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A Virtual Reality Exposure Therapy Application for Iraq War Military Personnel with Post Traumatic Stress Disorder: *From Training to Toy to Treatment*

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Abstract

Post Traumatic Stress Disorder is reported to be caused by traumatic events that are outside the range of usual human experiences including (but not limited to) military combat, violent personal assault, being kidnapped or taken hostage and terrorist attacks. Initial data suggests that 1 out of 6 Iraq War veterans are exhibiting symptoms of depression, anxiety and PTSD. Virtual Reality (VR) exposure treatment has been used in previous treatments of PTSD patients with reports of positive outcomes. The aim of the current paper is to specify the rationale, design and development of a Virtual Iraq PTSD VR application that has been created from the virtual assets that were initially developed for a combat tactical training simulation, which then served as the inspiration for the X-Box game entitled *Full Spectrum Warrior*.

Keywords: Virtual Reality, PTSD, Exposure Therapy, Full Spectrum Warrior

Introduction

In 1997, researchers at Georgia Tech released the first version of the Virtual Vietnam VR scenario for use as a graduated exposure therapy treatment for Post Traumatic Stress Disorder (PTSD) with Vietnam veterans. This occurred over 20 years following the end of the Vietnam War. During that interval, in spite of valiant efforts to develop and apply traditional psychotherapeutic approaches to PTSD, the progression of the disorder in some veterans severely impaired their functional abilities and quality of life, as well as that of their family members and friends. The tragic nature of this disorder also had significant ramifications for the U.S. Veteran's Administration healthcare delivery system often leading to designations of lifelong service connected disability status. In mid-2004, the first systematic study of mental health problems due to the Iraq conflict revealed that *"…The percentage of study subjects whose responses met the screening criteria for major depression, generalized anxiety, or PTSD was significantly higher after duty in Iraq (15.6 to 17.1 percent) than after duty in Afghanistan (11.2 percent) or before deployment to Iraq (9.3 percent)"* (Hoge et al., 2004). With this history in mind, the USC Institute for Creative Technologies (ICT) has initiated a project that is creating an immersive virtual environment system for the treatment of Iraq War veterans diagnosed with combat-related PTSD. This project has now been funded as part of a larger multi-year effort by the U.S. Office of Naval Research that brings together the technical, clinical and creative forces of ICT, Virtually Better, Inc. and the Virtual Reality Medical Center. The VR treatment environment is based on a cost effective approach to recycling virtual graphic assets that were initially built for a combat tactical simulation scenario entitled *Full Spectrum Command*, which later inspired the creation of the commercially successful X-Box game, *Full Spectrum Warrior*. This paper will present the vision, rationale, technical specifications, clinical interface design, and development status of the Full Spectrum PTSD treatment system that is currently in progress at the ICT.

Post Traumatic Stress Disorder

According to the DSM-IV (1994), Post Traumatic Stress Disorder is caused by traumatic events that are outside the range of usual human experiences such as military combat, violent personal assault, being kidnapped or taken hostage, terrorist attack, torture, incarceration as a prisoner of war, natural or man-made disasters, automobile accidents, or being diagnosed with a life-threatening illness. The disorder also appears to be more severe and longer lasting when the event is caused by human means and design (bombings, shootings, combat, etc.). Such incidents would be distressing to almost anyone, and is usually experienced with intense fear, terror, and helplessness. Typically, the initiating event involves actual or threatened death or serious injury, or other threat to one's physical integrity; or witnessing an event that involves death, injury, or a threat to the physical integrity of another person. Symptoms of PTSD are often intensified when the person is exposed to situations or stimulus cues that resemble or symbolize the original trauma in a *non-therapeutic* setting. Such *uncontrolled* cue exposure may lead the person to react with a survival mentality and mode of response that could put the patient and others at considerable risk. The essential feature of PTSD is the development of characteristic symptoms that may include:

- Intrusive thoughts and flashbacks
- Anger
- Isolation
- Emotional numbing and constriction
- Anxiety
- Depression
- Substance abuse
- Survivor guilt
- Hyper-alertness
- Suicidal feelings and thoughts
- Alienation
- Negative self-image
- Memory impairment
- Problems with intimate relationships
- Emotional distance from family and others
- Denial of social problems

Rationale for Virtual Reality Therapy Applications for PTSD

Prior to the availability of VR therapy applications, the existing standard of care for PTSD was *imaginal* exposure therapy. Such treatment typically involves the graded and repeated imaginal reliving of the traumatic event within the therapeutic setting. This approach is believed to provide a low-threat context where the patient can begin to therapeutically process the emotions that are relevant to the traumatic event as well as de-condition the learning cycle of the disorder via a habituation/extinction process. While the efficacy of imaginal exposure has been established in multiple studies with diverse trauma populations (Rothbaum, Meadows, Resick, et al., 2000, Rothbaum & Schwartz, 2002), many patients are unwilling or unable to effectively visualize the traumatic event. In fact, avoidance of reminders of the trauma is inherent in PTSD, and is one of the defining symptoms of the disorder. It is often reported that, "*...some patients refuse to engage in the treatment, and others, though they express willingness, are unable to engage their emotions or senses*." (Difede & Hoffman, 2002). Research on this aspect of PTSD treatment suggests that the inability to emotionally engage (*in imagination*) is a predictor for negative treatment outcomes (Jaycox, Foa, & Morral, 1998).

The use and value of Virtual Reality for the treatment of cognitive, emotional, psychological and physical disorders has been well specified (Glantz, Rizzo & Graap, 2003, Rizzo, Schultheis, Kerns & Mateer, 2004). The first use of VR for a Vietnam veteran with PTSD was reported in a case study of a 50-year-old, Caucasian male veteran meeting DSM-IV criteria for PTSD (Rothbaum et al., 1999). Results indicated post-treatment improvement on all measures of PTSD and maintenance of these gains at a 6-month follow-up. This case study was followed by an open clinical trial of VR for Vietnam veterans (Rothbaum, Hodges, Ready, Graap & Alarcon, 2001). In this study, 16 male PTSD patients were exposed to two HMD-delivered virtual environments, a virtual clearing surrounded by jungle scenery and a virtual Huey helicopter, in which the therapist controlled various visual and auditory effects (e.g. rockets, explosions, day/night, yelling). After an average of 13 exposure therapy sessions over 5-7 weeks, there was a significant reduction in PTSD and related symptoms. Similar positive results have also recently been reported for VR applied to PTSD resulting from the attack on the World Trade Center (Difede & Hoffman, 2002). In this report, a case study was presented using VR to provide re-exposure to the trauma with a patient who had failed to improve with traditional exposure therapy. The authors reported significant reduction of PTSD symptoms by exposing the patient to explosions, sound effects, virtual people jumping from the burning buildings, towers collapsing, and dust clouds and attributed this success partly due to the increased realism of the VR images as compared to the mental images the patient could generate in imagination. Positive treatment outcomes from a wait-list controlled VR study with patients who were not successful in previous imaginal therapy are currently in press by this group (Joanne Difede, personal communication, March 17, 2005). Such early results suggest that VR may be a valuable technology to apply for the treatment of PTSD and that it may be a promising component of a comprehensive treatment approach for persons with combat-related PTSD.

The Full Spectrum Virtual Iraq PTSD Therapy Application

Background and Development History

The primary aim of the current project is to use the already existing ICT Full Spectrum Warrior graphic assets (go to: ftp://imsc.usc.edu/pub/uploads/Skips%20Stuff/PTSD%20Stuff/ for video demos of the content) as the basis for creating a clinical VR application for the treatment of PTSD in returning Iraq War military service personnel. The ICT games project has created two training tools for the U.S. Army to teach leadership and decision making skills. Full Spectrum Command (FSC) is a PC application that simulates the experience of commanding a light infantry company. FSC teaches resource management, adaptive thinking, and tactical decision-making. Developed for the Xbox game console, Full Spectrum Warrior puts the trainee in command of a nine person squad. Trainees learn small unit tactics as they direct fire teams through a variety of immersive urban combat scenarios. These tools were developed through collaboration between ICT, entertainment software companies, the U.S. Army Training and Doctrine Command (TRADOC), and the Research, Development, and Engineering Command, Simulation Technology Center (RDECOM STC). Additionally, Subject Matter Experts from the Army's Infantry School contributed to the design of these training tools.

Technical Specifications

The current VR PTSD application is designed to run on two Pentium 4 notebook computers each with 1 GB RAM, and a 128 MB DirectX 9 compatible graphics cards. The two computers are linked using a null Ethernet cable. One notebook runs the therapist's control application while the second notebook drives the user's head mounted display (HMD) and orientation tracker. We are exploring the usability of three different Head Mounted Displays (HMDs) for use in this application aiming to find the best instrument available to conduct deliver this treatment at the lowest cost. This design goal is important in order to promote maximum accessibility to this system in the future. The three HMDs that are being tested for this purpose are: 1. The 5DT HMD 800 capable of 800x600 (SVGA) resolution (see for specs: http://www.5dt.com/products/phmd.html); 2. The Icuiti v920 HMD capable of 640x480 (VGA) resolution (see for specs: http://www.icuiti.com/); and 3. The eMagin OLED z800 HMD capable of 800x600 (SVGA) resolution (see for specs: http://www.emagin.com/). The Intersense InertiaCube2 tracker is being used for 3DOF head orientation tracking and the user navigates through the scenario using a USB gamepad device. It should also be noted that while we believe that the HMD display approach will provide the optimal level of immersion and interaction characteristics for this application, the system is be fully configurable to be delivered on a standard PC monitor or within a large screen projection display format. The application is built on ICT's FlatWorld Simulation Control Architecture (FSCA). The FSCA enables a network-centric system of client displays driven by a single controller application. The controller application broadcasts user triggered or scripted event data to the display client. The client's real-time 3D scenes are presented using Numerical Design Limited's (NDL) Gamebryo graphics engine. The content originally used in Full Spectrum Warrior was edited and exported to the engine using Alias' Maya software.

We are also adding olfactory and tactile stimuli to the experience of the environment. Scent is delivered into the VR scenario through the use of a Scent Palette (Envirodine Studios, Canton, GA). This machine interfaces with the VR program through the computer's USB port and is activated by triggers programmed into the environment via the FlatWorld Simulation Control Architecture. This allows for the simultaneous delivery of these stimuli with visual and audio events to create a more realistic multi-modal experience for the user in order to enhance the sense of presence in the environment. The amount of scent to be released is specified in seconds. For example, one could have a one second burst of concentrated scent delivered which would provide a subtle hint of the scent as when passing by a flower garden while moving between scenes. Conversely, the machine could be programmed to deliver a longer bust of scent such as might be experienced when approaching someone wearing cologne. The scents are concentrated and gelled much like an air freshener cartridge and enclosed within the Scent Palette in an airtight chamber that fills with compressed air. When activated, the scent is released into an air stream provided by 4 electric fans inside the Scent Palette so that it moves past the user and then dissipates into the volume of the room. The scents that have been selected for this application thus far include burning rubber, cordite, garbage, body odor, smoke, diesel fuel, Iraqi spices and gun powder. The addition of tactile input in the form of vibration is designed to add another sensory modality to the virtual environment, again to enhance presence. Vibration is obtained through the use of sound transducers (Aura Bass Shakers, Aura Sound, Inc. Santa Fe Springs, CA) driven by an audio amplifier. The sound files embedded in the software are customized to provide vibration consistent with relevant visual and audio stimuli in the scenario. For example, explosions and gunfire can be accompanied by this additive sensation and the vibration can also be varied as when a virtual vehicle moves across seemingly uneven ground.

Scenario Settings, User Perspective Options & Clinical Interface Design and Development
In parallel with our efforts to seek the funding required to create a comprehensive VR application to address a wide range of possible combat-related PTSD experiences, we created a prototype virtual environment designed to resemble a middle-eastern city (see Figures 1-5). This VE was designed as a proof of concept demonstrator and as a tool for initial user testing to gather feedback from both Iraq War military personnel and clinical professionals in order to refine the city scenario and to seek guidance for options needed for the future expansion of the system to include other relevant scenario settings. Current ONR funding has now allowed us to evolve this existing prototype into a full-featured version 1.2 application that is currently undergoing user-centered design feedback trials with non-PTSD soldiers at the Naval Medical Center - San Diego (NMCSD) who have returned from an Iraq tour of duty. The vision for the project includes not only the design of a series of diverse *scenario settings* (i.e. city, outlying village and desert scenes), but as well, the creation of options for providing the user with different first person *user perspective options*. These choice options when combined with real time clinician input via the "Wizard of Oz" *clinical interface* is envisioned to allow for the creation of a user experience that is specifically customized to the needs of the patient participating in treatment. This is an essential component for giving therapist the capacity to modulate patient anxiety as is required for an exposure therapy approach. Experience customization and flexibility are key elements for these types of VR exposure applications.

Scenario Settings
The software is being designed such that clinical users can be teleported to specific scenario settings based on a determination as to which environment most closely matches the patient's needs, relevant to their individual combat related experiences. All scenario settings are adjustable for time of day or night, weather conditions and lighting illumination. The following are the scenario settings that are being created for the application:

1. **City Scenes** – In this setting, we envision two variations. The first city setting (currently developed in our prototype version 1.2) has the appearance of a desolate set of low populated streets comprising of old buildings, ramshackle apartments, warehouses, a mosque, factories and junkyards (see Figures 1-5). The second city setting will have similar street characteristics and buildings, but will be more highly populated and have more traffic activity, marketplace scenes and monuments.
2. **Checkpoint** – This area of the City Scenario will be constructed to resemble a traffic checkpoint with a variety of moving vehicles arriving, stopping and then moving onward into the city.
3. **City Building Interiors** – Some of the City Scenario buildings will have interiors modeled that will allow the user to navigate through them. These interiors will have the option of being vacant (see Figure 5) or have various levels of populated virtual characters inhabiting them.
4. **Small Rural Village** – This setting will consist of a more spread out rural area containing ramshackle structures, a village center and much decay in the form of garbage, junk and wrecked or battle-damaged vehicles. It will also contain more vegetation and have a view of a desert landscape in the distance that is visible as the user passes by gaps between structures near the periphery of the village.
5. **Desert Base** – This scenario will be designed to appear as a desert military base of operations consisting of tents, soldiers and an array of military hardware.

6. **Desert Road** – This scenario has been constructed and consists of a paved roadway which will eventually connect the City, Desert Base and Village scenarios. The view from the road currently consists of desert scenery and sand dunes (see Figure 6) with occasional areas of vegetation, ramshackle structures, battle wreckage, debris and an occasional virtual human figure standing by the side of the road.

User Perspective Options

The system is designed such that once the scenario setting is selected, it will be possible to select from a variety of user perspective and navigation options. These are being designed in order to again provide flexibility in how the interaction in the scenario settings can be customized to suit the clinical user's needs.

Figure 1. City View

Figure 2. City View

Figure 3. "Flocking" Patrol

Figure 4. "Flocking" Patrol

Figure 5. Interior View

Figure 6. Desert Road View

Figure 7. HUMVEE View

Figure 8. Helicopter View

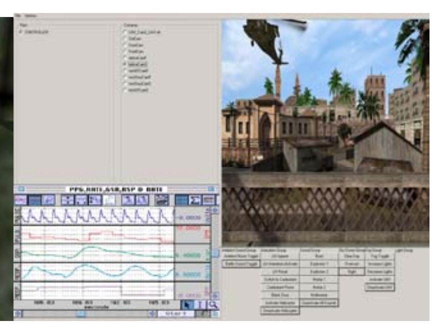

Figure 9. Clinical Interface

User perspective options will include:

1. User walking alone on patrol from a first person perspective (see Figures 1-2).
2. User walking with one soldier companion on patrol. The accompanying soldier will be animated with a "flocking" algorithm that will place them always within a 5-meter radius of the user and will adjust position based on collision detection with objects and structures to support a perception of realistic movement.
3. User walking with a patrol consisting of a number of companion soldiers using a similar "flocking" approach as in #2 above (see Figures 3-4).
4. User view from the perspective of being either inside of the cab of a HUMVEE or other moving vehicle or from a more exposed position in a gun turret above the roof of the vehicle. Options are provide for automated travel as a passenger through the various setting scenarios (see Figure 7) or at the driving column that allow for user control of the vehicle via the gamepad controls. The interior view will also have options for other occupant passengers that will have ambient movement. This view is also adjustable to support the perception of travel within a convoy or as a lone vehicle.
5. User view from the perspective of being in a helicopter hovering above or moving over any of the scenario settings (see Figure 8).

In each of these user perspective options, we are considering the wisdom of having the user possess a weapon. This will necessitate decisions as to whether the weapon will be usable to return fire when it is determined by the clinician that this would be a relevant component for the therapeutic process. Those decisions will be made based on the initial user and clinician feedback from the version 1.2 application.

Clinical Interface

We have created a "wizard of oz" type clinical interface (see Figure 9) to control all of the above features in the system. This interface is a key element in the application, as it needs to provide a clinician with a usable tool for placing the user in VE locations that resemble the setting and context in which the traumatic events initially occurred. As important, the clinical interface must also allow the clinician to further customize the therapy experience to the patient's individual needs via the systematic real-time delivery and control of "trigger" stimuli in the environment. This is essential for fostering the anxiety modulation needed for therapeutic habituation.

In our initial configuration, the clinician can use a separate computer monitor or tablet laptop to display and actuate the clinical interface controls. While the results from our initial user feedback trials is currently guiding the interface design modifications, our initial candidate setup provides four quadrants in which the clinician can monitor ongoing user status information, while simultaneously directing trigger stimulus delivery. The upper left quadrant will contain basic interface menu buttons used for placement of the patient (and immediate removal if needed) in the appropriate scenario setting and user perspective. This quadrant also contains menu keys for the control of time of day or night, atmospheric illumination, weather conditions and initial ambient sound characteristics. The lower left quadrant will provide space for real-time display of the patients' heart rate and GSR readings for monitoring of physiological status when that feature is integrated. The upper right quadrant contains a window that displays the imagery that is present in the user's field of view in real-time. And the lower right quadrant contains the control panel for the real-time delivery of specific trigger stimuli that are actuated by the clinician in an effort to modulate appropriate levels of anxiety as required by the theory and methodology of exposure-based therapy.

The specification, creation and addition of such trigger stimuli will likely be an evolving process throughout the life of the application based on relevant patient feedback. We began this part of the design process by including options that have been reported to be relevant by returning soldiers and military subject matter experts. For example, Hoge et al., (2004), in their study of self-reported anxiety, depression and PTSD-related symptomatology in returning Iraq War veterans, present a useful listing of combat related events that were commonly experienced in their sample. These events provided a useful starting point for conceptualizing how relevant trigger stimuli could be presented in a VR environment. Such commonly reported events included: "*Being attacked or ambushed, Receiving incoming artillery, rocket, or mortar fire, Being shot at or receiving small-arms fire, Shooting or directing fire at the enemy, Being responsible for the death of an enemy combatant, Being responsible for the death of a noncombatant, Seeing dead bodies or human remains, Handling or uncovering human remains, Seeing dead or seriously injured Americans, Knowing someone seriously injured or killed, Participating in de-mining operations, Seeing ill or injured women or children whom you were unable to help, Being wounded or injured, Had a close call, was shot or hit, but protective gear saved you, Had a buddy shot or hit who was near you, Clearing or searching homes or buildings, Engaging in hand-to-hand combat, Saved the life of a soldier or civilian.*" (p. 18). From this and other sources, we have begun with our initial effort to conceptualize what is both functionally relevant and pragmatically possible to include as trigger stimuli in our current clinical interface. There appear to be at least four general classes of trigger stimuli that are relevant for this application: 1. Auditory (i.e., weapons fire, explosions, vehicle noise, wind, human voices), 2. Static Visual (i.e., human remains, wounded civilians and combatants, wrecked vehicles), 3. Dynamic Visual (i.e., distant views of human and vehicle movement), 4. Dynamic Audiovisual (i.e., nearby human and vehicle movement, battlefield engagement with enemy combatants).

Thus far in the Version 1.2 prototype, we have created a variety of auditory trigger stimuli (i.e., incoming mortars, weapons fire, voices, wind, etc.) that can be actuated by mouse clicks. We can also similarly trigger dynamic audiovisual events such as helicopter flyovers above the user's position and verbal orders from a commanding officer who is gesturing in an excited manner. The creation of more complex events that can be intuitively delivered from the clinicians interface while providing a user with options to interact or respond in a meaningful manner is one of the ongoing focuses in this project. Perhaps it may be of value to actually immerse the user in varying degrees of combat in which they may see members of their patrol (or themselves) get wounded or in fact have the capability to fire a weapon back at enemy combatants. However, such trigger options will require not only interface design expertise, but also clinical wisdom as to how much and what type of exposure is needed to produce a positive clinical effect. These issues will be keenly attended to in our initial clinical trials.

Conclusions

War is perhaps one of the most challenging situations that a human being can experience. The physical, emotional, cognitive and psychological demands of a combat environment place enormous stress on even the best-prepared military personnel. In this regard, one of the more foreboding findings in the recent Hoge et al., (2004) report, was the observation that among Iraq War veterans, *"…those whose responses were positive for a mental disorder, only 23 to 40 percent sought mental health care. Those whose responses were positive for a mental disorder* *were twice as likely as those whose responses were negative to report concern about possible stigmatization and other barriers to seeking mental health care."* (p. 13). While military training methodology has better prepared soldiers for combat in recent years, such hesitancy to seek treatment for difficulties that emerge upon return from combat, especially by those who may need it most, suggests an area of military mental healthcare that is in need of attention. To address this concern, perhaps a VR system for PTSD treatment could serve as a component within a reconceptualized approach to how treatment is accessed by veterans returning from combat.

One option would be to integrate VR-delivered combat exposure as part of a comprehensive "assessment" program administered upon return from a tour of duty. Since past research is suggestive of differential patterns of physiological reactivity in soldiers with PTSD when exposed to combat-related stimuli (Laor et al., 1998, Keane et al., 1998), an initial procedure that integrates our VR PTSD application with psychophysiological monitoring could be of value. If indicators of such physiological reactivity are present during an initial VR exposure, a referral for continued care could be negotiated and/or prescribed. This could be provided in a format whereby the perceived stigma of independently seeking treatment could be lessened as the soldier would be simply involved in "non-combat reintegration training" in similar fashion to other designated duties to which they would participate. As well, current generation military personnel, having grown up with digital gaming technology, may actually be more attracted to and comfortable with participation in a VR application approach as an alternative to what is viewed as traditional "talk therapy" (even though such talk therapy would obviously occur in the course of a recommended multi-component approach for this disorder). This potential for a reduction in the perceived stigma surrounding treatment has been anecdotally reported by practitioners who treat civilians with aerophobia (fear of flying) using VR (Wiederhold & Wiederhold, 2004). These observations indicate that some patients have reported that prior to treatment, they had "just lived with problem" and never considered seeking professional treatment. Upon hearing of VR therapy for fear of flying, often via popular media reports, they then sought out VR exposure treatment, typically with resulting positive outcomes.

In addition to the ethical factors that make an unequivocal case for the importance of exploring new options for assessment and treatment of combat-related PTSD, economic drivers for the Department of Veterans Affairs healthcare system and the military also provide incentives for investigating novel approaches in this area. Currently there are 13,524 Gulf War Veterans who are receiving compensation for PTSD from the Department of Veterans Affairs as of September 2004 (VA Fact Sheet, 12/2004). In addition to the direct costs for benefit compensation, medical care usage by persons with PTSD is estimated to be 60% higher than average (Marshall, Jorm, Grayson & O'Toole, 2000) and lost income-based tax revenues raise the "hidden" costs even higher. These data make the initial development and continuing infrastructure costs for running PC-based VR systems pale by comparison. The military could also benefit economically by way of reduced "turnover" of soldiers with mild PTSD. These personnel might be more likely to reenlist if their mental health needs were addressed soon after combat in a progressive manner via early VR assessment and treatment. As well, such a VR tool initially developed for exposure therapy purposes, offers the potential to be "recycled" for use both in the areas of combat readiness assessment and for stress inoculation. Both of these approaches could provide measures of who might be better prepared for the emotional stress of combat. For example, novice soldiers could be pre-exposed to challenging VR combat stress scenarios delivered via hybrid VR/Real World stress inoculation training protocols as has been reported by Wiederhold & Wiederhold (2005) with combat medics.

Finally, one of the guiding principles in our development work concerns how VR can *extend* the skills of a well-trained clinician. This VR approach is not intended to be an automated treatment protocol that could be administered in a "self-help" format. The presentation of such emotionally evocative VR combat-related scenarios, while providing treatment options not possible until recently, will most likely produce therapeutic benefits when administered within the context of appropriate care via a thoughtful professional appreciation of the complexity and impact of this disorder.

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