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Assessment of Physiological Responses for the phobia in a Virtual Environment

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요 약 : 최근 들어 컴퓨터와 디스플레이 기술의 발달로 실제 공포 상황에서의 자극과 거의 유사한 자극을 유발할 수 있는 가상환경의 창조가 가능하게 되었으며 이러한 실제 상황에서의 노출치료 대안으로 가상현실을 이용한 공포증의 치료방법이 사용되어져 왔다. 하지만 가상환경이 공포증 환자에게 심리적이나 생리적으로 어떠한 영향을 미치는지에 대한 연구는 거의 전무한 실정이다. 따라서 본 논문에서는 가상환경 하에서 공포증환자와 정상인의 생리적 반응에 대한 평가를 함으로써 가상환경이 미치는 영향에 대하여 분석하고, 또한 가상현실 치료 시에 공포증환자의 생리적 반응의 변화를 측정함으로써 치료의 성공유무를 판단할 수 있는 지표를 제시하고자 한다. 본 실험은 스물 두 명의 정상인 (평균 32.94세)과 서른여섯 명의 비행공포증 환자를 대상으로 두 그룹으로 나누어 진행되었다. 생리적 반응으로는 심박동수, 피부저항, 그리고 피부 온도를 측정하였다. 실험결과, 두 그룹에서의 피부저항은 유의한 차이($T(56)=2.978$, $P<0.01$)를 보였으며, 공포증 환자 그룹 중 가상현실로 공포증이 치료가 된 서른세 명의 피부저항은 치료가 진행됨에 따라 점차 정상인의 특성 쪽으로 가까워짐을 보였다. 본 연구를 통해 생리적 반응, 특히 피부저항은 가상환경에서 피험자의 상태를 이해하거나, 가상환경을 이용한 치료의 결과를 검증하는데 유용하게 사용될 수 있을 것이라 사려된다.

Abstract : The goals of this study are twofold: To investigate non-phobics' and phobics' physiological response in virtual environments, and to analyze the trend of phobics' physiology during virtual reality treatment. As a measure of physiology, heart rate, skin resistance, and skin temperature were acquired. The data of two group subjects were analyzed: twenty-two non-phobic subjects (M=32.94 years), thirty-six subjects with fear of flying (M=40.12 years) who met the DSM-IV criteria for a fear of flying. As a result, skin resistance showed significant differences between non-phobics and phobics, $T(56)=2.978$, $P<0.01$. And the physiological responses of 33 subjects among the phobics, who succeed to fly without medicine after virtual reality treatment, showed a gradual trend toward the non-phobics' physiological responses as therapy sessions went on. In this study, physiological monitoring, skin resistance appeared to be useful both in understanding the physiological state of phobic individuals and in evaluating the results of treatment in virtual reality psychotherapy.

Key words : Virtual reality, Psychotherapy, Physiology

INTRODUCTION

Virtual reality technology have recently attracted much attention in clinical medicine. Given the new opportunities offered by this technology, several studies have been successfully conducted using virtual reality for graded-exposure therapy, especially in the treatment of phobias [1-7]. Most of these studies relied on the individual's subjective feeling of distress for evaluating anxiety level or the results of treatment by using subjective units of discomfort (SUDs) or questionnaires such as fear questionnaire. While analyses of SUDs or questionnaires may

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elucidate the phenomenology of experiences, they remain subjective and post-test measures dependent on memory for an event. According to Lang's 1985 proposal, anxiety assessment should include subjective and objective measures. He also stated that the motor program of fear (as evidenced by physiological arousal) must be activated in order to change the person's fear structure and have resulting behavioral change[8]. A few researchers, therefore, have tried to objectively measure anxiety and stress responses in real time by using physiological response such as heart rate, respiration rate, skin resistance, skin temperature and peripheral brain wave EEG activity in virtual environments. Wiederhold, Davis & Wiederhold found the differences between the one non-phobics' physiological responses and the four phobic's response when placed in a flying virtual environment related to the phobia[9], but, the results could not show the significant difference between two groups. Meehan found a high and significant correlation between presence and Skin conductance level with 10 non-phobic participants in virtual room environments[10]. Stoermer et al. showed heart rate variability was a powerful and easy-to-use instrument for monitoring the user's stress[11]. While they showed the necessity of monitoring user's psycho-physiological states in virtual reality psychotherapy, they failed to find a systematic relationship between the non-phobic's and the phobic's physiological response to virtual environments. The purposes of the study, therefore, are twofold. One was to investigate the differences between the non-phobic's and the phobic's physiological response in virtual environments. And the other was to analyze the changes of the phobic's physiology as virtual reality treatment sessions went on.

HYPOTHESES

In conventional works, new stimuli evoked arousal, which has generally been conceived of as a drive state or a nonspecific energizer of behaviour, something that describes the intensity of an experience but not it's quality [12, 13]. Descriptions of arousal go hand in hand with considerations of physiological activity. For example in Duffy's (1962) activation theory arousal is synonymous with activity in the brain reticular formation, projecting to the cortex. In comparison, theories of emotion have concentrated on activity in the autonomic nervous system [14]. If VE is a new stimulus, it evokes the normal participants arousal and physiological activity. Also, when stimuli is repeated, the physiological activity decreases according to habituation theory, which is resulting from repeated presentations of a stimulus is as decremental process ,which occurs in the interneurons of the central nervous system(Fig. 1). Andreassi and Whalen (1985) showed that new learning, perhaps because of the novelty of the situation and the materials to be learned and produced the highest levels of physiological activity[15]. Overlearning, because of stimulus and situational habituation, led to significant decreased in activity.

* **Hypothesis 1 : The physiology in a resting state is different from one in a VR exposure.-Arousal**
* **Hypothesis 2 : The physiology at the beginning part of VR exposure is different from one at the last part of the VR exposure.-Habituation**

Non-phobic participants reacted to a VE like a new stimulus, while phobic participants reacted to VEs with defensive mechanism. Therefore, the increased autonomic nerve activity would make the physiological activity of phobic ones different from one of phobic participants.

* **Hypothesis 3 : The phobic's physiological response is different from non-phobic's one to the VEs.-Defensive mechanism**

Virtual reality psychotherapy is based on systematic desensitization that Wolpe defined as follows: "if a response inhibitory of anxiety can be made to occur in the presence of anxiety-evoking stimuli, it will weaken the bond between these stimuli and the anxiety" [16]. Also he defined anxiety "as an individual organism's characteristic constellation of autonomic responses to noxious stimulation". It is no surprise therefore that a literature has developed concerning the evaluation of autonomic nervous system responses during systematic desensitization; and much of that literature employs physiological measures as an index of autonomic nervous system activity. We could ask ourselves that when the patient was treated with VRT, whether or not the physiological activity decreases and moves toward one of normal people (Fig. 1).

* **Hypothesis 4 : when the patient successfully is treated with VRT, the physiological activity decreases and moves toward one of normal people. Systematic Desensitization**

Table 1. The Characteristics of participants

	NonPhobic	Phobic
Total		
N	22	36
Gender		
Male/Female	10/12	14/22
%	45/55	39/61
Age		
Mean	32.0	40
SD	9.4	12.1
Range	18-51	20-73

Table 2. Student T-test of between baseline and each 5-minute segment (beginning part and last part in VR session)

	Interval	Mean	SD	t-value
⊿Skin Resistance	0-5 minute	-0.199	0.261	-3.577*
	5-15 minute	0.060	0.458	0.614
⊿ Heart Rate	0-5 minute	0.012	0.041	1.419
	5-15 minute	0.019	0.053	1.632
⊿Skin Temperature	0-5 minute	-0.008	0.025	-1.463
	5-15 minute	0.0006	0.018	0.163

Statistical results are noted as, * : P<0.0

METHODS

A. Subjects

Twenty-two non-phobic subjects (M=329.4 years) were participated through recruit advertisement. And Thirty-six subjects with fear of flying (M=4012.1 years) who came to California Advanced Multimedia Psychotherapy center for treatment. They met the DSM-IV criteria for a specific phobia. Table 1 shows the characteristics of participants.

B. Apparatus

The virtual environment system for this study consisted of a head mounted display (Liquid Image Inc.), electromagnetic head tracker (INSIDETRAK, Polhemus Inc.) and flight seat with subwoofer that delivered subjects vibration. It was designed by Drs. Hodges and Rothbaum of Virtually Better, Inc. (Atlanta, Georgia) who have previously performed VR treatment for acrophobia and fear of flying[1, 4].

C. Measure

Skin Resistance (SR) was measured for seeing the changes in sweat gland activity. SR generally decreases as sweat gland activity increases. SR was monitored with two silver/silver chloride electrodes placed on the ring and index fingers of the left hand. For the heart rate (HR), a small amount of electrode gel was placed on each disposable electrode attached to the participant's the part of right and left wrist. And the temperature was placed the ring on the right hand with adhesive tape for measuring skin temperature. An I-330 C-2 computerized biofeedback system manufactured by J&J Engineering (Poulsbo, Washington) was used to collect physiological data. For the phobic participants, Subjective Units of Discomfort Scale (SUDS) was administered. It is to rate anxiety on a scale from 0 to 100, with 0 being no anxiety and 100 being the most anxiety they have ever felt.

D. Procedures

i. The non-phobic

After signing an informed consent, a 5-minute eyes open baseline was taken. The participant then was placed in a MRG4 head-mounted display by Liquid Image. The participant was allowed to look around the virtual plane to become oriented for short while before the flight began. During the 20-minute VR flight with the HMD on, the participant was instructed to look out the left window during entire flight. This was to insure that each participant was exposed to exactly the same stimuli. The participant wore a HMD and viewed a three dimensional computer generated image of the following flying scenes: sitting in the passenger cabin of a plane with the engines on, taxiing, taking off, flying in good weather, flying in

Table 3. Student T-test between phobic and non-phobic participants

	T	Sig. (2-tailed)
⊿Heart Rate	-0.906	0.369
⊿Skin Temperature	-1.042	0.302
⊿Skin Resistance	2.978	0.004

bad weather and landing.

ii. The Phobic

Every phobic patients lasted 8-12 sessions on average as following protocol. First session : All treatment procedures and their rationale are explained and informed consent for treatment was obtained. The patient was given a intake to assess for seizure, history, heart problems, and medication usage. Session 2 : All participants got taught relaxation and diaphragmatic breathing skills, with the use of visual feedback of heart rate and respiration rate, prior to beginning the virtual reality exposure therapy. Remaining sessions : Patients were placed in a VR environment and in cooperation with the therapist the experience was increased to fit the individual needs of the participant. At every step, the therapist could see and hear what the client was experiencing in the virtual plane. If the participant's level of anxiety became overwhelming, participants returned to a less stressful level of treatment, or simply removed the head-mounted display and exited the virtual aircraft.

Analysis The percentage change from baseline was used for analyses rather than absolute values because physiology levels often vary widely by individual and environment. Therefore, before comparing physiology with presence measures, percentage change of heart rate(ΔHR) was calculated as follows:

⊿HR = (MeanVR-MeanBaseline)/MeanBaseline

MeanVR : Mean of Heart Rate during experiencing VR MeanBaseline : Mean of Heart Rate during baseline

Percentage change of skin temperature(⊿ST) and Percentage change of skin resistance(⊿SR) were also calculated using the same method. Data was analyzed using conventional Student t-test (Hoel, 1971).

RESULTS

A. The analysis of the non-phobic participants' physiology

It was calculated by the average of all 22 participants' skin resistance. It showed that when placed in the VEs, skin resistance dropped to 25% compare to baseline, indicating some physiological arousal. Also Student t-test with each 5-minute segment of physiological measures showed the beginning part of skin resistance response was significantly different from a baseline skin resistance response, while last part of skin resistance response was not (Table 2). Heart rate and skin temperature These supported that the physiology in a resting state is

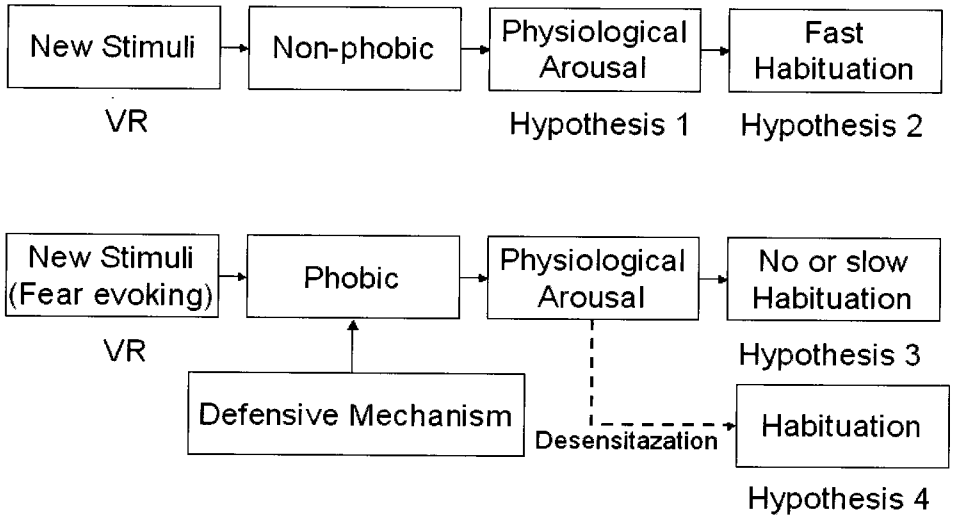

Fig. 1. The diagram of physiological changes in the non-phobic and the phobic

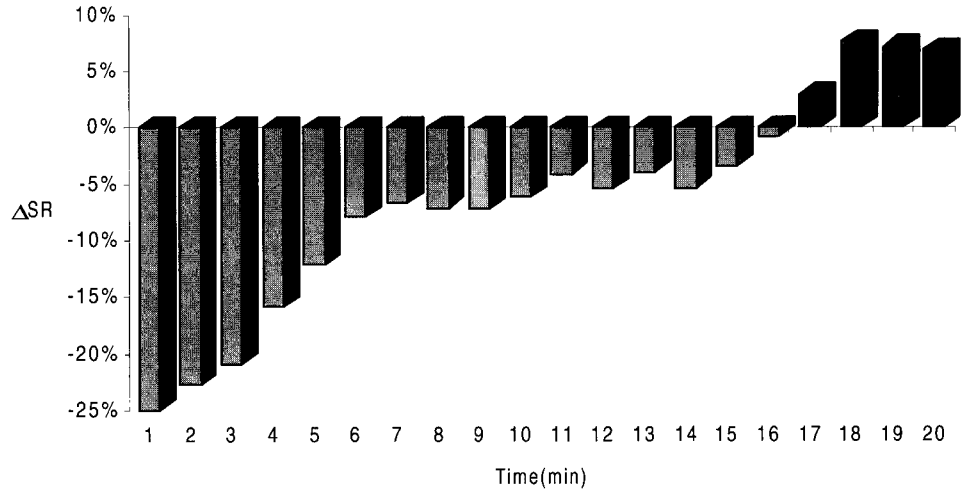

Fig. 2. The plot of change of skin resistance and skin temperature over time

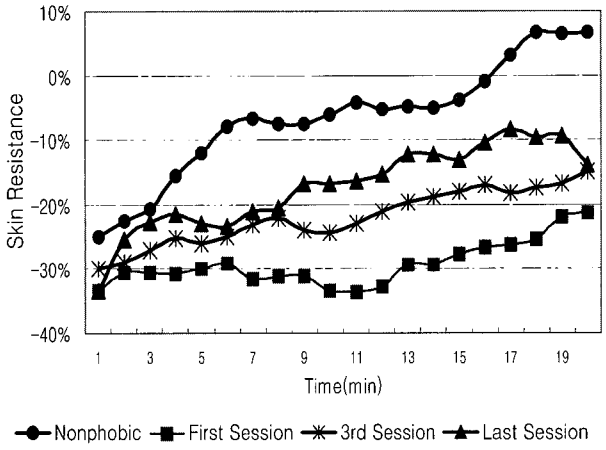

Fig. 3. The average change of skin resistance in non-phobic participants and phobics' 1st, 3rd, last session who make a flight without medicine after treatment

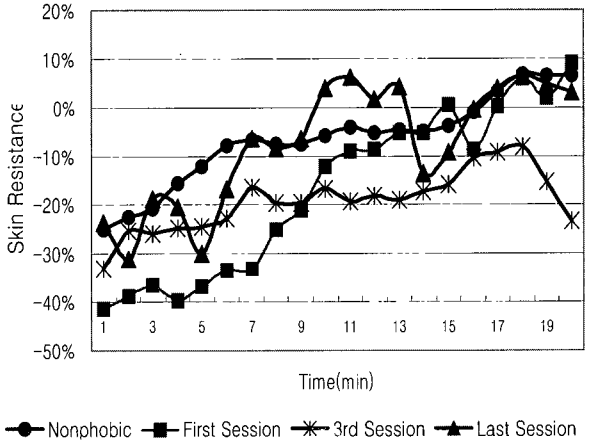

Fig. 4. The average change of skin resistance in non-phobic participants and phobics' 1st,3rd,last session who failed to fly after treatment

different from one in a VR exposure (Hypothesis 1) and the physiology at the beginning part of VR exposure is different from one at the last part of the VR exposure (Hypothesis 2). Fig. 2 showed the trend of Skin Resistance over time. The repeated measured variance analysis was conducted with skin resistance over time. It resulted $F(19) = 4.626$, $P<0.001$. It meant that skin resistance response was changed over time. As orientation to the stimulus occurred, physiological arousal decreased and skin resistance increased to baseline levels. As the 20-min virtual flight continued, increased physiological relaxation and increased levels of skin resistance occurred. Subjectively, relaxation also continued to occur as the participants realized the new and novel stimulus was not dangerous.

B. The comparison of phobic's physiology with non-phobic's

The result of conventional Student T-test between non-phobics and phobics' physiological response in Virtual Environment was showed in Table 3. Third session data of whole sessions that phobic subject took for virtual reality therapy, was used for this analysis, because it was first experience in virtual environments according to treatment protocol. The percentage change of skin resistance(ΔSR) showed significant differences between non-phobics and phobics, $T(56)=2.978$, $P<0.01$. It supported that the phobic's physiological response is different from non-phobic's one to the VEs due to defensive mechanism (Hypothesis 3). Before the experiment, it was predicted

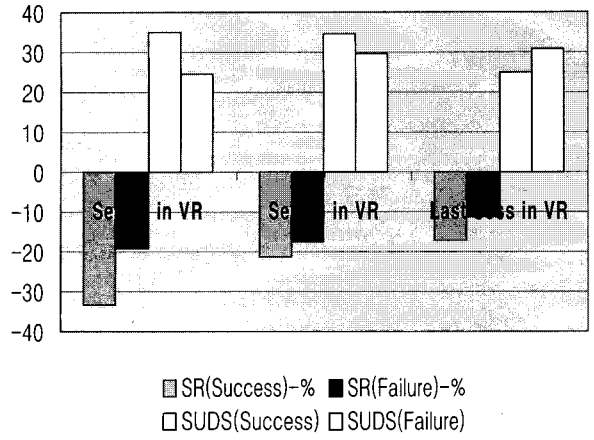

Fig. 5. The comparison between two groups of phobic participants: Average SUDS(subjective units of discomfort scale) and the average change of SR(skin resistance)

that percentage change of heart rate would also show significant difference between two groups. It will be required to analyze heart rate in depth by using other methods such as heart rate variability. After treatment of phobic subjects, 33 subjects succeed to fly without any medicine and three subjects failed. Fig. 3 illustrated the trend of ⊿SR of non-phobic participants and "fly-success" phobic participants and non-phobic participants. The line of non-phobics in Fig. 3 showed that they were aroused at the beginning part of experiences in virtual environments and getting back to normal state as time went on. According to previous works, repetition of a stimulus that is novel because of its unexpectedness reduces the information in the stimulus and, thus, the reaction was rapidly habituated [17, 18]. Contrary to normal participants, phobic participants still got aroused until first VR session finished. And the physiological responses of 33 subjects among the phobic, who succeed to fly without medicine after virtual reality treatment, showed a gradual trend toward the non-phobic participants' physiological responses as therapy sessions went on (Hypothesis 4). That meant that desensitization, a treatment based on gradually and systematically exposing the phobic person to the feared object of situation, and calming them, was effected to the treatment of phobia using virtual environments. It, also, proved the insistence of Foa and Kozak that, as treatment continues and habituation occurs, there should be a lessening of arousal [19]. The physiological responses of three subjects who failed to fly after VRT were illustrated in Fig. 4. The patterns appeared to be irregular and last session did not show any movement to normal people, as not similar as "fly-success" subjects. The comparison between two groups of phobic participants was in Fig.5. The Average SUDS(subjective units of discomfort scale) and the average change of SR(skin resistance) were decreased in the response of the "fly-success" phobic participants along the session, whereas those of "fly-failure" phobic participants did not matched with each othe

CONCLUSION

In this study, the phobic's physiological response and non-phobic's one to the VEs were analyzed. The results commonly showed that skin resistance could be used as a reliable and objective measure both in differentiating two groups and in measuring the presence in VEs. By analyzing skin resistance response, all hypotheses made before experiments could be accepted. The asserted hypotheses were like these:- The physiology in resting state is different from one in VR exposure. - The physiology at the beginning part of VR exposure is different from one at last part of VR exposure. - The phobic's physiological response is different from non-phobic's one to the VEs.- When the patient successfully is treated with VRT, the physiological activity decreases and moves toward one of normal people As described previously, measuring physiological responses such as skin resistance could help therapists deciding the result of treatment in VRT and developer constructing more effective virtual environment. Especially, it is expected that the results of this study would be applied to various areas and be useful both in understanding the physiological states of individuals and in evaluating the results of treatment in the virtual reality psychotherapy. In future, more systematical research will be required with including subjective measures such as questionnaires, overt behavioral check and the other analysis like heart rate variability. In spite of those limitations, physiological monitoring (skin resistance, and skin temperature) appeared to be useful both in understanding the physiological state of phobic individuals and in evaluating the results of treatment in virtual reality psychotherapy.

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