Analysis of Physiological Response to Neutral Virtual Reality Worlds

Bert Busscher
Department of Clinical, Health and Neuropsychology, Leiden University, The Netherlands
VALK Foundation
Leiden, The Netherlands
info@valk.org

Daniel de Vlieger, Yun Ling, Willem-Paul Brinkman
Delft University of Technology
The Netherlands
Netwin@hetnet.nl, ellachaos@gmail.com, w.p.brinkman@tudelft.nl

ABSTRACT
Using virtual reality technology for exposure therapy to treat patients with anxiety disorders is attracting considerable research attention. The ability to monitor patient anxiety level helps therapists to set appropriate anxiety arousing situations. Physiological measure has been put forward as objective indicator of anxiety levels. Because of individual variation, they need a baseline recording which is often conducted in neutral virtual world which does not include phobic stressors. Still because of the novelty of the virtual world, reports in the literature suggest that individuals already show some level of arousal when placed in these worlds. This paper presents two studies which look at the effect two different neutral virtual worlds can have on individuals. Findings suggest that a neutral world does not have to result in an increased level of arousal.

Categories and Subject Descriptors
H.5.1 [Information interfaces and presentation]: Multimedia Information Systems - *virtual realities*

General Terms
Measurement, Design, Experimentation, Human Factors.

Keywords
Virtual reality, exposure therapy, physiological measurements, neutral worlds.

INTRODUCTION
Virtual Reality Exposure Therapy (VRET) is receiving considerable research attention for a treatment of patient suffering from anxiety disorder, such as claustrophobia, fear of driving, acrophobia, spider phobia, social phobia, panic disorder with agoraphobia, post traumatic stress disorder, and fear of flying. VRET is based on the ideas of gradual exposure in vivo, considered the gold standard for treatment of phobias. Recent meta-studies [5,16,17] show that exposure in VR is as effective as exposure in vivo. An important element of the therapy is that the exposure is done gradually to more anxiety arousing situations. Therapists are, therefore, continuously monitoring the anxiety level of a patient. This can be done using Subjective rating of Anxiety (SUD), behavioural observations or physiological measures. The latter has the advantage of being more objective, but needs a base line measurement because of individual variation. One often used procedure is to obtain a physiological base line recording when the patient is placed in a neutral VR world, i.e. a VR world which should not include phobia related stressors. Even if this world has no phobia related stressor, it is not clear whether experience of being placed in a Virtual Environment (VE) causes some level of anxiety. Some authors [27] have suggested that the majority of non-phobic individuals do get some level of arousal when placed in a VE. For example Jang et al [10] report a study with non-phobic individuals and observed that participants were initially aroused in the VR exposure, but returned to a normal base line after approximately 7 minutes. In another study, Wiederhold et al. [26] also report that non-phobics, when placed in a VE, initially show some level of anxiety. They argued that the VE is a new and novel stimulus and therefore causing this effect. Extending on this line of reasoning, this paper explores whether the design of the neutral world can also contribute to this effect. Or in other words, would it be possible to design a truly neutral world. As reported in this paper, we were confronted with this question after results of our first study suggested that both phobic and non-phobic participants showed higher heart rates during exposure in a neutral virtual world than both in the VE with phobic stressors and in the recovery phase after the VR exposure. Furthermore, both phobics and non-phobic individuals experienced moderate to severe nausea in the neutral VR condition. This called into question the neutrality of the neutral virtual world and led our research into the creation of neutral virtual world.

The paper starts with briefly discussing key concepts such as VR systems, presence and problems experienced by patients. After this, the first study is presented in which both non-phobic and phobic individuals are placed in a neutral VR world, a virtual airplane, and a recovery phase. The second study starts with a discussion of the design of a new neutral VR world. This virtual world aims to be an almost identical representation of the room the individual is sitting in. Results are presented from data collected in four

conditions: the real world room, the new neutral VR world, virtual airplane, and recovery phase. The paper concludes by discussing the findings which suggests that it might be possible to design a truly neutral world. Also no support was found for a possible transfer of habitation from the physical room to the neutral virtual room.

BACKGROUND

The sense of being a part of the VE even when a person is physically situated in a totally different real world is considered a key element of VRET. This concept of presence is related to four components: technological devices; user-computer interactions; main task and the user [9,29]. In the application field of VRET, the main technical devices used are a head mounted display (HMD) and computer automatic environment (CAVE). The CAVE has relatively higher immersion level with stereoscopic images on four to six sides around the user while the HMD has only one stereoscopic image in front of the user. In a study on the effects of VRET in patients with acrophobia using CAVE and HMD, it is reported that VRET was superior to no-treatment on anxiety, behavioral avoidance and attitudes towards heights. Although the therapy given in the CAVE resulted in higher level of presence than the therapy given through HMD, no differences in effect were found between them and the results remained stable during the following six months [13]. This therefore seems to suggest that only a certain level of presence is needed for treatment to be effective. Even with devices as a HMD or a CAVE patients can still experience low level of presence causing them to drop out of the treatment [14]. This underlines that presence is also determined by individual factors such as vision ability, cognitive processing ability [20] of the VE, and personality [25]. Cybersickness is another potential human factor, which is a form of motion sickness that occurs as a result of exposure into VE and can range from a slight headache to an emetic response [23]. Although physiological measurement can be used for determining anxiety during the VRET therapy, the side effect of cybersickness can also arouse physiological changes in people [15]. Both cybersickness and presence therefore seem important factors that might explain, besides the initially suggested habitation, physiological effects in neutral virtual worlds.

STUDY 1

Method

The first study was initially set out to study physiological response of both phobic and non-phobic individuals in a VE with phobic stressors. Both groups were exposed to three conditions: a neutral virtual world, a virtual flight, and a recovery phase. Both the effects for two groups and conditions on physiological recordings and self-reported anxiety were analyzed.

VR system

The VRET Delft 2007 system is described in detail elsewhere [1,7,21]. Briefly, the HMD used was the stereoscopic Cybermind Visette Pro with a resolution of 640x480 per display and a 60 Hz refresh rate. An Ascension Flock of Birds was used as the tracking tool. Two personal computers (PC) were used in the system, the therapist computer where the therapist controls the therapy session and a patient PC which gets input from the HMD and therapist computer. Both the neutral virtual world and the flight world were created with WorldUp R4 by Sense8.

Figure 1: Left, the neutral courtyard, right virtual flight world.

Sound was delivered via the inbuilt HMD speakers and two additional speakers in front. Participants were seated on a normal desk chair during the neutral virtual world (Figure 1, left) and on a real passenger seat from a KLM airplane during the virtual flight (Figure 1, right). To enhance the feeling of presence in the Airplane world, two AuraSound AST-3B-4 Bass Shakers including a 100-Watt digital amplifier were added to the system.

Participants

Participants for experiment 1 were aviophobics that applied for therapy at the VALK foundation, and non-paid volunteers without fear of flying who acted as a control sample. The VALK foundation is a mental health clinic that specializes in aviation related anxiety. During the recruitment period 46 phobic clients who applied for treatment received written information regarding the VR study at their home address two weeks before their first visit. Out of this group, 40 phobics were willing to participate. One client was excluded because of the use of cardioactive medication (ß-blockers). This left 39 phobic clients (15 men) with an average age of 44.5 (*SD* = 12.4), who fulfilled the DSM-IV criteria for specific situational phobia furnishing usable data. In the same period 22 non-paid volunteers without fear of flying and an average age of 48.3 (*SD* = 11.4) successfully completed a part of the same protocol. Volunteers were recruited through the social network of the research institution's staff. Healthy subjects were matched with the sample of patients on age and sex. One of them received a positive diagnosis for aviophobia during the intake and was excluded. Another control subject's questionnaire data rendered unusable, her physiological data was included for analyses. The 21 non-phobics had flown at least several times; most of them had flown within 18 months of the experiment. None of the control subjects was ever treated for fear of flying. Before start of the experiment, informed consent was obtained from all participants.

The research protocol has been approved by the local medical ethics committee.

Measures

For the physiological recordings, the three target variables were Heart Rate (HR), Pre Ejection Period (PEP) and Respiratory Sinus Arrhythmia (RSA). PEP is considered a measure of (inflammatory) sympathetic cardiac control [22] whereas RSA is a measure of (calming) parasympathetic control [2]. Scoring of these variables from thorax impedance and the ECG is described in detail elsewhere [3,4]. Briefly, from the ECG (sampling rate 1000 Hz) the HR was obtained from the time between two adjacent R waves. PEP was defined from the ECG and ICG as the time interval from the Q-wave onset, the onset of the electromechanical systole, to the B-point (from the ICG), which signals opening of the aortic valves [22,28]. RSA was obtained from the ECG and respiration signals by subtracting the shortest IBI during HR acceleration in the inspirational phase from the longest IBI during deceleration in the expirational phase (i.e. the peak-through method) [6]. When no phase-related acceleration or deceleration was found, the breath was assigned a RSA score of zero. Automatic scoring of PEP and RSA was checked by visual inspection of the impedance and respiratory signal from the entire recording. Our focus on cardiac parameters reflects two major considerations: measurements needed to be as non-invasive as possible and they needed to respond to changes in psychological state over a time scale of a few minutes. The PEP and RSA measures are uniquely qualified to meet both demands [3,28]**.** Using a visual display of the output of an inbuilt vertical accelerometer, we identified artefact free periods in each condition that lasted at least 5 minutes each.

All questionnaires were administered in the Dutch language, they were:

- The Visual Analogue Flight Anxiety Scale (VAFAS) was used to examine to what extent participants were anxious about flying [24].
- The Subjective Units of Discomfort (SUD) scale was used to examine to what extent participants were feeling anxious at several moments. They had to indicate their perceived anxiety on a scale from 1 ("totally relaxed") to 10 ("extremely anxious") [30].
- The Igroup Presence Questionnaire (IPQ) was used to measure the feeling of being in the VE [19].

Procedure

All measurements took place at the VALK facility. Upon arrival participants were informed about the procedure. For the aviophobics it was emphasized that participating was voluntary and neither participation nor refusal to participate impacted on the quality of treatment. After informed consent was given, six electrodes were attached and connected to the Vrije Universiteit Ambulatory Monitoring System (VU AMS) which records the thorax impedance and the ECG in freely moving individuals [3,4,8,18,28].

Participants were then seated upright in a normal chair and partook in three experimental conditions, always in the same fixed order. Participants first received a 7 minutes VR exposure in a neutral VE after which they were asked to fill out the IPQ. The neutral VE [21] consisted of a courtyard in which participants moved around under therapist control, i.e. locomotion is not controlled by the participants. The locomotion was standardized and automated. Participants completed two rounds along the outer perimeter of the courtyard (Figure 1, left). This condition was followed by 7 minutes VR flight simulation in a real airplane seat. Participants were seated upright and followed a standardized program consisting of taxi-out, take-off, a short cruise flight, descent, approach and landing. Subsequently, participants were given 7 minutes of recovery time while seated in the airplane seat. Subjective units of distress (SUD) were measured at four discrete moments: before the start of the experiment, directly after both VR presentations and at the end of the recovery period. The VAFAS was administered before start of the experiment.

Results

Comparison of phobic and non-phobic control participants on sociodemographic characteristics and the VAFAS scale were performed with one-way ANOVA. Table 1 shows the main characteristics for the group of phobic participants and the control group.

An ANOVA was conducted on the SUD scores collected in three conditions (neutral VR world, virtual flight, and recovery) from the two participant groups (phobic, and control). Significant condition ($F(1.73,91.54) = 3.81$, $p = .031$) and group ($F(1,53) = 21.68$, $p < .001$) effects were found for self-reported distress. Phobics had higher levels throughout, while on average participants reported less fear during recovery compared to the virtual flight. Follow-up analyses for both groups separately showed significant differences in reported anxiety between the recovery condition and both the neutral VR world ($t(1, 37) = 2.51$, $p = .017$) and the virtual flight ($t(1,33) = 3,09$, $p = .004$) for the flight phobics, while no significant differences between conditions were seen for the control group (Figure 2).

Table 2: Number of subjects, gender, age, Body Mass Index (BMI) and VAFAS score in study 1.

	Phobics M (SD or %)	Non-phobics M (SD or %)
Number of participants • Total • Men • women	39 15 (38%) 24 (62%)	21 11 (52%) 10 (48%)
Age (years)	44.5 (12.4)	48.3 (11.4)
BMI	24.6 (3.8)	23.5 (2.4)
VAFAS	8.0 (1.4)*	0.6 (0.7)

* Phobics differ from non-phobics at $p < .001$

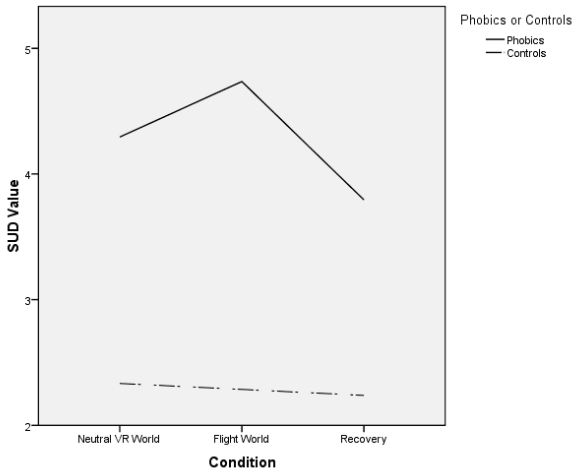

Figure 2: SUD scores for phobic and control participants.

An ANOVA with same independent variable was also conducted on the physiological data. Of the physiological variables, RSA had to be log (ln) transformed to obtain normal distributions. For HR a significant main effect was found for condition (F(1.78, 101.62) = 16.94, p <.001). Both control participants and phobic participants had higher heart rates during the neutral VR world than in any other condition (Figure 3). In contrast to the main effect of condition for HR, no significant effects of condition were found in RSA and PEP data. In fact, there was no significant main or interaction effect in RSA at all. A significant main group effect did emerge in PEP data, phobic participants had significantly shorter PEP values than control subjects, indicating higher cardiac sympathetic control (F(1,58) = 5.83, p =.019).

A one-way ANOVA was conducted for the IPQ. Non-phobic subjects scored significantly higher on the total IPQ scale (F(1,57)=10.42, p=0.002) including its subscales Spatial Presence (SP: F(1,57)=11.45, p < 0.05) Involvement (INV: : F(1,57)=5.24, p < 0.05) and Realism (Real: : F(1,57)=4.08, p < 0.05). IPQ scores were relatively high compared with other studies[18]. No significant correlations between IPQ scores and SUD scores were found.

Almost all participants complained either during or directly after the neutral VE exposure about dizziness and nausea. This was corroborated by an elevated HR during this supposedly non-provocative neutral condition. No difference in anxiety between the neutral VR world and the flight world was reported by the flight phobics. All other measures did not differentiate between conditions. This led us to the conclusion that the neutral VR world probably was not truly neutral after all.

[18] For comparison data see www.igroup.org

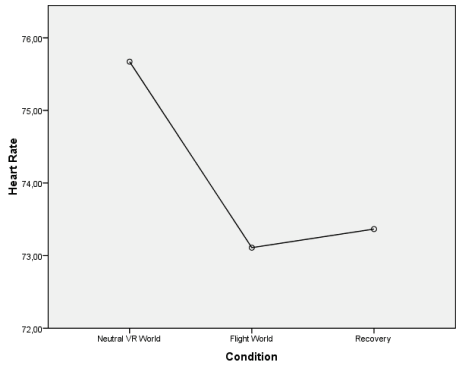

Figure 3: Average HR for phobic and non-phobic combined.

STUDY 2

Method

Novelty of a new environment or cybersickness might have caused the higher level of arousal in the neutral VR world in study 1. This would suggest that arousal level could be reduced by removing the novelty and therapist controlled locomotion element from the neutral VR world. The aim of the second study was therefore to examine whether a new neutral world would still result in an elevated level of arousal. In addition the study was also set out to study the suggested novelty effect or possible transfer of habituation by changing the order in which physiological recording was collected (the actual room first, or virtual room first).

VR system and new neutral world

To make a possible transfer of habitation possible a virtual world was created which was a close replication of the actual room the individual was situated in, causing participants to see the same environment when they would put on or take off the HMD. Participants were seated in front of a television (Figure 4, right) showing a documentary about wildlife. In the new neutral VR world (Figure 4, left) participants were seated in front of the same television set which shows the same documentary. Looking around with or without the HMD would give the same view of the room. The new neutral VR world ran on the same hardware as the VR flight and the old neutral VR world but used different software with exception of the Windows XP operating system. The Vizard Virtual Reality Toolkit, Vizard 3.0 was used to create an executable that provided head tracking and the image for the HMD. The model of the room was created with Autodesk Maya 2008 and textures were edited with Adobe Photoshop CS2. The model consisted of the room in which a table, television set, room dividers and a metal rail were modelled in detail. There were 18 textures made with several different sizes ranging from 2048 x 2048 pixels (the wall closest to the patient) to 64 x 512 pixels (a table leg). The world was displayed with a resolution of 640 x 480 to match the resolution of the HMD used in VR flight. All textures where file textures. The textures were made out of photographs taken from the location

where the patient would sit. Every visible face got its own unique texture. No dynamic lights or computer generated shadows were used. Distortion was removed from the images and the colour balance of several images was altered. Some objects were edited out of textures, like the table that was removed from the photograph that formed the texture for the wall behind the television set, which was facing the patient. Shadows belonging to objects that were removed from the scene were edited out like the radio and chair in front of the table. Some shadows had to be drawn in by hand like the shadow of the table on the part of the wall behind the table. A video could be displayed on the television set triggered by a keyboard button press. The video used was ripped from DVD and recompressed with a resolution of 720 x 576 at 25 frames/second. The video format and codec used was VC-1, WMV3 (Windows) and the audio format and codec used was WMA2, 161 (Windows). The video was edited to a duration of 6 minutes and 29 seconds. A DVD with the exact same edited video was made so that the video could be played on the DVD player in the actual room.

Figure 4: Left, new neutral virtual world, Right, picture of the actual room.

Participants

44 People participated, 32 students who earned credits by participating and 12 non-paid volunteers recruited by means of word-to-mouth. All participants received an email with information regarding the study before start of the experiment. One participant was excluded because of the use of cardioactive medication. Another two participants were partly excluded from analyses because of equipment failure during physiological recordings; their questionnaire data was included for analysis. Average age of all 43 (16 men) participants was 25.6 (*SD* = 8.0), the youngest being 18 years old, the oldest 51.

Measures

The Simulator Sickness Questionnaire (SSQ) was include in addition to IPQ and SUD to examine to what extent participants experienced symptoms associated with simulator sickness caused by the VR exposure. The SSQ consists of a checklist of 27 symptoms, each of which is rated in terms of degree of severity (none, slight, moderate, severe). It is normally administered twice, before and after a VR exposure [12]. The instrument provides three subscales (Nausea, Oculomotor and Disorientation) and a composite Total Severity Score, which is used in the present study. The instrument's psychometric properties are good [11]. The internal consistency in the present study was good, Cronbach's Alpha .78.

Procedure

Participants started with filling out the VAFAS and the SSQ (pre-exposure). After attachment of the electrodes of the VU AMS participants were seated upright in a normal seat. Participants randomized started either with the new neutral VR world, or the neutral real world. Participants were asked to complete the IPQ and SSQ-post-exposure directly after the neutral VR world. These two conditions were followed by 7 minutes VR flight simulation seated in a real airplane chair. Participants were seated upright and followed a standardized program consisting of taxi-out, take-off, a short cruise flight, descent, approach and landing. Subsequently, participants were given 7 minutes of recovery time while seated in the airplane seat. SUD score were recorded at five discrete moments: before the start of the experiment, directly after both neutral worlds, after the virtual flight and at the end of the recovery period. Before start of the experiment informed consent was obtained from all participants. The research protocol had been approved by the local medical ethics committee.

Results

As was done with study 1, a series of ANOVAs were conducted to study the effect of two independent variable: condition (real world, new neutral VR world, virtual flight, recovery), and groups (first real world then new neutral VR world, or first new neutral VR world and then real world).

Table 3: Number of participants, gender, age, Body Mass Index (BMI) and VAFAS score in study 2.

	M (SD or %)
Number of participants • Total • Men • Women	43 16 (37%) 27 (63%)
Age (years)	25.6 (8.0)
BMI	22.6 (2,8)
VAFAS	0.8 (1,2)

A significant main effect was found for condition ($F(2.46, 100.9) = 3.29$, $p = .032$) in the SUD scores. Participants reported lower levels of anxiety during the real world than during any other condition. Follow-up analyses for both groups separately showed a significant difference in reported anxiety between the real world and both the new neutral VR world ($t(1, 20) = -2.32$, $p = .031$) and the virtual flight ($t(1,20) = -2,35$, $p = .029$) for the participants who saw the real world first (Figure 5). Interestingly no significant differences between conditions were found when the new neutral VR world was presented first.

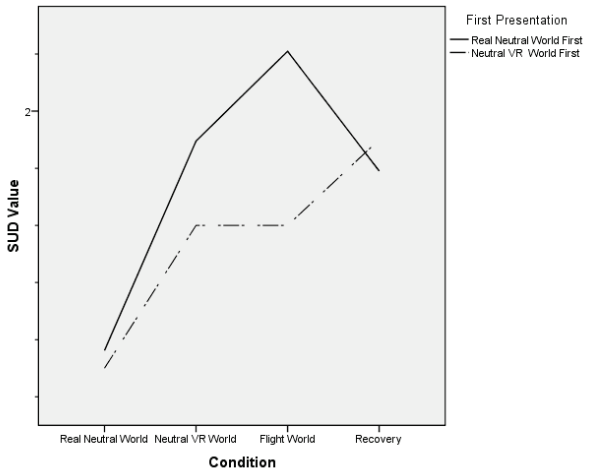

Figure 5: SUD scores for both groups.

The analysis of heart rate found a significant condition by group interaction ($F(2.19, 85.32) = 5.48$, $p = .005$), together with a main effect of condition ($F(2.19, 85.32) = 10.12$, $p < .001$). Follow-up tests revealed that HR during virtual flight was significantly lower than HR in any other condition (all $p <. 001$), while the interaction with group was driven by an increase of HR during the real world condition for the participants who saw the real world first (Figure 6).

In contrast to the condition by group interaction for HR, no significant condition by group interactions were found for RSA and PEP. Significant main condition effects did emerge for overall RSA and PEP levels. Participants had significantly longer RSA values during virtual flight compared to all other conditions, indicating higher parasympathetic control during virtual flight ($F(2.72, 106.04) = 9.06$, $p < .001$), and significant longer PEP values during virtual flight compared to the new neutral VR world and the recovery condition ($F(3, 37) = 5.12$, $p = .003$), indicating less cardiac sympathetic control during virtual flight.

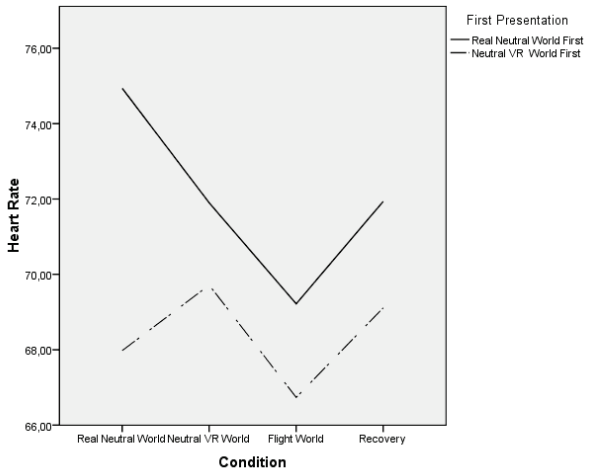

Figure 6: Average HR for both groups.

On average participants had a significant decrease in SSQ from pre- to post-presentation measurement ($t(1, 41) = 2.65$, $p = .011$). These changes from pre-to post scores on the SSQ were significantly correlated to the SUD values from the Virtual Flight such that decreased simulator sickness was accompanied by a lower anxiety score during the flight condition ($r = -.437$, $p = .003$). SSQ-post scores were significantly correlated with SUD-Flight ($r = .508$, $p = .001$) and SUD-Recovery ($r = .522$, $p < .001$). Participants with lower post presentation simulator sickness scores report lower anxiety during virtual flight and the recovery condition, while participants with higher post presentation SSQ values report more anxiety in both conditions.

No significant correlations between IPQ scores and SUD scores were found. A significant negative correlation was found between IPQ and SSQ-Post ($r = -.325$, $p = .033$) and a significant positive correlation was found between IPQ scores and SSQ pre-post ($r = .391$, $p = .009$). On average participants with a higher presence score had a lower post-presentation simulator sickness score than participants with lower IPQ score, while participants with a higher presence score show a stronger decrease in simulator sickness compared to participants with lower IPQ scores.

CONCLUSION AND DISCUSSION

In the second study all physiological measures differentiated between the flight condition on one side and the VR neutral world and recovery condition on the other side, while no physiological difference was apparent between the VR neutral world and recovery. Even self-reported distress showed no significant differences between conditions when the new VR neutral world was presented first. This seems to refute the idea that a virtual world by definition will generate arousal and anxiety [16,17,27]. The second study found only an interaction effect between the condition and the groups in HR. Still, follow-up analyses only found a significant decrease, instead of an increase, in HR when recordings were first collected in actual room and then in neutral VR room. This observation is therefore contra to the idea that novelty of VE would always cause arousal. Also the follow-up analyses did not find a significant difference in the HR of the participants group in which the recording took place in the opposite order (first neutral VR world, second actual room). A significant decrease would have provided support for the hypothesis of transfer of habitation from one environment to another. The lack of interaction effects in the other physiological measure, therefore, makes this hypothesis again less likely. Thus suggesting that to obtain neutral physiological measurements the VE does not have to be a replication of the actual room the individual is situated in. The study also found presence and cybersickness to be negatively related. Although only a certain level of presence is needed for treatment to be effective [13], maximizing presence might reduce simulator sickness and thereby minimize drop out. A principal finding in study 1 is that phobics were more anxious during the entire experiment than non-phobics, as expressed in significantly higher SUDs and

sympathetic activation (PEP). This contributes to the validity of VR as a useful tool in exposure based therapy.

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Bert Busscher

- Aviation Psychologist
- VALK Trainer
- Captain Boeing 747 KLM

VALK Foundation

Virtual Reality Exposure Therapy (VRET)

- Fear of Flying
- Fear of Heights
- Claustrophobia

Study 1

2 groups
- Flight Phobics, n = 39
- Non-Phobic Controls, n = 21

3 conditions
- Neutral Virtual World
- Virtual Flight
- Recovery

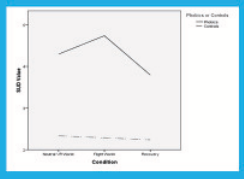
VR Worlds

Measurements

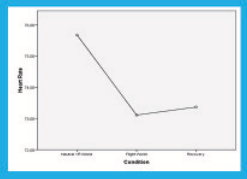
- Anxiety
  - SUD Subjective Units of Discomfort
- Arousal
  - HR Heart Rate
  - RSA Respiratory Sinus Arrhytmia ("Calming")
  - PEP Pre Ejection Period ("Activating")
- Presence
  - IPQ Igroup Presence Questionnaire

Results Study 1

Phobics report Sign lower anxiety during Recovery than during both VR Worlds



All subjects have highest HR during "Neutral" VR World



Conclusion

- All participants complained during or after neutral VR World of dizziness and nausea
- No difference in anxiety between neutral VR world and Flight world
- Elevated HR during neutral world
- All other measures did not differentiate between conditions

→ This neutral world was not truly neutral after all

Study 2

2 groups (n = 43)
- Real world first
- New Neutral VR World first

4 conditions
- Real World
- New Neutral Virtual World
- Virtual Flight
- Recovery

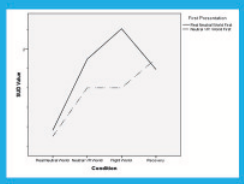
New Neutral Virtual World | Actual Room

Measurements

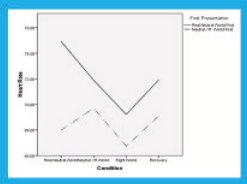
- Anxiety
- Arousal
- Presence
- Simulator Sickness
  - SSQ Simulator Sickness Questionnaire
- Imaginative Power
  - VVIQ Vividness of Visual Imagery Questionnaire

Results Study 2

- **Real world first: Both VR worlds more anxiety**
- **Neutral VR world first: No significant difference between conditions**



- **Real world first: Highest HR during real world**
- **Neutral VR world first: No significant difference between conditions**



SSQ, VVIQ and SUD

- SSQ pre-post significant decrease
- SSQ pre-post correlated with SUD-Flight (r= -.437, p=.003)
- SSQ post correlated with SUD-Flight (r= .508, p=.001)
  → Decreased simulator sickness and lower post presentation simulator sickness was accompanied by lower anxiety scores

- IPQ correlated with SSQ pre-post (r= .391, p=.009)
- IPQ correlated with SSQ post (r= -.325, p=.033)
  → Higher Presence goes together with lower post-presentation sickness and stronger decrease in simulator sickness

- VVIQ no relationship with IPQ and SUD

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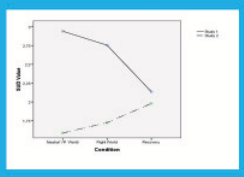
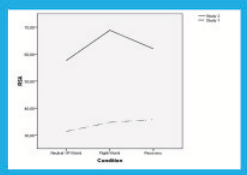
Cross Comparison only non-phobics

Controls study 1 highest distress throughout, highest anxiety during neutral VR



RSA study 2 same for neutral VR world and Recovery, flight highest. PEP same effect



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Conclusion

- No physiological differences between new VR Neutral world and Recovery
- All physiological measures differentiated between flight and neutral VR world/Recovery
- No difference in self-reported distress between conditions when new VR neutral world was shown first

→ The new neutral world seems truly neutral

- Presence and cybersickness seem negatively related

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WORKSHOP DISCUSSION

[Willem-Paul Brinkman] What order (Real world, Neutral world) should therapist use in the future?

> It seems that you might not need base-line measurement in the real world anymore.

[Maurice Mulvenna] Why not have a real world baseline?

> By using a real world baseline you never know for sure if the effects of a non-neutral VR world are due to this specific world or due to the VR presentation in general. With a VR neutral world a truly neutral baseline is measured, thereby facilitating research on the effects the phobic world might have.