AKROPHOBIA Treatment Using Virtual Environments: Evaluation Using Real-Time Physiology

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Abstract. In the present paper a VR (Virtual Reality) exposure treatment program for Acrophobia (fear of heights) is introduced and evaluated against an in vivo exposure with the same success rate. During the VR exposure psychophysiological parameters (heart rate, respiratory rate) are collected. VR offers the good opportunity to study psychophysiological effects under almost standardized conditions. The findings reflect partly the somatic correlates during an anxiety attack. Beside the opportunity of standardized circumstances other advantages of VR techniques are discussed (cost effectiveness, enhancement of the narration process, higher user acceptance).

Keywords: VR therapy, Acrophobia, presence physiological correlates, narration process, desensitization.

1 Introduction

Psychotherapy has become a big research and application field for VR in the last decade. One newly defined field within this "Cyberpsychology" is the treatment of phobias in VR [1], [2].

Despite the fact that a lot of somatic symptoms are included in the diagnostic criteria of anxiety and panic disorders there are only little research efforts focusing on psychophysiological parameters [3]. An objective measurement would also alleviate a valid evaluation of the therapeutical effect [4].

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VR offers the opportunity to focus on psychophysiological parameters such as heart and breathing rate under standardized circumstances. The virtual environment guarantees more controllable conditions compared to an in vivo exposure in the real world (other people, weather, etc.).

A clinical trial study was performed at the University of Basel comparing Acrophobia desensitization in Virtual Reality vs. desensitization in vivo. 67 participants were recruited via advertisement in the local newspaper. Special emphasis was given to the selection of the participant. Patients with phobia were only allowed to participate if they had no other psychiatric comorbidity.

2 Experimental Setup

The experimental setting can be described as following: while patients with acrophobia are confronted with their fear in VR (outside elevator), they had to rate their subjective discomfort (anxiety level) every three minutes on a the “SUD-score” scale [5]. At the same time the heart and respiratory rate are measured.

3 Aims of the Study

First goal was to demonstrate that a VR program with a simple HMD system has the same effect for the treatment than a “lege artis” in vivo confrontation.

Second goal was to show that during desensitization physiological parameters will reflect the progress of the therapy.

Third goal was to describe the benefit of VR tools for the narration during the desensitization process.

4 Description of the Measured Data (Dependent Variables)

Beside the subjective anxiety level, heart rate and respiratory rate are measured.

5 SUD Score

Participants had to rate their level of anxiety (0 – 100) every two to three minutes or at every change of the height. “0” equals total relaxation and “100“ equals fear of death.

6 Heart Rate

Heart rate was measured via ECG at 250 Hz and recorded the whole duration of the exposure. After different corrections the interbeat-intervals were calculated. From these the heart frequency was calculated in the beat-to-beat-modus. After a visual evaluation and a half automatic correction of the artefacts the mean heartbeat was composed and lowered on a frequency of 0.1Hz. With respect to other studies [6], [7] we were expecting a higher heart beat frequency due to higher sympathetic nervous system activation during the exposure and an adaptation of the heart beat frequency with increasing habituation.

7 Respiratory Rate

An impedance pneumogram was the basis to calculate the respiratory rate. Breathing was measured via ECG electrodes and recorded with 250 Hz. The percentage of clippings due to movement and speech was calculated and corrected. After a filtering and detrending of the row value a correction of the aorta pulsation was performed. As maximum signals were missing (due to the clipping) the period lengths were calculated for thorax movements above threshold with respect to the resting respiratory position rate for positive und negative zero trials. After that a transaction of gasps per minute was following as well as a floating averaging and a downsampling to 0.1 Hz. The validity of the data is sufficient although the best quality is achieved during speech and motion free periods.

Due to influences from the central cortex we are expecting a inclination of the breathing rate during exposure [8], [9]. In total were three different measuring times during each VR exposure session:

1.	2.	3.
Baseline (before the exposure): reading a neutral text	First two minute interval on maximum height	Last two minute interval on maximum height (after habituation = significant decline of the SUD)

8 Results

During the study three major questions were addressed:

1. Do patients feel anxiety during the VR confrontation?
2. What are the psychophysiological correlates?
3. Is the treatment in VR as successful as an in vivo exposure?

Ad 1: Do Patients Feel Anxiety During the VR Confrontation?

Paired t- test for “SUD” (measuring the anxiety level) comparing first and second measurement during first therapy session:

Paired t test

N=31

Variable	Obs	Mean	Std. Err.	Std. Dev.	95% Conf. Interval	
1. Measurement	31	0.26	0.25	1.4	-0.25	0.78
2. Measurement	31	48.2	3.93	21.88	40.17	56.22
Diff	31	-47.93	4.00	22.32	-56.12	-39.75

Null hypothesis:	**mean SUD 1 - mean SUD 2 ≥ mean(diff) ≥ 0**
Alternative hypothesis:	**mean(diff) < 0**
	t = -11.956
	P = 0.000

Conclusion: Null hypothesis has to be rejected: VR exposure leads to an inclination of anxiety.

Ad 2 a) Are There any Correlation During the VR Exposure with Heart Rate?

Paired t test

N=25

Variable	Obs	Mean	Std. Err.	Std. Dev.	95% Conf. Interval	
1. measurement	25	87.78	1.99	9.98	83.65	91.90
2. measurement	25	88.94	1.68	8.42	85.46	92.42
Diff	25	-1.16	1.44	7.20	-4.14	1.80
Null hypothesis:		**mean(Messung 1 - Messung 2) ≥ mean(diff) ≥ 0**				
Alternative hypothesis:		**mean(diff) < 0**				
		t = -0.8106				
		P = 0.2128				

Conclusion: Null hypothesis cannot be rejected! Even though it would have been expected, the VR exposure does not affect the heart rate. The second measurement does not show a significant difference compared to the first measurement (baseline).

Ad 2 b) Are There any Correlation During the VR Exposure with Respiratory Rate?

Paired t test

N=28

Variable	Obs	Mean	Std. Err.	Std. Dev.	95% Conf. Interval	
1. measurement	28	15.40	0.49	2.61	14.38	16.41
2. measurement	28	16.00	0.33	1.77	15.31	16.69
Diff	28	-0.59	0.49	2.60	-1.60	0.40
Null hypothesis:		**mean(Messung 1 - Messung 2) ≥ mean(diff) ≥ 0**				
Alternative hypothesis:		**mean(diff) < 0**				
		t = -1.2204				
		P = 0.1164				

Conclusion: Null hypothesis cannot be rejected! The VR exposure does not affect the respiratory rate. In parallel to the heart, there is no positive correlation between the exposure and the respiratory rate.

Ad 2 c) Comparison of the Heart Rate at the Beginning and After the Exposure – the (physiological) Habituation Effect: Measurement 2 & 3

Paired t test

N=13

Comparison 2nd with 3rd measurement				
Variable	**Mean 2nd measurement**	**Mean 3rd measurement**	**T-score**	**P value**
1. session	87.15	83.76	3.217	0.0037
2. session	86.48	83.39	3.0964	0.0046
3. session	83.11	82.67	0.3051	0.3827
Null hypothesis:		**Mean (second measurement- third measurement) ≥ mean(diff) ≥ 0**		
Alternative hypothesis:		**mean(diff) < 0**		

Conclusion: The null hypothesis has to be rejected for the first and second therapy session. It can be concluded that the heart rate slowed down after the exposure. A physiological habituation effect can be interpreted!

Ad 2 d) Comparison of the Respiratory Rate at the Beginning and After the Exposure – the Physiological Habituation Effect (Measurement 2 & 3)

Paired t test

N=14

Comparison 2nd with 3rd measurement				
Variable	**Mean 2nd measurement**	**Mean 3rd measurement**	**T-score**	**P value**
1. session	15.69	15.18	1.50	**0.07**
2. session	15.72	15.40	0.89	**0.19**
3. session	16.49	16.09	0.77	**0.22**
Null hypothesis:		**mean(second measurement- third measurement) ≥ mean(diff) ≥ 0**		
Alternative hypothesis:		**mean(diff) < 0**		

Conclusion: The null hypothesis cannot be rejected for none of the therapy session. A trend for the first session can only be concluded in the way that the respiratory rate slows down after the exposure. A physiological habituation effect can be interpreted with caution!

Ad 3: Is the Treatment in VR as Successful as an in Vivo Exposure?

During the planning of the study we faced the problem that it is difficult to find clear criteria for the evaluation of the effects. We consider a VR (N= 35) as well as an in vivo treatment (N= 32, control group) successful when 6 or more points are achieved on the following scale:

Yes = 1	No = 0

1. Confirmation of the subjective benefit of the therapy after the third session
2. Confirmation of the permanent subjective benefit
3. Achievement of maximum height during therapy
4. Augmentation of 30 % of the achieved height compared to the beginning of the sessions
5. Achievement of maximum anxiety level (SUD = 100)
6. 30% reduction of the symptoms (first and last session)
7. Permanent reduction of the symptoms (first and last session)
8. Achievement of maximum height during follow up (in vivo)
9. Reduction of the avoidance behaviour

Kriterium	In vivo	VR	Signifikanztest P-Wert
Success (6 or more points)	15/25	24/32	0.262 n.s.
Drop-outs	7/32	3/35	0.175 n.s.

The results clearly demonstrate that the null hypothesis can not be rejected and therefore is no difference in the success rate between the VR and the in vivo exposure. Compared to other exposure treatments the drop-out rate is very low.

Conclusion: The advantages of VR treatment can be summarized as follows. There is a clear effect of the VR treatment. The success rate is comparable with an in vivo confrontation. Standardized circumstances present another advantage as they allow to measure psychophysiological correlates. Partly the results are in accordance with the clinical criteria for anxiety indicating that somatic effects rise occur during anxiety attacks and adapt with habituation of the anxiety.

Other advantages of VR treatment are drawn from the experience of the therapists during the exposure and can be summarized as following. A well known problem in traditional psychotherapy is the low ability of the patient to introspection. Very often it is difficult for patients to verbalize their feelings and initial thoughts when they experience a panic attack. It is highly important for a successful psychotherapy to know details about the development and progress of the phobia. In cognitive – behavioral psychotherapy it is not required to explore the “absolute last reasons” of the phobia (e.g. childhood), but is binding to embed the phobia in a macroanalytic background (first onset, family background, critical life events, etc.). This is crucial for the recovery and it helps the person to integrate the phobia in his/her biography. Therefore the big advantage of VR treatment can be seen in supporting the process of introspection.

Surveys estimate that for special phobias the prevalence lies between 10-20% of the population [2]. To treat the fear of flying, heights, tight spaces, etc. VR exposure therapy is a safe and successful procedure. Its popularity is justified by its lower costs than in vivo exposure, its ability to have total control of the environment, the repeatability of any phobic stimuli and its safety. In controlled stages patients will be exposed to virtual environments using stereoscopic displays as HMDs or projection based systems, where the virtual environment elicits progressively higher levels of anxiety. Each stage can be repeated until the patients anxiety has lessened and they feel ready to move to a higher level.

The demand for cost effective treatment as a common argument for the implementation of VR scenarios in treatment and should be mentioned. But, beside cost effectiveness. VR also offers a big variety of application scenarios which almost never occur in real live. In our simulation for the treatment of Acrophobia, the patients have to cross a barrow which lies between two skyscrapers. By fulfilling this scenario the patient can generate different mental scenarios how to overcome his/her fear. In general VR scenarios can be used very creative. As already mentioned this is especially important for the detection of unknown thoughts. For patients it is very often difficult to explain their fears. VR scenarios can be used to identify these “internal dialogues” and enhance the introspection/ narration process.

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