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Controlling a Stream of Paranoia Evoking Events in a Virtual Reality Environment

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Abstract. Although virtual reality exposure has been reported as a method to induce paranoid thought, little is known about mechanisms to control specific virtual stressors. This paper reports on a study that examines the effect of controlling the stream of potential paranoia evoking events in a virtual restaurant world. A 2-by-2 experiment with a non-clinical group (n = 24) was conducted with as two within-subject factors: (1) the cycle time (short/long) for when the computer considers activation of a paranoia evoking event and (2) the probability that a paranoia-evoking event (low/high) would be triggered at the completion of a cycle. The results showed a significant main effect for the probability factor and two-way interaction effect with the cycle time factor on the number of paranoid comments participants made and their self-reported anxiety.

Keywords. Paranoia, virtual reality, stressors, exposure

Introduction

Several studies [2; 10] report that exposure in virtual reality (VR) can elicit paranoid thought. Paranoia is a continuous phenomenon and has been studied also in a non-clinical population, which shows similar yet smaller effects than found in a clinical population [10]. This paper explores the idea of exposing individuals in a virtual environment (VE) to a random set of independent events. In a state of paranoia, characterized by hypervigilance, emotional arousal and selective attention for threat, people's interpretation and sense making process might combine these events and result into paranoid thought. Controlling the stream of these events, would potentially give therapists the ability to dynamically control paranoia evoking stimuli in the VE and therefore offer the ability of controlled gradual exposure. The hypothesis was therefore that the stream of paranoia evoking events affects paranoid thought.

1. Method

1.1. Virtual World Characteristics

A virtual restaurant world was selected as a suitable social environment for prolonged exposure where an individual could sit for a relatively long time while observing

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several virtual humans engaged in social interactions. Given this setting, the following stressors were selected that would fit naturally within this social setting: the eye gaze of other virtual restaurant visitors directed towards the individual, their facial expression, snatches of their conversation or laughter, people passing by, people passing by who stop to look around, and flash news messages on a TV screen. To control all these events, an event-stream manager [4] was developed that allows operators to set the probability for each of these events. In addition, operators could set the ratio from 0 to 100 for three mutually exclusive events: (1) conversation or laughter, (2) angry or happy facial expressions, and (3) the walking characters looking at the individual or looking at other virtual characters. The event-stream manager cyclically considered whether to trigger these events or not. As events in the natural world occur at a different pace, the event-stream manager used three timers to control the cycles to consider triggering specific behaviors of (1) sitting characters, (2) the walking characters, and (3) the TV news flashes. With a single slider, the operator could set the cycle time for these timers to go off and force the manager to consider whether or not to trigger an event based on the probability set by the operator for that event. For this, the manager would take a random number between 0 and 1. If this number was lower than the probability set by the operator, the paranoia-evoking event in the virtual restaurant would be triggered. A list of 52 dialogue snatches were pre-recorded and 27 news flash texts were made. Both lists were rated by 3 patients in treatment for first episode psychosis and 7 therapists, resulting in 37 snatches rated as paranoia provoking and 15 rated as more neutral snatches. For news flashes, 14 were rated as paranoia provoking and 13 were rated as more neutral. The neutral snatches and news flashes were used as neutral events when the randomizer did not select a paranoia-evoking event if a timer went off.

1.2. Materials and Measurements

To immerse the participants into the VE, the participants wore a Sony HMZ-T2 Personal 3D Viewer Head Mounted Display (HMD). To track the participants' view position and orientation, the Razor tracker with 3 Degrees of Freedom was used. As individuals with paranoid thoughts may also experience arousal and anxiety, the Mobi8 data recorder with Xpod Oximeter from TMSi was used to measure the participants' heart rate and their Galvanic Skin Response (GSR). Furthermore participants were asked to report their anxiety on the Subjective Unit of Discomfort (SUD) scale [12]. Prior to the experiment, they were asked to complete the Social Interaction Anxiety Scale (SIAS) [7], the Green et al. Paranoid Thoughts Scale (GPTS) [3], the Computer Experience Questionnaire (CEQ) [9], the Immersive Tendencies Questionnaire (ITQ) [11] and Simulator Sickness Questionnaire (SSQ) [6]. After the experiment participants completed the Igroup Presence Questionnaire (IPQ) [8] and SSQ. Furthermore, participants were instructed to observe their surroundings and to give running commentary on their experiences. They were instructed to focus their comments on how they perceived the environment rather than providing simply an 'objective' description of the environment or an assessment of the quality of the VR environment. The participants' voice was recorded using Audacity software. In additions, after the exposure in virtual reality, they were asked to summarize their experience. The comments were coded using two coding schemes: the Coding Scheme Paranoid Thoughts Commentaries (CSPTC) [5] to classify the type of paranoid thought (i.e. persecution/accusation, distress, and threat), and one to classify the type of stressors

that had elicited the paranoid thoughts (i.e. eye gaze, emotion, laughing, snatch of conversation, walk, walk and look, news flash, other, and unclear). Both schemes used mutually exclusive categories. CSPTC was extended with a Self-Reference category for references regarding mistakenly believing that a virtual character is talking about, referring to, or laughing about the individual, for example: *the man behind me is laughing about me*; *somehow I feel like he is talking about me*; *I don't know whether they are talking about me or about someone else*. Not included in this category were references that factually state that a virtual character was looking at them.

1.3. Experimental Design

The experiment had a 2-by-2 within-subjects design, with the cycle time (short or long) and the probability of the paranoia evoking events (low or high) as within-subjects factors. The cycle time for the sitting characters, walking characters, and TV news flashes were set to 18, 90 and 36 seconds respectively for the long cycle time condition, and to 10, 50 and 20 seconds respectively for short cycle time condition. In the low probability condition, probability was set to 20% and in the high condition to 80%. The mutually exclusive event ratios were set to 50. As participants were exposed to all four experimental conditions, the order of the conditions was counterbalanced.

1.4. Procedure and Participants

Twenty-four students (21 males and 3 females) of Delft University of Technology participated in the experiment. The participants' age ranged between 21 and 42 years old (M = 28.42, SD = 4.83) and all participants had at least a bachelor degree. All participants reported to have no history of paranoid disorder and to have little to no experience in developing a virtual world. To obtain a based-line physiological and SSQ measurement and train participants on the think-aloud protocol, participants were first exposed in a neutral virtual world [1] that consisted of a small room with TV set and no virtual characters were present in this room. On a virtual TV set, participants could look at a wildlife video. After this, participants saw a 6.5-minute video of a news report on street violence and read a fake news report about violence in the Netherlands. This priming procedure has been shown to induce paranoid thought in a non-clinical population [5]. Next, participants were exposed in the virtual restaurant world four times, for three minutes each time. Directly after each exposure condition, participants were asked for a SUD score and asked to summarize their experience. At the end of the experiments, participants completed IPQ and SSQ. Ethical approval for the experiment was obtained from the university ethics committee.

1.5. Statistical Analysis

Analysis of the number of coded paranoid comments made by an individual both during exposure in VR (Spearman r = .87, n = 96, $p.$ < .01) and afterwards (Spearman r = .75, n = 96, $p.$ < .01) showed an acceptable level of consistency between two independent coders. On comments that coders initially coded differently, the coders were asked to discuss and agree on a single classification. Of 24 participants only 13 made paranoid comments, therefore a Generalized Linear Mixed Model analysis with repeated measures was conducted on the number of paranoid comments made by these 13 participants, while for SUD, GSR, and heart rate data the analyses were conducted

on data of all participants. The comments analysis used a negative binomial probability distribution while the other analyses used a gamma probability distribution. All analyses used a log link function and a diagonal covariance structure for both the repeated and the random intercept covariance. Furthermore, to reduce variance caused by individual differences in GSR baseline levels, the (*a*) measurement from the experimental conditions were set against the (*b*) measurement obtained from the neutral virtual world, using the following formula: (*a*-*b*)/*b*. To avoid negative or zero values for the log function transformation, a constant value of one was added to the SUD and to GSR values used in the analyses.

2. Results

Table 1 shows the participants' characteristics. Some significant increase of simulation sickness was reported after the exposure (*t*-test, *p*. = 0.02, bootstrap). Probability of events had a significant effect (during exposure: $F(1, 16) = 16.14$, $p = .001$; after exposure: $F(1, 26) = 17.22$, $p < .001$) on the number of paranoid comments made by the 13 participants that made these comments. More paranoid comments were made in the high probability condition (during: $M = 2.5$, $SD = 2.8$; afterwards: $M = 1.4$, $SD = 1.6$) than in the low probability conditions (during: $M = 0.6$, $SD = 1.0$; afterwards: $M = 0.4$, $SD = 0.8$) (Figure 2). For comments made during the exposure, the analysis also found a significant two-way interaction effect ($F(1, 13) = 5.92$, $p = .03$) between the cycle time and the probability of the events. As figure 2 shows, in the low probability conditions significantly ($t(25) = 2.26$, $p = .033$) more comments were made in the short cycle time condition than in long cycle time condition, whereas no significant ($t(19) = 1.05$, $p = .305$) difference was found in the high probability conditions.

Table 1. Participants' characteristics.

Measure	*M*(*SD*)
Paranoid thoughts (GPTS)	
Persecution	21.3(6.8)
Social reference	31.2(9.7)
Total	52.5(14.3)
Social Anxiety (SIAS)	26.0(12.9)
Computer Experience (CEQ)	14.8(2.6)
Immersive Tendencies (ITQ)	69.3(14.3)
Presence (IPQ)	49.4(11.8)
Simulation Sickness (SSQ)*	
Before exposure	78.5(20.4)
After exposure	108.5(35.2)

*sig ($p<.05$) difference before and after

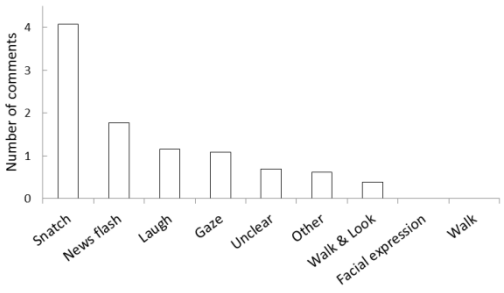

Figure 1. Mean number of paranoid comments made according to paranoia-evoking stressors.

Whereas no significant difference was found between the extended CSPTC categories of the type of paranoid thought ($\chi2(3) = 3.86$, $p = .28$) (e.g. threat and self-reference), a Friedman analysis found significant ($\chi2(3) = 30.26$, $p < .001$) difference between the paranoia-evoking stressors (e.g. laughing and news flash) of the paranoid comments. As figure 1 shows, snatches of conversation were related to a relative higher number of paranoid comments, whereas facial expressions and characters only walking around were never mentioned in these comments. The analysis also found a significant two-way interaction effect ($F(1, 7) = 9.16$, $p = .021$) in the self-reported distress. In the

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low probability conditions, participants reported significantly ($t(19) = 2.89$, $p = .010$) more distress in the short cycle time condition than in the long condition (Figure 3). No significant effects ($p > .05$) for probability and cycle time factors were found in the GSR and heart rate data.

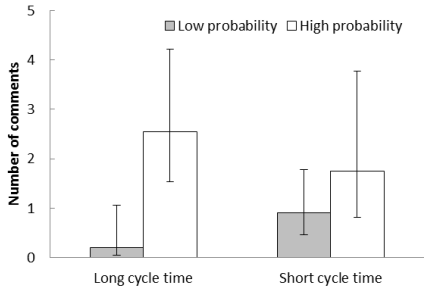

Figure 2. Mean (95% CI) number of paranoid comments made during exposure.

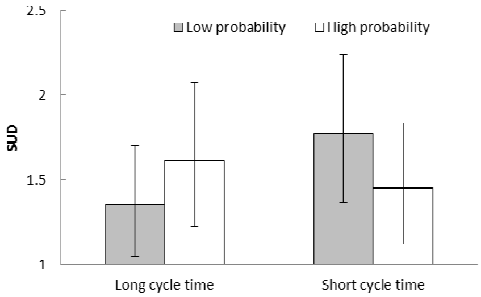

Figure 3. Mean SUD score made at end of exposure (95% CI).

3. Conclusion

Controlling the cycle time and probability of events can give therapists the ability to dynamically control paranoia evoking stimuli in the virtual environment as the results show that it can increase the number of paranoid comments and self-reported anxiety.

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