Effects of priming and videogame play habits on responses to a virtual environment

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Abstract
Our project used a virtual environment called DarkCon to simulate a military reconnaissance mission. In this study, we investigated the differential effects of priming on a group of 34 Army Ranger “recycles” from Fort Benning, GA. Half were given a military-style, and half a game-style instructional video and briefing. We tested subjects for simulator-sickness, immersive tendencies, self-reported degree of presence, and recall of scenario elements. We hypothesized that the priming condition would result in different behavior within the virtual environment, and possibly differences within subjects' recall of their experience. We also examined the effects of subjects' prior game play experience and habits on their behavior. Implications of our findings and directions for future research are discussed.

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1 Introduction
Our research lab was established by the United States Army as a university research center tasked with investigating ways to make training for soldiers more effective. We set out to show that more affective immersive training environments could contribute to more effective training systems for soldiers. Our project focused on immersive training environments delivered via traditional virtual reality techniques. We started with several related hypotheses: a) That virtual environments for training can be made more emotionally evocative, b) that emotional response in virtual environments tends to increase users’ overall physiological arousal states, significantly impacts users’ behavior, may improve immediate recollection of scenario experience, and may enhance retention of scenario experience, and c) that inclusion of additional sensory modalities in the scenario experience will heighten the responses listed above. Given the increasing trend towards using games for military training, we also set out to demonstrate that encouraging a specific mental schema in a user that is appropriate to the scenario, as either a game or a serious training mission, induces a particular cognitive approach that affects the user’s emotional response.

Our first task was to develop methodologies for creating a more emotionally evocative virtual scenario for use in our experiments, resulting in the scenario DarkCon. DarkCon is an immersive virtual environment, run on a custom Performer GL engine on a mobile three-node PC cluster, and experienced through a head mounted display (HMD) providing the user with a fully explorable 3D environment. The participant navigates through this virtual space via a hand-held joystick and a Polhemus magnetic tracking system attached to the user that provides 6 degrees of freedom (DOF) information back to the simulation. DarkCon was based on the premise that the integration of sensory modalities mitigated the need for photo realistic graphics. We call this approach "cognitive realism". We used techniques from art, design, theatre, film, story, and psychology in the design process, as well as the latest information from cognitive and neuro-sciences on how our brains respond to and integrate sensory stimuli for emotional response. For detailed information on the design of DarkCon, please see Morie et al. [2003].

One factor we suspected as a strong influence on the responses of an individual in a training scenario is the set of expectations he or she has going into the virtual environment (VE). Given the ubiquity of gaming in the generation most appropriate to join the Army we asked ourselves the question: Would there be a difference in behavior if the subject believed the VE scenario was a game, as opposed to a serious exercise?

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more quickly to the semantically-related word ‘car’ than to the non-related word ‘flower’. Priming may be induced by both sensory (primarily visual) and linguistic stimuli. It can inform individuals what to expect, but it can also influence the way in which they perceive subsequent events. A successfully primed participant becomes biased, whether they are aware of it or not. For further details on the development of priming and gameplay on 34

We expected that the priming given to the subjects in our tests would influence their later perception of the virtual environment as either a competitive (game) or a responsible (military) situation. As a result of these perceptions, we expected that distinct behavior patterns would emerge between groups. Our hypothesis was that subjects who believed the simulation was “just a game”, with a corresponding feeling of impunity to important consequences, would not behave as cautiously or as responsibly as their counterparts who believed it to be a serious training exercise.

We anticipated that individual differences would also impact subjects’ behavior, and therefore administered a modified version of the Immersive Tendencies Questionnaire to each of them [Witmer & Singer, 1998]. Part of our modification was the inclusion of questions about video-game play habits as part of our measurement. Since the virtual environment was to be presented to half of our subjects as a videogame, we decided to investigate the influence of videogame experience on their behavior as well. According to a recent study of children, time spent playing video or computer games currently exceeds time spent watching television [Christakis et al., 2004], and studies of the potential effects of video games, typically restricted to the study of violence and aggression, have demonstrated that behavior can be and is affected by frequency of videogame play [Anderson, 2004]. We expected that this would therefore have an effect on behavior in a virtual environment as well.

A prior experiment in the DarkCon environment tested 63 civilian subjects and found that priming affected their behavior, physiology, and memory of the experience [Luigi et al., 2005]. The present study examined the effects of priming and gameplay on 34 Army Ranger “recycles” from Fort Benning, GA. “Recycle” refers to trainees who are required to repeat one of the Ranger training modules. We examined soldiers specifically because of the applications of DarkCon as a training environment for military reconnaissance, rather than as a civilian exercise. Soldiers and civilians are expected to respond differently to the experience; these distinctions will be cursorily discussed below, but will be the subject of future reports.

2 Methods

Subjects were alternately assigned to a priming condition in advance of their arrival at the testing facility: game-style priming (n=16) or mission-style priming (n=18). After giving informed consent, participants filled out a slightly modified Immersive Tendencies Questionnaire (ITQ) [Witmer & Singer, 1998], and the standard Simulator Sickness Questionnaire (SSQ) [Kennedy et al., 1993]. Participants were fitted with electrodes for physiological measurement of heart rate and skin conductance, collected using the Cleveland Medical BioRadio 110 wireless acquisition system. A skin conductance sensor was built to be used with the BioRadio 110, which has preset gain of 1 and 10 mV/µS. Both EKG and SCR channels were recorded with 16bits resolution and a sampling rate of 640Hz. Participants were then fitted with a Polhemus magnetic 6DOF tracking system with navigation wand and Kaiser Electro-Opticals ProView XL-50 HMD. Preliminary training was necessary to help the subjects familiarize themselves with the specific skills required within the 3D environment; therefore, a simple orientation environment was constructed to train the subject for his or her required virtual-world tasks. Physiological data was recorded during this training orientation to provide baseline metrics (for details on baseline acquisition, see Morie et al. [2002]).

The DarkCon scenario was run on a mobile three-node PC cluster. Two nodes of this cluster were dedicated to left- and right-eye view in stereo mode, while the remaining node drove a 5.1 spatialized 3-D sound system (this evaluation was run in mono visual mode). For further information on cluster construction and hardware, please see Morie et al. [2005].

Before the participant was presented with the DarkCon scenario, he or she was given a mission briefing (via video) that had been designed with the priming condition in mind. Participants in the military-primed group were given their instructions by a person introducing himself as “Major O’Neill”, and addressing them as “soldier”, whereas the game-priming group was briefed by a civilian who told them about the fun role-playing game they were about to experience. While the instructional videos had different contexts, the actual instructions given were identical between priming groups.

The scenario environment represented a small area of an unnamed Eastern European country. Participants were instructed to walk through a culvert and up to a designated building, while determining a. whether the inhabitants of the area were refugees or paramilitary rebels, and b. which (if either) group had been using the culvert. Objects in the culvert served as corroborative details, intentionally placed clues designed to make participants draw conclusions about the culvert inhabitants (see figure 2). If the area appeared hostile and rebel-controlled, participants were to place a GPS transmitter on the building in order to guide a missile strike, and leave. Participants were instructed to be cautious and observant, and were told that they would be required to report their findings.
The DarkCon simulation then began, with fully-spatialised audio and visual input to the participant. During the scenario, physiological data was continually recorded. The DarkCon environment server was synchronized with the computer controlling the physiological recording device in order to correlate the psycho-physiological reaction of the participant with events and situations in the scenario. When an end of scenario (EOS) condition was met (being caught by a guard, for instance), the VR equipment was removed from the participant who was then seated and given a structured interview about their experience. The after-action interview comprised 11 questions regarding participants’ recollections of their goals, their perceptions of their own failure or success at the mission, recall of categories of objects within the scenario (vehicles, weapons, people, remains, items in the culvert), and their perception of the inhabitants of the scenario. Interviews were recorded and coded for later analysis. Finally, they were taken to another room and provided with a second set of follow-up questionnaires designed to evaluate “presence”: a modified version of Witmer and Singer’s Presence Questionnaire (PQ) [1998] and of Usoh and Slater’s Virtual Environment Questionnaire (VE) [1999]. They also completed the SSQ once more [Kennedy et al., 1993].

3 Analysis and results

Data from this sample does not include physiological or behavioral data. Due to difficulties in data reduction, we were unable to include these in this analysis; however, we expect to discuss them in future publications. The after-action recall interview was coded for correct responses. For instance, question four asked “How many vehicles did you observe in the environment? Please describe”. There were five correct answers that the subject could give. Each vehicle that he reported correctly was coded ‘1’; vehicles that he did not report were coded ‘0’. This resulted in problems with the equal-variances assumption of ANOVA. Groups frequently varied widely. In addition, groups occasionally demonstrated a 0% or 100% report on a particular item, thus making robust tests not relying on equal variance (Welch and Brown-Forsythe) impossible due to zero variance.

Differences between priming groups were first computed using one-way ANOVA. Significant effects were found for question one, regarding subject’s understanding of mission goals, on “determine whether [inhabitants of the area were] enemy forces” (unequal variance; Brown-Forsythe statistic 10.284, p=0.004), and “so that the weapon may be fired” (F=4.857, p=0.035). A third significant effect was found under question four, regarding vehicles, on “truck on the bridge” (unequal variance; Brown-Forsythe statistic 5.956, p=0.022).

We then examined the impact of videogame-play frequency as measured by the ITQ, questions 22 through 26, as well as its “games” subscale. Participants were asked to rate how often they played each type of videogame listed (first-person shooter, real-time strategy, online roleplaying, and puzzle games) from 1 (“never”) to 7 (“every day or every two days, on average”). Subjects were then assigned to a level based on their response: low (1-2), mid (3-5), and high (6-7). Their total ITQ Games score was also assigned a level (low [0-10], mid [11-20], high [21-30]). Each question of after-action recall was examined separately, to probe for overall effects of priming and gameplay in each category (goals, vehicles, people, and so on).

We found that first-person shooter gameplay frequency (low n=21; mid n=8; high n=5) affected users’ self-report of presence on the VEQ (F=5.620, p=0.009). Real-time strategy gameplay (low n=21; mid n=9; high n=4) significantly affected users’ report of the “truck on the bridge” under vehicles (question four) (F=3.342, p=0.050). Puzzle gameplay (low n=27; mid n=7; high n=0) was found to affect report of “determine who is using the culvert” as a mission goal (F=10.165, p=0.003; variance unequal, robust tests not performed). Users’ total ITQ Games score (low=16; mid=11; high=7) affected their report of the “truck on the bridge” under vehicles (F=4.065,
Finally, we examined the data for interactions between priming condition and videogame-play frequency in each category and overall. We found that priming interacted with frequency of real-time strategy gameplay on question one, “determine who is using the culvert” \( (F=11.604, \ p=0.001) \). There were no “high” frequency puzzle game players; with that in mind, there also appeared an interaction between frequency of puzzle gameplay on question one, for “determine who is using the culvert” \( (F=10.250, \ p=0.003) \), “[place the transmitter] on the southwest corner” \( (F=4.309, \ p=0.047) \), and “escape via the culvert” \( (F=4.066, \ p=0.053) \). Finally, an interaction effect was found between levels of the ITQ Games subscale and priming condition on the total number of items correctly reported on question one \( (F=4.132, \ p=0.027) \).

No effects were found on presence reported by the PQ or increases in simulator-sickness reported by the SSQ.

### 4 Discussion

Initial comparisons between priming groups revealed striking differences in the way that subjects in each group understood and reported their goals. Subjects who underwent ‘game’ style priming reported “determine whether [people in the area are] enemy forces” as a goal nearly twice as often as those who underwent ‘military’ priming. In contrast, they were only half as likely to report the launching of a weapon (as a consequence of placing the GPS transmitter). These two differences show the contrasting emphasis placed on aspects of the mission by each group. The group primed to treat the DarkCon experience as a serious military mission (for which, being in the military, they had prior training) appear to have taken specific details from their mission briefing: go in and place the transmitter so that the paramilitary forces may be destroyed by a missile. The lack of emphasis on reconnaissance, determining whether inhabitants were in fact enemy forces, seems to have been exchanged for emphasis on military action and a prejudgement that inhabitants of the area were enemies. Keeping in mind our methodology, however, the contents of the after-action report do not necessarily reflect participants’ recall of scenario details, but much more reliably reflect their likelihood of reporting said details after the fact. As such, it is entirely possible that this differential emphasis on mission details came about not as a result of subjects’ understanding of instructions, but of their having completed the experience. For example, it is possible that, having determined that the inhabitants were in fact enemy paramilitary forces, the reconnaissance required for making that determination became less important than the actions required after it, namely the placing of the transmitter for the purposes of neutralising the enemy. From wherever the differentiation arises, in approach or in recollection, each group perceived their experience differently after the fact, thus demonstrating that they in some significant ways received different ‘training’ from DarkCon as a result of the priming condition.

The report of mission goals was also significantly different between groups of gamers. Firstly, a strong interaction appeared between priming conditions and level of general videogame-play frequency in the total number of correct mission goals reported. As indicated in figure 3, it appears that at low levels of gameplay, priming groups are basically similar. As gameplay frequency increases to ‘high’, however, the game-primed group decreases amount of goals reported, while the military-primed group increases. In subjects who play videogames frequently, ‘serious’ priming has a significant positive impact on their report of mission goals, while ‘game’ priming lessens their recall or inclination to report these details. A similar interaction effect appeared under the specific heading of puzzle game-play frequency, in which occasional puzzle game players (there were no high-frequency players in this category) in the military-style priming group reported more details of their mission than did those in the game-style priming group. Overall, military priming resulted in improved report of details in terms of the mission objectives, especially when subjects were high-frequency (“every day to every two days, on average”) players of video games.

![](estimated_marginal_means.png)

Figure 3: Graph of total correct items reported on question 1 of after-action free-recall, “What did you understand your goals to be, as described in the instructional video?”

This finding may be interpreted in several different ways. When we take into account the potential ambiguity between actual recall and the likelihood of reporting details, two interpretations present themselves. The first, in which subjects in the aforementioned group in fact recall more details of their mission, suggests that they may have paid
greater attention to their briefing (improved recall of goals over the scenario is not suggested, given the overall lack of difference on report of other items). The second interpretation is that subjects in that group perceived the detailed mission goals with high importance, while other subjects perhaps perceived them as of insufficient importance to report. If this were due to some aspect of the priming video, such as the perceived authority of the messenger, then we would expect priming to appear as a main effect rather than as an interaction. Similarly, if this were due exclusively to an effect of gameplay frequency, we would not expect high-frequency players to perform so much more poorly in the game-priming condition. It appears that gameplay frequency does have a positive effect on recall and/or report (possibly even understanding) of task instructions, but only when combined with a serious approach. When frequent game-players are presented with a scenario in which they are told to “have fun”, they cease to view detailed instructions as important, perhaps paying insufficient attention to recall them in total.

Overall, questionnaires and after-action recall do not appear to indicate any major differences in behavior, with the exception of one item. In the scenario, a truck passing overhead in the culvert, and over a bridge, is triggered by the participant moving to a point at the culvert exit threshold. Reports of the truck on the bridge differed between priming groups, and also between levels of gameplay frequency, though there do not appear to be any significant interactions on this item. Military-primed subjects were less likely to report the truck overall. As frequency of general gameplay increased, so did report of the truck. Figure 4 shows that the two groups are equivalent in their report of the truck in high-frequency, but differ significantly in low-frequency. Given the overall lack of difference in recall of items, differential report of the truck does not point to any trends; however, it may demonstrate differences in behavior. From its triggering location in the culvert, the truck is audible (and can be felt via the subwoofers of the 5.1 sound system), but the bridge over which it passes is not visible; however, some seconds pass before it approaches the participant’s location. If the participant were to remain at the triggering location, therefore, he would hear and sense the rumbling of some sort of heavy engine passing overhead, and might venture a guess as to its source, but would not see what is generating the noise unless he moved forward, to the exit of the culvert or out into the environment, from which vantage point the bridge (and truck) can be seen.

In a general way, a difference in report of the truck may speak to participants’ behavior. Let us assume for the moment that a participant who did not report the truck on the bridge did not see it (confirmation on this point must wait until data is recovered using our visualisation tool, Phloem [Morie et al., 2005]). After reaching the point at which the truck event was triggered, those participants must either have remained inside the culvert, at a point far enough from the exit that the bridge was not visible, or have moved outside the culvert so far that the noise of the truck did not register. Those who did report the truck must have moved toward the culvert exit or another location such that they saw it after it was triggered.

There are several possible scenarios to explain this difference in behavior (part of the sometimes frustrating nature of analysis of an essentially free-will environment). The first is that subjects in the high-frequency gameplay group moved to the culvert exit in time to hear the rumbling noise overhead and investigate its origin by surveying the environment. In this case, we might assign a certain amount of exploratory initiative to these subjects. Another possibility is that they were already moving faster through the culvert than subjects in other groups, such that they were outside as the truck passed overhead, looking backward to investigate the noise. In this case, we might interpret their behavior as less observant (taking less time to explore the culvert), somewhat more careless (due to the potential consequences of being seen by the driver of the truck or others), but possibly more directed toward the goal of placing the transmitter than toward reconnaissance and stealth. This is not supported by the fact that there are no genuinely significant differences in recall other than this one – we would expect that if subjects were less concerned with observation, they would report fewer items in the after-action interview. On the other hand, the delay between the triggering of the event and the event itself is such that subjects could have been long gone from the culvert before the truck was visible. The final possibility, that all subjects were at the culvert exit in time to see the truck pass overhead, while only some were looking towards the bridge, is somewhat unlikely: the truck is quite loud, and is likely to draw attention in an otherwise quiet environment. Without behavioral data (for instance,
total time spent in the culvert), it is difficult to speculate as to which of the first two scenarios is more likely. However, the first possibility seems to fit more snugly with the other data described above. This scenario would also support our hypothesis that military-primed subjects would act displaying greater caution and responsibility than subjects in the game-primed group.

Finally, we had anticipated the possibility that differences between groups might arise in their self-reported measurement of presence. The only group comparison that revealed a difference in presence was in the first-person shooter category of gameplay frequency: frequent FPS players reported less presence than occasional or rare players did. This difference only arose in the measurements of the VEQ; no difference occurred between groups on the PQ. The two questions that require answers, therefore, are 1. Why did the high-frequency FPS players report less feeling of presence, and 2. Why do the VEQ and PQ disagree? The first question may have to do with the nature of first-person shooter games, vis-à-vis the nature of the DarkCon experience. DarkCon is a first-person environment with a military theme, much like many FPS games (though the ‘S’ is implied, rather than overt). As such, we might expect that the ‘look and feel’ of the experience might have been less novel to subjects who play these sorts of games frequently.

Upon closer examination of the VEQ itself, however, the difference between scores is clarified, and appears to be a methodological issue. The VEQ includes three questions that measure pre-existing individual differences, which the PQ does not measure. The two scales therefore measure presence differently. As a result, the divergence of the total presence scores appears to be primarily a disagreement of definition between the two measures. This is admittedly a divisive issue in the area of virtual environments research (For details on the issues surrounding the definition and utility of presence as a concept, please see Slater [2004]).

5 Conclusions and future research

From our data, we believe that the following conclusions are warranted:

- Using priming, it is possible to manipulate subjects’ recollection and/or understanding of a task.
- Users who play videogames frequently will experience and interact with a virtual environment differently than those who do not.
- Differences in the frequency of videogame play leads users to respond differently to manipulation of their viewpoint via priming.

It must be said that there were fewer differences between groups than we would have expected. When taken in concert with the results of our civilian study [Luigi et al., 2005], it would appear that priming did not produce the impact on learning and recall that we thought it would. However, we believe that this may be largely a methodological issue. Firstly, we collected physiological and behavioral data from subjects that have yet to be analysed; we expect to discuss these findings, and to compare them to the aforementioned civilian study, in subsequent publications.

Secondly, the differences between priming conditions may not have been as great in magnitude as we initially believed. We were cautious in our use of priming: all users were aware of the fact that DarkCon was virtual, and while we encouraged the subjects in the military-priming group to take the scenario and its consequences seriously, all users were aware that they would not be punished or rewarded by the experimenters based on their performance. While their perception of the task was somewhat different, as indicated above, it appears that subjects in each group largely did not respond to the relatively subtle priming manipulations to which they were exposed.

There is a deeper and more problematic issue with our methods as well, which may be oversimplified as follows: If it looks like a game, plays like a game, and feels like a game, then it probably is a game, regardless of what the instructional video said. Despite the fact that the military-style instructional video implied that subjects ought to take the scenario environment seriously, the perceived consequences of actions in a virtual environment are limited by the fact that it is, in fact, virtual. Ethical considerations apply to employing negative consequences in the real world. Similar considerations apply to the use of deception, in order that a user might believe his actions could potentially have real-world consequences. This study was performed on soldiers in training, and we would expect that they might in general take the exercise more seriously than their civilian counterparts (this appears to be the case anecdotally, but a comparison of both subject groups is forthcoming). On the other hand, it is easy to perceive DarkCon (especially, one might expect, to frequent gamers) as an especially advanced videogame. Further experiments on priming in virtual training environments should seek to mitigate this conflict.

As shown above, users respond to a virtual environment very differently depending on their familiarity with, and frequency of play of, videogames. We analysed game play levels only as an addendum to our primary study, and we therefore were not able to equalize the size of each group. The unbalanced nature of this analysis should not provoke scepticism; rather, it should inspire curiosity. If our findings are robust, they demonstrate significant differences between game-players and the rest of the population, and suggest methodology for further investigations of the effects of frequent game play, both within virtual environments and more generally. They may be of use also for study of the effects of videogames on behaviour directly. Current research is
largely restricted to the study of violent videogames and aggression, and excludes examination of game play with minimal violent or aggressive components. The results of the present study are indicators, we believe, that the effects of frequency and type of videogame play should be investigated deliberately and directly.

References


