The Design and Implementation of a Virtual Reality Exposure Therapy System for Patients Suffering from Paranoia

I always know what he is thinking
This time he won’t get away!
I can see him
If he knows it, he would not be that calm

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Author: Reza Giga Isnanda, 4038592, gigaisnanda@yahoo.com

Committee: Prof. Dr. Mark Neerincx, Dr. ir. Willem-Paul Brinkman, Dr. Wim Veling

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Abstract:

Paranoia is described as state of mind where the subject has an unfounded belief that other people will, intentionally, cause him a harm. Being suspicious is not a bad thing. In certain circumstances, being suspicious is often encouraged because it is really helpful in maintaining safety. However, when this suspicious is exaggerated or unfounded, it becomes unhealthy. In the worst case scenario, people may start avoiding social contact and spend more time worrying about their unfounded fear. This is the case of paranoia that needs to be treated.

Various methods have been proposed to treat paranoia. This research focused on designing and implementing a Virtual Reality Exposure Therapy (VRET) system to treat paranoia where the patients were exposed to various stressors in a simulated virtual environment. Throughout the design and development process of the application, this research followed a Situated Cognitive Engineering (sCE) approach by collaboratively working with the therapists on finding out how VRET system could be extended to treat patients suffering from paranoia. By the end of the research, a prototype of the application was developed.

The prototype accommodated prolonged exposure approach where patients are exposed to certain level of stressors for a prolonged time. The stressors are exposed as random paranoid thought provoking events that were triggered based on its probability and its rate of timer. Throughout the exposure, the patients main task is to reduce their anxiety level and not to avoid the situation, while the therapist aims to control the patients’ anxiety level within certain bandwidth by changing the probability and the rate of the random events.

Throughout the research, two experiment were conducted. The first experiment aimed to examine if priming can induce paranoid thought in non-clinical population. The result suggested that priming can indeed increase paranoid thought comments in the non-clinical group that would less often exhibit paranoid thought. The second experiment aimed to examine if controlling the rate of the random event and its probability can evoke and control the paranoid thought. The result suggested that probability had significant main effect in evoking and controlling paranoid thought and there was interaction effect between the rate and the probability of the random events.

Keyword: Paranoia, prolonged exposure, virtual reality exposure therapy, mental health computing
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1 Introduction

Liz, a 24-year-old musician from Bristol: I once thought a housemate was trying to steal my possessions as I often caught her standing in the corridor near my room and nowhere near her own room. I got really wound up about this and ended up locking some of my valuables in the garden shed. After this I began to have other thoughts - like she was trying to poison me because she was always asking me to eat food that she had made and giving me new foreign alcohol to try. (Freeman, Freeman, & Garety, 2006, p. 14)

The story from Liz above is an example of paranoia. Paranoia is described as state of mind where the subject has an unfounded belief that other people will, intentionally, cause him a harm (Freeman & Freeman, 2008). It has been shown in several studies that paranoia can also occur in general population where people have no history on mental illness (Freeman et al., 2008; Green et al., 2011). Being suspicious is not a bad thing. In certain circumstances, being suspicious is often encouraged because it is really helpful in maintaining safety. However, when this suspicion is exaggerated or unfounded, it becomes unhealthy. In the worst case scenario, people may start avoiding social contact and spend more time worrying about their unfounded fear. This is the case of paranoia that needs to be treated.

To treat patients suffering from paranoia, several methods have been proposed. It ranges from antipsychotic medications to psychosocial treatments. One of the proposed methods is exposure therapy where the patients are exposed to feared objects or environments (which are called stressors) to overcome their fear. There are various forms of exposure therapy, one of which uses a VRET (Virtual Reality Exposure Therapy) system.

A VRET system is a system which uses Virtual Reality (VR) to treat the patient by exposing them with stressors in a simulated virtual environment. VRET system uses the capabilities of VR to trigger responses similar to the responses in a real world. Several studies had been conducted to develop VRET system to treat various anxiety disorders (Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008). This study focuses on developing a VRET application to treat people with paranoia. This thesis will explain the steps taken to design and develop the application.

This chapter starts from explaining the research question and several associated sub-questions which were attempted to be answered throughout the research process. Afterwards, the various steps taken throughout the research is explained in detail.

1.1 Research Question

The main research question of this study is: Is it possible and what is required, to extent VRET system for treating patients suffering from paranoia?

In the VRET system, the patients are situated in a simulated social situation, in which, they are exposed to stressors. To treat patients suffering from paranoia with VRET system, there are various possible social situations that can be simulated and various approaches to
expose the stressors to the patients. The main concern is how the VRET system should be developed so that it can be used in clinical practice by a therapist.

During the process of exploring this question, several sub-questions emerged. The first sub-question is: **What kinds of stressors are effective in evoking paranoid thought in patients?** As there are various stressors that can be used to evoke paranoid thought in patients, this sub-question concerns which stressors are effective in evoking paranoid thought in patients in a clinical practice. This sub-question also concerns which stressors are appropriate for exposure therapy and which are inappropriate.

The second sub-question is: **Is it possible to induce paranoid thought in a non-clinical population when they are exposed by the stressors in the virtual environment?** During the research process, it was difficult to ask patients to participate for the testing phase to examine the potential effects of the application first. As a result, participants from non-clinical population were considered. However, non-clinical participants might behave differently from clinical participants. Therefore, it might be difficult to ensure that they would experience paranoid thought when exposed in the virtual environment. This sub-question concerns how to induce paranoid thought in a non-clinical population so that they are more likely to experience paranoid thought when they are exposed to stressors in a virtual environment.

The third sub-question is: **How should the therapist control the stressors?** Basically, the therapist has two tasks during the exposure: monitoring the patients and controlling the virtual environment. Because the main task of the therapist is to treat the patients, thus, monitoring the patients should be his main focus. Therefore, controlling the virtual environment should not distract him. As a consequence, it was necessary to provide the therapist with a stressor controller that could help him control the virtual environment without distracting him from monitoring the patients.

### 1.2 Research Approach

Throughout the design and development process of the application, this research followed a Situated Cognitive Engineering (sCE) approach (Brinkman & Neerincx, 2012). sCE is an iterative process with active involvement of users. During the entire design phase, the requirement baseline was refined based on new insight from expert’s review and prototype evaluation. sCE had been used in various domain (Diggelen, Janssen, Mioch, & Neerincx, 2011; Greef, Oomes, & Neerincx, 2009; Neerincx, 2010). In addition, it had also been used in mental health domain (Brinkman & Neerincx, 2012).

Figure 1.1 shows the model of sCE. sCE consists of 4 phases:

1. Derive phase
   
   This phase focuses on understanding the problem, the current situation, the existing knowledge, and the existing solution that will help in designing the application. The output of this phase is the preliminary vision.
2. Specify phase
   This phase focuses on extending the preliminary vision into the requirement baseline of the application by identifying the core function, formulating claims, and creating Use Cases.

3. Test phase
   This phase focuses on testing the requirement baseline by reviewing it with the users, developing the prototype, or simulating the prototype in experiment.

4. Refine phase
   This phase focuses on refining the requirement baseline based on the result of the review, experiment, or simulation.

![Diagram: Situated Cognitive Engineering (sCE) approach]

In this research, the first step was the Derive phase where literature study and discussion with the therapist was conducted. The purpose of the literature study and discussion was to explore the Operational Demands, Human Factors and Values, and The Envisioned Technology for designing and developing the application. In the end of this phase, the preliminary requirements and its rationale were formulated. The detail of this phase can be found in chapter 2.

Before moving to the Specify phase, there was concern on how to conduct the prototype testing without asking patients to participate since the potential effects of the prototype to the users needed to be established first. As a consequence, non-clinical participants were considered as participants. However, there was no guarantee that non-clinical participants would experience paranoid thought when exposed with paranoid evoking stressors. To solve the problem, a method using text and video priming to induce temporary paranoid thought in non-clinical participants was proposed and an experiment to investigate it was conducted. The result of the experiment suggested that prior priming with the purpose to raise the participants’ sense of insecurity could indeed increase the number of paranoid...
thought experience in non-clinical participants. The detail of the experiment can be found in chapter 3.

In the Specify phase, the preliminary requirement was extended by identifying the core function and formulating the associated claims. Afterwards, the core functions and its claims were reviewed together with the therapists by using a storyboard to explain the scenario. Then, the results of the discussion were used to refine the preliminary requirement. Throughout this research process, two discussion sessions with the therapists were conducted, with two different treatment approaches were proposed: the gradual exposure approach and the prolonged exposure approach. In the end, the prolonged exposure approach was chosen as the treatment approach implemented in the application.

In this approach, the patients are exposed with stressors in a social situation and the therapist needs to monitor the patients’ condition and avoid situation where their anxiety level is too high or too low by controlling the stressors. The stressors are exposed as random paranoid thought provoking events that are triggered according to timers. To control it, the therapist could change the rate of the random events or change the probability of the events. The main goal of this approach is to teach the patients to always remain calm in any given stressors level. The detail of this phase can be found in chapter 4.

After refining the preliminary requirement, the prototype of the application was designed and developed. The design process included the formulation of the preliminary vision, the selection of stressors, the construction of the system architecture, the design of the virtual environment, and the design of the therapist user interface. The detail of the design and development process can be found in chapter 5.

When the development of the prototype finished, the next step was to investigate the ability of the prototype to elicit paranoid thought in the users by changing the rate of the random events and the probability of the events. The result of the experiment showed that people experience more paranoid thought when they were exposed in condition with higher probability of events. In addition, there was interaction effect between the rate and the probability of the random events. The detail of the experiment can be found in chapter 6.

The conclusion of this research along with the research limitations and the suggestion for future work can be found in chapter 7.
2 Domain Analysis

This chapter focuses on describing the derive phase of the sCE approach. The main goal of this phase was to understand the problem, the current situation, the existing knowledge, and the existing solution that would help in designing the application. In this phase, literature study and discussion session with therapists were conducted. By the end of this phase, a preliminary requirement was formulated and was used in the Specify phase.

This chapter starts with the background theory of schizophrenia and paranoia. Then, the focus shifts to a discussion on the expected Operational Demands, the Human Factors and Values, and the Envisioned Technology of the application. The chapter is concluded by explaining the preliminary requirement of the application.

2.1 Schizophrenia and Paranoia

Schizophrenia

Schizophrenia, as defined in DSM-IV-TR (American Psychiatric, 2000, p. 298), is “a disorder that lasts for at least 6 months during which there is at least 1 month of two or more active-phase symptoms such as: delusions, hallucinations, disorganized speech, grossly disorganized or catatonic behavior, negative symptoms”.

A common characteristic for people suffering from schizophrenia is the psychotic symptom in which they start hearing or seeing things that actually do not exist in reality (e.g. seeing people who already dead, hearing the voice of God). Popular movies such as “Beautiful Mind” (Howard, 2001) and “Verloren Jaren” (Labruyère, 2010) depict very thoroughly the characteristic of people suffering from schizophrenia.

Schizophrenia affects about 0.7% of the world’s adult population between 15-35 years old based on the statistic from World Health Organization (Schizophrenia, n.d.). In other statistics, Trimbos Institute records that, in 2010, approximately 0.5% of the Netherlands population up to 65 years old suffering from the same illness (Graaf, Have, & Dorsselaer, 2010).

Schizophrenia can be divided further into various subtypes. One of its subtypes is paranoia, which is the main focus of this research. The reason to focus on paranoia is because few studies had been focused in treating paranoia using VR, especially using VRET system where the patients have to confront their fear.

Paranoia

Paranoia is described as state of mind where the subjects have an unfounded belief that other people will, intentionally, cause them harm (Freeman, 2007; Freeman & Freeman, 2008; Freeman & Garety, 2000). This state is characterized by hyper vigilance, emotional arousal and selective attention for threat. The main difference between paranoia and schizophrenia is the lack of delusion and hallucination in paranoia. Paranoia exists as a continuum of severity ranging from slight general level to severe clinical level (Os &
Verdoux, 2002; Jim van Os, Hanssen, Bijl, & Ravelli, 2000; J. van Os, Linscott, Myin-Germeys, Delespaul, & Krabbendam, 2009). In other word, individuals from the general population who have no history of mental illness can experience paranoid thought, and several studies had demonstrated it (Freeman et al., 2005; Freeman et al., 2008; Green et al., 2011). However, the severity of paranoid thought in individuals from the general population is still small because they generally tend to ignore it. On the contrary, the clinical patients tend to overthink this thought and have too much faith in it without confirming its validity. In psychotic disorder, paranoia can be delusional.

Freeman et al. (Freeman et al., 2006) stated that the offender in paranoia case can take form of anything. It can be someone or something that physically exists (family, neighbours, government, etc.), it can be someone or something that does not physically exist: (alien, ghost, monster, etc.), and, in some cases, it can be something that the patients themselves are unsure of. For the last case, the patients only sense the threat without knowing the identity of the offender. In addition, Freeman et al. (Freeman et al., 2006) also stated that the harm the patients feel can take any kind of form. Some examples are physical harm (injury, wound, being killed, etc.), financial harm (someone will steal or break my property), social harm (being excluded or ridiculed), and psychological harm (being threatened or being annoyed).

Figure 2.1 shows the outline on how paranoia is developed (Freeman et al., 2006). At the beginning, subjects suffering from stress and major life changes. These events lead to changes in their emotion, some of them tend to be more anxious, worried, or depressed. When this happens, they may start noticing some internal or external events, and they will naturally try to understand it. However, by being negatively emotional, they tend to understand the event negatively. This is strengthened by impairment in reasoning by which they start blaming others or jump into conclusion too fast. In the end, the combination of these 5 factors may result in paranoia.

![Figure 2.1 Outline on how paranoia is developed (Freeman et al., 2006)](image)

Paranoia can also be developed from overexposure of a danger. Freeman et al. (Freeman & Freeman, 2008) stated that repeatedly watching or reading news about dangerous news...
that are overexposed may increase anxiety, which in turn, can change into paranoia. An example of this is the Sea Empress incident, 2001 Anthrax incident, and other incidents which are described in chapter 3 of Freeman’s book (Freeman & Freeman, 2008).

Paranoia usually occurs when there is a misinterpretation in the process of understanding an event. Freeman et al. (Freeman et al., 2006) explained that the events which can trigger paranoid thought are divided into two main types: external triggers and internal triggers. External triggers are the situations, events, and experiences that people encounter in the world. These triggers include (Freeman et al., 2006):

1. **Social situation.**
   People tend to have paranoid thought when they are being “forced” to perform in social situation or being “forced” to fit in with other people (e.g. party event or meeting event).

2. **Situation from which it is difficult to escape.**
   People might have paranoid thought when they cannot escape from the situation easily (e.g. sitting in a bus or standing in a crowded elevator).

3. **Situation in which we feel exposed.**
   Paranoid thought might appear when people feel that all attentions are focused on them.

4. **Situation in which we might be blamed or accused.**
   Doing something wrong, or just feeling as though we had done it, is frequently a trigger for paranoid thought.

5. **Situation in which we are in minority/alone.**
   People tend to have paranoid thought when they are in a minority or when they are (feel) alone. Living in a place with apparent cultural differences is an example of this trigger.

6. **Coincidences or unusual events.**
   Some people might have paranoid thought because they misinterpret a coincidental or unusual event.

Internal triggers are the way the people feel inside. When people are feeling one of the following trigger, paranoid thoughts might occur (Freeman et al., 2006):

1. **Emotions**
   Paranoid thought might occur when people become emotional. These emotions include anxiety, low-mood, anger, and elation.

2. **Arousal**
   Arousal in this case means the state where people feel of being especially alert and sensitive. Paranoid thought might occur because they might notice something that they do not notice before and then misinterpret it.

3. **Anomalous experience**
   Anomalous experience is the change in the way people perceive the world around them. When anomalous experience occurs, people might try to make sense of the event. When they misinterpret this, Paranoid thought might occur.
Being suspicious is not a bad thing (Freeman et al., 2006). Some circumstances encourage people to be suspicious toward other people in order to maintain safety. For example, a security guard who always suspects anybody who acts strangely in front of him or a former victim of robbery who starts avoiding going out at night to prevent him from becoming a victim again. Those two examples show the proper example of being suspicious toward other people, because both of them have valid reason why they choose to act like that. However, when people start to suspect other person without valid reason, their suspicion becomes unhealthy. For patients suffering from paranoia, they start worrying about their unfounded fear and they become attached to it that they cannot get rid of it. In the worst case, people might start avoiding social contact because they cannot trust anybody.

**Treatment**

Treatment for people suffering from paranoia can be divided into two parts: pharmacological treatment and psychosocial treatment. Pharmacological treatment uses antipsychotic medications to treat the patient and has been primary treatment since 1950s (NCCMH, 2010).

On the other hand, psychosocial treatment focuses on structured counseling between the patient and the therapist rather than medications. Psychosocial treatment in treating paranoia emerges in various forms. Among those is Cognitive Behavioral Therapy (CBT). CBT is a systematic, goal-oriented procedure treatment method that focuses on understanding and examining the source of the patient’s negative thinking and then tries to change it into positive thinking by challenging the way they think and the way they react. In CBT, the therapy primarily uses Socratic questioning where the therapist does not provide the answer to the patient’s negative thought but helps and guides the patient to discover the answer himself (Morrison, 2004). Several studies have shown that CBT improves the positive and negative symptoms (Rector & Beck, 2001; Tarrier et al., 1998) and has long-term durability (Sensky T & et al., 2000; Turkington et al., 2008).

The overall process and structure of therapy using the CBT to treat paranoia consists of several steps (Morrison, 2004):

1. **Engagement**
   The first step of the therapy focuses on engaging the patients to agree to adhere to the therapy. In this step, the therapist needs to ensure the patients that they can trust and depend on the therapist to help them achieve their goals. Without established engagement, the next step cannot be continued.

2. **Socialization and normalization**
   This step focuses on socializing the patients to the cognitive model and normalizing the patients’ experiences. Introducing the patients to the cognitive model has the benefit of giving the patients the consideration to have alternative explanations for their paranoia.

3. **Formulation**
   This step focuses on formulate the patients’ experiences, which consists of establishing the early hypothesis of the development and maintenance of patients’ present condition. Although formulation primarily benefits the therapist in
selecting appropriate treatment strategies and techniques, it also benefits the patients in recognizing alternative explanation for the development and maintenance of their problems.

4. Problem list generation
   This step focuses on generating the list of the patients’ problem. First, the problem areas in general are identified, followed by narrowing it down to specific problems in those areas. Afterwards, the priority list of the generated problem list is created. The priority list should start from the problem which gives the most advantageous effect when it is resolved.

5. Identification of goals
   This step focuses on identifying the goals of the treatment. The goals need to be specific, measurable, achievable, realistic, and time limited. First, the general goals are established followed by breaking it into smaller specific goals. This includes the identification of the short, medium, and long-term goal.

6. Intervention
   This is the step where the active therapy is conducted. Therapist needs to select the appropriate interventions based on the formulation, problem list, and the goals. The effectiveness of the intervention needs to be evaluated regularly and changes need to be made when the evaluation finds that the interventions are ineffective.

7. The end of active therapy
   The end of the active therapy is occurred when the therapist is assured that the patients are able to achieve the goals by themselves or when it has been decided to stop the therapy before achieving the goals. When the latter occurs, both the therapist and the patients need to identify the problem that hinders the progress while reflecting on the progress made by the patients throughout the active therapy.

8. Relapse work
   This step focuses on preventing relapse when the patients try to achieve the goals by themselves. The patients’ vulnerabilities need to be identified and their progress needs to be monitored.

9. Progress evaluation
   This step focuses on the evaluation of the whole therapy, including the effectiveness of the strategies, techniques, and relapse plan employed throughout the therapy.

In order to understand the patients’ problem and resolve it, the therapist needs to elicit and evaluate the negative automatic thoughts (NATs) of the patients throughout the therapy (Morrison, 2004). One of the techniques used to elicit the NATs is exposure therapy.

The idea of exposure therapy is to expose the patients to the feared objects or environments, which are called stressors, while maintaining the safety of the exposure process itself in order to overcome the fear. This technique is useful for the patients that cannot access or remember the NATs during therapy session despite reporting high occurrence of it outside of therapy session (Morrison, 2004). When the patients are
exposed to the stressors, they can access and remember the thought process that is responsible for their paranoid thought. In addition, their behavioral responses can also be accessed and remembered. Uncovering and understanding their thought process and behavioral responses are vital for the therapist to truly understand their problem and to select the appropriate interventions for treatment. By slowly and gradually exposing them with their fear, coupled it with counseling session with the therapist, the patients can understand the thought process that is responsible for the cause of their paranoid thought. Afterwards, they can start to understand that their paranoid thought is unfounded and, therefore, start overcoming the problem that will lead to fear extinction.

There are various forms of exposure therapy. One of them is the exposure in vivo. Here, the patients are exposed to their fear in an actual real life situation. The problem with in vivo exposure is that it is very difficult to arrange it if the therapist needs to assists the patients during exposure (e.g. setting up the scenario, arranging the actors, etc.), which sometimes can cost lots of time and money. In addition, it is very difficult for the therapist to control the stressors (e.g. creating a relax or hostile scenario).

Nowadays, with the fast development of Virtual Reality (VR), substituting exposure in vivo with exposure in VR is a possibility. This is because simulating a social situation in a VR has the ability to trigger responses similar to the responses in a real world where people treat the virtual characters and the environments as if they are real, eventhough people know that they are not. Fornells-Ambrojo et al. (Fornells-Ambrojo et al., 2008) had demonstrated that patients suffering from paranoia could have paranoid thought towards the virtual charcters in the VR, which is a result that encourages the use of VR for exposure therapy to treat paranoia.

Although there might be concern on the effectiveness of exposure in VR compared to exposure in vivo, several meta-analyses have shown that exposure in VR is as effective as exposure in vivo for anxiety disorders (Gregg & Tarrier, 2007; Parsons & Rizzo, 2008; Powers & Emmelkamp, 2008). In addition, the patient’s refusal rate for the in vivo exposure is higher than in VR exposure (Garcia-Palacios, Botella, Hoffman, & Fabregat, 2007). Furthermore, it had been demonstrated that briefly exposing patients and non-patients of paranoia in a neutral VR world results in no significant increase in anxiety level and simulator sickness, no adverse reactions, and no intrusive thought (Fornells-Ambrojo et al., 2008; Valmaggia et al., 2007). Moreover, the same studies also conducted a one week follow-up interview and reported that none of the patients and non-patients had intrusive thoughts or images, negative emotions associated with the exposure, or change in behaviour. In the end, in treating paranoia, it is possible to substitute exposure in vivo with exposure in VR without concerns on its feasibility and safety.

Several studies have been conducted to study or treat schizophrenia using VR with different main focus. For example, Ku et al. (Ku et al., 2003) and Park et al. (Park et al., 2009) focused on studying schizophrenia by assessing the patient’s cognitive ability using VR system. On the other hand, Banks et al. (Banks et al., 2004) and Tichon et al. (Tichon, Banks, & Yellowlees, 2003) focused on helping the therapist in understanding the patients’
psychotic symptoms. However, few studies have been focused on treating paranoia using exposure therapy in VR.

In addition to CBT, other forms of psychosocial treatment include family therapy and Cognitive Remediation Therapy (CRT). In family therapy, the family of the patients is actively involved in the therapy. The involvement includes psychoeducation about schizophrenia or paranoia, improvement on communicative skill, group sessions for family and patients, etc. On the other hand, CRT is a treatment method that focuses on neurocognitive remediation to overcome the cognitive deficits on patients that suffering from paranoia. The goal of the CRT is to improve the performance level of the specified cognitive functions. This can be done through cognitive drills or compensatory interventions.

2.2 Operational Demands

To fully understand the Operational Demands for the application, a literature review was conducted to gain more insight about the problem, the constraint, and the existing solution. In addition, a discussion session with a therapist was organized to understand the key requirements that are vital in designing an application that can help both the therapists and the patients for the treatment in the clinical practice.

Before the discussion was organized, literature review was conducted to gain more insight on paranoia and the stressors that can be used to induce paranoid thought on patients. In the previous section, several events that can trigger paranoid thought are introduced (Freeman et al., 2006). From these events, various possibilities of potential stressors for exposure therapy were derived. All the proposed potential stressors were put on a presentation slide and it can be found in appendix A. In the discussion, the proposed potential stressors were reviewed by the therapist to find out which stressors were actually applicable, effective, and appropriate to be included in exposure therapy.

The participants for the discussion consisted of two people from Delft University of Technology and one therapist from Parnassia Psychiatric Institute in The Hague who has experience in treating patient with psychosis and paranoia. The discussion focused on the basic concept of the exposure therapy, the potential stressors for the exposure therapy, the treatment constraint, and the demand from the therapist. In the end, the result of the discussion was used to formulate the preliminary requirement and to formulate the treatment strategy.

The result of the discussion included the potential stressors, basic concept of exposure, and treatment personalization. All of these are explained in detail in the following sub-section.

2.2.1 Potential Stressors

From the discussion, some stressors were considered to be appropriate and applicable for exposure therapy in VR, and some were not. Stressors such as flashing light, negative voice, and visual/sound distortion were not appropriate because these stressors were associated to delusion or hallucination. The therapist wanted to avoid both delusion and hallucination because these symptoms are not a common paranoia symptoms. During the discussion, the
therapist also suggested few numbers of stressors such as people passing by, snatches of conversation, and color.

In the end, the potential stressors for the application which were deemed appropriate, applicable, and helpful for exposure therapy were:

1. Pre-narrative Text.
2. Information About Danger.
3. Laughing.
5. Eye Gaze.
6. Coincidental Event or Unexpected Event.
7. Appearances and Facial Expression.
9. Darkness / Lighting.
11. Color (whether a specific color is dominant in the virtual environment).
13. Ambiguous messages in media such as music or TV.

2.2.2 Basic Concept of Exposure
For the therapist, the goal of the application should focus on treating the patients rather than purely making them afraid. Therefore the application should help them in the process of overcoming their paranoia.

The therapist suggested that the application should implement a daily life situation into the exposure because the patients can learn how to appropriately behave in a non-paranoid behavior when dealing with the simulated situation in the VR world. If they could do that, they might transfer what they learn to the real life.

One treatment strategy was also explored during the discussion. The main idea was to incorporate game element into the exposure in which the patients were situated in a social situation and they were forced to make decision based on the situation they encountered. This approach will be explained in detail in chapter 4.

2.2.3 Treatment Personalization
During the discussion with the therapist, it became apparent that every patient might have different paranoid thought trigger. For example, one patient might be afraid of eye gaze while the other does not actually think it is frightening. Therefore, the application should allow the therapist to personalize the treatment scenario so that it can suit the patients’ problem.

2.3 Human Factors and Values
In the derive phase, identifying and studying the Human Factors and Values is important in creating the preliminary requirement and vision. The important Human Factors and Values
in this research included the patient’s cognitive deficit, the potential risk of VR, the high level goals of the treatment, and the therapist’s cognitive task load.

2.3.1 Patient’s Cognitive Deficit
One of the characteristics of people suffering from paranoia is cognitive deficit with varying degree in across multiple domains (Heinrichs & Zakzanis, 1998; Mohamed S, 1999). These deficits include the deficit in attention, memory, and working memory (Goldberg & Gold, 2002). Because of this, it is important for the application to avoid giving the patients complex procedures to follow during the exposure.

2.3.2 VR Potential Risk
Although using VR to study or treat paranoia has several advantages, it might also have several potential risks. One of it is the simulator sickness, which usually occurs when people is immersed in virtual environment.

Simulator sickness is a condition which has symptoms that similar to motion sickness (e.g. nausea, dizziness, vertigo), but less severe, has lower rate of occurrence, and can happen without the subject actually moving (Kennedy, Lane, Berbaum, & Lilienthal, 1993). One of many explanations for simulator sickness is sensory conflict theory where there is conflict between the information acquired by the visual system with the information acquired by the vestibular system (Reason, 1978). When the patients suffering from significant levels of simulator sickness, they might reluctant to use the VR in the future to avoid suffering the same sickness again. When this occurs, it can hinder their progress to achieve their goal.

In addition to simulator sickness, there is also potential risk in VR that the patients will start having intrusive thought or seeing intrusive images after the exposure. This intrusive thought or images might lead the patient to have negative emotions associated with the exposure or to change their behaviour. If this occurs, using VR would only worsen the patient condition.

Although there are several potential risks in using VR, several studies had demonstrated that briefly exposing patients suffering from paranoia in a neutral VR world did not increase the simulator sickness level nor the anxiety level significantly (Fornells-Ambrojo et al., 2008; Valmaggia et al., 2007). In addition, the one week follow-up study also showed that no patient reported intrusive thought or image, negative emotions, and a change in their behaviour as a result of the exposure.

However, it needs to be noted that both studies only exposed the participants for four minutes, which might not be enough for therapy. Therefore, the application should ensure that there is no significant increase in simulator sickness level during exposure and no significant negative side effects following the exposure. In addition, the therapist can follow Bouchard et al. (Bouchard, Robillard, Renaud, & Bernier, 2011) recommendation on reducing the unwanted side effects during VR therapy session that includes educating and preparing the patient about the possibility of side effects, pausing session every 20-30 minutes, and stopping the session when the patient experience severe sickness symptoms.
2.3.3 High-Level Goals of the Treatment

Schuemie (Schuemie, 2003) constructed the high-level goals of the treatment for the therapist and the patients. Figure 2.2 shows the goals of the therapist. The main goal of a therapist is to cure the patient from his fear. To accomplish it, three sub-tasks are created. In the first sub-task, the therapist needs to determine the fear level of the patients. This is important to understand whether the scenario or the stressors during the session is suitable. The therapist wants to avoid the condition in which their fear level during the session is too low or too high. To understand the fear level, the therapist can directly ask them about their Subjective Unit of Discomfort (SUD) score (Wolpe, 1968). SUD score is a scale between zero and ten that tells the personal level of discomfort. Using this score, the patients can give direct feedbacks to the therapist regarding to their experiences during the session.

![Figure 2.2 Therapist’s high level goal (Brinkman, Mast, Sandino, Gunawan, & Emmelkamp, 2010)](image)

The second sub-task of the therapist is to control the exposure. After determining the fear level of the patient, the therapist can control the exposure when necessary by directly instructing the patient or by adjusting the scenario and/or parameters that will change the virtual environment.

The last sub-task of the therapist is to solve ambiguity. During the session, there might be some cases where the patients do not fully understand the treatment procedure. It is the therapist’s job to answer their questions and clear their doubt to avoid any ambiguity. By solving ambiguity, although it is not directly related to the main goal, they can perform better during the session.

Figure 2.3 shows the goals of the patients. By taking the exposure therapy, the patients want to get rid of their fear. The patient believes that they can achieve this by following the instruction of the therapist. However, because of their fear, they tend to avoid fearful situation. This tendency tends to conflict with the therapist’s instruction. In some cases, they might not fully understand the treatment procedure. In that case, they need to ask the therapist to solve their ambiguity in order to perform better during the session.

2.3.4 Therapist’s Cognitive Task Load

To understand the workload of the therapist, the cognitive task load model of Neerincx can be used (Neerincx & Besouw, 2001). Cognitive Task Load is described as the function of three load factors: the percentage time occupied, the level of information processing and the number of task-set switches. Percentage time occupied is the amount of time, in
percentage of total available time, that a person occupied with a task. The level of
information processing (LIP) is the complexity level of a task. LIP assesses the amount of
information processing needed by a person to make a decision. The number of task-set
switches indicates the amount of switching between tasks that a person needs to do. Some
complex tasks consist of several different tasks with different goals. The more switches
between different tasks, the bigger the amount of the load factor.

![Diagram](image.png)

Figure 2.3 Patient’s high level goal (Brinkman et al., 2010)

During the exposure therapy, the therapist’s main task is to monitor the patient while
controlling the stressors in the virtual environment. As the therapist’s main goal in the
treatment process is to cure the patient, monitoring the patient becomes the highest
priority task for him because it will help him to understand the patient and his problem in
order to come up with a solution. However, difficulty in controlling the stressors has the
potential of increasing the amount of LIP and task-set switches. The worst scenario occurs
when the therapist puts too much focus on controlling the virtual environment and forgets
his main task.

To overcome the potential problem, as suggested by Brinkman et al. (Brinkman, Sandino, &
Mast, 2009), the interaction between the application and therapist should be minimized
and the effort for the therapist to fully understand the application and how to run it should
also be minimized.

## 2.4 Envisioned Technology

In the past, several studies had been done to understand and treat schizophrenia or
paranoia. Some of these studies included the development of technology as a solution for
the problem. In this sub-section, several existing technologies which related to the using of
VR for studying or treating schizophrenia or paranoia are discussed.

### 2.4.1 VR for Exposure Therapy

Virtual Reality Exposure Therapy (VRET) system is a system that uses VR for exposure
therapy. In this system, the patient is situated in a virtual environment which simulates a
scenario that represents the conditions in real world of which the patient is afraid. In the
virtual environment, the patient will be exposed to stressors that can evoke anxiety. During
this process, the therapist is responsible for monitoring the patient’s behaviors and
responses while also controlling the virtual environment. By the end of the session, the
therapist and patient can discuss the result of the exposure alongside with the patient’s
progress.
VRET has been used in several studies such as arachnophobia (Bouchard, Cote, St-Jacques, Robillard, & Renaud, 2006), acrophobia (Krijn et al., 2004), fear of flying (Krijn et al., 2007; Rothbaum et al., 2006) and social phobia (Brinkman et al., 2012; Klinger et al., 2005). These past results open the possibility to expand VRET system capabilities to treat patients suffering from paranoia.

2.4.2 VR for Cognitive Ability Assessment
The development of VR allows people to treat the avatars and the environment in VR as if they are real. Because of this, it is possible to use VR as an ideal tool to study human behavior (Tarr & Warren, 2002). One potential of it is to use VR for cognitive ability assessment. Compared to conventional assessment method, VR provides realistic and convincing environment in which the patient is able to engage social interaction with the environment. The patients’ performance in the VR can later be used by the therapist as basis of assessment (Kim & Kim, 2010). In addition, conventional assessment method is vulnerable from subjectivity, either from the therapist or from the patients (Kim & Kim, 2010; Park et al., 2009). Several studies have focused on developing VR for cognitive ability assessment.

Ku et al. (Ku et al., 2003) focused on developing VR system to assess the cognitive and navigation ability of people suffering from schizophrenia. The VR system could provide the patient with multimodal visual and auditory stimulus and could evaluate the patients’ performance by making them interpret the given stimulus and react according to it while also remembering it for a given period time. The result of the study shows that the system is comparable to the Wisconsin Card Sorting Test (WCST) and the Standard Progressive Matrices (SPM).

Park et al. (Park et al., 2009) focused on developing a VR system, called Virtual Reality Functional Skills Assessment (VRFSA) to assess the functional skill of the patient. VRFSA assessed the patient’s performance automatically and is based on analogue scale. In VRFSA, the patients’ receptive skills and expressive skills are assessed using six VR scenarios in which he had a conversation with the avatar. The functional skill assessed in VRFSA is consisted of four parameters: Initiation (latency time after avatar speaking), Duration (percentage of time spent to watch the avatar), proxemics (average distance from the avatar), and eye contact (the average angle of head orientation from the avatar’s eyes). The result of the study suggests that VRFSA is sensitive in detecting subtle changes of functional skills, especially in short-term clinical trials without raters’ biases and therefore is well-suited for short term clinical trials.

2.4.3 VR for Helping to Understand Psychotic Symptom
One trait of schizophrenia is psychotic symptom in which the patients start hearing or seeing something which does not actually exist in reality. During therapy sessions, the patients have to explain their hallucination experience to the therapist. However, it is difficult for the therapist to actually share the experience in order to make evaluation objectively. As a consequence, patients often feel that the therapist does not really understand them. On the other hand, the therapist has difficulty in understanding the nature of the patients’ psychotic symptoms.
To overcome this problem, several studies have been conducted to develop VR to help the therapist in understanding the nature of the patient’s psychotic symptom by experiencing it first hand in the VR (Banks et al., 2004; Tichon et al., 2003). The goal of the study was to create a VR system in which the patients can use it collaboratively with the therapist to recreate their experience in order to give the therapist the idea of their psychotic symptoms and allow enhancement in monitoring.

In other study, Leff et al. (Leff, Williams, Huckvale, Arbuthnot, & Leff, 2013) developed a system where the patients with auditory hallucinations can create a virtual character that represent their persecutor. Afterwards, the therapist encourage the patients to confront the virtual character and learn how to take control their hallucinations. Result of their pilot study reported that almost all of the patients reported a reduction in the severity and the frequency of the hallucinations.

2.5 Preliminary Requirement

From the Operational Demand, the Human Factors and Values, and the Envisioned Technology, preliminary requirement of the application can be made. The list of the requirement and its rationale can be seen in Table 2.1.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Rationale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implement a daily life situation into treatment</td>
<td>Simulating social situation which represents a real daily life situation can help patients’ learning process. By learning how to appropriately behave in a simulated social situation, the patients can transfer what they learn into the real social situation.</td>
</tr>
<tr>
<td>Provide treatment personalization</td>
<td>Every patient has different paranoid thought trigger. Therefore, the treatment scenario for each patient should be different. As a consequence, the application needs to allow the therapist to create a treatment scenario for each patient.</td>
</tr>
<tr>
<td>Avoid complex treatment procedures</td>
<td>Cognitive deficit is one of characteristics of schizophrenia. As a consequence, it is important for the application to avoid giving the patient complex procedures to follow during the exposure.</td>
</tr>
<tr>
<td>Avoid significance increase in simulator sickness level and avoid post-exposure negative side effects</td>
<td>VR might cause simulator sickness to the patient. In addition, negative side effects might occur after the exposure. Therefore, the application should not increase the level of simulator sickness significantly and should not cause negative side effects to the patients after the exposure.</td>
</tr>
<tr>
<td>Ensure that controlling the exposure will not distract the therapist</td>
<td>Monitoring the patient should be the therapist highest priority task during the therapy. However, difficulty in controlling the stressor can distract him from his main task. Therefore, the interaction between the application and the therapist should be minimized and his effort to fully understand the application and how to run it should also be minimized.</td>
</tr>
</tbody>
</table>
3 First Experiment: Inducing Paranoid Thought in Non-Clinical Population

This chapter focuses on describing the first experiment which was a necessary step before starting to develop the end solution. The experiment was done for 2 main reasons: to investigate if prior priming could induce paranoid thought in non-clinical participants, and if participants could indeed experience paranoid thought in the created virtual environment despite prior priming. The result determined how the testing phase of the application would be conducted with non-clinical participants.

This chapter starts with the explanation of the background and the purpose of the experiment. Then, the experiment method is elaborated, including the participants, the measure, the setup, and the procedure. Afterwards, the result is presented and discussed. Finally, this chapter is concluded by discussing the conclusion from the result.

3.1 Introduction

During the discussion with the therapists, there was concern on the difficulty to ask actual patient to participate in the testing phase since the potential effects of the application itself were unclear. As a consequence, samples from non-clinical population would be asked to participate instead. Several studies already reported about people in the general population experiencing paranoid thought; still, there was concern because it was unclear whether they can indeed experience paranoid thought when they are exposed in virtual environment.

Results from a couple of study showed that samples from non-clinical population also experienced paranoid thought in virtual environment. First, Freeman et al. (Freeman et al., 2008) reported that over 40 percent of their 200 members of the general population experienced paranoid thought toward the virtual characters even though the characters were programmed to behave neutral. Second, Brinkman et al. (Brinkman, Veling, et al., 2011) reported that people without psychosis experienced more fluctuation on physiological responses and higher level of distress when the population density and the proportion of virtual characters with other ethnicity in the virtual environment were increased. Both results encouraged the possibility to have non-clinical participants to participate in the testing phase.

However, as easy as it could to get non-clinical participants, it was difficult to ensure that they would have paranoid thought when immersed in the virtual environment. Furthermore, results from Freeman et al. suggested the need for relative large samples which were impractical. Therefore, a method to induce temporary paranoid thought to non-clinical participants during exposure was essential. One idea to solve this problem was using priming prior to exposure.

The effectiveness of priming prior to exposure in virtual environment had already been demonstrated by Bouchard et al. (Bouchard, St-Jacques, Robillard, & Renaud, 2008). Their
study reported that informing individuals, with a snake phobia, about the existence of dangerous snakes in the virtual environment could increase their anxiety in the virtual environment later on. In addition, Qu et al. (Qu, Brinkman, Wiggers, & Heynderickx, 2013) also showed that text and video priming could increase the chance that individuals would mention a specific keyword in a discussion with virtual characters.

The result of both studies encouraged the idea to investigate whether it was also possible to induce temporary paranoid thought in non-clinical participants using priming prior to exposure. Therefore, an experiment to investigate it was conducted. In addition, the experiment also investigated whether the created virtual environment could actually elicit paranoid thought from the participants despite the prior priming. It needs to be noted that the experiment did not focus on how long the effect of the priming last. The video and text priming used in the experiment were aimed to raise feelings of threat and increase the level of vigilance, so that the participants could carry-over these feelings into exposure, and influenced the way they perceived the virtual characters and the virtual environment.

Three hypotheses were formulated before the experiment was conducted:

H1: Individuals who hardly exhibit paranoid thought would exhibit more when primed.
H2: Giving paranoid priming prior to exposure would make the participants experienced more paranoid thought compared to giving neutral priming prior to exposure.
H3: The participants with higher base paranoid level would experience more paranoid thought in the virtual environment compared to the participants with lower base paranoid level.

3.2 Method

3.2.1 Design

Figure 3.1 shows the conceptual model for the experiment. The experiment was based on a mixed two by two within-between-subject design. Each participant was immersed in all experimental conditions and the order was counterbalanced. Furthermore, double-blind procedure was implemented in the experiment where both the participants and the experimenter did not know the order of the experimental condition. The experiment was approved by TU Delft Ethics committee.

![Figure 3.1 The conceptual model for the first experiment](image)
The within-subject factor was the type of prior priming which consisted of two levels: paranoid priming and neutral priming. The paranoid priming was the priming with the intention to manipulate the participants to have paranoid thought. On the other hand, the neutral priming was the priming with no intention to manipulate the participants to a specific thought. Further explanation on priming can be found in the priming section.

The between-subject factor was the participants’ base paranoid level, which was based on the result of the participant Green et al. Paranoid Thoughts Scale (GPTS) Total score (Green et al., 2007), and consisted of two groups, high base paranoid level group and low base paranoid level group. It was included to examine whether individual with different base paranoid level would respond differently to priming. The idea was based on the result from Fett et al. (Fett et al., 2012) study where individuals with heightened risk of psychotic and individuals from healthy control group responded differently in a trusting game. The assignment of the participants into which group was based solely on the median value of the GPTS Total score. In the end, two equal groups were created.

The participants were immersed in two virtual environments. The first one was a restaurant environment and the other was a train station environment (Brinkman et al., 2012). All the virtual characters in both virtual environments did not have specific tasks, did not show specific emotions, and did not initiate any conversation or physical interactions with the participants. However, several virtual characters were programmed to look at the participants or walking around the virtual environment occasionally.

3.2.2 Measures

The experiment used several questionnaires which were grouped into two sets: the pre-experiment questionnaire set and the experiment questionnaire set. The pre-experiment questionnaire set was given to the participants during the recruitment process, while the experiment questionnaire set was given to the participant during the lab experiment. These questionnaires were used to understand individual’s characteristics and to measure individual’s performance throughout the lab experiment.

Green et al. Paranoid Thoughts Scale (GPTS) measures paranoia by separating the ideas of social reference and the ideas of persecution (Green et al., 2007). Each part is measured using multidimensional scales which consist of 16-item self-report measures scored from 1 (Not at all) to 5 (Totally). The scores for each scale ranges from 16 to 80 where higher scores mean higher levels of paranoid thinking. GPTS was included in the pre-experiment questionnaire set.

Computer Experience (CE) measures the subject’s experience with computers and 3D programs (Schuemie, 2003). It consists of 5-item questionnaires scored from 1 to 5 where higher scores mean higher experience in using computers and 3D programs. The questions included in the questionnaires are: “How do you rate your overall computer skills?”, “How often do you use computer?”, “How often do you play 3D games on your computer?”, “How often do you use 3D programs (excluding games)?”, “Have you ever used a VR-helmet before?”. CE was included in the pre-experiment questionnaire set.
Immersive Tendencies Questionnaire (ITQ) measures differences in the tendencies of individuals to experience presence (Witmer & Singer, 1998). ITQ consists of 17-items which are rated on 7-point scales; and 1 item, which produces categorical data. ITQ was included in the pre-experiment questionnaire set.

State Social Paranoia Scale (SSPS) measures state of paranoid thinking level based on 2 elements: feared harm and offender intent (Freeman et al., 2007). Freeman et al. reported that SSPS is suitable for experimental studies. SSPS consists of 10-items rated on 5-point scales from 1 (Do not agree) to 5 (Totally). The minimum score is 10 and the maximum score is 50 in which higher scores means higher level of paranoid thinking. The scale also includes 5-items concerning positive view and 5-items concerning neutral view which is used to establish the divergent validity. SSPS was included in the experiment questionnaire set.

Igroup Presence Questionnaire (IPQ) measures the sense of presence experienced in a virtual environment (Schubert, Friedmann, & Regenbrecht, 2001). IPQ consists of 14-items which are constructed of three subscales (Involvement, Spatial Presence, Experienced Realism) and one additional general item not belonging to any subscale. Items are rated using 7-point scale ranged from -3 to 3 with higher score indicates higher level of presence. IPQ was included in the experiment questionnaire set.

Simulator Sickness Questionnaire (SSQ) measures the side effects caused by the simulator of the system to the participant (Kennedy et al., 1993). SSQ consists of 16-items derived from three distinct symptom clusters, which are Oculomotor, Disorientation, and Nausea. The items are rated using 4-point scale ranged from 0 (None) to 3 (Very Strong). Higher scores indicate a higher level of symptoms. SSQ was included in the experiment questionnaire set and was filled by the participants before and after the experiment.

In addition to the questionnaires, the experiment also used several additional measures. These measures were Subjective Unit of Discomfort (SUD) score, physiological measurement, and paranoid comments.

Subjective Unit of Discomfort (SUD) score (Wolpe, 1968) is a scale from zero to ten which gives the participant’s subjective anxiety level. Zero for no anxiety and ten for the highest level of anxiety they could imagine. SUD score was asked to them before and after exposure in the virtual environment.

The participants’ physiological measurement was recorded using Mobi8 data recorder from TMSi where their heart rate (HR) during exposure was measured using the Xpod Oximeter.

The paranoid comments measures participant’s paranoid thought based on the recording of the comments made by the participant toward the virtual characters and the virtual environments during the exposure. Besides the comments, the recording also included what the participants saw in the virtual environment. The total amount of the recording data was 240 minutes (two – five minutes sessions from each of 24 participants).

To measure the paranoid thought using paranoid comments, a coding scheme was created to define the important keyword that should be annotated by the coder when listening to
the recording. The coding scheme was not created to measure how severe the participants experienced paranoid thought, but to measure how often the participants experienced paranoid thought. Therefore, the categories in the coding scheme were nominal categories and each of them was mutually exclusive. The categories were based on events that indicated the participants experienced paranoid thought. The events were divided into three nominal categories. Table 3.1 shows these three categories and examples of it.

Table 3.1  
**Coding Scheme for Paranoid Thought Comments**

- **Persecution/accusation:** a reference that suggests that a virtual character is suspicious, dangerous, or other negative characteristics.
  - Examples: *he looks suspicious; I believe he has bad intentions; he is up to no good.*

- **Distress:** a reference regarding feeling uncomfortable or distressed, which was caused by a virtual character or the environment.
  - Examples: *the way he looks at me makes me feel uncomfortable; people keep staring at me and it makes me feel uncomfortable; I am not feeling comfortable to sit beside him.*
  - Not included: references to feelings that are caused by unrelated events or objects, such as: *I feel uncomfortable since there is no food on my table; it is very uncomfortable to sit here since the view outside is better; I am bored.*

- **Threat:** a reference towards a threat from a virtual character or the environment or a feeling of unsafety.
  - Example: *the way he looks at me makes me feel insecure; I do not think this place is a safe place.*
  - Not included: references that are caused by unrelated events or objects such as: *I am afraid that the HMD will fall if I move too active; My head feels dizzy and that worries me; I am not feeling safe wearing all these gadgets.*

To ensure the reliability of the coded data, two coders, separately, were asked to do the coding on all recordings. The coders annotated all the participants’ comments which corresponded to one of the categories. The annotation was based on word/segment of sentence, not whole sentence. Therefore, it was possible for a sentence to be annotated several times since the specific words were mentioned repeatedly. Furthermore, one word could only be annotated in one category.

An example of a sentence that could be annotated for more than once is: *That guy is really suspicious and I am starting to feel insecure about it.* In that sentence, *that guy is really suspicious* refers to persecution/accusation event; while *I am starting feel to insecure about it* refers to threat events. Therefore, that sentence can be annotated twice. Another example is: *That suspicious guy keeps looking inside and it makes me feel unsafe, especially since there is no security around.* That sentence can be annotated three times with one annotation for persecution/accusation and two for threat event.

For analyses, the result of the annotated comments from all three categories in the coding scheme were summed up into one single variable which represented the amount of paranoid thought experienced by the participants during exposure. Higher sums of the annotated comments indicated that the participants experienced more paranoid thought during exposure.
3.2.3 Participant
The participants for the experiment were students of TU Delft recruited using the convenience sampling strategy. A total of 24 people (16 males and 8 females) participated in the experiment. The participants’ age ranged between 23 and 33 years old ($M = 27.83$, $SD = 2.76$). All the participants had at least bachelor degree.

All the participants reported to have no history of paranoia and to have little to no experience in developing a virtual world. The reason for recruiting individuals with no history of paranoia was to ensure that the priming was indeed effective to non-clinical population. On the other hand, the reason for recruiting individual with no background in developing virtual world was to minimize the focus on the quality of the VR world which could distract them during the experiment.

During the recruitment process, the participants received consent form that informed them about their rights during the experiment, the experiment procedure, and the following additional information:

1. Participant with history of paranoia or epilepsy was not encouraged to participate in the experiment.
2. Participant using pacemaker was not encouraged to participate in the experiment as the magnetic field emitted by the tracker (the Ascension Flock of Birds) might cause problem with the pacemaker.

However, the participants were never informed about the hypotheses of the experiment until the experiment had ended. They were only informed that their participation would help in developing a virtual environment which could be used to help treating people with mental disorder.

In addition to the consent form, the participants were asked to fill in the pre-experiment questionnaires. The mean value and the standard deviation for each questionnaire can be seen in Table 3.2.

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPTS Reference</td>
<td>35.50</td>
<td>9.72</td>
</tr>
<tr>
<td>GPTS Persecution</td>
<td>25.54</td>
<td>10.19</td>
</tr>
<tr>
<td>GPTS Total</td>
<td>61.04</td>
<td>18.08</td>
</tr>
<tr>
<td>CE</td>
<td>13.63</td>
<td>2.22</td>
</tr>
<tr>
<td>ITQ</td>
<td>69.04</td>
<td>11.97</td>
</tr>
</tbody>
</table>

Note. $n = 24$

After filling in the questionnaires, the participant was invited to come to the lab to participate in the lab experiment. Before the experiments, all of the participants read and signed the consent form. In addition, the experimenter also gave the participants enough chance to ask any question regarding the experiment.
3.2.4 Material
For the experiment, only one computer with one monitor and one speaker set was required. The computer was used by the experimenter to control the experiment. The experimenter was located in the same room as the participant.

For the exposure, the participant wore a Sony HMZ-T1 Personal 3D Viewer Head Mounted Display (HMD) to view the virtual environment. The participant view’s position and orientation was tracked using the Ascension Flock of Birds tracker with 6 Degrees of Freedom (DOF). Both devices were connected to the computer. A microphone was used to record the participants comment during the exposure. Mobi8 data recorder from TMSi was used to measure the participants’ heart rate. Figure 3.2 shows the setup of the hardware including the participant and the experimenter.

3.2.5 Virtual Environment
Three virtual environments were used in this experiment. They were neutral virtual world, train station environment and restaurant environment. All the virtual environments were developed using WorldViz’s Vizard 3.0 software.

Neutral virtual world (Busscher, Vliegher, Ling, & Brinkman, 2011), a virtual environment consists only of a small room and no virtual characters, was used as a baseline where the participants were trained to get used to the virtual environment and to understand their task during the immersion. In addition, the participants’ baseline heart rate was measured.

In the train station environment (Brinkman et al., 2012), the participants were seated on couch on a platform at a train station with another platform and a bus station in front of him and a large building behind him. The participants’ movement was limited in this environment. They could not walk around the virtual environment; however, they could turn their head or turn their chair to look around so they can still observe the environment from their seat. There were 18 virtual characters in this environment consisted of 13 virtual characters in high polygon and 8 virtual characters in low polygon. Virtual characters in high polygon had more details and were placed close to the participants, while virtual characters in low polygon had less detail and, therefore, were placed far from the
participants. All of the virtual characters in the environment had basic animation which was one or more of the following animation: sitting and looking around, standing and looking around, talking to other virtual character, listening to other virtual character, and leaning to wall. Figure 3.3 shows some example pictures from the train environment.

Eleven virtual characters (seven virtual characters in high polygon and four virtual characters in low polygon) were programmed to occasionally look at the participants or look at a random point. In addition, five virtual characters (three virtual characters in high polygon and two virtual characters in low polygon) were programmed to occasionally walk around, either in fixed path, where the virtual characters were just following designated paths, or in random path, where the virtual characters could stop or make a turn on random point on the designated path.

In the restaurant environment (Brinkman et al., 2012), the participants were seated at one of the table in the restaurant. The restaurant itself consisted of the inside part and the outside part of the building. From the participants’ seat, they were able to observe both parts. Similar to the train station environment, the participants’ movement was limited and they could only observe the virtual environment from their seat. In the restaurant environment, all of the virtual characters had one or more of the following basic animation: sitting and looking around, standing and looking around, sit and eating, and working on laptop. Figure 3.4 shows some examples from the restaurant environment.

There were 21 virtual characters in this environment with 12 virtual characters in high polygon and 9 virtual characters in low polygon. From these virtual characters, 10 virtual characters, all in high polygon, were programmed to be able to look around with the same concept as the virtual characters in the train station environment. In addition, 2 virtual characters, both in high polygon, were programmed to walk around the environment. One virtual character walked inside the restaurant while the other one walked outside the restaurant and sometimes stop to look inside the restaurant.
3.2.6 Priming
As mentioned in the design sub-section, the within-subject for the experiment was the type of prior priming and consisted of two levels: paranoid priming and neutral priming. Paranoid priming aimed to evoke paranoid thought by raising the participants’ sense of insecurity toward individuals and the environment. On the other hand, neutral priming had no intention to evoke specific thoughts.

The priming was conducted in a priming session prior to exposure in VR world and each priming used two materials: a one A4 page long article and a video which was edited to have 6.5 minutes duration. For the neutral priming, the participants read an article about mountain animal and watched video about how mountain animal survives in their habitat (Busscher et al., 2011). Although the video similar to the video in the neutral VR world, the video in the neutral VR world was never played during baseline condition to avoid bias. For the paranoid priming, the participants read fake article about violence in Netherlands and watched video of a news report on street violence (snoopinc, 2009, July 22). The articles for both conditions can be found in appendix B. Throughout the experiment, both articles were put into two separate envelopes with a label on it (A and B) so that both the experimenter and the participants never knew the type of the article prior to priming session.

3.2.7 Procedure
Participant’s Anonymity Procedure
The participants were informed in the consent form that the experiment was related with mental disorder. In addition, due to the private nature of some of the questions, the participants might less willing to answer them. Therefore, it was necessary to create additional procedures to maintain the anonymity of the participant. The anonymity procedure was created to make the experimenter, in the end, unable to trace back the identity of the participants based solely on the result.
In the anonymity procedure, the participants were asked to choose a set of four random 3-digits number from given list. After the experiment finished, the participants used each of the selected numbers to label four kinds of data collected throughout the experiment without revealing it to the experimenter. These four kinds of data were the pre-questionnaire, the experiment questionnaire, the physiological measurement, and the paranoid comments. Then, the participants wrote down all four numbers in a small paper and put it inside a sealed envelope. The sealed envelope was sent to a researcher who was not directly involved in the experiment. The other researcher's task was to combine all the data, which was later sent by the experimenter after tabulation, into a new dataset with a new label. In the end, the new dataset was sent back to the experimenter for further analysis.

The whole procedure was written in the consent form and was also explained to the participants before the experiment began. In addition, the experimenter gave the participants enough time and chance to ask any question regarding the anonymity procedure. Therefore the participants could be assured that they would remain anonymous throughout the experiment and could answer or behave as honestly as possible.

**Experiment Procedure**

The complete procedure of the experiment is shown in Figure 3.5. Throughout the experiment, all the participants were immersed in three conditions: the baseline condition, the neutral condition, and the paranoid condition. Between each condition, a priming session to prime the participants before exposure was conducted. All the participants always had the baseline condition as their first exposure.

![Figure 3.5 Experiment procedure of the first experiment](image)

After the participant was briefed about the consent form and the experiment procedure, the participants were asked to fill in the SSQ questionnaire. Then, the participants were immersed in the baseline condition for at least 2 minutes in order to train them to get used to virtual environment and to train them to understand their task during exposure. In addition, the participants’ baseline physiological measurement was also established.

In the next step, the participants were immersed in the experimental conditions, which were the neutral condition and the paranoid condition. Neutral condition consisted of neutral priming session followed by exposure in one virtual environment, while paranoid condition consisted of paranoid priming session followed by exposure in another virtual environment. Both conditions were set to have different virtual environment for each participant. Therefore, there were no cases where the participants were immersed in the same virtual environment. Because there were two sets of priming condition and two kinds
of order, therefore, there were four different sets of orders (Table 3.3). These sets of orders were used 6 times for 24 participants. Since the experiment implemented double blind procedure, a random sequence of the 24 orders was written in a list and the list was put inside an envelope. Throughout the entire experiment, the experimenter had no knowledge about its content and only the participants were allowed to open and read it.

Table 3.3
Counterbalanced Order of the Experimental Condition

<table>
<thead>
<tr>
<th>1st Priming</th>
<th>1st Virtual Environment</th>
<th>2nd Priming</th>
<th>2nd Virtual Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutral</td>
<td>Train platform</td>
<td>Paranoid</td>
<td>Restaurant</td>
</tr>
<tr>
<td>Neutral</td>
<td>Restaurant</td>
<td>Paranoid</td>
<td>Train Platform</td>
</tr>
<tr>
<td>Paranoid</td>
<td>Train platform</td>
<td>Neutral</td>
<td>Restaurant</td>
</tr>
<tr>
<td>Paranoid</td>
<td>Restaurant</td>
<td>Neutral</td>
<td>Train Platform</td>
</tr>
</tbody>
</table>

During the priming session, first, the participants were asked to read the article as relaxed as possible without memorize anything for 3-5 minutes. To find out the order of the article that they had to read, the participants were asked to open the envelope and read the list. The order of the article in the list was already linked with the order of the video in the computer. Therefore, there were no cases where the priming session used article and video from different type of priming. When the participants finished reading the article, they needed to put the list and the article back into its envelope and return it to the initial position. Afterwards, they were asked to put on the HMD in order to watch the priming video. When the video finished, the priming session finished.

To further ensure that the experimenter never knew what type of priming condition the participants were given, the experimenter always left the experiment room during the priming session and only came back when the participant confirmed that they already finished reading the article or watching the video.

After the priming session, the participants were asked for their SUD score before the exposure started. Throughout the five minutes exposure, the participants’ task was to observe the environment and to comment freely on it, including the virtual characters. In addition, they were instructed to focus their comments on how they perceived the environment rather than simply providing an ‘objective’ description of the environment or an assessment of the quality of the VR environment. However, descriptive comments which were used to emphasize their argument were allowed. If the participants stop commenting for more than twenty seconds, the experimenter would give neutral suggestions about some places that the participants might comment on. While the participants were exposed in the virtual environment, the experimenter recorded what the participants saw in the virtual environment and what they said for further observation.

After the exposure, the participants were asked for their SUD score and were also asked to fill in the SSPS questionnaires. After short break, the second priming condition was conducted with the exact same procedure. When the second exposure finished, the participants were asked to fill in SSQ and IPQ questionnaires.
Once the participants finished filling in the questionnaires, they were asked to complete the anonymity procedure. In the end, they were debriefed about the real purpose and the hypotheses of the experiment.

3.3 Result

3.3.1 Preparation

All the analyses of the experiment’s result were conducted using the Statistics Package for the Social Sciences (SPSS). Before the data were analyzed, several preparations to the data were conducted. First, the participants’ were split into two groups: the high GPTS group which consisted of participants with higher base level of paranoia, and the low GPTS group which consisted of participants with lower level of paranoia. The creation of the group was based on the distribution of the GPTS Total score. The GPTS Total score is the combined value of GPTS reference score and GPTS Persecution score (Green et al., 2007).

Figure 3.6 shows the distribution of the GPTS Total score. As the median was 58.5, the participants with GPTS Total score 58 or lower were assigned to low GPTS group, while the participants with GPTS Total score 59 or higher were assigned to high GPTS group. After the split, both groups contained equally 12 participants. The group creation was solely based on the distribution data without considering how high the GPTS Total score for someone to actually be considered suffering from paranoia.

Second, the reliability of the paranoid comments was checked. Using Spearman Correlation analysis, the results of both coders were significantly correlated ($r = .83$, $n = 48$, $p < .01$), suggesting a strong level of strong level of inter-observer correlation. Therefore, the reliability of the coded data was acceptable. For further analysis, the average value of paranoid comments from both coders was used.

3.3.2 Presence and Simulator Sickness

Analyses were conducted to examine the level of presence of the virtual environment and the effect of the simulator sickness on the participants throughout the experiment. The
level of presence was examined to find out if the created virtual environment could establish an acceptable level of presence for exposure. On the other hand, the effect of the simulator sickness was examined to find out if the created virtual environment would increase the simulator sickness severe enough that it would concern to be used for exposure therapy. Descriptive statistic of SSQ before exposure, SSQ after exposure, and IPQ total score can be seen in Table 3.4.

Table 3.4

<table>
<thead>
<tr>
<th>Variable</th>
<th>M/Mdn</th>
<th>SD/IQR</th>
<th>Sig. a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre SSQ – Total Score</td>
<td>14.96 (Mdn)</td>
<td>25.24 (IQR)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Post SSQ – Total Score</td>
<td>33.66 (Mdn)</td>
<td>43.95 (IQR)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>IPQ Total</td>
<td>43.08 (M)</td>
<td>11.80 (SD)</td>
<td>.948</td>
</tr>
</tbody>
</table>

Note. n = 24

a Shapiro-Wilk test Sig. value (normality test)

To examine the level of presence, the result of the participants’ IPQ total was compared to the online IPQ data set\(^1\), a method which was previously used in other studies (Heijden & Brinkman, 2011; Ling, Brinkman, Nefs, Qu, & Heynderickx, 2012). This was done to examine whether the level of presence established by the created virtual environment was deemed acceptable. To create a proper comparison, the result of the IPQ total was compared only to the non-stereoscopic HMD result of the online data set.

Using a one sample T-test between the participants’ IPQ Total score and the mean of the online IPQ Total (44.08), no significant difference was found between the both scores (t(23) = -.41, p = .683). The result suggested that the participants’ level of presence inside the virtual environment were on the same level.

To examine the effect of the simulator sickness throughout exposure, the SSQ score before exposure and after exposure was compared. Since both scores did not come from normal distribution, 2-related sample Wilcoxon Signed Rank Test was used. The result showed that there was significant difference between both scores (z = -2.52, p = .012), where the SSQ score after the immersion (Md = 33.66) was higher than the SSQ score before immersion (Md = 14.96). This meant that virtual environment increased the participants’ level of simulator sickness significantly. In addition, compared to result from Brinkmann et al. (Brinkman, Hattangadi, Meziane, & Pul, 2011) and Ling et. al. (Ling, Nefs, Brinkman, Qu, & Heynderickx, 2013), the median of the SSQ score after immersion was higher than the mean of the SSQ score after immersion of both studies, which was 18.0 and 24.78, respectively.

However, the median of both SSQ scores was still low compared to the ranged of the SSQ Total Score (0-235.62). In addition, no participants dropped out from the experiment because of severe cybersickness symptoms. Furthermore, as recommended by Bouchard et al. (Bouchard et al., 2011), participants did not leave the lab immediately after the

\(^1\) Downloaded on 28 March 2013 from http://www.igroup.org/pq/ipq/data.php
exposure. They were instructed to fill in questionnaires and finish the anonymity procedure. By the end of the experiment, which took about 10-15 minutes after the end of the exposure, no participants reported cybersickness symptoms.

### 3.3.3 Analysis on Paranoid Thought

Analyses of main effects on paranoid thought were conducted using repeated-measures ANOVA with the priming condition and the participant’s base paranoid level as independent factors, and both SSPS score and paranoid comments as dependent variables. Both dependent variables were used to represent whether the participants experienced paranoid thought during exposure. Descriptive statistic of both dependent variables can be seen in Table 3.5. Normality test using Shapiro-Wilk test showed that both variables did not come from normal distribution. Because of that, both variables needed to be transformed first using Aligned Rank Transform (ART) for nonparametric factorial procedure (Wobbrock, Findlater, Gergle, & Higgins, 2011) before proceeding to the repeated-measures ANOVA. The result of the repeated-measures ANOVA can be seen in Table 3.6.

#### Table 3.5

<table>
<thead>
<tr>
<th>Variable</th>
<th>Paranoid Priming</th>
<th>Neutral Priming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mdn</td>
<td>IQR</td>
</tr>
<tr>
<td>SSPS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>19.50</td>
<td>15.00</td>
</tr>
<tr>
<td>Low Group</td>
<td>18.00</td>
<td>14.25</td>
</tr>
<tr>
<td>High Group</td>
<td>21.50</td>
<td>15.00</td>
</tr>
<tr>
<td>Comments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>2.00</td>
<td>2.38</td>
</tr>
<tr>
<td>Low Group</td>
<td>2.25</td>
<td>1.88</td>
</tr>
<tr>
<td>High Group</td>
<td>1.50</td>
<td>3.25</td>
</tr>
</tbody>
</table>

*Note.* n = 24

*average paranoid comments from two coders*

#### Table 3.6

<table>
<thead>
<tr>
<th>Variable</th>
<th>GPTS Group</th>
<th>Priming</th>
<th>GPTS Group x Priming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F(1,22)</td>
<td>p.</td>
<td>F(1,22)</td>
</tr>
<tr>
<td>SSPS</td>
<td>3.05</td>
<td>.095</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Comments</td>
<td>0.75</td>
<td>.395</td>
<td>0.77</td>
</tr>
</tbody>
</table>

*Note.* n = 24

*average paranoid comments from two coders*

The analyses only found a significant interaction effect between base paranoid level and priming on paranoid comments ($F(1,22) = 5.104, p < .05$). Further investigation on the interaction effect of paranoid comments was conducted using 2-related sample Wilcoxon Signed Rank Test. The result showed that for the low GPTS group, there was significant difference ($z = -2.68, p < .01$) in the number of comments between paranoid condition ($Mdn = 2.25$) and neutral condition ($Mdn = 0.75$), suggesting there was simple effects of priming on low GPTS group. On the other hand, for the high GPTS group, no significant difference ($z = -0.55, p = .58$) was found between paranoid condition ($Mdn = 1.5$) and
neutral condition (Mdn = 2.0). However, the numbers of paranoid comments made by the participants in high GPTS group were relatively higher compared to participants in low GPTS group. Moreover, the number of paranoid comments made by participants in high GPTS group were on the same level as the number of paranoid comments made by participants in low GPTS group when they were primed with the paranoid priming.

Further analysis with Mann-Whitney U test analysis on difference between high GPTS group and low GPTS group showed significant difference between the groups in neutral priming (z = -2.08, p = .04), but it showed no significant difference in paranoid priming (z = -.29, p = .80). Figure 3.7 shows the median difference of the SSPS and paranoid comments of each group in both conditions.

Although the main effect for the base paranoid level on SSPS scores (low GPTS group Mdn = 15.5, high GPTS group Mdn = 24.5) approached significant level of 0.5, no significant main effect for priming or an interaction effect between priming and GPTS groups were found on both.

3.3.4 Analysis on Anxiety

Additional analysis was conducted to investigate the effect for priming and base paranoid level on Anxiety. Descriptive statistic of Heart rate, SUD Score before exposure and SUD Score after exposure can be seen in Table 3.7. Since both SUD scores did not come from normal distribution, it was transformed first using ART for nonparametric factorial procedure before analyses with repeated measures ANOVA.

Table 3.7
Descriptive Statistic of Heart Rate and SUD Score

<table>
<thead>
<tr>
<th>Variable</th>
<th>Paranoid Priming</th>
<th>Neutral Priming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M/Mdn</td>
<td>SD/IQR</td>
</tr>
<tr>
<td>Heart Rate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>83.02 (M)</td>
<td>9.31 (SD)</td>
</tr>
<tr>
<td>Low Group</td>
<td>85.85 (M)</td>
<td>10.54 (SD)</td>
</tr>
<tr>
<td>High Group</td>
<td>80.18 (M)</td>
<td>7.24 (SD)</td>
</tr>
<tr>
<td>Pre SUD Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.00 (Mdn)</td>
<td>1.00 (IQR)</td>
</tr>
<tr>
<td>Low Group</td>
<td>3.00 (Mdn)</td>
<td>0.75 (IQR)</td>
</tr>
<tr>
<td>High Group</td>
<td>3.00 (Mdn)</td>
<td>1.00 (IQR)</td>
</tr>
<tr>
<td>Post SUD Score</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall</td>
<td>3.00 (Mdn)</td>
<td>0.75 (IQR)</td>
</tr>
<tr>
<td>Low Group</td>
<td>3.00 (Mdn)</td>
<td>0.00 (IQR)</td>
</tr>
<tr>
<td>High Group</td>
<td>3.00 (Mdn)</td>
<td>1.75 (IQR)</td>
</tr>
</tbody>
</table>

Note. n = 24
Repeated measures ANOVA analyses were conducted on Heart Rate and ART SUD Score after exposure. Only the SUD score after exposure was used because the SUD score before exposure mainly was affected with anticipation anxiety which could influence the analyses. In addition, repeated-measures ANOVA on ART SUD score before exposure found no significant effects of priming and base paranoid level which further suggested that there is no systematic effect on SUD score before exposure. The result of the repeated-measures ANOVA analyses can be found in Table 3.8.

Table 3.8  
Results of ANOVA on Heart Rate and SUD Score  
<table>
<thead>
<tr>
<th>Variable</th>
<th>GPTS Group</th>
<th>Priming</th>
<th>GPTS Group x Priming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F(1,22)</td>
<td>p</td>
<td>F(1,22)</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>4.22</td>
<td>.052</td>
<td>0.06</td>
</tr>
<tr>
<td>SUD Scorea</td>
<td>0.11</td>
<td>.745</td>
<td>0.99</td>
</tr>
</tbody>
</table>

Note. n = 24  
*a* SUD Score after exposure

Result of analyses found no significant effect of priming and base paranoid level either in Heart Rate or SUD Score. Further analyses were conducted to examine the correlation between anxiety and paranoid thought in the same experimental condition. Table 3.9 shows the result of the Spearman correlation between paranoid comments and other variables (GPTS, SSPS, Heart Rate and SUD score after exposure). Result suggested that there is no correlation between paranoid thought and anxiety (Heart Rate and SUD Score after exposure), which suggested that priming might have different effects on paranoid thought and on anxiety. In addition, there were positive correlations between SSPS and paranoid comments in both conditions since both variables measures paranoid thought.

A closer look at the correlation between GPTS and paranoid comments would reveal that there was weak correlation in neutral condition but no correlation in paranoid condition. This result confirm previous finding where the paranoid priming could raise the amount of paranoid thought in both group on the same level eventhough there were differences in neutral condition.

Table 3.9  
Results of Spearman Correlation between Paranoid Comments and Other Variables  
<table>
<thead>
<tr>
<th>Variable</th>
<th>Paranoid Condition</th>
<th>Neutral Condition</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r(22)</td>
<td>p.</td>
<td>r(22)</td>
</tr>
<tr>
<td>GPTS</td>
<td>.046</td>
<td>.832</td>
<td>.344</td>
</tr>
<tr>
<td>SSPS</td>
<td>.552</td>
<td>.005</td>
<td>.609</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>.016</td>
<td>.942</td>
<td>-.193</td>
</tr>
<tr>
<td>SUD Score</td>
<td>.068</td>
<td>.752</td>
<td>-.030</td>
</tr>
</tbody>
</table>

Note. n = 24

Similar to SSPS score, although the main effect for base paranoid level on Heart Rate (low GPTS group $M = 86.2$, high GPTS group $M = 79.6$) approaching significant level of .05, no
significant main effect for priming or an interaction effect between priming and base paranoid level were found.

3.4 Conclusion and Discussion

Results of the experiment supported H1 where the created VR world was able to induce paranoid thought in participants eventhough they had neutral priming before exposure. This result confirmed that exposure in a virtual environment could induce paranoid thought.

Although the result did not fully support H2 where priming only had simple effects on participants in low GPTS group, the result suggested that prior priming with the purpose to create feelings of threat and vigilance could increase the number of paranoid thought experience in a non-clinical participants that otherwise would less often exhibit paranoid thought. Although the difference between both priming conditions in high GPTS group were not statistically significant, the number of paranoid comments made by the participants in both priming conditions were on the same level with the number of paranoid comments made by the participants in the low GPTS group when they were primed in paranoid condition. This suggested that the paranoia priming can raise the numbers of paranoid thought experienced by participants in both group to the same level.

Furthermore, the result seemed to not fully support H3 where participant’s base paranoid level only had simple effects on neutral priming condition, while in the paranoid priming condition, the numbers of paranoid thought in both groups were on the same level.

Although the main effect of the base paranoid level (low GPTS group Mdn = 15.5, high GPTS group Mdn = 24.5) approached a significant level of .05, no significant main effect for priming or an interaction effect between base paranoid level and priming was found. It could be argued that the effects of priming had worn off as time passed by. As a result, the effect of the priming might not be apparent on the participants’ answer when the questionnaire was filled in. In addition, the questionnaire relied on the memory of the participants and only measured their overall experience in the VR world, compared to paranoid comments which measured the instance moment of paranoid thought experience during exposure. Therefore, it was possible that priming might not have large effect on the recollected experience.

Similar result was also found on heart rate where the main effects of the base paranoid levels (low GPTS group $M = 86.2$, high GPTS group $M = 79.6$) approached a significant level of .05 while no significant effect was found on both priming and interaction between priming and base paranoid level. It could be argued that priming might not have large physiological effect.

In regards to anxiety, the result suggested that priming had no effects on anxiety. One explanation for this was because the participants came from non-clinical populations. For them, when they were experiencing paranoid thought, it did not mean that they were also afraid in that instance. In addition, result of Spearman correlation analysis between paranoid thought and anxiety showed no correlation, which further supported that experiencing paranoid thought did not directly translate to anxiety.
In the end, the result of the experiment suggested that non-clinical participants, when they were appropriately primed, could possibly be used to evaluate the ability of a VR environment in eliciting paranoid thought. In addition, it was confirmed that the created VR world, with minimal paranoia stressors included, were actually able to trigger paranoid thought from the participants despite the prior priming.
4 Core Functions, Claims, and Scenarios

This chapter focuses on describing the Specify phase of the sCE approach. The main goal of this phase was to create the preliminary requirement baseline of the application. In this phase, the core functions were identified and the associated claims were formulated based on the data acquired previously from the Derive phase. Claims are statements that justify the core functions with its consequences (Rosson & Carroll, 2003), including its advantages, disadvantages, or trade-offs.

To help understanding the core functions and the claims, scenarios were written. Scenario helps to describe how a system works by describing how the people will use the system rather than how the system operates (Rosson & Carroll, 2003). It includes a setting (starting state), actors with goals, and a sequence of events or actions. The usage of scenario allows different stakeholders to discuss the usage possibilities of the system and its concerns. By imagining the situation if the system was applied, the stakeholders could understand the user situations and context better.

To help explaining the scenario to the therapists, a storyboard was created. This storyboard explained how the therapist used the application for the treatment, starting from the beginning of the treatment until the evaluation session between the therapist and the patient. In addition, the storyboard also introduced the low-level fidelity prototype to help describing the application further.

After the storyboard was created, the core functions and the associated claims were discussed with the therapists to ensure that the formulated requirements were indeed effective in clinical practice. Then, the result of the discussion was used to refine the preliminary requirement baseline. Finally, the refined preliminary requirement baseline was used to design and develop the application.

Throughout the process, two discussion sessions with therapists were organized, with two different approaches for treatment were proposed. In the first discussion session, the gradual exposure approach was proposed. However, the therapists considered it was too complex for the patient. As a result, a simpler approach for treatment was created for the second discussion session. In this session, the prolonged exposure approach was proposed. By the end of the second discussion, the second approach, that was the prolonged exposure approach, was chosen to be developed further.

This chapter starts with the elaboration of the first approach, the gradual exposure approach, followed by the elaboration of the second approach, the prolonged exposure approach. The elaboration includes the core functions identification, claims and requirements formulation for each core function, and scenarios creation. The chapter is concluded with the result of the review session with the therapist on the prolonged exposure approach.
4.1 First Cycle: Gradual Exposure Approach

During the first discussion with the therapist, one approach for treatment using VR was explored. The main idea was a gradual exposure approach that incorporated game element into the treatment. In short, the basic ideas were:

- a) There should be instances in the simulated social situation where the patients have to make a decision in order to progress in the situation.
- b) Every decision would have its own consequences. Paranoid decision would lead to undesirable consequences and non-paranoid decision would lead to desirable consequences.
- c) There are several decision points that allowed the patients to return back and choose the other options. This is important to help the patients compared the difference of the consequences between decisions.

This approach aimed to teach the patients that they might experience undesirable consequences if their decisions were driven by their paranoid thought. On the other hand, desirable consequences might come if they could overcome their paranoid thought. By teaching them that every decision had its own consequences, thus, they could learn how they should base their decisions in every situation, and they could also implement it on similar situation in the real life.

The idea was investigated further during concept designing. In the end, a gradual exposure approach using VR world with multiple levels was proposed.

The basic concept of the proposed approach was to expose the patients in VR worlds with multiple levels that had different levels of difficulty between them. The difficulty here referred to the difficulty of the decisions that the patients had to make in that level. The stressors, called Social Situation, were exposed to them through the difficulty of the simulated social situation in which they were situated.

In addition to the Social Situation, another group of stressors, called Independent Stressor, were used. The aim of the Independent Stressor was to change the difficulty of a level by exposing stressors irrelevant to the Social Situation that could influence the patients’ thought process and behaviour throughout exposure. Independent Stressors were used independently in the exposure, and because of that, the amount and the intensity of them were also not related to the level of the Social Situation.

List of stressors which were included to the Independent Stressor were:

2. Eye Gaze.
3. Pre-narrative Text.
4. Information About Danger.
5. Appearance and Facial Expression.
7. Passing by people.
Both these stressor groups could be configured and controlled by the therapist. In addition, he was responsible for controlling the dialog of the virtual character during the interaction between the virtual character and the patients. Figure 4.1 shows how the therapy is conducted.

![Multiple Level VRET System](image)

**Figure 4.1 Basic concept of the gradual exposure approach**

### 4.1.1 Core Function Identification

The list of the identified core functions corresponded to the gradual exposure approach was:

1. VR world with multiple levels.
2. Implementing daily life situations into the treatment.
3. Treatment personalization.
4. Exposure configuration and controller that minimize therapist’s workload.
5. Automatic Scoring.

Each of the identified core functions, including the underlying claims, is explained in detail in the next section.

**VR World with multiple levels**

The gradual exposure approach implements VR world with multiple levels. Figure 4.2 shows the concept of the VR world with multiple levels. The idea came from game element concept where players were provided with several levels with different levels of difficulty. In this concept, each level had different Social Situation in which patients were situated. To complete a level, they had to perform specific tasks that were the same for each level. However, the Social Situations would gradually get more difficult as the level got higher. If the task was not completed, they would remain at that level. However, they could leave the virtual environment anytime. When they completed a level, a score to evaluate their performance was calculated. The requirement for this core functions and the underlying claims can be seen in Table 4.1.

On the therapist side, the application should allow him to start the treatment at any level. In addition, it should allow him to repeat a level if the score of the patients’ performance was not sufficient. To avoid carry-over effect, when a level was repeated, the role, the appearance, and the location of the virtual characters in the virtual world were changed.
Table 4.1

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple levels VR world for exposure.</td>
<td>The application should consist of multiple levels VR world with different levels of difficulty and the patients need to perform specific task in order to complete a level.</td>
</tr>
<tr>
<td></td>
<td>+ Providing multiple levels helps the patient in learning how to encounter different social situation in real world.</td>
</tr>
<tr>
<td></td>
<td>- Complicated task can distract patients from the main goal of overcoming their fear. Inability to complete the level might make them less motivated.</td>
</tr>
</tbody>
</table>

**Implementing daily life situations into the treatment**

One of the major points in the preliminary requirement was the idea of implementing daily life situations into the treatment. By teaching the patients how to behave appropriately in a social situation that simulates real social situation, it might be easier for them to transfer their knowledge to the real life. To accomplish this goal, the Social Situations and the task should represent real daily life social situations. The requirement for this core function and the underlying claims can be seen in Table 4.2.

Figure 4.3 shows the flow of the patients’ task in a level from the beginning until the completion of the level. The proposed common theme for the Social Situations was a meeting with an unknown people for the first time in a restaurant. There were two main reasons for choosing this theme. First, this theme complements the idea of implementing daily life situations because meeting someone in a restaurant is not an uncommon situation. Second, when attempting to meet someone in restaurant, especially for the first time, people might encounter various social situations where they have to make a decision on how to behave. These various social situations are good reasons to implement a multiple levels VR world by making one social situation as one scenario element.
Table 4.2

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social situations and tasks for the exposure that represent real daily life situations.</td>
<td>The created social situation should represent the real daily life social situation.</td>
</tr>
<tr>
<td></td>
<td>+ Patients can transfer what they learn to the real world.</td>
</tr>
<tr>
<td></td>
<td>Increase motivation during treatment since the result of the treatment is concrete in real world.</td>
</tr>
<tr>
<td></td>
<td>- Inability to complete a level might make the patients less motivated as they might be under the impression that they will not succeed in the real world.</td>
</tr>
</tbody>
</table>

Figure 4.3 The patient’s course for finishing a level

The unknown people, referred here as “Target”, whom the patients met was portrayed as an unknown friend of a friend with specific information related to a job that they really wanted. They needed to meet him in order to extract the specific information, which was a 4-digits telephone number. This telephone number would be used by them to make an appointment to a company for a job interview. After the meeting was completed, they need to go to the “Finish Line”, which was a telephone box. Here, they needed to dial the 4-digits telephone number that they got from the “Target”. When they dialed the correct number, the level was completed.

Based on the suggested common theme, 6 scenario elements for the Social Situation were formulated. Each scenario element had different side tasks that the patients needed to complete in order to complete their main task. Each side task had different complexity that related to the difficulty of the decisions that the patients needed to make. The formulated 6 scenario elements were:

1. Meet Target.
   In this scenario element, the patients meet the “Target” directly in an empty restaurant without any side task.
2. Meet Target by asking waiter.
   In this scenario element, the patients’ side task is to talk to the waitress in order to find the “Target”.
   In this scenario element, the patients’ side task is to buy drinks for the “Target” by choosing between two bartenders. One bartender will look scary but has no queue and the other bartender will look friendly but has long queue. The choice made by them will determine how long it will take to talk to “Target”.


4. Queue.
   In this scenario element, the patients’ side task is to wait in a queue before entering the restaurant. Their behavior during this moment will determine whether they are able to enter the restaurant easily or not.

5. Wrong Target.
   In this scenario element, the patients’ side task is that they first meet the wrong “Target” and then have to search for the correct one by asking people in the restaurant.

   In this scenario element, the patients’ main obstacle is to choose between having their bike taken away because they are too afraid to meet the security guard or keeping their bike by helping the security guard moves the bike.

More explanation on the formulated 6 levels of scenarios elements with the respective storyboard presented to the therapist can be found in appendix C.

**Treatment personalization**

Every patient that suffering from paranoia could have different paranoid thought trigger. In addition, every patient might had different reactions on given stressors. As an example, a patient might find that laughing is very scary while other patient might find it not scary at all. These differences led to differences in the treatment scenario. Therefore, the application should allow the therapist to create a treatment scenario for each patient. The associated requirement and claim can be seen in Table 4.3.

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Treatment personalization.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>The application should allow the therapist to configure Social Situations and to configure the amount and the intensity of the Independent Stressors for each patient.</td>
</tr>
<tr>
<td>+</td>
<td>The treatment can adapt to the patient’s paranoid thought trigger.</td>
</tr>
<tr>
<td>-</td>
<td>Increase the work load of the therapist.</td>
</tr>
</tbody>
</table>

To allow treatment personalization, the therapist could combine two or more Social Situations into one new level. In addition, he could also configure the hierarchy of the level freely. Furthermore, the therapist could include or exclude the Independent Stressor into treatment, and configure the amount and the intensity of the stressors in Independent Stressor.

Figure 4.4 shows the basic concept of the creation of the dynamic level and dynamic hierarchy. In this example, the therapist creates a new dynamic level by including scenario element B, C, and D along with the Independent Stressor. Afterwards, the new level is inserted as level 4 in the created dynamic hierarchy that consisted of 5 dynamic levels.
Exposure configuration and controller that minimize therapist’s workload

During exposure, the therapist’s main task is to monitor the patients; however, configuring and controlling the exposure might distract him from his main task or increase his workload. To solve the problem, the application should allow the therapist to create and configure a complete set of treatment for a patient from the easiest level until the most difficult one before the exposure.

With the proposed solution, the therapist’s workload would be high only before treatment when his main focus is not on the patients and the exposure. Therefore, when the exposure started, he could just monitor the patients without having the need to control the exposure often. When the treatment finished, he could just decide to let the patients repeat a level or allow them to progress to the next level which was already created before. Furthermore, for patients with similar problem, he might not need to create a new set of treatment.

In other words, the proposed solution allows the therapist to focus on monitoring the patient during the exposure with minimum distraction and workload. The requirement for this core functions and the underlying claims can be seen in Table 4.4.

**Automatic Scoring**

A score that indicated the patient’s performance during exposure could be useful for both the therapist and the patients. For therapist, a score could help him in evaluating the patients’ performance in the virtual world. For patients, a score could help them in evaluating their decision so that they could perform better in the future. Since scoring could be useful, the application should have automatic scoring system to evaluate the patients’ performance. The scoring was based on the decision they made, the physiological
measurement, the completion time, and their behavior in the VR world. The requirement for the automatic scoring and the underlying claims can be seen in Table 4.5.

Table 4.4

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure configuration and controller that minimize therapist’s workload.</td>
<td>The application should allow the therapist to create and configure a complete set of treatment for a patient before the exposure so that the therapist’s workload is moved to pre-treatment session.</td>
</tr>
<tr>
<td></td>
<td>+ Time efficiency once the configuration finished.</td>
</tr>
<tr>
<td></td>
<td>Maximize the therapist focus on monitoring the patient when he is really needed to attend to the patient.</td>
</tr>
<tr>
<td></td>
<td>- Might take time during the configuration of the treatment.</td>
</tr>
<tr>
<td></td>
<td>Requires that therapist sets a time aside before treatment to configure the system.</td>
</tr>
</tbody>
</table>

One concern with the scoring system was when should the score be revealed to the patients. Revealing the score during the exposure had the advantage of informing them about their current performance. However, the presence level of the virtual environment might decrease as they could see lots of data or numbers during the exposure. In addition, these performance indicators might trigger paranoid thoughts on the patient.

Table 4.5

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Claim</th>
</tr>
</thead>
<tbody>
<tr>
<td>Automatic scoring of the patients’ performance.</td>
<td>A score that represents the patients’ performance during the exposure should be automatically provided to both patients and therapist.</td>
</tr>
<tr>
<td></td>
<td>+ Score can help therapist in evaluating the patients’ performance. Score can help the patients in reflecting their past performance.</td>
</tr>
<tr>
<td></td>
<td>- Decrease the patients’ presence level if provided during the exposure. Can trigger paranoid thoughts if provided during the exposure.</td>
</tr>
</tbody>
</table>

4.1.2 Discussion with the Therapists

After the core function was identified, including the respective underlying claims, a discussion with the therapists to review the proposed solution was conducted. The participants for this discussion consisted of two people from Delft University of Technology and two therapists from Parnassia Psychiatric Institute in The Hague. Both therapists had experiences in treating patient with psychosis and paranoia. The therapists were presented with the basic concept of the gradual exposure approach, the basic idea of Social Situations and Independent Stressors, and the potential scenario elements for the Social Situations.

Overall, the therapists supported the idea of incorporating game elements into treatment. They also supported the idea of dynamic level and the idea of separating the Social Situation and Independent Stressor because it would give them more options in creating treatment scenarios. In addition, the created potential scenario for the Social Situation already reflected the real world situation enough.
However, the therapists considered that the approach was too complicated for the patients. In addition, teaching the patients about making the right decision in a simulated social situation was considered to be too advanced for the patients to learn. The reason was because the patients might be too scared when they were exposed with stressors, and as a consequence, they could not make decision calmly. The therapists suggested that it was better if the patients were taught on how to always remain calm and not to avoid the situation. If the patients were able to keep themselves calm in any situation, other approaches such as gradual exposure approach could be taught much easier.

To follow-up the new idea, the therapists suggested to implement prolonged exposure approach in the treatment. In this approach, the patients were exposed with stressors in a VR world for long time (around 15-20 minutes). Throughout the exposure, the patients’ main task was to reduce their anxiety level for any given stressors level. At the same time, the therapist needed to modify the stressor level to match the patient’s response. After several exposure sessions with the therapist, the patients would learn how to remain calm and how they should behave when they encounter the real stressors in the real life.

The therapists also suggested removing the dialog as a stressor because it was not an effective stressor for paranoia. They thought that patients suffering from paranoia were considered to be more afraid of other stressors such as eye gaze, laughing, and talking behind the back instead of interacting with other people. Therefore, if dialog had to be included in the application, they suggested that it should be a neutral dialog with the main focus was to further the storyline.

Feedbacks from the therapists were used to refine the idea for the application and instead of continuing using the gradual exposure approach, the prolonged exposure approach was considered for the second cycle.

### 4.2 Second Cycle: Prolonged Exposure Approach

Based on the result of review session with the therapists, the idea of using gradual exposure approach was discontinued. Instead, a new idea to implement prolonged exposure into treatment was considered. The basic ideas for this approach were:

a) The patients were situated in the VR world and exposed to certain level of stressors for 15-20 minutes.

b) Throughout the exposure, the patients’ main task was to reduce their anxiety level and not to avoid the situation.

c) The therapist needed to modify the stressors level to adapt with the patients’ response and avoid condition where their anxiety level was too low or too high. This was important since patients would learn nothing if their anxiety level was too low and they could not learn anything if their anxiety level was too high.

d) Both the therapist and the patients evaluated the patients’ performance once the exposure finished.

The aim of this approach was to teach patients how to remain calm when exposed to a number of stressors. If they could do it, they would be calmer when they made decision. This was important when they needed to interpret or response to stressors in real life.
Furthermore, they could start learning more advanced approaches to overcome paranoid thought.

For this approach, stressors were exposed to patients as a paranoid thought provoking event which was performed by the elements of the VR world (mostly virtual characters). The events were triggered randomly to make it difficult for them to predict when and from where it would occur. This idea could represent the real world where stressors could happen anytime and from anywhere. However, if the random events were not synchronized with each other, it would not look natural. To synchronize it, timers were used to decide when an event was triggered and each timer was linked to several elements of the VR world.

In this approach, the therapist could configure and control the stressors by deciding which stressors should be included into the exposure and configuring its probability to occur and its rate of timer. With this method, therapist could create either a more relaxing scenario where the stressors rarely occurred, or a more paranoia provoking scenario where the stressors often occurred. In addition, a more relaxing scenario could be created where most of the VR world elements were not included into the exposure and vice versa for the paranoia provoking scenario.

Furthermore, based on the result of review session with the therapists, dialog was not used as stressor in this approach. This would reduce the therapist’s workload further.

4.2.1 Core Function Identification

The list of the identified core functions corresponded to the prolonged exposure approach was:

1. Implementing daily life situations into the treatment.
2. Implementing prolonged exposure into the treatment.
3. Exposing the patients with random events while still preserve its naturalness.
4. Treatment personalization.
5. Exposure controller with minimum number of parameter to be controlled by therapist.

Each of the identified core functions, including the underlying claims, is explained in detail in the next sections.

Implementing daily life situations into the treatment

Similar to gradual exposure approach, implementing daily life situation into treatment was important to help the patients’ learning process. To accomplish this goal, the main requirement for this core function was to create simulated social situations with scenarios that could represent the real world.

In addition, the created social situation should limit the amount of direct interaction between the patients and the elements of the VR world. The reason was because direct interaction with elements of the VR world, either verbally or physically, was still not a priority for patients in the early treatment phase. Moreover, with limited interaction, the
treatment procedure would not be as complicated as the gradual exposure approach, and this would be helpful for the patients, especially those who also suffering from cognitive impairment. The requirement for this function and the respective underlying claims can be seen in Table 4.6.

To follow-up, it was decided to create a social situation which was based in a restaurant. A restaurant was chosen because it was an everyday social situation to have lunch or dinner at a restaurant. Therefore, what the patients learnt during the exposure could actually be implemented when they came to a restaurant. In addition, restaurant is an example of public place with many strangers with limited control that can evoke social anxiety and paranoia to the patients.

Table 4.6

| Requirement | Claim | Table 4.6 Requirement and Claims for Implementing Daily Life Situations into Treatment |
|-------------|-------|----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| A social situation for the exposure that implements daily life situations. | The created social situation should represent the real life social situation with limited direct interaction between the virtual environment’s elements (e.g. virtual character) and the patient, either verbally or physically. | Requirement: The created social situation should represent the real life social situation with limited direct interaction between the virtual environment’s elements (e.g. virtual character) and the patient, either verbally or physically. |
| | + Patients can transfer what they learn into the real world. Less interaction makes the treatment less complicated. | **Claim:** The created social situation should represent the real life social situation with limited direct interaction between the virtual environment’s elements (e.g. virtual character) and the patient, either verbally or physically. |
| | - Inability to remain calm might make the patients less motivated as they might be under the impression that they will not succeed in the real world. | **Claim:** The created social situation should represent the real life social situation with limited direct interaction between the virtual environment’s elements (e.g. virtual character) and the patient, either verbally or physically. |

The proposed scenario was for the patients to act as customers and they were seated at one of the table in the restaurant. Throughout the exposure, they only sat and they could not walk around the restaurant. This was necessary to avoid them interacted with any of the elements of the VR world.

In this scenario, several virtual characters acted as customers of the restaurant while other virtual characters acted as people passing by inside or outside of the restaurant. Most of the stressors were performed by these virtual characters (i.e. eye gaze, talking, laughing, etc.), however, some stressors could also be performed by other elements of VR world (i.e. music, lighting, TV, sign, etc.).

**Implementing prolonged exposure into the treatment**

To implement prolonged exposure approach, several requirements were needed. The first requirement was to give a suitable task to the patient during the exposure. The task should allow the patients to maximize their exposure. As a consequence, it was important to minimize giving distraction task that might distract their attention from the exposure itself. In addition, the task should not be too complicated for them. The requirement and claim for this can be seen in Table 4.7.

For this approach, the proposed task for the patients was to observe their surrounding during exposure. By observing the surrounding, patients would have higher chance to notice and response to the stressors. Afterwards, they could start learning how to remain calm and not to avoid the situation. In addition, this task was simple since they did not
need to walk away from their seat to observe their surroundings. Furthermore, this task was useful for the therapist since he could use the patients’ responses to the stressors to evaluate their performance and progress.

Table 4.7

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Task for the patient during the exposure that maximizes their exposure and not too complicated to follow.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>The patients should not be given distracting tasks during the exposure which, otherwise, can interfere with the goal of the prolonged exposure approach. The task should also not be too complicated for them.</td>
</tr>
<tr>
<td></td>
<td>+ With minimum distraction task, the patients can pay attention to all stressors, which in turn, maximize their exposure.</td>
</tr>
<tr>
<td></td>
<td>- A complicated task can lead the patients to overload or avoidance behavior.</td>
</tr>
<tr>
<td></td>
<td>A distracting task might divert the patient from the initial goal.</td>
</tr>
</tbody>
</table>

For the second requirement, the created social situation should last until the exposure finished with minimum numbers of repeated scenes or animation. If there are too many repetitions, the patient’s presence level might decrease. The requirement and claim for this can be seen in Table 4.8.

Table 4.8

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Social situations for prolonged exposure of 15-20 minutes with adequate presence level.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>The social situation should last for the whole exposure (15-20 minutes) with minimum numbers of repeated scenes or animation.</td>
</tr>
<tr>
<td></td>
<td>+ Maintain patient’s presence level.</td>
</tr>
<tr>
<td></td>
<td>- Minimum repetition can represent the real social situation better.</td>
</tr>
</tbody>
</table>

**Exposing the patients with random events while still preserve its naturalness**

In this approach, stressors were exposed as a random paranoid thought provoking event performed by the elements of the VR world. As mentioned by Freeman (Freeman et al., 2006), patients suffering from paranoia tended to be more sensitive and started to notice internal or external events. When they noticed it, they would naturally try to understand and interpret it as if it had specific meanings even when it actually occurred randomly. Because of that, exposing stressors as random events could elicit paranoid thought when patients started to notice it and try to understand it.

However, randomly exposing the patients with stressors without managing it properly could lead to undesirable result since the events would look unnatural. For example, if eye gaze was used as a stressor, there might be a chance that lots of virtual characters gazed at the patients at the same time. Another example was that there might be a chance that the same virtual character kept gazing at the patients repeatedly. As a consequence, the patients’ presence level could decrease. Moreover, they might get scared not by the
stressors but by the unnatural behavior of the elements of the VR world, and this was not the appropriate method to increase their anxiety level.

To overcome the problem, a proper management system was required to synchronize the stressors with each other when it was exposed to the patient. The requirement and the underlying claim for this core function can be seen in Table 4.9.

A proposed approach for a stressor synchronization management was to use timers to synchronize stressor events performed by various elements of VR world. In this approach, events should occur only whenever the timer went off and once it went off, it would start again for the next cycle. From each timer, only one event would occur and it was determined by the probability of the stressors set by the therapist. Then, each timer was linked to one or more elements of VR world that perform similar events; forming into one group.

Table 4.9

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Stressor synchronization management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>The stressors are exposed as random paranoid thought provoking events. However, the stressors should be in synch with each other so the event can appear natural.</td>
</tr>
<tr>
<td></td>
<td>+ Increase patient’s presence level.</td>
</tr>
<tr>
<td></td>
<td>The naturalness of the event can represent the real social situation better.</td>
</tr>
<tr>
<td></td>
<td>- If not maintain properly, the stressors can scare the patient for the wrong reason.</td>
</tr>
</tbody>
</table>

With this approach, several elements of VR world that could perform similar events can be organized using one timer that linked them, especially since each timer would produce only one event per cycle. This meant that when the timer went off, only one element from the group could perform an event. Therefore, a situation where multiple elements perform at the same time could be avoided. In addition, different groups could be organized further by setting the starting time of the timer and its rate.

**Treatment Personalization**

Similar to the previous approach, allowing the therapist to personalize treatment scenario for each patient was important to help patients with different paranoid thought trigger. The associated requirement and claim can be seen in Table 4.10.

Table 4.10

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Treatment personalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>The application should allow the therapist to configure different treatment scenario and include or exclude stressors. Different scenarios can be created by configuring the probability of stressors to occur.</td>
</tr>
<tr>
<td></td>
<td>+ The treatment can suit the patient’s problem</td>
</tr>
<tr>
<td></td>
<td>- Increase the workload of the therapist</td>
</tr>
</tbody>
</table>
The disadvantage of treatment personalization was the increase of the therapist’s workload. To minimize the increase of the therapist’s workload in configuring treatment scenario, other requirements for treatment personalization was needed. Two ideas were proposed to solve the problem.

The first one was to separate the stressor configuration and the stressor controller. In the stressor configuration, the therapist only focused on creating a scenario by deciding which stressors should be included and configuring its probability to occur once the timer went off. The stressor configuration was done before the exposure and it could not be modified once the exposure started. In the stressor controller, the therapist only focused on controlling the stressors.

With separation, most of the therapist’s workload would be shifted toward pre-exposure phase, which was the moment when the therapist main focus was still not on the patients and the exposure. Therefore, when the exposure started, he could focus solely on the patients and the exposure without being distracted often by the need to modify the stressors.

The second idea was to allow the therapist to save a created scenario and re-use it in the future. This would minimize the workload of the therapist when he treated a patient with a similar paranoid thought trigger. The therapist could just load the scenario or modify it slightly before using it. Table 4.11 shows the requirement and the claim regarding of optimizing the therapist’s workload during the stressor configuration

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Shift most of the therapist’s workload toward pre-exposure phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>Claim</td>
<td>Scenario is configured during pre-exposure phase and the therapist is able to save a created scenario and reuse it later.</td>
</tr>
<tr>
<td></td>
<td>+ Taking scenario configuration to pre-exposure phase would reduce therapist workload during exposure (moment when he is really needed to attend to the patients).</td>
</tr>
<tr>
<td></td>
<td>Allowing the therapist to save and reuse a scenario would reduce his workload during scenario configuration, especially when he treated patient with similar paranoid thought trigger.</td>
</tr>
<tr>
<td></td>
<td>- The therapist cannot change the scenario without finishing the exposure first.</td>
</tr>
</tbody>
</table>

To configure the stressors, the therapist was provided with checkboxes and sliders. Checkboxes were used to choose which stressors to be included into the exposure, while sliders were used to configure the probability of the stressors. Higher probability was translated to higher chance for the stressors to occur once the timer went off and vice versa.
Exposure controller with minimum number of parameter to be controlled by therapist

In prolonged exposure approach, allowing the therapist to control the stressors during the exposure was important since he needed to modify the stressors level based on the patient’s responses. If the patient’s anxiety level was too low, the stressors level should be increased and vice versa. However, controlling the stressors should not be the therapist’s main task. Instead, he should focus more on monitoring the patient. Therefore, controlling the stressors during exposure should not distract him too much. To minimize the distraction, the application should allow the therapist to control the stressors with minimum parameter. One idea was to provide the therapist with just one slider to control the exposure.

In the proposed stressor synchronization management, a timer was introduced to decide when an event should occur. By controlling the rate of the timer to go off, the therapist could control the rate of the random events. This meant that a lower rate produced less random events and vice versa. With less random events, the patients might notice less stressors, which in turn might decrease their anxiety level. With the similar approach, more random events might increase their anxiety level. Therefore, it was possible to control patients’ anxiety level by modifying the rate of the events, and it could be done simply by using one slider. The requirement and the claim for this function are shown in Table 4.12.

However, providing only one slider for the therapist to control the stressors also meant that his option was restricted. In addition, the therapist could not change the scenario until the exposure finished. Moreover, the therapist could not change the rate for each stressor, as the slider only controlled the stressors as a whole.

Table 4.12
Requirement and Claims for the Stressor Controller

| Requirement                                                                 | Claim                                                                 |
|----------------------------------------------------------------------------|Adam|  The stressors are controlled just by using one slider which controls the rate of the timer in the stressor synchronization management. The modified rate in turn will modify the rate of the random events which in turn might change the patient’s anxiety level.  
+ Minimize the therapist’s workload during controlling the stressors.  
Optimize the therapist focus on monitoring the patient.  
- It is impossible to change the scenario or the rate of each stressor without finishing the exposure first. 
One slider can be too few for the therapist to control the stressors. |
|----------------------------------------------------------------------------|

4.2.2 Discussion with the Therapist

Another discussion with the therapist to review the prolonged exposure approach was conducted with the same participants as the previous discussion. In this discussion, the basic concept of the exposure and the low-fidelity prototype of both the stressor configuration and the stressor controller were presented to the therapists. In addition, storyboard was created to help the therapists understand the proposed approach from the set-up of the scenario and the stressors until the evaluation session with the patient.
The prototype of the stressor configuration can be seen in Figure 4.5. As explained previously, checkboxes were used to choose which stressors to be included into exposure and sliders were used to set the probability of stressors to occur. The stressors configuration was done before the exposure started and afterwards it could not be modified until the exposure finished.

![Figure 4.5 Low-fidelity prototype of the Stressor Configuration](image)

The prototype of the stressor controller can be seen in Figure 4.6. Here, the therapist could understand the patient’s condition using several indicators: SUD score, heart rate, or Galvanic Skin Response. Based on these indicators, the therapist used the slider to modify the stressors level. Higher stressors level was translated to higher chance for random events to occur which might increase the patient’s anxiety level and vice versa. When the therapist modified the slider, the stressors level in the VR world would change instantly.

![Figure 4.6 Low-fidelity prototype of the Stressor Controller](image)

Overall, the therapists supported the core functions and its claims. They supported the idea of using random events to expose the stressors, and, if it was done properly, the random events could really represent the randomness in real social situation. The idea that the patients only sat during the exposure was understandable since it was a method to limit the interaction between the patients and the elements of the VR world. They had no problem to use only one slider to control the exposure; however, they also agreed that it needed to be investigated further.

The therapist supported the idea that the patients should be instructed to observe their surrounding during exposure. However, the task did not guarantee that they would keep on observing their surrounding for the whole exposure. Therefore, it was agreed that additional task might be needed by therapist during exposure.

However, there was difficulty in finding what kind of additional task should be given. Suggestions about finding numbers on the body of the virtual character were declined because it could distract patients’ attention from observing the surrounding and noticing the stressors. Other suggestion about finding the most suspicious virtual characters were
also declined because giving pre-conception that there was always a suspicious person in a social situation was contradicting with the real social situation where it was unlikely that a suspicious person existed in that situation. In addition, it was also declined since the focus of the exposure was to learn how to remain calm, not to suspect someone. In the end, the additional task was still undecided until the end of the discussion.

The therapists made two recommendations when they were asked about where should patients sit in the restaurant. First, they suggested that patients sit in the middle of the restaurant since it was the best place for patients to maximize the learning process. Patients tended to avoid sitting in this position because the stressors could be exposed to them from all directions. By forcing them to sit in this position and maximizing the location of the source of the stressors, the learning process could be maximized as well.

However, for other patients in the beginning of the treatment, the therapists suggested that they should sit somewhere safer, such as in the corner of the restaurant or with their back faced to the wall. Here, they could be more relaxed since the stressors could only come from certain direction.
5 Design and Implementation

This chapter focuses on describing the Design and Development phase of the application’s prototype. The main goal of this phase was to develop the application’s prototype based on the created preliminary vision. Afterwards, the prototype would be tested in the testing phase. The design process in this phase included the selection of stressors which would be included in the prototype, the construction of the system architecture, the design of the user interface, and the design of the VR world.

During this phase, a discussion session with the therapists to review the design of the prototype was conducted. To help the therapists understand the prototype, a short movie was created to explain the system architecture, the user interface, and the VR world. The feedbacks from the discussion were used to refine the design further. In the end, a prototype of the application was created and was used for the testing phase in an experiment.

The chapter starts by elaborating the preliminary vision of the application. Then the focus is shifted to the stressors which were included in the prototype and which element of the VR world would perform it. Next, the application’s system architecture is elaborated. Then, the stressor manager algorithm, which was the algorithm to choose the random event, is elaborated. Afterwards, the design of the VR world and the design of the user interface are elaborated. In the end, the chapter is concluded with the result of the review session with the therapist.

5.1 Preliminary Vision

From the discussion with the therapists about the prolonged exposure approach, they supported the core functions and the associated claims. In addition, several additional feedbacks were made and were used to refine preliminary requirement baseline. Afterwards, this refined preliminary requirement baseline was used to design and develop the application. Before starting the design phase, a preliminary vision for the application was formulated.

Therapy Concept

The therapy would be based on prolonged exposure approach where the goal was to teach the patients to remain calm in a social situation by exposing them in the virtual environment using one or more stressors for a prolonged time. If they were able to remain calm and not avoid the social situation, then they were one step closer toward the goal.

Before the therapist decided to use the application as a tool to help the treatment, he needed to understand the patients and their paranoid thought trigger. This was necessary since he needed the information to create a scenario that suited the patients’ problem. When he was satisfied with the created scenario, the exposure therapy could start.

After the exposure started, the first step was to increase the patients’ anxiety level to a certain level by modifying the stressors level. When this level was reached, the therapist
then monitors the patients’ response. Throughout the exposure, the therapist aimed to control their anxiety level within certain bandwidth. If there was a significant change to their anxiety level, he could modify the stressors level to adapt to the change. A good sign of a successful therapy was if whether patients’ anxiety decreased in the condition set by the therapist. When the exposure finished, the therapist could have an evaluation session with the patient to discuss the progress of the therapy.

**Stressors and Stressor Synchronization Management**

In chapter 2, the potential stressors which were potentially appropriate, applicable, and helpful for exposure therapy are listed. These potential stressors were:

1. Pre-narrative Text.
2. Information About Danger.
3. Laughing.
5. Eye Gaze.
6. Coincidental Event or Unexpected Event.
7. Appearances and Facial Expression.
9. Darkness / Lighting.
11. Color.
13. Ambiguous messages in media such as music or TV.

Not all the stressors were used in the prototyping phase because the focus of the prototyping phase was to test whether it was possible for the therapist to control the patient’s anxiety level using only one slider. Therefore, it was not necessary to use all of the listed stressors. Only stressors which were applicable and look natural in a restaurant social situation were used. Detailed explanation about this is given in section 5.2 (Stressors).

All the stressors in the application were exposed as random paranoid thought provoking events that were triggered according to the associated timer. Timers were used to manage the synchronization among stressors. To extend the idea, a stressor synchronization management system consisted of managers, subordinates, and timers was created. Figure 5.1 shows how stressor synchronization management is realized with these 3 components.

The timer was the component that decided when an event should occur. Everytime the timer set off, it sent a notification to the manager so it could start processing the next step.

The manager was the component that decided what event should occur and which subordinate should perform it. In addition, the manager also kept track of which subordinate had been chosen previously to avoid choosing the same subordinate repeatedly. In deciding which event should occur, the manager based it on the probability of the stressors. When the choice was made, it sent a notification to the chosen subordinate.
The subordinate was the component that linked the event directly to the respective element of VR world. The element could be a single virtual character, multiple virtual characters, or other non-virtual character element such as lighting, TV, or music. When the subordinate received a notification from the manager, it instantly controlled the act of the respective element.

![Diagram showing the relationship between Timer, Manager, Subordinate, and VR element]

**Virtual Environment**

The virtual environment in the application would simulate a social situation in the restaurant. Patients would be customers who sat in the middle of the restaurant. This location was chosen to allow the stressors to come from all directions. Their movement was limited and they could only observe the surrounding from their seat.

There were two different roles for the virtual characters in the virtual environment. One group of virtual characters had the role as customers that sat around the patient. They would have basic animation that imitated the natural behavior of people inside a restaurant, such as eating or talking to other virtual characters. Other group of virtual characters had the role as people who walk inside or outside the restaurant. All the virtual characters were programmed to not initiate direct interaction with patients.

Most stressors in the virtual environment (e.g. eye gaze, snatches of conversation, laughing, etc.) were performed by the virtual characters. In addition, other elements of VR world (e.g. music, TV, or lighting) could also perform stressors.

Initially, all the events occurring in the virtual environment were neutral events where all the virtual characters did not have specific tasks, and did not show specific emotions. This included the animation/behaviour of the virtual characters where it was not aimed to provoke specific thought from patients. In addition, additional neutral events such as neutral dialogs between virtual characters and neutral news flash in TV screen could trigger occasionally. These additional events were considered by the manager only when it chose no random paranoia provoking event. However, when the timers set off and the random paranoia provoking events occurred, it was executed on top of the neutral events and the additional neutral events.

For the application, configuring the probability of the stressors only determined whether the paranoia provoking events occurred more often or not, and it did not have any direct relation with the neutral events or the additional neutral events. As a result, a more paranoia provoking scenario was basically a scenario where stressors occurred more often.
and it covered up the neutral events. On the other hand, a more relaxing scenario was basically a scenario where stressors occurred less often, and because of that, it let the neutral events to occur more often.

Figure 5.2 shows the relation between paranoia events and neutral events in the virtual environment. Detailed explanation about how the paranoia events and the additional neutral events were chosen by the manager and afterwards occurred in the virtual environment is given in section 5.4 (Stressor Manager Algorithm).

![Figure 5.2 Relation between paranoia provoking events and neutral events](image)

**Therapist User Interface**

The therapist user interface was divided into two parts. The first part was the stressor configuration where the therapist created the scenario and determined which stressor should be included into the exposure using checkboxes and sliders. Checkboxes were used to choose which stressor was included into the exposure. On the other hand, sliders were used to determine the probability of the stressors. On the side of each slider, numbers that represented the probability set by the slider were shown to help the therapist. The stressor configuration could only be done before the exposure started. When it started, the configuration could not be modified until the exposure finished.

In the stressor configuration, the therapist could also save a scenario and reuse it in the future. Once the therapist was satisfied with the created scenario, he could save the scenario into a file. When he wanted to use similar scenario, he could just load the file and used it directly or modified it slightly before the exposure.

The second part of the user interface was the stressor controller that allowed the therapist to control the rate of the random events using just one slider. When the slider was changed, the stressor level in the virtual environment would instantly change.

To help the therapist understand the patients’ condition during the exposure, the application would provide their SUD score, heart rate, and Galvanic Skin Response. Based on this information, the therapist could make necessary changes on the stressor level to adapt to patients’ condition.
5.2 Stressors

The created preliminary vision listed all stressors that were considered potentially appropriate, applicable, and helpful for exposure therapy, especially in clinical practice. However, not all of these stressors were necessary to be included into the prototype because the main purpose of the testing phase was not to investigate which stressors were effective to elicit paranoid thought. Instead, it was to investigate whether it was possible to control the patients' anxiety level with the provided stressor controller. Therefore, only some of the listed potential stressors were included into the prototype.

The stressors were selected based on the likelihood of the stressors to occur in a restaurant. The reason was to maintain the naturalness of the simulated social situation so it could represent the real world. Therefore, stressors that were rarely occurred in a restaurant or were unnatural to occur in a restaurant were not considered. From the list of the stressors in the preliminary vision, the stressors which were included in the prototype were:

1. Eye gaze
2. Facial Expression
3. Snatches of conversation
4. Laughing
5. Passing by people
6. Ambiguous messages in TV
7. Population density

Eye gaze as stressor simulated the event where people were gazing or looking at other people either intentionally or not. For the prototype, when the eye gaze was triggered, a virtual character would always look at the patients for several seconds and afterwards return to its basic animation. For some virtual characters, later in this section would be referred as walking virtual character, they could look not only at the patient, but also at other virtual characters.

Facial expression as stressor used only two basic facial expressions: angry and happy. Only virtual characters that sat close to the patients could show facial expression since the patients could still recognize the changes in its facial expression from their position. If the virtual characters sat further, it would be very difficult to recognize the changes. Figure 5.3 shows both facial expressions.

![Figure 5.3 Virtual character's facial expression](image)

(a) happy  (b) angry
Snatches of conversation were set as a stressor that simulated the snatches of conversation that people could hear in the restaurant. The conversation consisted of neutral dialogs and paranoia dialogs. The paranoia dialogs were used to elicit paranoid thought on the patients when they heard it. To achieve it, the content of the dialogs were made to be full of negativity. In addition, it was made to be ambiguous so that the patients, by mistake, might relate the content of the dialog to them. On the contrary, the neutral dialogs were used with the intention not to elicit specific thought or feeling. It was used as one of additional neutral events. For the prototype, eight people (four males and four females) were recruited to become the voice actors for the snatch of conversation stressors. Since the number of voice actor was limited, the system allowed the same voice to be used by different virtual characters even if their placement were different.

TV as stressor was used to broadcast message on the TV screen that the patient could read in the restaurant. The broadcasted message consisted of neutral TV news flashes and paranoia TV news flashes which had similar idea to the snatches of conversation. In paranoia TV news flashes, the broadcasted messages had the purpose of eliciting paranoid thought by broadcasting messages that full of negative theme such as crime, social insecurity, and local or global problem. On the other hand, in neutral TV news flashes, the broadcasted messages used neutral themed news with no intention in eliciting specific thought. Similar to neutral snatches of conversation, it was used as one of additional neutral events.

To create the dialogs for snatches of conversation and the texts for news flash, a list of items based on Visual Analogue Scale (VAS) was created. The list contained 52 dialogs for snatches of conversation and 27 texts for news flash. From those dialogs, 37 were paranoia dialogs and 15 were neutral dialogs. On the other hand, from those news flash texts, 14 were paranoia news flashes and 13 were neutral news flashes. The list was sent to a set of expert consisted of 3 patients suffering from paranoia and 7 therapists with experience in treating paranoia. They were asked to rate on how likely the dialog or the news flashes would cause suspicious or paranoid thought when they noticed it. The neutral dialogs and news flashes were included in the list to ensure that the experts group also thought that they were indeed neutral. The content of the list can be seen in appendix D.

Dialogs or news flashes which were included into the application were based on the distribution of data. Figure 5.4 the boxplot of the dialogs and news flashes data. For the neutral dialogs (Figure 5.4 (a)) and neutral news flashes (Figure 5.4 (b)), if there was outlier which was significantly higher, it would not be included into the application. On the other hand, for the paranoia dialogs (Figure 5.4 (a)) and paranoia news flashes (Figure 5.4 (b)), if there was outlier which was significantly lower, it would not be included into the application. In the end, all 52 dialogs and 27 news flashed included in the list were included into the application.

Passing by people as stressor simulated the event where people might walk passing by the restaurant, either from inside or outside. In the prototype, the passing by people were triggered as one of two events: the virtual character just walked in a designated route without stopping, or the virtual character walked and then stopped in the middle of its
route to look at the patient's or other virtual character before continued to walk. To realize both of these events, passing by stressor was divided further into two separate stressors: walking and looking. Walking stressor only represented whether the virtual character would walk or not, while looking stressor represented whether the virtual character would stop during his walk to look around or not.

In the VR world, all the stressors were performed by one or more elements of the VR world. These elements were divided into four types, and each type would execute different group of stressors. These four types were:

1. Individual sitting virtual character, which were virtual characters that sat alone in the restaurant. Virtual characters that belong to this group could perform eye gaze and facial expression stressors.
2. Group sitting virtual character, which were virtual characters that sat in the restaurant as a group. Virtual characters that belong to this group could perform eye gaze, facial expression, snatch of conversation, and laughing stressors. However, since the number of virtual character in the prototype that could show facial expression was limited, none of the virtual character in the group sitting virtual character could perform facial expression stressor.
3. Walking virtual character, which were virtual characters that walked around as passerby. Walking virtual character performed passing by people stressor.
4. Other element, which in the prototype consisted only of TV. TV performed TV news flash stressor.

### 5.3 System Architecture

Designing the application's prototype started with the construction of the system architecture. The system architecture did not only address the components that were...
inside the prototype, but also on how the prototype interacted with the user, with the hard
disk, and with each component. Furthermore, it also described the stressor synchronization
management, including the use of multiple timers and managers to synchronize the
random paranoia provoking events. The system architecture can be seen in Figure 5.5.

The complete explanation of each block in the system architecture can be found in the
appendix E. To interact with the application, the therapist was provided with 4 blocks:
Scenario Configuration to load and save a scenario, VR World Element Configuration to
include and exclude virtual characters or other VR elements into the VR world, Stressor
Configuration to include or exclude the stressors and to configure the probability of the
stressors, and Rate Controller to control the rate of the random events.

Rate Controller linked directly with Event Trigger, which worked as the timer for the
random event. Here, multiple timers were used to manage the random event of similar
group. If the therapist changed the value of the rate using the Rate Controller, the rate of
the timer in Event Trigger would change instantly. When the exposure started, the starts of
all timers were randomized to avoid all timers started at the same time. When the timer
set off, Event Trigger sent notification to the respective Stressor Manager.

Stressor manager was responsible for choosing an event based on the configuration made
by the therapist through the Stressor Configuration. How the Stressor Manager chose an
event is explained in detail in section 5.4 (Stressor Manager Algorithm). Then, the chosen
event was passed to the respective Event Coordinator.

Event Coordinator determined which subordinate should act. Event Coordinator chose the
subordinate randomly. After choosing the subordinate, the Event Coordinator would pass
the chosen event to the chosen subordinate.

Each element or group of elements of the VR world was handled by one subordinate. Each
subordinate, in this research, is categorized into one of six types:

1. **Emotion Sitting Coordinator**, which handled all the virtual characters that were able
to perform facial expression stressors. For the prototype, this also meant that
Emotion Sitting Coordinator handled individual sitting virtual character since only
this type of virtual character could perform facial expression stressors.
2. **Left Sitting Coordinator**, which handled all group sitting virtual characters that were
placed on the patient’s left front side.
3. **Right Sitting Coordinator**, which handled all group sitting virtual characters that
were placed on the patient’s right front side.
4. **Back Sitting Coordinator**, which handled all group sitting virtual characters that
were placed on the patient’s back side.
5. **Walking Coordinator**, which handled all walking virtual character in the VR world.
6. **Other Coordinator**, which handled other element in VR world, which in the
prototype was TV.

Each similar type of subordinate formed a group which was managed by one Event
Coordinator.
Figure 5.5 System architecture of the VRET system for paranoia treatment
Initially, there were only three Event Coordinator blocks and three types of subordinates. However, with this setup, the maximum number of random events whenever the timer set off was three. It was discovered later on, that these numbers were too small. With only a maximum of three events triggered per cycle, the patients might miss the events, especially events that based on eye gaze, facial expression, passing by, and TV stressors which could only be noticed by seeing it directly. Therefore, the number of Event Coordinator and the subordinate were added to overcome this problem.

Because the number of Event Coordinators and the subordinates were added, there were four Event Coordinators which controlled four groups of Sitting Coordinator. Three of those groups handled group sitting virtual character that could perform snatches of conversation or laugh stressor. As a consequence, there might be a chance where three snatches of conversation or laugh event occurred at the same time. If it occurred, the sound might become incomprehensible. As a result, the effectiveness of the stressor might be dropped. To overcome this problem, it was decided to force that, at maximum, only one laugh and one snatch of conversation could occur every time the timer set off. In addition, the beginning of the dialog or laugh was randomized to minimize the possibility of two sounds triggered at the same time.

When the subordinate received a notification from the Event Coordinator and the chosen event from the Stressor Manager, it would pass the chosen event to the respective element of the VR world so it could perform accordingly. For group sitting virtual character, the respective subordinate would randomly choose one of the virtual characters in the group to perform the event.

VR manager was the block responsible to manage the VR world and its element. When an event was triggered, the VR Manager would use the command from the Sitting Virtual character, Walking Virtual character, or Other Element to make necessary changes on the associated element of the VR world accordingly. In the end, the VR world and its element including the random event were shown to the patient through the use of the Display and Speaker block.

5.4 Stressor Manager Algorithm

Stressor Manager was the block in the system architecture that was responsible to choose an event that in the end would be performed by the respective element of the VR world. To choose an event, Stressor Manager implemented Stressor Manager Algorithm that was designed using a probabilistic approach. Before the Stressor Manager could work, the probability of each stressor needed to be configured by the therapist during the stressor configuration.

There were two kinds of probability used in the stressor configuration. The first one was the single probability of which the therapist configured the probability of single stressors to occur in an event. It ranged from 0 to 100 where 0 meant that the stressor would never occur and 100 meant that the stressor would always occur. Examples of stressors associated with single probability were eye gaze, passing by people, and TV.
The second one was the paired probability of which the therapist configured the probability of a pair of stressors. Here, the probability controlled the likelihood of one of the pair of the stressors to occur in an event. For example, if A and B were a pair of stressors, then if the probability was set to 75 percent, it meant that A could occur with 75 percent chance, otherwise, B would occur. Only one stressor could occur in an event. The paired probability ranged from 0 to 100 where 0 meant that B would always occur and 100 meant that A would always occur. The reason for creating paired probability because some stressors could not occur simultaneously. Such example was facial expression where a virtual character could not show both expressions simultaneously.

In relation with the paired probability, there was one single probability for each paired probability that controlled whether the result of paired probability occurred or not. Without this probability, an event would always occur regardless of the result of the paired probability. As a consequence, it was impossible to control the occurrence of the event especially if the therapist wanted to create a more relaxing scenario. There were three single probabilities created for this purpose:

1. Emotion probability to control facial expression (angry and happy)
2. Talking probability to control snatches of conversation and laughing
3. Looking probability to control the eye gaze of the walking virtual character (to patient or to other virtual character)

Once the therapist configured the stressors, the Stressor Manager could use it to choose an event during exposure. Figure 5.6 shows the flowchart of the Stressor Manager Algorithm.

When the Stressor Manager received a notification to choose an event, each stressor would be represented by binary number. For single probability, 1 meant that the stressor would occur and 0 meant that the stressor would not occur. On the other hand, for paired probability (A-B), 1 meant that A would occur and 0 meant that B would occur. Whether the binary numbers would be 0 or 1 were based on the probability set by the therapist.

Afterwards, all the binary numbers were used to construct an n-digits binary number where n represented the number of stressor that the Stressor Manager was responsible for. For example, stressor manager for individual virtual character consisted of three digits (for eye gaze, emotion, and angry-happy pairs), while stressor manager of TV consisted of one digit (for TV). Finally, this n-digits binary number was decoded into the event. Because the n-digits binary number could consist of several stressors, therefore, an event could be a
combination of two or more stressors that occurred simultaneously. Such example was the event where the virtual character was performing both snatch of conversation and eye gaze stressor simultaneously.

When formulating the decoder, the hierarchy of the stressor was considered. This meant that the occurrence of certain stressors was depended on other stressor. Figure 5.7 shows the hierarchy of the stressors.

Each paired probability was depended on its related single probability. For example, angry-happy pair was depended on emotion. Whenever the related single probability did not occur, the paired probability would also not occur regardless of its result.

For sitting virtual character, talking and eye gaze were on the same hierarchy. This meant that both stressors could occur without depending on each other. However, emotion depended on eye gaze, since virtual characters could not show its expression without looking at the patients. If eye gaze did not occur, emotion would automatically not occur (even when the probability was 100%). For walking virtual character, looking as stressor depended on walking. If walking did not occur, the looking would automatically not occur.

Some Stressor Managers could also consider triggering additional neutral events. Additional neutral events in the prototype only consisted of two events: neutral snatch of conversation for group sitting virtual character and neutral TV news flash for TV. These events were considered only if the decoding process resulted in no paranoia provoking events occurred at all. If the events were considered, it had 25% chance of occurring.

In the end, if the Stressor Manager managed to choose an event, it would be passed to the respective VR world’s element to be acted upon accordingly.
5.5 Virtual Environment

For the virtual environment, the application used the restaurant environment which had been used in the first experiment (Brinkman et al., 2012). The layout of the virtual environment can be seen in Figure 5.8.

The patients (triangle) were seated in the middle of restaurant and their movement was limited. They could not walk around; however they could still turn their head or their chair to observe the virtual environment.

In this virtual environment, a total of 23 virtual characters and 6 TVs could be used to expose the stressors to the patient. From the 23 virtual characters, 18 virtual characters were active virtual characters and 5 virtual characters were passive virtual characters. Active virtual characters (star) were virtual character that could expose the stressors to the patient actively since they could face the patient. These stressors included eye gaze, facial expressions, passing by, etc. On the other hand, passive virtual characters (circle) could only expose the stressors to the patient passively. These stressors only included snatch of conversation and laughing.

![Figure 5.8 Layout of the VR world](image)

The virtual characters in the VR world consisted of:

1. Three virtual characters as individual sitting virtual character type (E, F, and I) that belonged to Emotion Sitting Coordinator subordinate.
2. Two groups of virtual characters as group sitting virtual character type (C and H) that belonged to Left Sitting Coordinator subordinate.
3. Two groups of virtual characters as group sitting virtual character type (D and G) that belonged to Right Sitting Coordinator subordinate.
4. Three groups of virtual characters as group sitting virtual character type (J, K, and L) that belonged to Back Sitting Coordinator subordinate.
5. Two virtual characters as walking virtual character type (A and B) that belonged to Walking Coordinator subordinate.
The walking virtual character walked by following a pre-determined route, which was represented by the arrow in Figure 5.9. In some events, the virtual character could stop at random location inside the box during its walk to look at the patient or at other virtual character before continuing his walk.

To configure the population density of the VR world, the therapist could select or de-select the VR world’s element during the stressor configuration. However, the therapist could only select or deselect the whole table, not per individual virtual character.

![Figure 5.9 The walking route and the random stop area of the walking virtual characters](image)

There were a total of nine TVs in restaurant of which six TVs were used to expose the TV stressors. The other three were not used because it was impossible from the patient’s position to see what was shown on the TV. Three TV monitors were placed at the left side of the patient and six LCD TV monitors were located at the right side of the patient. The layout of the TV placement in the virtual environment can be seen in Figure 5.10.

![Figure 5.10 Position of TV in the VR world](image)
Initially, all the TVs were showing newscasters of a news program. When the event involving TV was triggered, a text represented the title of the TV news flash was shown. After 8 seconds, the text disappeared and a random short video of a field reporter was shown. Afterwards, a random video showing the initial newscaster was played. Hence, a TV event was made to look like a real complete news flash which was part of a news program that started from the headline text of the news flash, followed-up by a field reporter who appeared as he was reporting the news, and finished by returning the news program to the newscaster.

De-selecting the TV during the stressor configuration meant that the TV would not be used as a stressor. However, the TV was not removed from the virtual environment, and it just played the newscaster video without ever showing any news flash or any field reporter video. In addition, the additional neutral events of neutral news flash was also not triggered.

5.6 Therapist User Interface

The design of the therapist user interface in this research expanded the VRET system’s therapist user interface that had been developed previously by Delft University of Technology. The elements of the therapist user interface consisted of the session information, the system status, the patient condition’s chart (SUD Score, Heart Rate, Galvanic Skin Response, etc.), the note/flag for the therapist, and the therapist VR world controller. This research only expanded the system status and the therapist VR world controller to match with the needs of the therapy procedure. Figure 5.11 Therapist user interface of the VRET system shows the therapist user interface.

![Figure 5.11 Therapist user interface of the VRET system](image)

Figure 5.11 Therapist user interface of the VRET system
5.6.1 System Status
The system status provided the therapist with the information about the VR world. In this research, three information elements about the VR world were provided using three status indicators. The first information element related to the loading process of the VR world, while the second information related to the loading process of the virtual characters and the stressors. Both status indicators would turn on if the loading process finished. The third information element related to the exposure. If the exposure was running, the status indicator would turn on. When the exposure finished, all status indicators would turn off. The design of the system status can be seen in Figure 5.12.

![Figure 5.12 Design of the System Status](image)

The reason for providing this information was to avoid system crash caused by starting the next process before the previous one finished. For the application to work properly, the loading process of the virtual character and the stressors should start only after the loading process of the VR world finished. Furthermore, the exposure should start only after the loading process of the virtual character and the stressors finished. Since the therapist could not see what happened beneath the system, therefore, the system status would help him in obtaining this information.

5.6.2 VR World Controller
The VR world controller for the therapist consisted of two tabs, the stressor configuration tab and the stressor controller tab. In the stressor configuration tab, the therapist configured the stressor for the VR world, while in the stressor controller tab, he controlled the stressors in the VR world.

Stressor Configuration Tab
Stressor configuration tab consisted of VR World Element Inclusion group box, Stressor Probability Configuration group box, map of the VR world, load scenario button, and save scenario button. Figure 5.13 shows the design of the stressor configuration tab.

VR World Element Inclusion group box was a group box in which the therapist could select or de-select the virtual characters through check boxes. However, he could only select or de-select the whole table, not per individual virtual character.

A map was placed next to the Stressor Inclusion group box to help locating the virtual character. When the mouse was hovering on top of a check box, the associated virtual characters would be shown in the map and their color would turn either yellow (active
virtual character) or red (passive virtual character). Furthermore, if the mouse was hovering on top of check boxes of virtual characters that belonged to the walking virtual character type, the map would also show its walking route and its random stop area.

Figure 5.13 Design of the Stressor Configuration Tab

The Stressor Probability Configuration group box was a group box in which the therapist could configure the probability of the stressors of the VR world by moving the associated slider to the desired number or typing in the desired number in the associated text box. Single probability was represented using slider with a label only on the left side of the slider, while paired probability was represented using slider with a label on both sides of the slider.

Load scenario button and save scenario button were used to load a scenario from the file and save it for re-using it in the future.

**Stressor Controller Tab**

Stressor controller tab consisted of the Exposure Configuration group box, Narrative Text group box, start exposure button, emergency stop button, and update rate controller slider. Figure 5.14 shows the design of the stressor controller tab.
Exposure Configuration group box was the group box in which the therapist could load the VR world, the virtual character, and the stressors. In addition, the therapist could set the patient’s gender using the patient gender radio button, and set the exposure duration using a text box or a spin box.

Setting the patient’s gender was important because most of the sentences used for the snatch of conversation contained words that were gender-dependent (he/she, him/her, his/her). As a result, to increase the chance that the patient would relate the conversation to himself, the patient’s gender needed to be set correctly.

The loading process was separated between the loading process of the VR world and the loading process of the virtual characters and the stressors. It was necessary since both the therapist and the patients could use the VR world to help them during the process of putting on the HMD. In addition, the loaded VR world was necessary during the calibration of the patient’s view since their initial view was not automatically located in the correct position and orientation due to the limitation of the software.

Afterwards, the selected virtual characters and the selected stressors could be loaded into the VR world. Once the loading process started, the stressor configuration tab would be locked and the therapist could not make further change on it until the exposure finished. When the loading process finished, the therapist could show a narrative text to the patients’ view using the Narrative text group box or start the exposure directly.

Narrative text group box was a group box in which the therapist could create, save, load, or show a narrative text to the patient’s view. The narrative text could be used as additional stressors to patients or to inform them about the situation they were put into.

When the exposure started, the therapist controlled the rate of the random event using the update rate controller slider. The rate of random events would change instantly when the therapist released the slider.

The timer displayed in the therapist user interface only displayed the timer for the Event Trigger related to sitting virtual character (with range from 60 seconds to 10 seconds). However, the slider was actually also connected to two other timers which related to walking virtual character and TV. In other words, moving the slider would not only change the sitting virtual character timer but also the other two timers. The timer for walking virtual character was always 40 seconds larger than the timer for sitting virtual character, while the timer for TV was always 10 seconds larger than the timer for sitting virtual character.

5.7 Discussion with the Therapist

After the designing of the application finished, another discussion with the same therapists was organized to review the design. To prepare the discussion with the therapist, an early prototype of the application was developed to help the therapist understood the expected prototype. Afterwards, a video was made to explain the result of the design and the expected prototype. Still of the video can be seen in Figure 5.15. The video contained explanation on:
1. System architecture
2. Stressor Manager Algorithm
3. Therapist user interface (explained using the early prototype)
4. The virtual environment (explained using the early prototype)
5. The stressor including how it is executed in the virtual environment (explained using the early prototype)

Figure 5.15 Still of the video created for the discussion

Overall, the therapists agreed with the created design. In the end, all the results of the discussion were used to refine the design and to develop the prototype of the application.
6 Second Experiment: Evoking and Controlling Paranoid Thought

This chapter focuses on describing the second experiment that was conducted to investigate if the participants’ paranoid thought comments could be evoked and controlled by changing the rate and the probability of the random paranoia provoking events.

This chapter starts with explanation on the background and the purpose of the experiment. Then, the experiment method is described, including the participant, the measure, the setup, and the procedure. Afterwards, the results are presented and discussed. The chapter is concluded by discussing the conclusion from the result.

6.1 Introduction

In the prolonged exposure approach, the therapist aimed to control the patients’ anxiety level within certain bandwidth. To control the anxiety level, two methods were proposed: by changing the probability of the random paranoia provoking events during stressor configuration, and by changing the rate of the events during the exposure. For the former method, it was hypothesized that the therapist could create a more relaxing scenario where the stressors rarely occurred, or a more paranoia provoking scenario where the stressors often occurred. For the latter method, it was hypothesized that faster rate would give more chance for stressors to occur. In addition, it was hypothesized that there was interaction effect between the probability of the stressor and the rate of the events. Evoking paranoid thought solely using the rate of events might be difficult if its probability was set very low. Therefore, for rate of events to be effective in evoking paranoid thought, there should be an interaction with the probability of events.

Since the ability to control the patients’ anxiety level was an integral part in the prolonged exposure approach, it was important to examine whether the proposed methods were actually feasible. Hence, an experiment was conducted to find out whether the participants’ paranoid thought could be evoked and controlled by changing the rate of the random paranoia provoking events and the probability of the events. The participants for this experiment were recruited from the non-clinical population. Therefore, they were primed first prior to exposure with the paranoid priming that was used in the first experiment.

Three hypotheses were formulated before the experiment was conducted:

H1: Compared to a slower rate of paranoia provoking events, a fast rate of these events would elicit more paranoid thought.

H2: Compared to a lower probability of events, a high probability of events would elicit more paranoid thought.

H3: There is an interaction effect between the rate of paranoia provoking events and the probability of events on the amount of the elicited paranoid thought.
6.2 Method

6.2.1 Design
As shown in Figure 6.1, the experiment was set up with a two by two within-subject design where each participant was immersed in all conditions and the order was counterbalanced. In addition, the experiment implemented a double blind procedure where both the participants and the experimenter did not know the order of the experimental condition. In total, participants were exposed in four conditions. The experiment was approved by TU Delft Ethics committee.

The within subject factors consisted of two independent variables. The first one was the rate of random paranoia eliciting events that consisted of two levels: fast, which referred to faster rate of events, and slow, which referred to slower rate of events. In the fast level, the timers for the sitting virtual character, walking virtual character, and TV were set respectively: 10, 50, and 20 seconds. On the other hand, in the slow level, the timers were set respectively: 18, 90, and 36 seconds. When the exposure started, the start of all timers in all experimental conditions was randomized to avoid all timers started at the same time.

The second within-subject factor was the probability of events factor that consisted of two levels: high and low. In the high level, the probability of all single probabilities was raised to 80%. On the other hand, in the low level, the probability of all single probabilities was reduced to 20%. The probability of all three paired probabilities (i.e. angry-happy, snatch-laugh, look at patient-look at other) was preserved at 50% in both levels.

<table>
<thead>
<tr>
<th>Rate of Random Events</th>
<th>Paranoid Thought</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast</td>
<td></td>
</tr>
<tr>
<td>Slow</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability of Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
</tr>
<tr>
<td>Low</td>
</tr>
</tbody>
</table>

The participants were immersed only in one virtual environment, which was the restaurant environment (Brinkman et al., 2012). To minimize carry over effect, four different setups of virtual characters, its position and orientation, and its basic animation were created and each was used only once in each condition. Although the position, orientation, and basic animation of the virtual character were fixed in each setup, the virtual character which was assigned to the given position, orientation, and basic animation was always randomized. Therefore, although two different participants could have the same setup, however, they would experience it differently since the same virtual character in both setups could be placed in different position. Further explanation on the virtual environment can be found in section 6.2.5 (Virtual Environment).
6.2.2 Measures

Similar to the first experiment, two sets of questionnaires were used: the pre-experiment questionnaire set and the experiment questionnaire set. All the questionnaires used in this experiment were the same as the questionnaires used in the first experiment, with the exception of Social Interaction Anxiety Scale (SIAS) that was added to the pre-experiment questionnaire set. Therefore, with the exception of SIAS, detail explanation on each questionnaire can be found in chapter 3.

Social Interaction Anxiety Scale (SIAS) measures the social interaction anxiety on individuals (Mattick & Clarke, 1998). Social interaction anxiety relates to the distress feeling whenever an individual meets or talks to other people. SIAS consists of 20-items which are rated on 5-point scale. Higher scores indicate higher social interaction anxiety.

Similar to the first experiment, three additional measures were also included: Subjective Unit of Discomfort (SUD) Score, physiological measurement, and paranoid comments. The detail explanation of the SUD score can be found in chapter 3.

The participants’ physiological measurement during exposure was recorded using Mobi8 data recorder from TMSi. However, in addition to the participants’ heart rate (HR), the participants’ Galvanic Skin Response (GSR) was also measured using the two fingers electrode.

The paranoid comments used the similar concept as the first experiment where the data was based on the recording of the comments made by the participant during the experiment. However, in addition to make running commentary during the exposure, the participants were also asked to describe their experience after the exposure. Therefore, each recording consisted of two phases: exposure phase and interview phase. The exposure phase related to the phase where the participants made comments about the virtual characters and the virtual environments during the exposure, while interview phase related to the phase where the participants described their experience in the virtual environment during an interview session conducted after the exposure. Detail explanation on each phase can be found in 6.2.6 (Procedure). The total amount of the recording data was ± 415 minutes (four conditions of ± four and a half minutes session from each of 24 participants).

For this experiment, two coding schemes were used to code the comments made by participants. Both coding schemes were mutually exclusive where one comment could only be coded into one category in each coding scheme. The total numbers of coded comments in both coding schemes were the same.

One coding scheme was created based on the coding scheme used in the first experiment. In addition to the previous three categories, one new category was added to the coding scheme. Table 6.1 shows these four categories with examples.

The other coding scheme was based on the type of the paranoid thought trigger. There were nine categories created for paranoid thought trigger. These categories consisted of the seven stressors included in the prototype (eye gaze, emotion, laughing, snatch of conversation, walk, walk and look, and news flash) and two additional categories: other and
unclear. Other was used whenever the coder could understand the paranoid thought trigger from the participants’ comment, however, it was not part of any of the seven stressors (e.g. *the way he dresses makes me feel insecure*). Unclear was used whenever the coder could not find the paranoid trigger from the participants’ comment. An instance where this could happen was when the participants only mentioned that they were feeling scared or uncomfortable without specifically mentioned what made him feel it.

Table 6.1

*Coding Scheme for Paranoid Thought Comments*

- **Persecution/accusation:** a reference that suggests that a virtual character is suspicious, dangerous, or other negative characteristics.
  - **Examples:** *he looks suspicious; I believe he has bad intentions; he is up to no good.*

- **Distress:** a reference of feeling uncomfortable or distressed, which is caused by a virtual character or the environment.
  - **Examples:** *the way he looks at me makes me feel uncomfortable; people keep staring at me and it feels uncomfortable; I am not feeling comfortable to sit beside him.*
  - **Not included:** references to feelings that are caused by unrelated events or objects, such as: *I feel uncomfortable since there is no food on my table; it is very uncomfortable to sit here since the view outside is better; I am bored.*

- **Threat:** a reference towards a threat from a virtual character or the environment or a feeling of unsafety.
  - **Example:** *the way he looks at me makes me feel insecure; I do not think this place is a safe place.*
  - **Not included:** references that are caused by unrelated events or objects such as: *I am afraid that the HMD will fall if I move too active; My head feels dizzy and that worries me; I am not feeling safe wearing all these gadgets.*

- **Self Reference:** a reference regarding mistakenly believing that a virtual character is talking about, referring to, or laughing at the person.
  - **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:** references that caused by eye gaze stressor since all the virtual characters were programmed to directly look at the participants when it was triggered. Thus, the participant would make no mistake whenever they made references that a virtual character was looking at them.

Similar to the first experiment, two coders, separately, were asked to do the coding on all recordings to examine the reliability of the coded data. Both coders annotated all the participants’ comments which corresponded to the categories in both coding schemes.

For analysis, the amount of paranoid thought experienced by the participants was represented by the total number of paranoid comments made by them, which was the sum of all coded data in a coding scheme. Higher number indicated that the participants experienced more paranoid thought during an exposure.

Since each condition consisted of an exposure phase and an interview phase, the paranoid comments were annotated separately for each phase. In other words, in each condition, there would be two paranoid comments sets.
6.2.3 Participant
The participants for the experiment were 24 (21 males and 3 females) students of TU Delft recruited using the convenience sampling strategy. The participants’ age ranged between 21 and 42 years old ($M = 28.42$, $SD = 4.83$) and all the participants had at least bachelor degree. All the participants reported to have no history of paranoia and to have little to no experience in developing a virtual world.

During the recruitment process, the participants received consent form that informed them about the experiment purpose, their right, the experiment procedure, and additional information that recommended participants with history of paranoia or epilepsy not to participate in the experiment. However, similar to the first experiment, the participants were never informed about the hypotheses of the experiment until it had ended. They were only informed that their participation would help in developing a virtual environment which could be used to help treating people with mental disorder. This was done to avoid giving the participants any hint about the experiment which could influence their behaviour and thought during the experiment.

In addition, the participants were asked to fill in the pre-experiment questionnaire set. The mean value and the standard deviation for each questionnaire can be seen in Table 6.2. Afterwards, they were invited to come to the lab to participate in the lab experiment. Before the experiments, the experimenter made sure that all the participants read and signed the consent form. The experimenter also gave them enough chance to ask any question regarding the experiment.

6.2.4 Material
One computer with one monitor was used to run the program for the experiment. One stereo headset device was used to relay the sound of the program to the participants’ ears. In addition to the computer, one laptop that was connected to a microphone was used to record the participants’ comment during exposure. Similar to the first experiment, the experimenter was located in the same room as the participants.

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPTS Reference</td>
<td>31.17</td>
<td>9.70</td>
</tr>
<tr>
<td>GPTS Persecution</td>
<td>21.33</td>
<td>6.76</td>
</tr>
<tr>
<td>GPTS Total</td>
<td>52.50</td>
<td>14.27</td>
</tr>
<tr>
<td>CE</td>
<td>14.83</td>
<td>2.58</td>
</tr>
<tr>
<td>ITQ</td>
<td>69.29</td>
<td>14.34</td>
</tr>
<tr>
<td>SIAS</td>
<td>26.04</td>
<td>12.86</td>
</tr>
</tbody>
</table>

*Note. n = 24*

To immerse the participants into the virtual environment, 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 (DOF) was used. Both devices were connected to the computer. Mobi8 data recorder from TMSi was used to
measure the participants’ heart rate and GSR. Figure 6.2 shows the setup of the hardware including the participant and the experimenter.

![Hardware layout for the second experiment](image)

**6.2.5 Virtual Environment**

Two virtual environments were used in the experiment. The first virtual environment was the neutral virtual world (Busscher, Vliegher, Ling, & Brinkman, 2010) which was used to measure the participants’ baseline heart rate and GSR. In addition, the participants were also trained to get used to the virtual environment and to understand their task during the exposure, which was to observe the surrounding and make comments about their experience.

The second environment was the restaurant environment (Brinkman et al., 2012), which was the same restaurant used in the first experiment. Figure 6.3 shows example pictures of the restaurant environment. In all experimental conditions, the participants were always seated in the same place in the middle of the restaurant. Since all four exposures were conducted using the same virtual environment, there was concern of a carry-over effect between the conditions. To overcome this problem, four different setups of the restaurant’s visitors were created and each setup was used only once in each condition.

The differences between each setup were the virtual character, its position and orientation, and its basic animation. The amount of virtual character in every setup was the same. In each setup, there would always be one virtual character that could change its facial expression to expose the emotion stressor. All virtual characters were in medium polygon; however, the virtual character that could express emotional facial expression was in high polygon since many details in the face of the virtual character (eye, mouth, etc.) which were necessary to perform the emotion stressor were only available in high polygon.
Similar to the prototype, three Event Triggers and six Event Coordinators were used. Each of the Event Trigger was used for sitting virtual character, walking virtual character, and TV. For the Event Coordinator, four were responsible for the sitting virtual character, one was responsible for walking virtual character, and the last one was responsible for TV. Twelve subordinates were used which comprised of: nine Sitting Coordinators, two Walking Coordinators, and one Other Coordinator.

Figure 6.4 shows the position and orientation of all virtual characters in each setup. The setup was called setup A, setup B, setup C, and setup D and was used, respectively, in the first, second, third, and fourth exposure condition. The triangle shape represents the participants’ location (which was similar to the patient’s position on the prototype). The star and the circle shapes represent the location of the active virtual characters and passive virtual characters respectively. The square shape represents the location of the emotion virtual character. Each setup has two walking virtual characters with the same walking route as the route used in the prototype. Both walking virtual characters are not shown in Figure 6.4 since their walking route and starting position are the same in each setup.

The virtual characters’ position, orientation, and basic animation were always fixed in each setup. However, the assignment of the virtual character on the given position, orientation, and basic animation was randomized. With this method, two participants in the same setup would see the same virtual character seated on different location. Therefore, a systematic effect of the setup on the participants’ experience was unlikely.

It needed to be noted that eventhough the assignment of the virtual characters was randomized, the virtual character with emotional facial expression was not included in the randomization. Furthermore, this virtual character always seated in the same table in each setup, which was located right in front of the participants’ table. Two reasons for this were, first, the assigned table was the best place for this virtual character that allowed the participants to notice the changes on its facial expression. Second, if this virtual character
was included in the randomization, there was the possibility that it would be placed somewhere far from the participants or placed in a position with its back facing the participants. As a result, the effectiveness of the stressors could drop significantly.

![Diagram of setups A, B, C, and D]

Figure 6.4: The virtual character setup for the second experiment

In all virtual environments, similar to the first experiment, the participants were not allowed to move away from their seat and could only observe the surrounding by moving their head or their chair. In addition, the Razor tracker used for this experiment was a 3 DOF tracker, unlike the Ascension Flock of Birds tracker which was a 6 DOF. As a result, any translation movement of the participants’ head did not make any differences toward the participants’ view, thus, limiting their movement further.

6.2.6 Procedure

The complete procedure of the experiment is shown in Figure 6.5. First, the participants were explained about the content of the consent form. During the explanation, the participants were given the opportunity to ask question about the consent form. The experiment would proceed to the next step only after they signed the consent form.
In the experiment, one of the participants’ tasks was to make a running commentary to describe their experience in the virtual environment. To ensure that they understood their task, the experimenter asked them to make a running commentary about the experiment room. The experiment would proceed to the next step only after they understood how to make a proper running commentary. Afterwards, they were immersed in the baseline condition for at least 2 minutes to further train them inside the virtual environment and to obtain their baseline physiological measurement.

After the baseline condition, the participants were asked to fill in the SSQ questionnaire. Then, they were primed using the article and video used in the first experiment. The purpose of the priming was to raise the sense of insecurity in the participants so that the paranoid thought could be induced in their thought process. Afterwards, they were immersed in the experimental condition.

The experimental condition consisted of four conditions that were created by using the two by two combinations of the two within-subject factors. The order was counterbalanced for four experimental conditions which resulted in 24 different orders. Each participant was randomly assigned to one set order of condition. Both the experimenter and the participants never knew the order of the experimental condition.

Exposure in each condition lasted for three minutes, and throughout which, the participants were instructed to observe their surrounding and to make a running commentary on how they experienced it. In addition, 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. However, descriptive comments which were used to emphasize their argument were allowed. This entire session was called the exposure phase.

Directly after the exposure, the experimenter asked the participants to summarize their experience. When making summary, they could talk freely for as long as they wanted. This entire session was called the interview phase.

When the participants finished with their summary, the experiment proceeded to the next condition. It needed to be noted that the participants’ SUD scores were asked before and after the exposure phase. These procedures were repeated until the participants were exposed to all four conditions. Afterwards, the participants were asked to fill in the IPQ and SSQ questionnaire. Then, they were asked to complete the same anonymity procedure.
used in the first experiment. In the end, the experimenter debriefed the participants about the true nature of the experiment.

6.3 Result

6.3.1 Preparation

All the analyses of the experiment result were conducted using the Statistics Package for the Social Sciences (SPSS) software. Before analyzing the data, the reliability of the coded paranoid comments was examined. Using Spearman Correlation analysis, the result of both coders was significantly correlated in both exposure phase ($r = .87$, $n = 96$, $p < .01$) and interview phase ($r = .75$, $n = 96$, $p < .01$). The result suggested a strong level of inter-observer correlation and therefore, an acceptable reliability level. Finally, both coders were asked to come to agreement on classification of comments that they were not agreed on initially. The result of the discussion was used for the analyses.

6.3.2 Presence and Simulator Sickness

The level of presence of the exposure and the effect of the simulator sickness on the participants throughout the experiment was examined. The level of presence was examined to find out if the created virtual environment could establish an acceptable level of presence for exposure. On the other hand, the effect of the simulator sickness was examined to find out if the created virtual environment would increase the simulator sickness severe enough that it would concern to be used for exposure therapy. Descriptive statistic of SSQ before exposure, SSQ after exposure, and IPQ total score can be seen in Table 6.3.

Table 6.3

<table>
<thead>
<tr>
<th>Variable</th>
<th>M / Mdn</th>
<th>SD / IQR</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre SSQ – Total Score</td>
<td>16.83 (Mdn)</td>
<td>31.79 (IQR)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Post SSQ – Total Score</td>
<td>28.05 (Mdn)</td>
<td>57.97 (IQR)</td>
<td>0.04</td>
</tr>
<tr>
<td>IPQ Total</td>
<td>49.38 (M)</td>
<td>11.83 (SD)</td>
<td>.485</td>
</tr>
</tbody>
</table>

Note. n = 24

*Shapiro-Wilk test Sig. value (normality test)

In regards to level of presence, the result of the participants’ IPQ total was compared to the online IPQ data set\(^2\), a method which was previously used in other studies (Heijden & Brinkman, 2011; Ling et al., 2012). To create a proper comparison, the result of the IPQ total was compared only to the non-stereoscopic HMD result of the online data set.

Using a one sample T-test between the participants’ IPQ Total score and the mean of the online IPQ Total (44.08), the result from the analysis shown that there was significant difference between the IPQ score ($t(23) = 2.19$, $p = .039$) where the result of the participants’ IPQ Total was higher than the online IPQ Total. It could be concluded that the level of presence in the created virtual environment was acceptable for exposure.

\(^2\) Downloaded on 28 March 2013 from http://www.igroup.org/pq/ipq/data.php
In regards to the simulator sickness, since both SSQ scores deviated from normal distribution, a 2-related sample Wilcoxon Signed Rank Test was conducted. The result shown that there was significant difference between both SSQ scores ($F(1,23) = 2.446, p = .01$), where the SSQ score after the experiment (Mdn = 28.05) was higher than the SSQ score before experiment (Mdn = 16.83). This meant that the created virtual environment increased the simulator sickness significantly throughout the experiment. One reason for this was because the participants were immersed for at least 20 minutes without any rest time. Therefore, it was very likely that some simulator sickness symptoms increased throughout these 20 minutes.

However, the median of both SSQ scores was still low compared to the range of the SSQ Total Score (0-235.62). In addition, no participants dropped out from the experiment because of severe cybersickness symptoms. Furthermore, as recommended by Bouchard et al. (Bouchard et al., 2011), participants did not leave the lab immediately after the exposure. They were instructed to fill in questionnaires and finish the anonymity procedure. By the end of the whole experiment, which took about 10-15 minutes after the end of exposure, no participants reported cybersickness symptoms.

### 6.3.3 Analysis on Priming Effect

Descriptive statistics of paranoid comments can be seen in Table 6.4. From Table 6.4, it was apparent that the median of paranoid comments in all conditions are 0.00. One of the main reason was that 11 of 24 participants did not experience paranoid thought in any condition. Table 6.5 shows the descriptive statistic of paranoid comment if the 11 participants who did not experience paranoid thought is left out, while Table 6.6 shows the sum of paranoid comments in all 4 conditions.

#### Table 6.4

**Descriptive Statistic of Paranoid Comments (all participants)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fast Rate</th>
<th>Slow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Prob</td>
<td>Low Prob</td>
</tr>
<tr>
<td></td>
<td>Mdn</td>
<td>IQR</td>
</tr>
<tr>
<td>Comments (exp)</td>
<td>0.00</td>
<td>1.75</td>
</tr>
<tr>
<td>Comments (inter)</td>
<td>0.00</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Note. n = 24, exp = exposure phase, inter = interview phase*

#### Table 6.5

**Descriptive Statistic of Paranoid Comments (13 participants)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fast Rate</th>
<th>Slow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Prob</td>
<td>Low Prob</td>
</tr>
<tr>
<td></td>
<td>Mdn</td>
<td>IQR</td>
</tr>
<tr>
<td>Comments (exp)</td>
<td>1.00</td>
<td>2.50</td>
</tr>
<tr>
<td>Comments (inter)</td>
<td>1.00</td>
<td>2.50</td>
</tr>
</tbody>
</table>

*Note. n = 13, exp = exposure phase, inter = interview phase*
Table 6.6

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fast Rate</th>
<th>Slow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Prob</td>
<td>Low Prob</td>
</tr>
<tr>
<td></td>
<td>Sum</td>
<td>Sum</td>
</tr>
<tr>
<td>Comments (exp)</td>
<td>27.00</td>
<td>13.00</td>
</tr>
<tr>
<td>Comments (inter)</td>
<td>18.00</td>
<td>7.00</td>
</tr>
</tbody>
</table>

*Note. n = 24, exp = exposure phase, inter = interview phase*

In the experiment, priming session was conducted to induce paranoid thought on the participants. Therefore, the next step was to investigate if the priming had different effect on participants with different base paranoid level and social interaction anxiety so that they responded to the stressors differently. The participants’ base paranoid level was based on GPTS score while their social interaction anxiety was based on SIAS score. To investigate it, three-way repeated-measures ANOVA on the total result of the exposure phase and interview phase paranoid comments was conducted with Rate and Probability as within-subject factors and GPTS or SIAS as between-subject factors. Because both Rate and Probability were deviated from normal distribution, Aligned Rank Transform (ART) for nonparametric factorial data analysis was conducted first (Wobbrock et al., 2011) before each analysis.

For the analysis on the effects of participants’ base paranoid level, first, the participants were split into two groups: the high group which consisted of participants with higher GPTS score, and the low group which consisted of participants with lower GPTS score. The group was based on the distribution of the GPTS Total score data is shown in Figure 6.6.

Based on the median value, which was 50.50, participants with GPTS score lower than 50.50 were included into the low group and participants with GPTS score higher than 50.50 were included into the high group. In the end, both groups contain equal number of participants.

![GPTS Total histogram](image)

Figure 6.6 GPTS Total histogram
The result found no significant effect of the participants' base paranoid level on the comment made by the participants. All the p-values related to the GPTS score were not significant: GPTS ($F(1,22) = 1.1$, $p = .307$), interaction with Rate ($F(1,22) = 0.2$, $p = .634$), interaction with Probability ($F(1,22) = 3.0$, $p = .100$), and interaction with both Rate and Probability ($F(1,22) = 0.1$, $p = .816$). This meant that no difference was found between both groups in experiencing the virtual environment.

Then, investigation on the effect of participants' social interaction anxiety on the paranoid comments was conducted. Similar to the participants' base paranoid level, first, the participants were divided into two groups based on the distribution of the SIAS score. Figure 6.7 shows the distribution of the SIAS value. Based on the median value (24.50), the participants were divided into low group and high group.

After transformation using ART for nonparametric factorial, the result from the three-way repeated-measures ANOVA also found no significant effect related to social interaction anxiety. All the p-values related to the SIAS value were not significant: SIAS ($F(1,22) = 0.1$, $p = .785$), interaction with Rate ($F(1,22) = 1.7$, $p = .200$), interaction with Probability ($F(1,22) = 0.8$, $p = .393$), and interaction with both Rate and Probability ($F(1,22) < 0.1$, $p = .864$). This meant that no difference was found between both groups in experiencing the virtual environment.

Based on this result, it could be concluded that both the participants' base paranoid level and the participants' social interaction anxiety did not have strong effect on the comments made by the participants in the exposure phase and the interview phase. This result seemed to confirm the findings in the first experiment where the priming could induce paranoid thought in participants in low group (both GPTS and SIAS) so that they experienced paranoid thought on the same level as participants in high group. However, from Table 6.4, it is also possible that the low amount of paranoid comments that caused no effect of GPTS and SIAS.

The same analyses were conducted with only the result of the 13 participants included, and the results suggested the same conclusion that GPTS and SIAS had no effect on paranoid
comments: GPTS (F(1,11) = 1.1, p = .319), GPTS with Rate (F(1,11) = 0.3, p = .621), GPTS with Probability (F(1,11) = 2.0, p = .185), GPTS with both Rate and Probability (F(1,11) < 0.1, p = .980), SIAS (F(1,11) = 0.1, p = .770), SIAS with Rate (F(1,11) = 0.1, p = .806), SIAS with Probability (F(1,11) < 0.1, p = .877), and SIAS with both Rate and Probability (F(1,11) = 0.3, p = .593). Therefore, Both GPTS score and SIAS score were not included for the remaining analyses.

6.3.4 Analysis on Paranoid Thought

From the paranoid comments, a total of 127 paranoid comments were coded. Figure 6.8 shows the bar chart for both categories. From Figure 6.8 (b), it shows that there were no comments triggered by emotion and walk stressors. This might be because the participants might not notice them or were not too concerned to make a comment about it. Figure 6.8 (b) also shows that there were 8 comments that were triggered by other stressor. Most of these comments were triggered by the appearance of the virtual character.

![Figure 6.8 Bar chart for both coding schemes](image)

First, result from the paranoid comments was analyzed using Friedman’s test to investigate whether there were differences among the results in the paranoid thought events category and the paranoid thought trigger category. The result suggested that there were no significant difference among the four codes in the paranoid thought events category ($\chi^2(3) = 3.86, p = 0.28$). On the other hand, there were significant differences among the categories in the paranoid thought trigger category ($\chi^2(8) = 30.26, p < 0.01$). In addition, even if both emotion and walk were not included in the analysis, there were still significant difference among the remaining categories ($\chi^2(6) = 15.23, p = 0.02$). Furthermore, if snatch of conversation was also not included in the analysis, the difference among the remaining 6 codes were not significant ($\chi^2(5) = 8.19, p = 0.15$). It can be concluded that snatch of conversation was significantly higher compared to other codes in paranoid though trigger category.

Analysis on paranoid thought was conducted on paranoid comments using repeated-measures analysis of variance (ANOVA). After normality test with Shapiro-Wilk test, it was apparent that paranoid comments was deviated from normal distribution. Therefore, before the data were analyzed with repeated-measures ANOVA, ART for nonparametric factorial was conducted to transform the data.

Afterwards, the effect of the Rate and Probability as the within-subjects toward the participants’ comment during the exposure phase and interview phase was investigated
using two-way repeated-measures ANOVA. Table 6.7 shows the result of the analysis on both phases.

Table 6.7  
Results of ANOVA on Paranoid Comments  

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rate</th>
<th>Probability</th>
<th>Rate x Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F(1,23)</td>
<td>p</td>
<td>F(1,23)</td>
</tr>
<tr>
<td>Comments (exp)</td>
<td>.75</td>
<td>.395</td>
<td>13.77</td>
</tr>
<tr>
<td>Comments (inter)</td>
<td>.93</td>
<td>.344</td>
<td>6.08</td>
</tr>
</tbody>
</table>

*Note. n = 24, exp = exposure phase, inter = interview phase*

The result suggested that there was main effect for probability on both the participants’ comments in the exposure phase ($F(1,23) = 13.77, p < .01$) and the interview phase ($F(1,23) = 6.08, p = .022$). In addition, there was also significant interaction effect between Rate and Probability on participants’ comments in the exposure phase ($F(1,23) = 6.95, p = .015$). However, the main effect of Rate was not found in both exposure phase and interview phase. Figure 6.9 shows the sum differences of paranoid comments in exposure phase.

![Figure 6.9 Sum differences of paranoid comments in exposure phase](image)

Further analyses were conducted using the 2-related sample Wilcoxon Signed Rank Test to investigate the interaction effect between Rate and Probability in exposure phase. Result of the pairwise analyses suggested that there was simple effect of probability for slow rate level where the increase of paranoid comments from low probability to high probability was significant in slow rate level ($z = -2.96, p < .01$). For the fast rate level, the increase from low probability to high probability was not significant ($z = -1.28, p = .20$).

In addition, there was simple effect of rate for low probability level where the number of paranoid comments increased significantly from slow rate to fast rate ($z = -0.20, p = .05$). For the high probability level, the difference between both rate levels was not significant ($z = -1.03, p = .31$).

6.3.5 Analysis on Anxiety  
Descriptive statistic of Heart Rate, GSR and SUD Score can be seen in Table 6.8 and in Table 6.9. To limit individual differences of GSR, the reported values were standardized by the calculation of the mean of the GSR value ($\alpha$) and the mean of the GSR value in neutral condition ($\beta$) using the formula ($\frac{(\alpha-\beta)}{\beta}$). Normality test using Shapiro-Wilk test showed that both SUD Score did not come from normal distribution.
Table 6.8
Descriptive Statistic of Heart Rate and GSR

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fast Rate</th>
<th></th>
<th>Slow Rate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Prob</td>
<td>Low Prob</td>
<td>High Prob</td>
<td>Low Prob</td>
</tr>
<tr>
<td>Heart Rate (exp)</td>
<td>M: 79.84 SD: 9.98</td>
<td>M: 77.89 SD: 8.44</td>
<td>M: 77.28 SD: 8.40</td>
<td>M: 76.95 SD: 8.04</td>
</tr>
<tr>
<td>Heart Rate (inter)</td>
<td>M: 80.60 SD: 10.12</td>
<td>M: 78.80 SD: 9.02</td>
<td>M: 79.08 SD: 9.45</td>
<td>M: 80.33 SD: 9.29</td>
</tr>
<tr>
<td>GSR^a (exp)</td>
<td>M: 0.29 SD: 0.32</td>
<td>M: 0.29 SD: 0.35</td>
<td>M: 0.33 SD: 0.43</td>
<td>M: 0.23 SD: 0.28</td>
</tr>
<tr>
<td>GSR^a (inter)</td>
<td>M: 0.29 SD: 0.33</td>
<td>M: 0.31 SD: 0.36</td>
<td>M: 0.31 SD: 0.35</td>
<td>M: 0.27 SD: 0.28</td>
</tr>
</tbody>
</table>

Note. n = 24, exp = exposure phase, inter = interview phase

^a calculated using (α-β)/β where α is mean GSR and β is mean GSR in baseline condition

Table 6.9
Descriptive Statistic of SUD Score

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fast Rate</th>
<th></th>
<th>Slow Rate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High Prob</td>
<td>Low Prob</td>
<td>High Prob</td>
<td>Low Prob</td>
</tr>
<tr>
<td>Pre SUD Score</td>
<td>Mdn: 1.00 IQR: 1.00</td>
<td>Mdn: 1.50 IQR: 1.00</td>
<td>Mdn: 1.00 IQR: 1.00</td>
<td>Mdn: 1.00 IQR: 1.00</td>
</tr>
<tr>
<td>Post SUD Score</td>
<td>1.00 1.00</td>
<td>2.00 1.00</td>
<td>1.50 1.00</td>
<td>1.00 1.00</td>
</tr>
</tbody>
</table>

Note. n = 24, exp = exposure phase, inter = interview phase

Additional analysis was conducted to investigate the effect for the Rate and Probability on the participants’ physiological measurement and the SUD score after exposure. Only the SUD score after exposure was used because the SUD score before exposure mainly was affected with anticipation anxiety which could influence the analyses. In addition, repeated-measures ANOVA on SUD score before exposure (which was transformed first using ART for nonparametric factorial) found no significant difference between conditions which further suggested that there was no systematic effect on SUD score before exposure.

Since SUD score after exposure deviated from normal distribution population, ART for nonparametric factorial data analysis was conducted first. The result of the repeated-measures ANOVA can be found in Table 6.10. The result, revealed a significant interaction effect on the SUD score (F(1,23) = 7.356, p = .012).

Table 6.10
Results of ANOVA on Heart Rate, GSR, and SUD Score^3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Rate</th>
<th>Probability</th>
<th>Rate x Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F(1,23) p</td>
<td>F(1,23) p</td>
<td>F(1,23) p</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>.479 .496</td>
<td>.005 .943</td>
<td>0.017 .898</td>
</tr>
<tr>
<td>GSR</td>
<td>.017 .897</td>
<td>2.30 .143</td>
<td>1.121 .301</td>
</tr>
<tr>
<td>SUD score</td>
<td>3.648 .069</td>
<td>.613 .442</td>
<td>7.356 .012</td>
</tr>
</tbody>
</table>

Note. n = 24

Further analyses were conducted using the 2-related sample Wilcoxon Signed Rank Test to investigate the interaction effect between Rate and Probability of the SUD Score. Figure 6.10 shows the median differences of SUD Score.

^3 Analysis was also conducted on the result of the interview phase and found significant interaction effect on heart rate. However, the research was mainly focused on anxiety during exposure phase
Result of the pairwise analyses suggested that there was simple effect of rate for low probability level where the anxiety level was significantly increased from slow rate to fast rate ($z = -2.50, p = .01$). For high probability level, the difference between slow rate and fast rate was not significant ($z = -1.67, p = .96$).

In addition, the result suggested that there was simple effects of probability for both rate levels where the difference of the anxiety level between both probability levels was significant, either in slow rate level ($z = -2.13, p = .03$) or in fast rate level ($z = -2.00, p = .05$). This suggested a cross-interaction effect on anxiety level.

Further analyses were conducted to examine the correlation between anxiety and paranoid thought in the same experimental condition. Table 6.11 shows the result of the Spearman correlation between paranoid comments and other variables (GPTS, SIAS, Heart Rate, GSR, SUD score after exposure) in exposure phase. Result suggested that there was no correlation between paranoid thought and anxiety, which inferred that Rate and Probability might have different effects on paranoid thought and on anxiety.

**Table 6.11**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Fast - High</th>
<th>Fast - Low</th>
<th>Slow - High</th>
<th>Slow - Low</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r(22)</td>
<td>p.</td>
<td>r(22)</td>
<td>p.</td>
<td>r(22)</td>
</tr>
<tr>
<td>GPTS</td>
<td>.328</td>
<td>.117</td>
<td>.266</td>
<td>.209</td>
<td>.046</td>
</tr>
<tr>
<td>SIAS</td>
<td>-.074</td>
<td>.731</td>
<td>-.004</td>
<td>.985</td>
<td>.034</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>-.016</td>
<td>.941</td>
<td>-.316</td>
<td>.133</td>
<td>-.274</td>
</tr>
<tr>
<td>GSR</td>
<td>.288</td>
<td>.172</td>
<td>.017</td>
<td>.938</td>
<td>.128</td>
</tr>
<tr>
<td>SUD Score</td>
<td>.228</td>
<td>.283</td>
<td>.054</td>
<td>.803</td>
<td>-.261</td>
</tr>
</tbody>
</table>

*Note.* n = 24

All variables, with the exception of GPTS and SIAS, are from exposure phase

### 6.4 Conclusion and Discussion

The result of the experiment supported H2 where high probability of stressors, compared to a lower probability of events, elicited more paranoid thought. In addition, the result also supported H3 where there was an interaction effect between the rate of paranoia provoking events and the probability of events on the amount of the elicited paranoid thought. However, the result did not fully supported H1 where the rate of random events only had simple effects on low probability level.
Since the participants’ base paranoid level and social interaction anxiety level had no effect on the number of comment made by the participants, it could be concluded that the participants were able to experience paranoid thought on the same level in spite of their base paranoid level or social interaction anxiety background. This result confirmed the result of first experiment where priming with the purpose to raise the participants’ sense of insecurity could increase the number of paranoid thought experience in a non-clinical participants from different groups to the same level.

However, it need to be noted that from 24 participants, only 13 participants (54%) mentioned at least 1 paranoid comment throughout the whole experiment. Because of that, it was possible that the reason for participants’ base paranoid level and social interaction anxiety level had no effect on paranoid comments is caused by the low factor of paranoid comments itself. Excluding the 11 participants who experience no paranoid thought, result of the same analyses on participants’ base paranoid level and social interaction anxiety level still suggested that both variables had no strong effect on paranoid comments. In addition, correlation between paranoid comments and GPTS/SIAS also showed weak relation either in 4 conditions or on average. However, by excluding 11 participants from analyses, the size of the sample became smaller and the counterbalanced order was gone.

From the result of the analysis on paranoid thought, it was shown that Probability had a main effect on the number of paranoid comments made by the participants either during the exposure phase or the interview phase. The result showed that the comments made in the high probability condition were significantly higher than the comments made in the low probability. This meant that the participants were able to recognize the stressor and experienced paranoid thought when the probability was set high.

However, it was also shown that Rate main effect did not have strong effect on the paranoid comment made by the participants in either exposure phase or interview phase. It could be argued that the duration for the exposure was not set long enough that the people might recognize the difference in rate, especially since the difference between both rate conditions in the high probability condition was not significant.

In addition, walk as stressor was only triggered at maximum once in slow rate condition and twice in fast rate condition, while on the other hand, gaze or snatch of conversation as stressor could be triggered 10 times in slow rate condition and 18 times in fast rate condition. Since there were no differences between the maximum occurrence of the walk stressor in slow rate and fast rate, the participants might be unable to perceive the difference in Rate based on the walk stressor. This was essential since walk as stressor was one of the stressor that could be easily noticed by the participants because it was executed for the longest time (±40 seconds) compared to any other stressor like gaze (±5 seconds). If the duration of each condition was made longer, the chance for walk stressor to occur would be higher, and people would be able to notice it and react to it.

In regards to interaction effect, the result suggested that interaction effect existed. However, the result suggested that the increase of the paranoid thought comments from low probability to high probability was more statistically significant on slow rate level, in
contrary to the hypothesis that higher rate level supposed to have stronger effect. It could be argued that the slow rate - low probability condition created additional low effect on paranoid thought compared to other experimental condition, which in turn, caused significant difference when the probability was changed from low to high. The argument was supported by the result where there was no significant difference among the three other experimental conditions.

Additional conclusion derived from the experiment was that snatch of conversation was coded as the highest number of the participants’ paranoid though trigger and had significant difference compared to other triggers. It could be inferred that snatch of conversation was the easiest stressor to be noticed by the participants and therefore, it had the highest chance in affecting the participants’ thought process throughout exposure.

This result was expected since sound, as a passive attention cue, was much easier to be noticed by participants. They did not have to look at the event directly, and instead, they only needed to hear it when it was triggered. Once they noticed it and could understand that it contained dialog, the chance for them to miss it when it was triggered for the next time was small. On the other hand, for other stressors, as an active attention cue, it heavily relied on the moment when the participants saw it when it was triggered. Since some stressors (i.e. eye gaze) only took subtle movement and the participants’ view area was wide, it was easy for the participants to miss it. Therefore, it was understandable if they did not react to it. In the end, snatch of conversation was recommended as stressors for the VR world that could elicit paranoid thought.

However, eventhough it was argued that the sound was a stressor which was easy to be noticed by the participants, some participants reported that they did not notice it because they talked over the sound during the exposure phase, which result in their voice drowned out the sound when it was triggered.

Additional conclusion from the experiment related to unexpected result in SUD score where there was cross-interaction effect between Rate and Probability. It could be argued that it happened because the participants came from non-clinical population. For them, when they experiencing paranoid thought, it did not mean that they were also afraid of it. This was supported by result of analyses where there is no correlation between paranoid thought and anxiety. In addition, Freeman et al. (Freeman et al., 2006) also stated that one of the reaction when people experiencing paranoid thought was that they ignored the thought. If this was what happened to the participants, it could be understandable if their anxiety level was not increased. Furthermore, in condition where the probability was set high, participants could hear snatches of conversation and laugh more often. There might be chance that they thought the conversation and laugh as something relaxing, which in turn would lower their anxiety level. Still, it is necessary to investigate if the same result also occurs if the participants come from clinical population. Therefore, it still could not be concluded that there was no correlation between paranoid thought and anxiety.
7 Conclusion
This chapter explains the conclusion derived from this research to answer all the research questions which were put forward at the beginning of the thesis. In addition, the research also suffers from some limitations which will encourage future works.

This chapter starts with stating again the research question and the conclusion for each question. Afterward, the limitation of this research is discussed and followed by proposing future works.

7.1 Research Question and Conclusion
In chapter 1, the main research question was formulated as: Is it possible and what is required, to extent VRET system for treating patients suffering from paranoia?

To answer this question, the research followed a Situated Cognitive Engineering (sCE) approach by collaboratively working with the therapists on finding out how VRET system could be extended to treat patients suffering from paranoia.

After several discussions with the therapists, the prolonged exposure approach was chosen as the main approach to treat paranoia since it was assumed to be much more basic and easier for the patients to follow. The main goal of this approach was to teach the patients to always remain calm and not to avoid the situation. When they could achieve it, it would be easier for them to function in everyday situation. In addition, it will be easier for the therapist to address other issues of the disorder.

In the prolonged exposure approach, the patients are exposed to a baseline condition first. Then the therapist increases the stressors level to a certain level. Afterwards, he monitors the patients’ response to the given stressors level and made adjustment based on it. If the patients are too scared, the therapist needs to be able to decrease the stressors level. On the other hand, if they feel no anxiety, he needs to be able to increase the stressors level. This can be done repeatedly in several sessions until patients experience no anxiety.

To create an appropriate VRET system which accommodated prolonged exposure, several core functions were identified:

1. Implementing daily life situations into the treatment.
   This was required so that the patients could implement what they learnt from the treatment to the real life social situation.
2. Implementing prolonged exposure into the treatment.
   This was required as the main approach of the therapy that teaches the patients how to remain calm when they are exposed to numbers of stressors for a prolonged time. To achieve it, the patients exposure needed to be maximized and distracting tasks needed to be avoided.
3. Exposing the patients with random events while still preserve its naturalness.
This was required to simulate the random events which represented real life social situation. Stressor synchronization was needed to maintain the naturalness of the random events.

4. Treatment personalization.
This was required since different patients could have different paranoid thought trigger, which needs different intervention from the therapist.

5. Exposure controller with minimum number of parameter to be controlled by therapist.
This was required so that the therapist could focus on monitoring the patients rather than controlling the stressors.

The core functions and the associated claims were reviewed by the therapists and the results were used as the base for designing and developing the prototype.

From the main question, throughout the research process, several sub-questions emerged in order to elaborate the question better. The first sub-question which emerged was: **What kinds of stressors are effective in evoking paranoid thought in patients?** This question concerned which stressors were effective and appropriate for eliciting paranoid thought in the patients in a clinical practice.

From the discussion with the therapist, several stressors were proposed and discussed. Some of the proposed stressors were rejected because they seemed ineffective or inappropriate. Some stressors were considered to be inappropriate because the stressors were associated with delusion and hallucination, which were not part of paranoia symptoms. By the end of the discussion, a list of stressors which were considered effective and appropriate was created. The list of the stressors was:

1. Pre-narrative Text.
2. Information About Danger.
3. Laughing.
5. Eye Gaze.
6. Coincidental Event or Unexpected Event.
7. Appearances and Facial Expression.
9. Darkness / Lighting.
11. Color (whether a specific color is dominant in the virtual environment).
13. Ambiguous messages in media such as music or TV.

However, not all of the stressors in the list were necessary to be included in the prototype of the application since the prototype was not created to examine which stressors were effective to elicit paranoid thought. Therefore, only some stressors which were applicable and natural to occur in a restaurant (the social situation used in the prototype) which were used. These stressors were: eye gaze, facial expression (happy and angry), snatches of conversation, laughing, passing by people, TV, and population density.
The second sub-question was: *Is it possible to induce paranoid thought in a non-clinical population when they are exposed by stressors in the virtual environment?* It was difficult to ask patients to participate for the testing phase without establishing the potential effects of the application first. As a result, participants from non-clinical population were considered. However, non-clinical participants were likely to behave differently from patients. Therefore, it might be difficult to ensure that they would experience paranoid thought when exposed in the virtual environment.

To solve the problem, a method to prime the participants prior to the exposure was proposed. The priming was aimed to raise feelings of threat and increase the level of vigilance, so that the participants could carry-over these feelings into exposure, and influenced the way they perceived the virtual characters and the virtual environment. The proposed method was tested in an experiment and the result suggested that priming could indeed increase the number of paranoid thought experience in non-clinical participants. Therefore, when non-clinical participants were appropriately primed, they could possibly be used to evaluate the ability of a VR environment in eliciting paranoid thought.

The final sub-question was: *How should the therapist control the stressors?* This question concerned how therapists could control the stressor without getting distracted from their main task to monitor the patients’ state.

The proposed solution was to separate the stressor configuration and stressor controller. During the stressor configuration, the therapist can put his focus on configuring the scenario without the need to attend to patients. To reduce his workload further, it is possible for him to create the scenario before the therapy started. In addition, it is possible for him to save a created scenario and reuse it in the future. When the exposure starts, he is provided with a stressor controller which consists of a single slider that controls the rate of the random paranoid thought provoking event occurring in the virtual environment. With only using one slider to control the stressor, he can focus more on monitoring the patient’s state during the exposure.

However, it was necessary to test whether controlling the rate of the random event and configuring the probability of the events can really evoke and control the paranoid thought of the patients. Therefore, the proposed method was tested in an experiment with non-clinical population and the result suggested that configuring the probability of the events was feasible in evoking and controlling paranoid thought. In addition, there was interaction effect between the probability and the rate of the random events. However, the main effect of the rate of the random events did not have strong effect on paranoid thought. An argument could be made that the duration of the exposure was not long enough for the participants to notice the difference in the rate.

In the end, it could be said that all the research questions have been answered and the research has successfully developed a prototype of the application based on collaborative work with the therapists and recursive design, development, and test process. The result showed that it was possible to evoke and control paranoid thought in the individuals, which was an integral part of the prolonged exposure approach. In addition, the participants were able to experience paranoid thought from the stressors exposed to them, which suggested
that the stressors might also be effective and applicable in clinical population. Furthermore, the proposed prior priming method was shown to be able to induce paranoid thought to the non-clinical participants when they were properly primed before exposure, which opened up the possibility of asking a sample from non-clinical population to participate in testing the ability of virtual environment in eliciting paranoid thought. It still needs to investigate whether therapist can actually use the VRET system to treat patients, whether it can evoke paranoid thought in patients, and whether one slider is actually enough for the therapist in controlling the stressors.

7.2 Research Limitation
Throughout the research process, there were several limitations encountered. First, both experiments only asked students of TU Delft to be participants. Although the proposed prior priming method was shown to be able to induce paranoid thought in a group of non-clinical participants, it is still important to investigate how actual patients would react to the prototype.

Second, the experiments were also conducted with small number of participants, which limited the analyses. Therefore, all the findings in the experiments might need to be validated with larger samples.

Third, although therapists were involved in the design process, they were never involved in usability testing. Therefore, it was not empirically examined whether the proposed scenario configuration and stressor controller can actually reduce their workload.

7.3 Future Research
As explained in the research limitation section, the research never tested the prototype with actual patients. It is crucial to investigate the patients’ thought process and response toward the prototype since they are the intended actual user of the application. As an alternative, the application can be tested to more general non-clinical population prior to testing with the patients. This research only asked students to test the application, in which they might have more similar thought process compared to people from other background. When the potential effects of the application on the patients has been established, further research can be conducted on whether the application can be an added value in the therapy compared to other method.

Further research related to the therapist can also be conducted. First, it needs to be investigated whether the therapist really benefit from the proposed scenario configuration and stressor controller. This research can explore whether one slider is enough or adding more parameter for stressor controller can be done without giving too much workload on the therapist.

In regards to the rate of the random events, it can be investigated whether the rate has any effect on the paranoid thought experienced by the participants when the duration of the exposure is made longer. As argued before, with longer duration, there is higher chance for the participants to be affected by the difference in the rate of the random events.
In regards to the stressor, further research can be done to study the effectiveness of the stressor to the participant. The research can focus not only on investigating the amount of the stressor but also on its intensity since it can be hypothesized that stressor with higher intensity will affect the participants more.

During the discussion with the therapist, a gradual exposure approach was also proposed. However, since the idea was postponed, no research was done towards this approach. It is worth to research whether game element can really be an added value toward treating patients suffering from paranoia. It needs to be investigated whether multiple dynamic level of difficulty can be used to teach patients how to behave in a simulated social situation. In addition, it can be investigated whether role-playing aspect also has the benefit for the patients, especially when they want to implement what they learn in real life social situation.
References


NCCMH. (2010). *Schizophrenia: Core Interventions in the Treatment and Management of Schizophrenia in Adults in Primary and Secondary Care*: Royal College of Psychiatrists.


Appendix

Appendix A: Potential Paranoia Stressors in Virtual Reality

Potential Paranoia Stressors In Virtual Reality

Appendix A: Potential Paranoia Stressors in Virtual Reality

Type of Triggers

- There are two main types of trigger for paranoid thinking (Freeman et al., 2006):
  - External Triggers
  - Internal Triggers

External Triggers

- Event/Environment/Situation
- Non Verbal Sign
- Verbal Sign
- (Pre)Narrative Story
- Information About Danger

External Triggers - Event/Environment/Situation

- Paranoid thinking might occur in certain event or situation (Freeman et al., 2006):
  - Social Situation
  - Situation From Which It Is Difficult To Escape
  - Situation In Which We Feel Exposed
  - Situation In Which We Might Be Blamed Or Accused
  - Situation In Which We Are In Minority/Minority
  - Coincidence Or Unusual Events

Social Situation

- People tend to have paranoid thinking when they are "forced" to perform in social situation or "forced" to fit in with other people.
- Potential Stressors:
  - meeting event
  - Party event

Situation From Which It Is Difficult To Escape

- People can have a paranoid thinking when they cannot escape from the situation easily.
- Potential Stressors:
  - Bus
  - Train
  - Elevator

Situation In Which We Feel Exposed

- Paranoid thinking might appear when people feel that all attention is on him.
- Potential Stressors:
  - EyesGaze (stranger, look at the patient)
  - Security Camera

Situation In Which We Might Be Blamed Or Accused

- Doing something wrong, or just feeling as though we have, is frequently a trigger for paranoid thinking.
- Potential Stressors:
  - Security Guard/Police
  - Accused of stealing (alarm is turned on when walk out of store)
  - Stop by an authority figure
Situation In Which We Are In Minority/Alone

- People tend to have paranoid thinking when they are in a minority.
- People also tend to have paranoid thinking when they are (feel) alone.
- Potential Stressors:
  - People density
  - Cultural differences (clothes, race, environment) — (Kendler, 1982)

Coincidences Or Unusual Events

- Coincidental or unusual events may provoke paranoid thinking.
  - A same car passing by for more than once
  - People wear sunglasses in cloudy day

External Triggers - Non Verbal Sign

- Potential stressors for non verbal sign includes:
  - Facial expression
  - People appearance (hair, facial hair, clothes)
  - Hand gesture
  - Eyes/glasses

External Triggers - Verbal Sign

- Potential stressors for verbal sign include:
  - Whispering
  - Laughing
  - Talking behind your back
  - Direct dialog/conversation
  - Background noise

External Triggers – (Pre)Narrative Story

- (Pre)Narrative Story can build assumption for people which can help in exposing paranoid thinking (Freeman et al., 2008)
- Potential Stressors:
  - Introduction text before entering the environment

External Triggers – Information About Danger

- Overexposure of a danger may increase people anxiety which in turn trigger a paranoid thinking (Freeman et al., 2008)
- Potential Stressors:
  - Sign of Danger (just a bit of warning sign in the Virtual Reality)
  - Policeman or Security Guard
  - Urban environment (Flett et al., 2008) as an unsure environment + some people that look like a bad guy

Internal Triggers

- Emotion
- Anxious
- Anomalous Event

Internal Triggers - Emotion

- Paranoid thinking might occur when people become emotional
  - Anxiety
  - Low-mood
  - Anger
  - Excitement
  - Potential Stressors:
    - Flashing light
    - Loud or aggressive music
    - Information about danger
    - Negative or suspicious voice over the headset
Internal Triggers - Arousal

- Arousal in this case means the state where people feel of being especially alert and sensitive.
- Potential stressors:
  - Information of Danger (Sign of Danger, Polizman, Man who looks like a bad guy, etc.)
  - Unexpected Event (Screening, etc.)
  - Unsafe environment (urban environment)

Reference


Internal Triggers - Anomalous Experience

- Anomalous experience is the change in the way people perceive the world around them.
- When anomalous experience occurs, paranoid thinking might occur when people try to make sense of the event.
- Potential stressors:
  - Visual and Sound Distortion
Mountain Animals

Mountain is one of the most inhospitable places on earth. The reason is the extreme conditions and the lack of vegetation on mountains. However, some animals are able to adapt to the extreme mountain life, whether from the rocky terrain, extreme weather, lower temperature, extreme competition for foods, and permanent residence.

The biggest challenge of mountain animals is the extreme weather at high altitude. For mountain animals size is important for them to survive. A very small mammal has to stay active and keep its internal furnace to be stoked to avoid losing heat so fast through its large skin surface area. The mountain shrew, for example, which is perhaps the smallest animal mammal at high altitude, has a high metabolism. It has to eat every hour and consume its own weight in food every day.

On the other hand, large mountain animals have some adaptations that help them to survive. Besides its very sure-footed and jumping ability, large mountain animals also have special horns, hooves, and teeth. The very sure-footed is useful to help them to run over such rough ground because they have to move very quickly in order to avoid the predators. Its horn will help them to defend from the predator.

The warm blooded animals have at least three ways to deal with the extreme cold weather: migration, hibernation, and by seeking shelter under the ground or snow.

Rockies elk and Bighorn sheep are examples of large mountain animal that have to migrate to the lower terrain in order to survive from the extreme cold weather, especially in winter. In late fall, they begin to head downward in order to avoid the hard and deep snows. They spend the winter in thick protected areas. When the spring comes and the snows melt, they will move upward again.

Hibernation is a condition when the animals sleep through cold weather. To deal the extreme cold winter, hibernation is chosen by many smaller mountain animals, for example a ground squirrel. It spends the winter by sleeping in its underground burrow for months and will wake up in the spring. In the hibernation process, it is characterized by its low body temperature, slow breathing and heart rate, and its slow metabolic rate.

If most large mountain animals migrate and the smaller mountain animals hibernate to deal with the extreme cold condition, Rocky Mountain goat is one of the mountain animal that does not do any of the rules mentioned above. It does not migrate, hibernate, or live under the ground or snow.

The mountain goat has well-suited feet to climb steep and rocky slopes, even this animal is among the sure-footed of all mountain animals. It spends its life mostly in the rocky land. Mountain goat is herbivore and it spends its time grazing. This kind of goat has four stomachs so that they can extract the last bits of nourishment from its bleak rations. This animal has no problem with the cold weather in the high altitude because of its thick woolly fur that can help to survive from the bitter cold weather.
Crime and Safety in Netherlands:  
It can happen to you  
by: Paul Neerinck

August 18th, 2011

Netherlands. Based on data from the Central Bureau of Statistics (CBS), crimes occur around a million times a year in Netherlands. Of those numbers, theft and destruction of private and public property forms the second largest percentage. In addition, around 100,000 crimes a year are related to physical violence. All these crimes give a strong impact on how one, subjectively, feels safe in the Netherlands. Both the feeling and the statistics point to residents in Utrecht, Amsterdam and The Hague feeling more unsafe than in other cities. Unsurprisingly, the crimes in these cities are the highest as well.

The CBS reports that 26% of Dutch residents occasionally felt unsafe in 2010. Feelings of insecurity, either in general or in their own vicinity, are more apparent among residents of highly urbanised regions. By the end of 2010, about one in three residents of the police districts of Amsterdam, Haaglanden, Rotterdam, Rijnmond and Limburg reported feeling unsafe occasionally. In those districts, people more often report to feel unsafe in their own communities. This statistic is in line with the number of crime victims, which is definitely above average in a more urbanised police districts.

It is difficult to say, where crimes occur most frequently. One could expect that tourist spots are areas where one might expect pickpocketing, but crimes actually occur everywhere and can happen to anyone.

Martijn, a 38 years old construction worker said “I never thought I could be a victim of a mugging. I never look like a person who would carry a lot of money wherever I go. But then, some guys just threaten me and ask for my money and then run away with it. If this happened to me it could happen to anyone.”

Anne, a 25 years old university student said “I never feel safe walking alone outside my flat. It happens often that I feel someone looking at me in suspicious way and when I look back at him, he immediately looks away. Whenever this happens, I always hope that these people are not thinking of me as a target.”

Martha, a 40 year old mother of 2 children said “The street in front of my house is often passed by some drunk teenagers. It is not an uncommon thing when they start destroying property or even fight among themselves. Sometimes, innocent passers by become a victim. Whenever I watch this, I pray that they will never hurt me, my husband, or my children.”

Routine Activity Theory, a sub-field of rational choice and criminology, suggests that crime is normal and depends on the opportunities available. The theory says that crime will occur if a target is not sufficiently protected and if the reward is worth it. Crime does not need to be perpetrated by hardened offenders, super-predators, convicted felons or wicked people. What crime really needs is just an opportunity. For crime to occur, three aspects are needed: 1) A Motivated Offender 2) A Suitable Target 3) The Lack of a Capable Guardian.

Based on police reports, the criminal offenders tend to choose their victims randomly. First, he or she observes his or her target before deciding to act out the crime. If the target is suitable, then he or she will wait for the right moment to act. The perpetrator usually has an elaborate plan on how or when to execute the crime.

In the end, the police suggest that the public maintain safety behaviours to avoid being victims of crime while the police is working hard to prevent it.
Appendix C: Scenario Elements

Meet Target

Scenario A: Meet Target

Patient just walks to an empty table and has to wait the target for some time.

Target will then come to patient table.

Patient talks to target until target gives patient a phone number.

The patient dials the phone number to end the level.
Scenario B: Meet target by asking waiter

- Patient meets the waiter and asks for target’s table.
- The waiter escorts the patient to target’s table.

Scenario B: Meet target by asking waiter

- Patient talks to target until target gives patient a phone number.
- The patient dials the phone number to end the level.
Scenario C: Bartender

Before patient can talk, target will ask patient to order a drink. The patient then orders a drink from one of two bartenders; a "scary" bartender which is free, or a "smile" bartender which is busy.
Scenario C: Bartender

If the patient orders from "smile" bartender when he come back to the table, target will not be there.

After waiting for some time or if patient chooses to order from "scary" bartender, the patient will meet target again.

Scenario C: Bartender

Patient talks to target until target gives patient a phone number.

The patient dials the phone number to end the level.
Queue

Scenario D: Queue

Before patient can enter the restaurant, he needs to wait in a line
If the patient does not wait in line, he will be unable to enter the restaurant. Thus, the mission cannot go further
During this moment, the patient will be exposed to the talking, laughing, and whispering from other people in line
The security guard can also talk to the patient (controlled by therapist)

Patient then meets the waiter and asks for the target's table
The waiter escorts the patient to the target's table
Scenario D: Queue

Patient talks to target until target gives patient a phone number.

The patient dials the phone number to end the level.
Wrong Target

Scenario E: Wrong Target

Patient meets the waiter and asks for target's table

The waiter escorts the patient to wrong table

Scenario E: Wrong Target

Patient asks the waiter again about the correct target's table

The waiter escorts the patient to the correct table
Scenario E: Wrong Target

Patient talks to target until target gives patient a phone number.

The patient dials the phone number to end the level.
Scenario F: Bike

Patient meets the waiter and asks for target's table

The waiter escorts the patient to free table and tells patient that target will come late

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Scenario F: Bike

Patient has to wait for target

Patient then hears announcement by the security guard that tells him to move his bike or he will lose it

After hearing this, the patient needs to meet the security guard and give him the key so he can move the patient's bike
Scenario F: Bike

If the patient decides not to meet the security guard, the security guard will start asking guest at each table. During this moment, one of the guests is going to be a witness that saw the patient lock the bike. He will inform the security guard about this. The patient can hear a snatch of conversation about this.

Then, when the security guard talks to the patient, he will ask the patient about the bike and also try to confirm whether what the witness said is the truth. During this moment, all the guest attention will be centered on the patient. The patient can tell the truth and give the key to security guard, or he can lie and the story goes on.

Scenario F: Bike

After the event, the target will arrive to the patient’s table.

Patient talks to target until target gives patient a phone number

The patient dials the phone number to end the level
Appendix D: List of Dialogs for Snatch and Texts for TV

Snatch of spoken conversation

**Instruction:** If you hear or overhear this snatch of conversation while sitting in a restaurant, likely will it cause suspicious or paranoid thoughts? Put a cross on the bar below the location that best reflects your answer.

1. How are you?

   ________________________________
   Not at all                      Very much

2. He will be caught.

   ________________________________
   Not at all                      Very much

3. He is not going to move anywhere.

   ________________________________
   Not at all                      Very much

4. He thinks he can get away with it.

   ________________________________
   Not at all                      Very much

5. How is your job?

   ________________________________
   Not at all                      Very much

6. I don't think he can see us.

   ________________________________
   Not at all                      Very much

7. How are your children?

   ________________________________
   Not at all                      Very much
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<td>I'm feeling good today!</td>
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<td>9.</td>
<td>I don’t think he knows us.</td>
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<td>I hate him!</td>
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<td>11.</td>
<td>I don't like him!</td>
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<td>12.</td>
<td>It’s a good day!</td>
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<td>13.</td>
<td>He has no idea about it.</td>
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<td>14.</td>
<td>Look at his clothes!</td>
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<td>15.</td>
<td>I love this place!</td>
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16. Did you order yet?

Not at all

Very much

17. Look at his hair!

Not at all

Very much

18. Look at him!

Not at all

Very much

19. I like it!

Not at all

Very much

20. I don’t want to be with him!

Not at all

Very much

21. Something is not right about him.

Not at all

Very much

22. The food is delicious!

Not at all

Very much

23. He is bad/stupid/any negative adjective!

Not at all

Very much
24. I can see him.

________________________________________________________________________

Not at all  

Very much

25. Should I go to him?

________________________________________________________________________

Not at all  

Very much

26. Should I talk to him?

________________________________________________________________________

Not at all  

Very much

27. If he knows it, he would not be that calm.

________________________________________________________________________

Not at all  

Very much

28. Do you want to order more?

________________________________________________________________________

Not at all  

Very much

29. We should come here more often!

________________________________________________________________________

Not at all  

Very much

30. I can understand why you think that way.

________________________________________________________________________

Not at all  

Very much

31. After looking at him personally, I can understand why you think that way.

________________________________________________________________________

Not at all  

Very much
32. He does not look normal.

Not at all  

Very much

33. Can you believe it?

Not at all  

Very much

34. He looks funny, or not?

Not at all  

Very much

35. He would never think about it.

Not at all  

Very much

36. Did you see that?

Not at all  

Very much

37. Nice weather!

Not at all  

Very much

38. He thinks he can just forget it.

Not at all  

Very much

39. He thinks he is in a safe place.

Not at all  

Very much
40. .....bad/hurting/killing/stupid...... → practically only a single adjective or negative word

Not at all | Very much

41. If I were him, I would be very afraid.

Not at all | Very much

42. If I were him, I would be very guilty.

Not at all | Very much

43. He cannot run away from it.

Not at all | Very much

44. I always know what he is thinking.

Not at all | Very much

45. I feel comfortable here.

Not at all | Very much

46. What if we do it after this?

Not at all | Very much

47. Let’s wait for his reaction/response.

Not at all | Very much
48. I think we should do it now!

Not at all    Very much

49. I’m off to London tomorrow.

Not at all    Very much

50. This time he won’t get away!

Not at all    Very much

51. I’m sure he is the one who does it!

Not at all    Very much

52. The chef cooks a really delicious food.

Not at all    Very much

Suggestion for snatch of conversation
**TV News Flash**

**Instruction:** If you see this news flash on TV while sitting in a restaurant, how likely will it cause suspicious or paranoid thoughts? Put a cross on the bar below the location that best reflects your answer.

1. **Food Poisoning in Dutch restaurants**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>

2. **Netherlands won 6 gold medals in the Olympics**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>

3. **Dutch government spending less on art and culture**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>

4. **Crime in the Netherlands: 5000 cases increase this year**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>

5. **20 people shot in Norway**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>

6. **Dutch Universities rank among the best in the world**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>

7. **Police believe bombing threat is serious**
   
<table>
<thead>
<tr>
<th>Not at all</th>
<th>Very much</th>
</tr>
</thead>
</table>
8. Netherlands among top 5 most strong economies in the world

Not at all

Very much

9. 35 years old man assaulted on his way home

Not at all

Very much

10. Rembrandt’s work on tour in Japan and South Korea

Not at all

Very much

11. Manchester United won in a close match

Not at all

Very much

12. Body of 20 years old women found in alley

Not at all

Very much

13. Anna Paquin gives birth to twins

Not at all

Very much

14. Lady Gaga holds world tour concert for her new album

Not at all

Very much

15. Drunk man assaulted 36 years old man

Not at all

Very much
16. Murder suspect on the run in Brussels

Not at all  |  Very much

17. Steven Spielberg to direct a new movie

Not at all  |  Very much

18. Assault case increase in the Netherlands by 500 cases

Not at all  |  Very much

19. Resident grow tired of the police inability to ensure safety

Not at all  |  Very much

20. J.K. Rowling plans to write new novel series

Not at all  |  Very much

21. Usain Bolt: winning the gold medal is an unbelievable experience

Not at all  |  Very much

22. Assault suspect still on the run

Not at all  |  Very much

23. 15 people involved in a fight outside of a bar

Not at all  |  Very much
24. 22 years old women found stabbed in alley

Not at all  | Very much

25. Police still searching for restaurant killer

Not at all  | Very much

26. Tom Hanks to star in a new drama

Not at all  | Very much

27. Novak Djokovic won a Grand Slam tournament

Not at all  | Very much

Suggestion for TV News Flash
Appendix E: Legend for the System Architecture

Description of each block in the system architecture of the VRET system for paranoia treatment (Figure 5.5):

a) Therapist
   Therapist is the person who is responsible for using and controlling the VRET System to treat the patients. Therapist can interact with the system through Scenario Configuration, Rate Controller, Stressor Configuration, and the Avatar Configuration
   Output: Scenario Configuration, Rate Controller, Stressor Configuration, Avatar Configuration

b) Patient
   Patient is the person who receives the treatment. To immerse the patient in the virtual environment and exposed him to stressors, both the virtual environment and the stressors are displayed in the Display and Speaker Block.
   Input: Display and Speaker

c) Scenario Configuration
   This block is used by the therapist to configure the scenario for the treatment. A preset scenario can be loaded from a file in Disk I/O through the File Processor. When a preset scenario is loaded, the data will be passed to the Stressor Configuration and the Avatar Configuration. If the therapist wants to create and save a new scenario, the data from the Stressor Configuration and the Avatar Configuration will be passed to this block before continuing to the File Processor.
   Input: Therapist, File Processor, Stressor Configuration, Avatar Configuration
   Output: File Processor, Stressor Configuration, Avatar Configuration

d) Rate Controller
   This block is used by the therapist to control the rate of the random event in the VR. When the Rate Controller is changed by the therapist, the timer in Event Trigger will react immediately according to it.
   Input: Therapist
   Output: Event Trigger

e) Avatar Configuration
   This block is used by the therapist to include or exclude the elements of the VR world. When the exposure starts, the data will be passed to the VR Manager. In addition, this block sends the data to the Emotion Sitting Coordinator, Left Sitting Coordinator, Right Sitting Coordinator, Back Sitting Coordinator, Walking Coordinator, and Other Coordinator to inform them which elements are active in the VR world. This block also interacts with the Scenario Configuration during the saving and loading of a scenario.
   Input: Therapist, Scenario Configuration
   Output: VR Manager, Scenario Configuration, Emotion Sitting Coordinator, Left Sitting Coordinator, Right Sitting Coordinator, Back Sitting Coordinator, Walking Coordinator, and Other Coordinator

f) Stressor Configuration
   This block is used by the therapist to configure the probability of stressors. When the exposure starts, the data will be passed to the Stressor Manager. This block also interacts with the Scenario Configuration during the saving and loading of a scenario.
Input: Therapist, Scenario Configuration  
Output: Stressor Manager, Scenario Configuration  
g) Display and Speaker  
This block is part of the User Level Interaction that responsible for displaying the VR and the sound to the patient through HMD and speaker/headphone.  
Input: VR Manager  
Output: Patient  
h) File Processor  
This block is responsible for processing the information from the Scenario Configuration in order to save the data into the hard disk. This block is also responsible for processing the data from the hard disk in order to load the file into the VRET system.  
Input: Scenario Configuration, Disk I/O  
Output: Scenario Configuration, Disk I/O  
i) Event Trigger  
This block acts as a timer which determines when an event should be triggered. The value of the timer in this block is controlled by the therapist through the Rate Controller. When the timer sets off, this block will notify the Stressor Manager to choose the event.  
Input: Rate Controller  
Output: Stressor Manager  
j) Stressor Manager  
This block is responsible for choosing which event should occur based on the probability set by therapist through Stressor Configuration. Afterwards, the chosen event is passed to Event Coordinator.  
Input: Event Trigger, Stressor Configuration  
Output: Event Coordinator  
k) Event Coordinator  
This block is responsible to choose which of its active subordinate coordinator has to trigger the chosen event when a notification from the Event Trigger and the chosen event from Stressor Manager is received. After choosing which active subordinate coordinator has to act, the chosen event is passed to it.  
Input: Stressor Manager  
Output: One of its active subordinate coordinator (Emotion Sitting Coordinator, Left Sitting Coordinator, Right Sitting Coordinator, Back Sitting Coordinator, Walking Coordinator, or Other Coordinator)  
l) Emotion Sitting Coordinator, Left Sitting Coordinator, Right Sitting Coordinator, or Back Sitting Coordinator  
This block is a subordinate coordinator of the Event Coordinator which is responsible for handling any event that concern with sitting virtual character. This event includes eye gaze, emotion (angry or happy), and talking (snatch or laugh). When it receives the chosen event, it will directly pass it to the Sitting Virtual Character. If the block responsible for Group sitting virtual character, it will randomly choose one virtual character and send it the chosen event  
Input: Event Coordinator  
Output: Sitting Virtual Character
m) Walking Coordinator
This block is a subordinate coordinator of the Event Coordinator which is responsible for handling any event that concern with walking virtual character. This event includes walking and looking (look at patient or look at other). When it receives the chosen event, it will directly pass it to the Walking Virtual Character.
Input: Event Coordinator
Output: Walking Virtual Character

n) Other Coordinator
This block is a subordinate coordinator of the Event Coordinator which is responsible for handling any event that concern with other element (e.g. TV). For the prototype, this event includes news flash. When it receives the chosen event, it will directly pass it to the Other Element.
Input: Event Coordinator
Output: Other Element

o) Sitting Virtual Character
This block is directly controlling the sitting virtual character in the VR world. When this block receives a notification from its coordinator along with the chosen event, it will command the virtual character in the VR Manager to act accordingly.
Input: Emotion Sitting Coordinator, Left Sitting Coordinator, Right Sitting Coordinator, or Back Sitting Coordinator
Output: VR Manager

p) Walking Virtual Character
This block is directly controlling the walking virtual character in the VR world. When this block receives a notification from its coordinator along with the chosen event, it will command the virtual character in the VR Manager to act accordingly.
Input: Walking Coordinator
Output: VR Manager

q) Other Element
This block is directly controlling the other element (e.g. TV) in the VR world. When this block receives a notification from its coordinator along with the chosen event, it will command the other element in the VR Manager to act accordingly.
Input: Other Coordinator
Output: VR Manager

r) VR Manager
This block is responsible for managing the VR world in the VRET system. When an event is triggered, this block uses the command from the Sitting Virtual Character, Walking Virtual Character, or Other Element to change the behaviour of the associated element accordingly. The VR world itself is displayed to the patient through the Display and Speaker
Input: Sitting Virtual Character, Walking Virtual Character, Other Element
Output: Display and Speaker

s) Disk I/O
This block is responsible for saving and loading the scenario data in the hard disk.
Input: File Processor
Output: Hard Disk
Appendix F: Paper for CYBER18 – CyberTherapy Conference 2013

Priming to Induce Paranoid Thought in a Non Clinical Population

Reza Giga ISNANDA\textsuperscript{a}, Willem-Paul BRINKMAN\textsuperscript{b}, Wim VELING\textsuperscript{b}
Mark van der GAAG\textsuperscript{b,c}, Mark NEERINX\textsuperscript{a}
\textsuperscript{a} Delft University of Technology, The Netherlands
\textsuperscript{b} Parnassia Psychiatric Institute, The Hague, The Netherlands
\textsuperscript{c} VU University and EMGO Institute of Health and Care Research, Amsterdam, The Netherlands

Abstract. Freeman et al. reported that a substantial minority of the general population has paranoid thoughts while exposed in a virtual environment. This suggested that in a development phase of a virtual reality exposure system for paranoid patients initially a non-clinical sample could be used to evaluate the system's ability to induce paranoid thoughts. To increase the efficiency of such an evaluation, this paper takes the position that when appropriately primed a larger group of a non-clinical sample will display paranoid thoughts. A 2-by-2 experiment was conducted with priming for insecurity and vigilance as a within-subject factor and prior-paranoid thoughts (low or high) as a between-subjects factor. Before exposure into the virtual world, participants (n = 24) were shown a video and read a text about violence or about mountain animals. While exposed, participants were asked to comment freely on their virtual environment. The results of the experiment confirmed that exposure in a virtual environment could induce paranoid thought. In addition, priming with an aim to create a feeling of insecurity and vigilance increased paranoid comments in the non-clinical group that otherwise would less often exhibit ideas of persecution.

Keywords. Paranoia, priming, virtual reality, exposure, mental health computing

Introduction

Paranoia is a state of mind where the subject has a belief that other people have intention to harm them. This state is characterized by hyper vigilance, emotional arousal and selective attention for threat. Paranoia can be delusional in psychotic disorder, but also occurs in the general population where people have no history of mental illness [1]. This creates the opportunity to study paranoia evoking stimuli in a non-clinical population, which is specifically relevant when evaluating new virtual reality (VR) applications in this area. Before studying with actual patients, research could be done with non-patients initially. Furthermore, Freeman et al. [2] reported that, although substantial, only a minority of above 40% of their 200 participants recruited from the general population had paranoid thoughts when exposed in a neutral VR world, suggesting the need for relative large samples to evaluate a VR application on its ability to evoke paranoid thoughts in non-patients. Because of the impracticability of using a large sample, this paper takes the position that when appropriately primed a larger group of the general population will more intensely display paranoid ideation in
a VR world. That priming is effective in VR has already been demonstrated by Bouchard et al. [3]. They showed that informing individuals, with a snake phobia, prior to the VR exposure about the existence of dangerous snakes in the VR world, could increase the anxiety experienced in VR later on. In addition, Qu et al. [4] also showed that text and video priming could increase the chance that an individual would mention a specific keyword in a discussion with a virtual character. Results from both studies encouraged an investigation into whether it is also possible to induce paranoid thought to a non-clinical sample using priming prior to the exposure. Therefore, this study aims to demonstrate that video and textual priming prior to exposure can indeed increase paranoid thought during VR exposure.

1. Method

1.1. Procedures and Participants

The experiment was set up with a two by two design, with type of priming (paranoid or neutral) as a within-subjects factor, and prior-paranoid thoughts (low or high) as a between-subjects factor. In addition, the experiment was controlled by a computer that followed a double-blind procedure where both the participants and experimenter did not know the order of the priming condition. 24 students of Delft University of Technology (16 male and 8 female) participated in the experiment. The participants' age ranged between 23 and 33 (M = 27.8, SD = 2.8). All the participants had at least a bachelor degree and reported to have no history of psychosis. Ethical approval for this experiment was obtained from the university ethics committee. Before the experiments, all the participants read, and signed a consent form. They were not informed about the hypothesis of the experiment until the experiment had ended. They were only informed that their participation would help in the developing a VR environment that could be used to help treating people with a mental disorder.

1.2. Interventions

The type of priming in the experimental condition consisted of two levels: paranoid priming and neutral priming. In the paranoid priming condition, the participants were shown a 6.5 minutes video of a news report on street violence and read an A4 page long fake news report about violence in the Netherlands. The aims of the video and the text was to raise attention to threat and increase the level of vigilance so that participants could carry-over these feelings into the VR exposure to influence the way they perceive the VR world. In the neutral-priming condition, participants were shown a 6.5 minutes wildlife video [5] and read an A4 page long text about mountain animals. Both this text and video were selected with the intention not to evoke suspicious thoughts or feelings. After reading the text and watching the video, participants were either exposed to a VR environment of a restaurant or a train platform [6] for 5 minutes each. The orders of the two priming conditions and the VR worlds were counterbalanced. Both environments included virtual characters that had no specific tasks, did not show specific emotions, and did not initiate conversations or physical

1 Downloaded on 27 February 2012 from http://www.youtube.com/watch?v=jQZpiht5ic
interactions with the participants. Some virtual characters walked around, either following a fixed path, or a random path, and stopped at random points to look around. Furthermore, some virtual characters looked occasionally at the participants. Figure 1 shows pictures from the VR environments. To establish a baseline measurement and to train the participants with a commenting protocol, participants were exposed in a training VR environment [5] at the start of the experiment after which they were presented with priming video and text.

![VR environment](image1.jpg) ![VR environment](image2.jpg)

Figure 1. The VR environment. Left the restaurant world and right the train platform world.

1.3. Materials and Measurements

The participants were exposed in the VR world by wearing a Sony HMZ-T1 Personal 3D Viewer head mounted display with resolution of 1280x720. The tracking was done using 6DOF Ascension Flock of Birds tracker. Mobi8 data recorder from TMSi was used to collect heart rate data from the participants. Throughout the exposure, the participants were instructed to comment freely on their environment, including the virtual characters. They were asked to focus on how they experienced and perceived the environment rather than simply providing an 'objective' description of the environment or an assessment of the quality of the VR environment. During the exposure the experimenter recorded what the participants said and also saw in the VR environment at that moment. The participants’ voice and screen view were recorded using Camstudio software. To measure the participants’ paranoid comments, two independent coders went through all 48 commentaries and counted the number of times participants made comments that could be labeled as paranoid thoughts (Table 1). In addition, The Green et al. Paranoid Thoughts Scale (GPTS) [7] was used as a measure of the participants’ base paranoid level prior to the experiment, and the State Social Paranoia Scale (SSPS) [8] was used as a measure of the participants’ paranoid thought directly after the VR exposure.

2. Result

A strong level of inter-observer correlation (Spearman $r = .83$, $n = 48$, $p < .01$) suggested an acceptable reliability level of the coded comments. For further analysis the average value of two coders was used. Taking the median score of 58.5 on the Green et al. Paranoid Thoughts Scale (GPTS) as a cut off point, the participants were split into two equal groups, a low and a high GPTS group. As the SSPS score and the paranoid comments deviated from a normal distribution, an Aligned Rank Transformation (ART) for nonparametric factorial data analysis [9] was conducted first. Afterwards, repeated-measures ANOVA analyses were conducted using the
priming condition and the two GPTS groups each time as independent factors and the ART of SSPS score, Heart Rate, and the ART of the number of paranoid comments as dependent variables. Table 2 shows the result of the analyses.

Table 1. Coding Scheme Paranoid thoughts commentaries.

- **Persecution/accusation**: a reference that suggests that a virtual character is acting suspiciously or is dangerous.
- **Examples**: he looks suspicious; I believe he has bad intentions; he is up to no good.
- **Examples**: the way he looks at me makes me feel uncomfortable or distressed, which was caused by a virtual character or the environment.
- **Examples**: the way he looks at me makes me feel uncomfortable; people keep staring at me and it feels uncomfortable; I am not feeling comfortable to sit beside him.
- **Not included**: references to feelings that are caused by unrelated events or objects, such as: I feel uncomfortable since there is no food on my table; I am bored.
- **Threat**: a reference towards a threat from a virtual character or the environment or a feeling of insecurity.
- **Examples**: the way he looks at me makes me feel insecure; I do not think this place is a safe place.
- **Not included**: references that are caused by unrelated events or objects such as: I am afraid that the HMD will fall if I move too actively; I am not feeling safe wearing all these gadgets.

Table 2. Results of analyses on SSPS, Heart Rate, and Paranoid comments.

<table>
<thead>
<tr>
<th>Measures</th>
<th>GPTS group</th>
<th>Priming</th>
<th>GPTS group x Priming</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>F(1, 22)</td>
<td>p</td>
<td>F(1, 22)</td>
</tr>
<tr>
<td>SSPS</td>
<td>3.05</td>
<td>.055</td>
<td>&lt; .01</td>
</tr>
<tr>
<td>Heart Rate</td>
<td>4.22</td>
<td>.052</td>
<td>.06</td>
</tr>
<tr>
<td>Paranoid comments</td>
<td>0.75</td>
<td>.395</td>
<td>.77</td>
</tr>
</tbody>
</table>

Although no significant main effects were found, analyses revealed a significant two-way interaction effect between GPTS groups and the priming condition ($F(1,22) = 5.10, p = .034$) on the number of paranoid comments (Figure 2).

![Figure 2](image)

**Figure 2.** Median number of paranoid comments mentioned in the exposure.

In the neutral priming condition, the low GPTS group ($Med = 0.75$) made significant ($z = -2.08, p = .04$) fewer paranoid comments than the high GPTS group ($Med = 2.0$), whereas in the paranoid priming condition no significant ($z = -2.09, p = .08$) difference was found between the low ($Med = 2.25$) and the high GPTS group ($Med = 1.5$). Also for the low GPTS group, the number of paranoid comments significantly increased between the neutral and the paranoid priming condition ($z = -2.68, p < .01$), while for high GPTS group, no significant difference ($z = -0.55, p = .58$) was found between the neutral and the paranoid priming condition. Instead, the number of comments seemed to remain relatively high. Furthermore, although the main effect for the GPTS groups on SSPS scores (low GPTS group $Med = 15.5$; high GPTS group $Med = 20.0$)
Mdθ = 24.5) and participants’ heart rate (low GPTS group M = 86.2; high GPTS group M = 79.6) approached a significant level of .05, no significant main effect for priming or an interaction effect between priming and GPTS groups was found on both.

3. Discussion

The result of the effects of priming on paranoid comments seems similar to the result of Fett et al.[10]. In a trust game, they found that the paranoid individuals were inflexibly mistrusting, while non-paranoid individuals were more trusting in neutral situations and mistrusting in situations in which they were cheated. No significant interaction effect between the GPTS groups and priming was found on the SSFS score and the heart rate. Presumably priming might not result in a large physiological effect, while SSFS score was only collected after the exposure, where the priming effect might have worn off, or might not have a large effect on the recollected experience of this non-clinical sample.

4. Conclusion

The results of the experiment confirmed that exposure in a virtual environment could induce paranoid thought. In addition, priming with an aim to create feelings of threat and vigilance could increase paranoid comments in a non-clinical group that otherwise would less often exhibit ideas of persecution. Together these findings suggested that when appropriately primed a non-clinical sample could be used to evaluate VR environment ability to elicit paranoid thought.

References