals of Emergency Medicine*, 48, 596-604.e593.

- Spiers, H. J., & Maguire, E. A. (2007). A navigational guidance system in the human brain. *Hippocampus*, 17, 618-626.
- Stanney, K. N., & Kennedy, R. S. (1997). The psychometrics of cybersickness. *Association for Computing Machinery. Communications of the ACM*, 40(8), 66.
- Stern, C. E., Corkin, S., Gonzalez, R. G., Guimaraes, A. R., Baker, J. R., Jennings, P. J., et al. (1996). The hippocampal formation participates in novel picture encoding: evidence from functional magnetic resonance imaging. *Proceedings of the National Academy of Sciences of the United States of America*, 93(16), 8660-8665.
- Thomas, K., Hsu, M., Laurance, H., Nadel, L., & Jacobs, W. (2001). Place learning in virtual space III: Investigation of spatial navigation training procedures and their application to fMRI and clinical neuropsychology. *Behavior Research Methods, Instruments & Computers*, 33(1), 21-37.
- University of Arizona Anxiety Research Group (n.d.). *The C-G Arena and the Data From It*. Retrieved December 20, 2008 from <http://web.arizona.edu/~arg/data.html>
- University of Michigan (2008). University of Michigan Virtual Reality Laboratory at the College of Engineering. Retrieved July 29, 2008, 2008, from <http://www-vrl.umich.edu/>
- University of Michigan (n.d.). *Virtual reality: A short introduction*. Retrieved November 3, 2005, 2005, from <http://www-vrl.umich.edu/intro/>
- Vecchi, T., Albertin, L., & Cornoldi, C. (1999). Self-assessment of everyday spatial memory and performance on memory tasks in old age. *Clinical Gerontologist*, 20(3), 57-66.
- Webber, L. S., & Charlton, J. L. (2001). Wayfinding in older adults. *Clinical Gerontologist*, 23(1/2), 168-172.

- Wint, S. S., Eshelman, D., Steele, J., & Guzzetta, C. E. (2002). Effects of distraction using virtual reality glasses during lumbar punctures in adolescents with cancer. *Oncology Nursing Forum*, 29(1), E8-E15.
- Zhang, L., Abreu, B., Seale, G., Masel, B., Christiansen, C., & Ottenbacher, K. (2003). A virtual reality environment for evaluation of a daily living skill in brain injury rehabilitation: Reliability and validity. *Archives of Physical Medicine and Rehabilitation*, 84, 1184-1124.

Table: Common Types of Virtual Reality Displays

VR Display Type	Example	Description and Examples	Possible Equipment Needed	Degree of Immersion
Head based	Head mounted displays (HMD) BOOM	In a HMD, the user wears goggles that display a stereo image to the user's eyes. Head motion is detected and communicated to the computer, which then visually changes the image so that the person has a sense being in a real environment. A BOOM device is similar, but the user looks into a box (attached to a moveable arm) which displays a stereoscopic image. The box can be moved by the user which changes the image (Sherman & Craig, 2003).	HMD, computer, BOOM device	Highly immersive
Projection based	CAVE, multi-screen projection venues,	A lifelike image is portrayed on walls of a room (CAVE), screens, or large computer monitors. In the CAVE, a person can walk within a defined space so that the projected image changes with movement. Props may be used or incorporated. Head and or body motion is deterred by sensors and/or tracking devices (University of Michigan, n.d). Other projection based platforms include screens or large computer based screens, which are similar to monitor based projection (below), but larger, thus offering a wider field of view (Sherman & Craig, 2003).	Space (a room big enough to house the projection screens), a powerful computer with high graphics capability, screens, props, stereoscopic glasses with eye tracking	Highly Immersive
<i>Monitor based</i>	Video Game platforms	A computer displays a virtual environment. Movement is accomplished by a joystick, mouse, or other movement device (Sherman & Craig, 2003).	Computer, movement device such as a joystick. May incorporate eye tracking.	Less immersive

Figure 1. Immersive virtual reality: The CAVE.
Image Courtesy of Eric Maslowski, the University of Michigan 3D Lab,
Ann Arbor.