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Virtual Reality: A new tool for interdisciplinary Psychology research.

by
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Abstract

VR has the potential to become a powerful scientific research tool for psychologist. VR serves as a bridge between different disciplines of psychology. Findings in one area are often easily applied to others, encouraging researchers who use VR to collaborate with experts from various fields.

To support these claims, I will describe VR research on the following psychological topics, spanning several levels of analysis and several disciplines of Psychology. In the process, I will describe how these various levels of analysis can inform and build upon each other.

1) <u>Perception</u>: Tactile augmentation, a technique for giving VR users the sensation of "touching" virtual objects with their real hands. (Hoffman et al, 1996; Hoffman, 1998).
2) <u>Memory and Cognition</u>: Virtual-Reality monitoring, the decision process by which people try to distinguish memories of real events from memories of virtual events. (Hoffman, in progress; Hoffman, Hullfish & Houston, 1995; Hullfish, 1996).
3) <u>Clinical Psychology</u>: VR exposure therapy for treatment of spider phobia: A case study. (Carlin, Hoffman & Weghorst,1997; Hoffman, Carlin & Weghorst, 1997).
4) <u>Medical applications of VR</u>. Use of VR to distract adolescent burn victims from burn pain: A case study. (Hoffman, Doctor, Carrougher, Taylor, Weghorst & Furness, 1998)

1) <u>Perception</u>: Hoffman, Groen, Rousseau, Hollander, Winn, Wells, & Furness III (1996) found that physically touching a virtual object (mixing real objects and VR) improves the quality of the virtual experience. For some objects, subjects saw a virtual object (e.g., an image of a ball) and touched its real counterpart (a rubber ball). Compared to visual VR only, converging evidence from both visual and tactile senses increased the illusion of "being in a place" when experiencing the virtual environment (see Figures 1, 2 & 3).

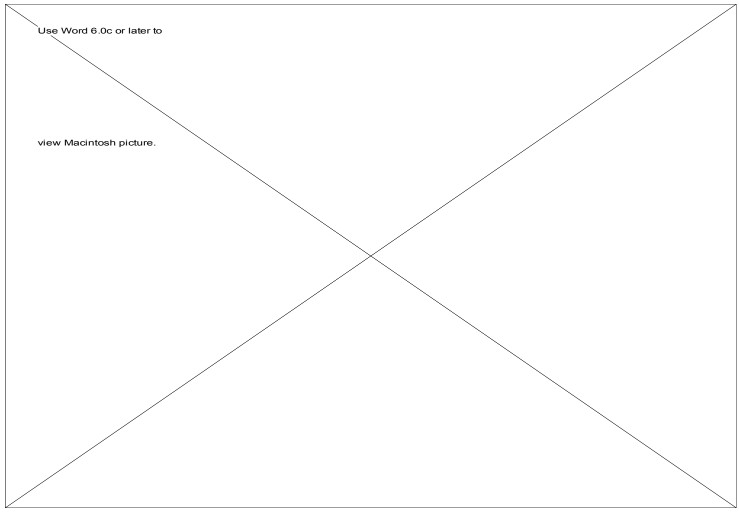

Figure 1. Tactile Augmentation, a type of mixed reality.
Subject holds a position tracked real plate he sees in VR
(image copyrighted by Hunter Hoffman, U.W.).

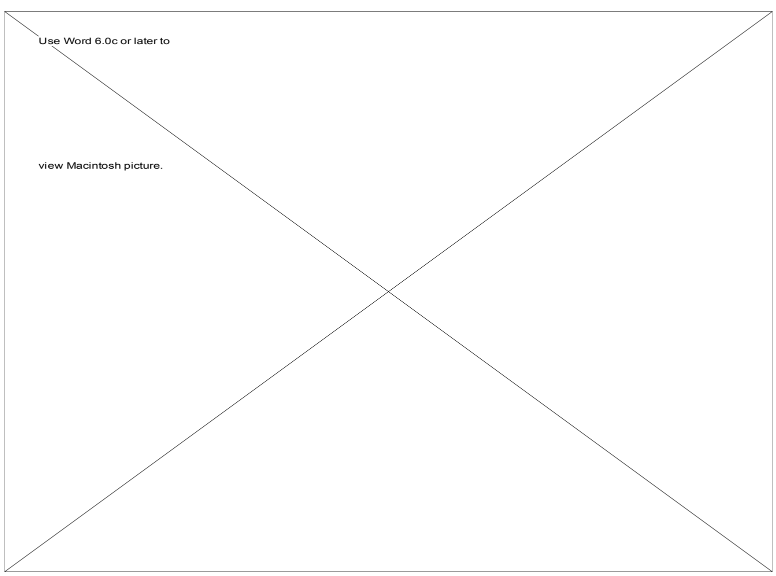

Figure 2. The plate seen by the subject in Figure 1 as seen through one eye
(image copyrighted by Hunter Hoffman, U.W.).

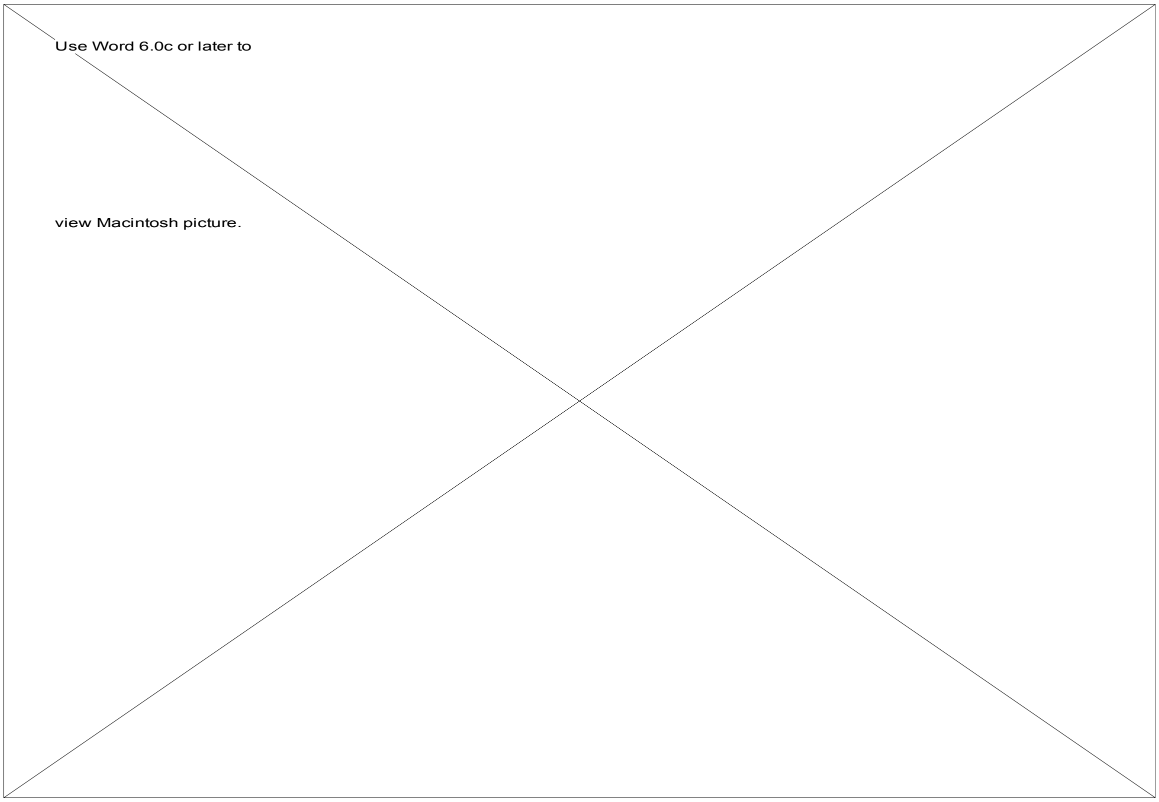

Figure 3. Means and standard errors from Hoffman et al., Exp. 1, (1997). Physically touching virtual objects enhanced VR users' sense of presence in the virtual environment (graph copyrighted by Hunter Hoffman, U.W.).

In Hoffman (1998), subjects in a "cyberheft" condition were able to touch and pick up a virtual plate that had solidity and weight. Compared to another group who picked up a weightless, non-solid virtual plate, subjects in the cyberheft condition predicted that other unexplored virtual objects, walls and countertops would have higher solidity, weight, and would obey gravity (see Figure 4). Adaptation to a virtual environment involves making inferences about what rules from the real world apply in the virtual world. The perception literature on how the brain unifies sensory input from touch and sight to create a single percept (e.g., Welch and Warren, 1980) was exploited toward the human factors goal of improving the quality of the human-computer interface. The use of real objects to enhance the realism of virtual reality, a technique called tactile augmentation, is a form of mixed reality, blurring the distinction between what is real and what is virtual.

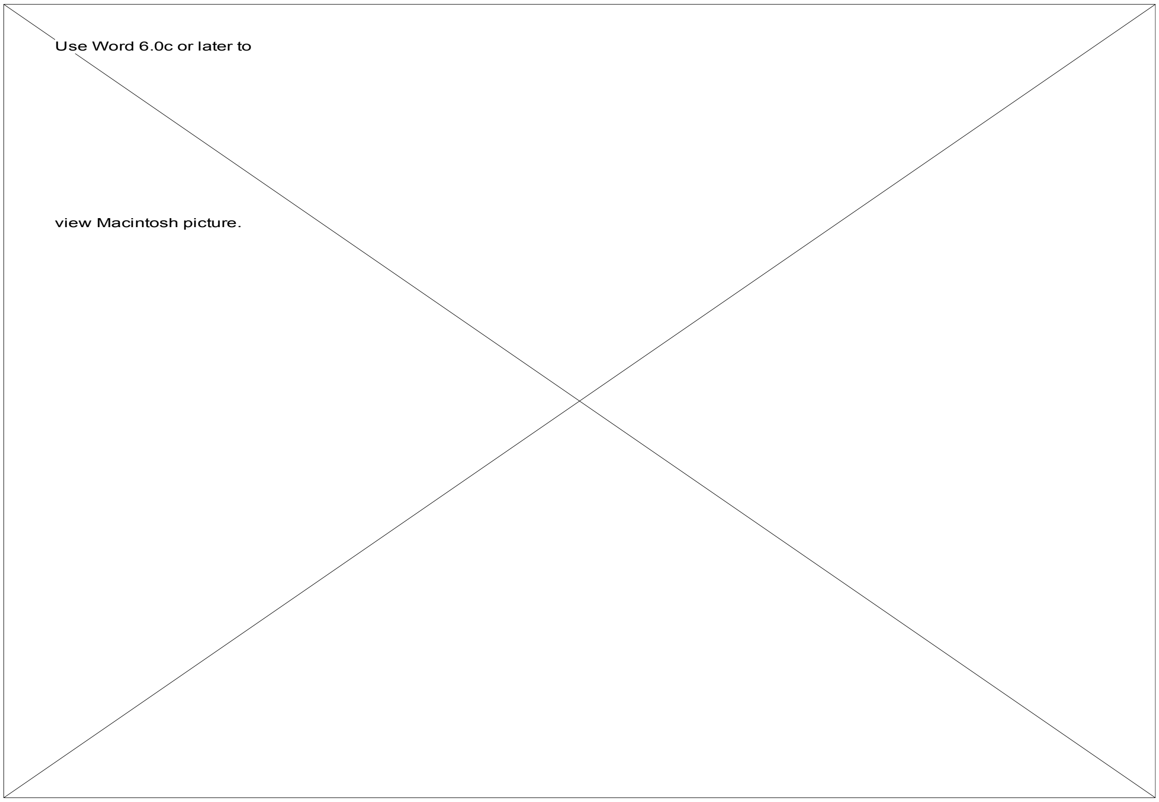

Figure 4. Results of Hoffman (1998). Cyberheft increased predictions about the laws of nature obeyed in Virtual Reality (graph **needs** permission from IEEE VRAIS '98. I have requested approval from IEEE but haven't heard back yet).

2) <u>Memory and Cognition</u>: The essence of immersive virtual reality is the experience of "being there" in the computer-generated environment (presence). Users become engaged in events in VR, experiences they remember later. Memories for events that occurred in VR constitute a new source of memories, different from the traditional memory sources (real world, imagined, or dreams). My colleagues and I (Hoffman, Hullfish and Houston, 1995; Hullfish, 1996) are conducting research on "Virtual-reality monitoring", a twist on the Johnson-Raye reality monitoring paradigm (Johnson & Raye, 1981). In the study phase of Hoffman (in progress), I exposed people to various common objects (e.g., an orange). Some objects were seen in VR, others were seen in the real world (subjects lifted up their helmet to see). Seven days later, subjects returned to take a memory source identification test. They were shown the name of an object (e.g., book) and had to decide whether they had seen it during the study phase in the real world, in the virtual world, or if it was new (i.e., not in the study phase). Later they filled out a Memory Characteristics Questionnaire designed to measure the phenomenological qualities associated with their memories. According to Johnson and colleagues (Johnson and Raye, 1981; Johnson, Hashtroudi and Lindsay, 1993) people infer whether an event was real or imagined based on qualities associated with the memory at time of retrieval. Hoffman, 1998, Exp. 1, explores whether people use a similar decision process when deciding if a memory was real vs. virtual. What qualities are associated with memories of virtual events? Do these qualities help people infer the virtual source of the memories? In other words, how useful is it to study virtual reality using the Johnson-Raye theoretical framework? In experiment 2 (in progress), for one group of subjects, tactile augmentation is being used to add physical properties (e.g., solidity, cyberheft) to the virtual objects. For example, subjects in the see-and-touch group touch a real orange with their position-tracked real hand while their virtual hand explores a virtual orange. For other objects they will lift their helmets and touch the real object while looking at the real object. A second "see only" group will see real and virtual objects, but will not touch either. Based on Hoffman, 1998, I predict the group that touches the virtual

objects will find them more realistic. If so, the qualities associated with the object in memory will likely be more similar to qualities associated with a memory for a real object, increasing real/virtual memory source confusions (virtual-reality monitoring errors) on the memory test one week later.

Like other source monitoring tasks (e.g., Dywan & Jacoby, 1990), virtual-reality monitoring may prove valuable for studying human memory (e.g., age-related declines in memory performance), and for "cybercognition", the study of how humans think in immersive and non-immersive computer-simulated environments.

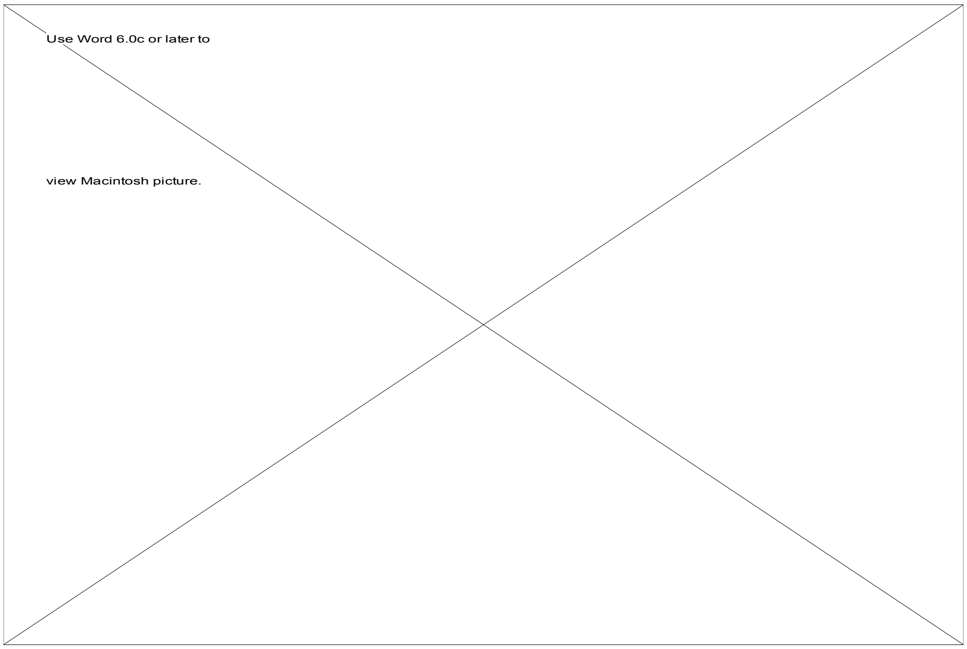

Figure 5: Experimenter demonstrates VR exposure therapy for spider phobia (photo copyrighted by Mary Levin, U.W., used with permission).

3) Clinical Psychology: A recent clinical case study explored the use of immersive virtual reality, including mixed reality tactile feedback, for treating spider phobia. We modelled our treatment after pioneering VR exposure therapy treatments for fear of heights (Rothbaum, Hodges, Kooper, Opdyke, Williford, & North, 1995), and fear of flying (Hodges, Rothbaum, Watson, Kessler, & Opdyke 1996; Rothbaum, Hodges, Watson, Kessler, & Opdyke, 1996). Prior to treatment, the subject displayed a number of serious symptoms, had been phobic for approximately 20 years, and was getting worse. Treatment (see Figure 5) involved exposure to a virtual brown Guyana bird-eating tarantula, and a virtual black widow (with cyberweb). VR successfully evoked strong but carefully controlled emotional reactions from the subject. She gradually became less fearful of virtual spiders, and able to progress to more frightening situations. After one month of therapy, she was ready to physically "touch" a mixed reality spider. Tactile cues were achieved by allowing her to feel a position tracked real object (a furry toy spider) with her real hand, that corresponded to the virtual spider she saw in the immersive virtual environment (tactile augmentation). Outcome after 3 months of therapy (twelve, one hour sessions) was excellent, as assessed by a number of ratings and measures, including her behavior toward real spiders outside of therapy. She now kills real spiders she finds in her house, is able to go camping in the woods, and no longer shows the obsessive-compulsive symptoms associated with her phobia. Her quality of life has improved dramatically (and one year after therapy she is still doing great). These findings converge with a growing body of evidence

showing that VR can serve as an effective tool for clinical therapy. A second patient has since been treated successfully.

One of the reasons we used tactile augmentation in SpiderWorld was to deliberately blur the distinction between fact and fantasy (VR). This served two functions: 1) to increase the level of anxiety evoked by the virtual spider, and thus the effectiveness of desensitization, and 2) to increase generalization of training from the virtual world to the real world. It does no good to cure a phobic's fear of virtual spiders if they remain afraid of real spiders. Blurring the distinction between reality and virtual reality likely helped desensitization toward virtual spiders generalize to real spiders as well. For our case study, treatment was very effective at reducing the patient's fear of real spiders. We plan to conduct controlled experiments exploring the value of VR exposure therapy for treating spider phobia. Whether tactile augmentation enhances the value of VR exposure therapy is an important research question.

In addition to blurring the distinction between fact and fantasy, tactile augmentation may increase the amount of attention drawn into the virtual environment. VR can be considered a sort of divided attention task (Hoffman, Prothero, Wells and Groen, in press). At some level subjects remain aware of the fact that they are standing in the laboratory wearing a helmet. But for many users, much of their attention is drawn into the virtual environment, and subjects largely forget about their real bodies and their physical location. This may be especially true when the realism of the virtual world is enhanced with tactile cues (using either tactile augmentation or computer-generated force feedback displays).

4) <u>Medical applications of VR</u>.

The attention grabbing nature of VR makes it attractive for certain medical applications. For example, severe burns require frequent dressing changes and painful wound cleansing (e.g., scraping off dead skin tissue from the burn). Both of these procedures can produce excruciating pain even in patients under heavy morphine medication. Part of this pain is due to anxiety and other cognitive factors, and tragically, much of this suffering is unnecessary (Melzack, 1990). Patterson and colleagues (Patterson, 1995; Patterson, Everett, Burns, & Marvin, 1992) have shown that psychological non-pharacological interventions such as hypnosis can reduce burn pain intensity and unpleasantness. These burn pain researchers at U.W. Harborview Burn Center have recently joined forces with VR researchers at the U.W. Human Interface Technology Center (part of the Washington Technology Center) to explore the possible use of VR for burn pain reduction.

The logic of why VR might help is as follows: Human attention is a flexible, sharable processing resource of limited availability (Kahneman, 1973; Navon and Gopher, 1979). If pain requires attentional resources, performing a task that draws heavily on the same attentional resources (ie., a task sharing pain's attentional resources), will reduce the amount of attention available for processing pain, reducing the subjective experience of pain and/or the amount of time patients spend thinking about the pain.

The Harborview/HITLab team (Hoffman, Doctor, Carrougher, Summer, Taylor, Weghorst & Furness, 1998) successfully used VR for burn pain distraction of an 11 year old boy with gasoline burns on his hand and leg. The child rated his pain while in VR considerably lower than his resting pain. After removing his VR helmet, he realized with surprise that while in VR he had temporarily "forgotten" that his burned leg hurt. He was delighted that he couldn't see his temporarily disfigured (real) leg while in VR. A second patient, Ryan Troy, a 16 year old with 3rd degree burns on his face, neck, arm and hand showed mixed results. Sometimes VR pain distraction significantly reduced his burn pain ratings, sometimes not. Encouragingly, during one session he remarked with annoyance that the questions about pain in VR were not appropriate, because he was focussing on the VR task, he wasn't thinking about this pain. Figuring out why some patients respond better to VR therapy than others is an important research topic. A third patient showed large reductions in pain ratings and amount of time spent thinking about pain during wound care (see Figure 7). Success with patient 3 is particularly important because pain during wound care reaches severe to excruciating levels for most burn patients Perry, Heidrich, & Ramos (1981), and is a target area for pain researchers.

One limitation of case studies is that they must be followed up with larger studies. While encouraging, the case reports described in this paper are by their nature inconclusive, and require converging evidence from carefully controlled experiments. In the future we plan to perform controlled experiments to determine whether the magnitude of the patient's sense of "presence" in the virtual environment influences how effectively VR distracts them from their pain. Our finding that Michael had high presence ratings and Ryan had lower presence ratings is interesting. Tactile augmentation (with mixed reality plates, cups and other objects) will likely help draw the burn patient's minds even further away from their pain-wracked bodies and deeper into the virtual world during these relatively brief durations of intense pain during wound care.

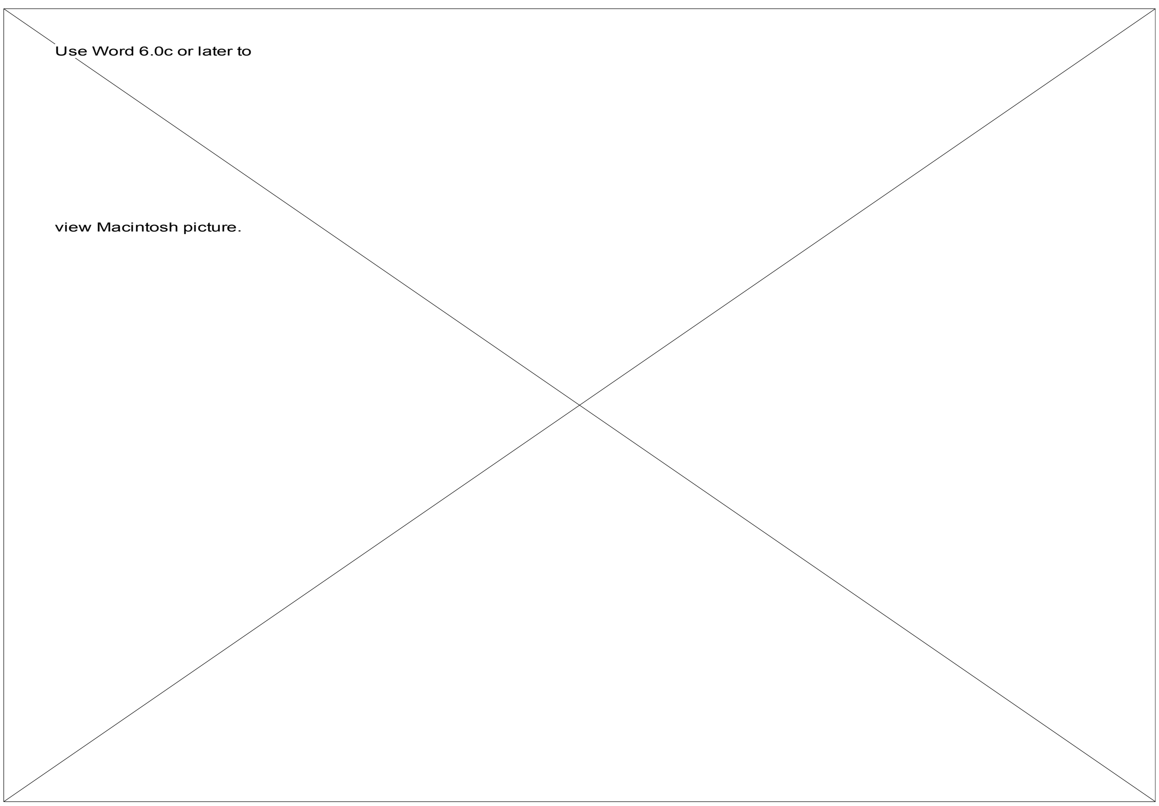

Figure 6: Hoffman et. al., (1998). Preliminary data
from the first use of VR for burn pain distraction (patient 1). (Copyrighted H. Hoffman, U.W.).

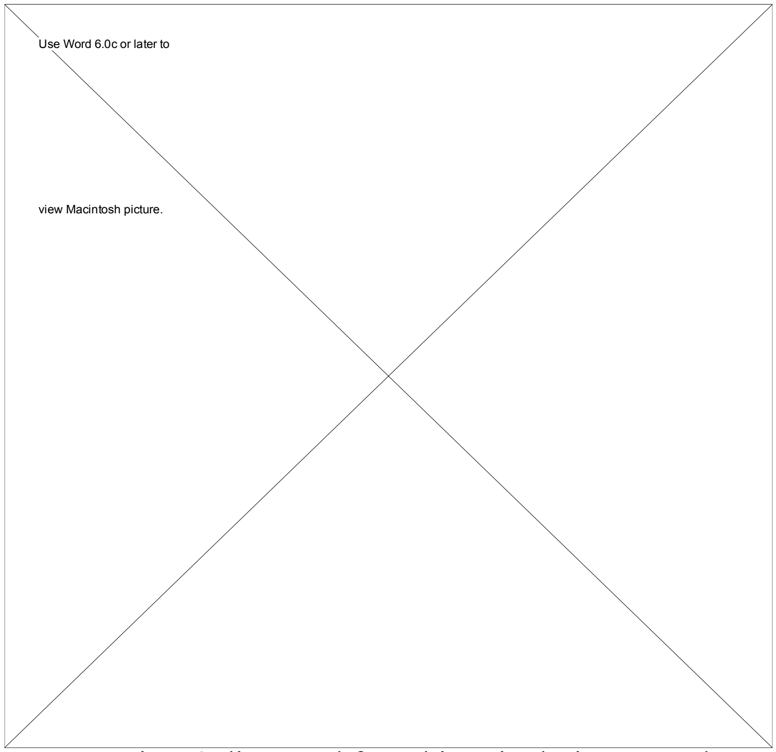

Figure 7: Burn patient 3 distracted from his pain during wound care.
(Photo copyrighted by G. Carrougher, U.W., used with permission)

In summary, VR technology is a catalyst for interdisciplinary research. Our experiments and treatments drew upon several levels of analysis: perception, cognition, clinical, and perhaps social (changes in attitudes toward spiders).

I am involved in some other projects at the HITLab 1) exploring educational applications of VR in the public school system (Winn, Hoffman and Osberg, in press; Winn, Hoffman et al., 1997). And 2) exploring military applications of VR for the Air Force. There is a good deal of cross talk between these fields. For instance, efforts by the HITLab's Learning Center to create a networked VR world for kids undergoing chemotherapy helped inspire the development of a multi-participant, distributed, networked military VR application, the Virtual Pilot (Wells, Baldis & Hoffman, 1996; Wells and Hoffman, 1997; Wells, Hoffman, Smith and Mitchel, 1998; see Figure 9). Thus, some core concepts transcend boundaries between entire disciplines of science.

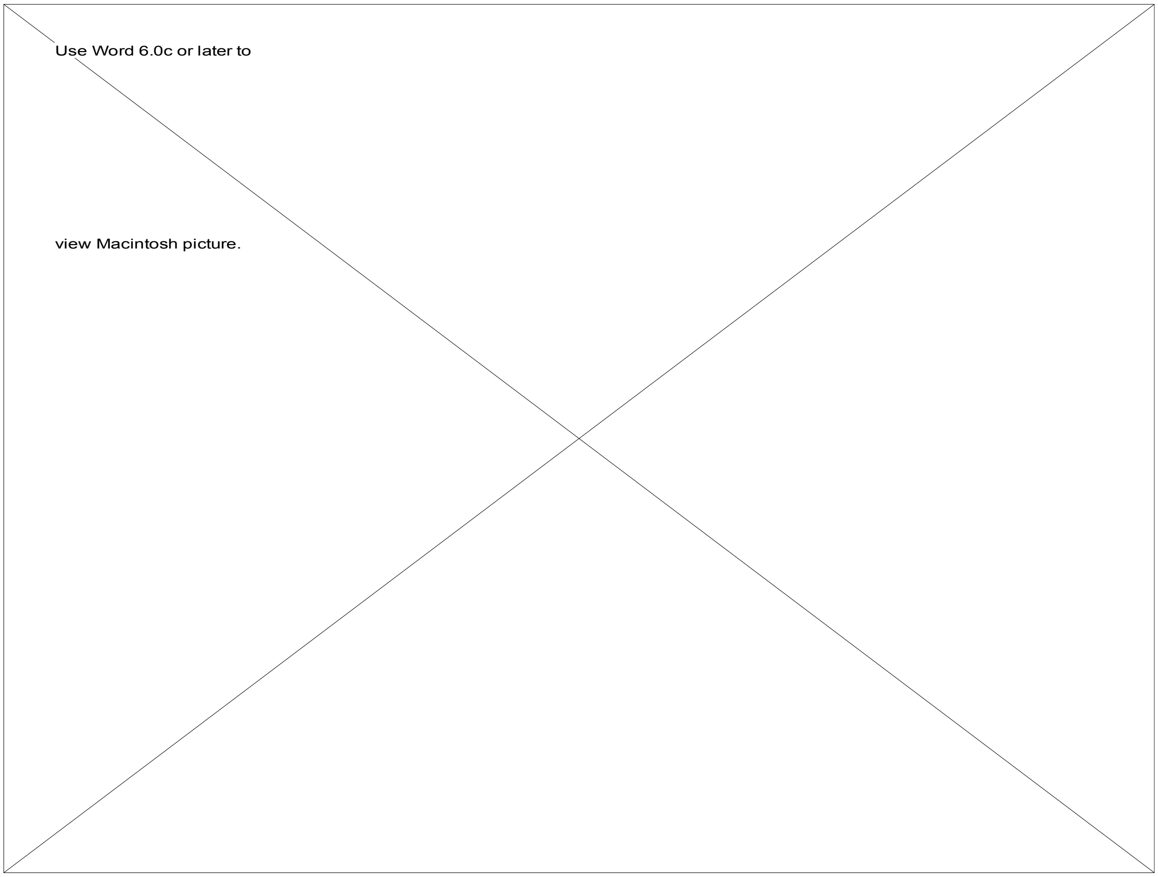

Figure 8. The virtual pilot. (Image copyrighted by Stig Hollup, used with permission).

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