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Effects of Immersive Technology Exposure on Stress Level Changes: A comparative analysis of zipline rides and immersive technology

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ABSTRACT

This research investigates the effects of immersive technology exposure on the people's stress level changes. A total of 115 randomly selected people participated in an experiment. The participants who shared similar demographic characteristics were then separated into three group--zipline, immersive technology, and reference groups--for an analysis. All the participants wore wearable device to measure their heartbeat per minutes (BPM) to see the differences, and they all answered the translated Global Assessment of Recent Stress (GARS) to measure their perceived stress levels after they experienced the zipline ride, video recorded zipline ride using the 360-degree camera, and none of the above. The result revealed that the heartbeat average of people in the zipline group was greater than those in either immersive technology group or the reference group. People's perceived stress level difference was not statistically significant when compared zipline and immersive technology group. The immersive experience of zipline through immersive technology could offer stress-relieving effects not notably different from a real zipline ride.

Keywords: *Zipline, Immersive Technology, Stress, GARS, 360-Degree Camera.*

1. INTRODUCTION

Though it is in the early stage of development, Virtual Reality (VR) market revenue is expected to grow by $80 billion by 2025--$45 billion in hardware and $35 billion in software (Sachs, 2016). With this positive outlook, 360-degree camera whose market amounts to $ 473,6 million in 2018 is expected to reach 1,569.2 million by 2023 (Market and market, 2018). With the advent and the spread of wired technology, market for 360-degree camera had grown exponentially over the past few years. Youtube with its largest subscribers throughout the world launched live 360 degree video streaming service, allowing users to savor realities of distant places through the wired technology.

Nested in VR platform, 360-degree technologies and streaming services opened the door of virtual experience of everyday event to anyone with the internet access. The vehement competition of the VR market is already pulling down the cost of VR equipment, thus making the 360-degree contents more accessible and affordable to the general public.

Goldman Sachs (2016) predicts that, beyond video game, VR/AR technology will soon encroach real estate, retail, and healthcare markets. National Association of Realtors (2017) has found that virtual tour, together with photo, as the most important factor attracting customers. Using virtual reality, Lowes offers so-called holoroom that allows customers to envision their home remodeling plans. Also, virtual reality exposure therapy (VRET) gains popularity for treatment for anxiety or phobia (Parsons & Rizzo, 2008).

Still, technology without a full inspection of its potential effects may incur undesirable outcomes. Especially, the technologies that are designed to stimulate people's psychological senses like VR, AR, or 360-degree equipment demand the most scrupulous appraisal to identify some unforeseen implications of its uses for users and developers.

Because now the primary reasons for VR, AR, and 360-degree technologies are placed on entertainment, or psychological relief from stressful daily routine, this research was set out to uncover how 360-degree technology with a head-mounted stereoscopic display affects people's stress levels by measuring the change of heartbeats of people in three different experimental settings. Followings are the research questions dealt in this research.

1. Is there a difference in heartbeat between engaging in actual sports and experiencing the same thing via a head-mounted stereoscopic display(HMD)?
2. Does people's perceived stress level differ when people engage in actual sports when compared to experiencing the same thing via HMD?

2. LITERATURE REVIEW

2.1 Virtual Reality

Chief Executive Officer of VPL Jaron Lanier first coined the word virtual reality (VR) in 1989 (Krueger, 1991). The most popular definitions of VR refer to a particular technological system that includes a computer capable of real-time animation, controlled by a set of wired gloves and a position tracker, and a head-mounted stereoscopic display (HMD) for visual output (Steuer, 1992). Ivan Sutherland was the pioneer who studied HMD in 1968(Sutherland, 1968).Coates (1992) defined virtual reality as "electronic simulations of environments experienced via head-mounted eye goggles and wired clothing enabling the end user to interact in realistic three-dimensional situations." According to Greenbaum's (1992) definition, VR is "an alternate world filled with computer-generated images that respond to human movements. These simulated environments are usually visited with the aid of an expensive data suit which features stereophonic video goggles and fiber-optic data gloves." When taking aforementioned characteristics into account, VR can be narrowed down to a technology that utilizes goggles 'n' gloves systems to access electronically simulated environment (Steuer, 1992). Pimentel & Teixeira (1993) defined VR as "a three-dimensional computer-simulated scenario in which a person can look, move around in, and experience an imaginary world." While these definitions are befitting VR in its early stage of development, they are not accurately reflecting the VR technology that advanced far more than they were defined. however, are indented.

2.2 360-degree Camera System

360-degree video is flocking an increasing amount of attention in the context of Virtual Reality (Ozcinar, Abreu, & Smolic, 2017). The sector that holds the largest size of the 360-degree camera market is the consumer sector. The Business Insider (2018) predicts the 360-degree camera market to reach 1,569.2 million dollars by 2023. "Increasing popularity of AR and VR content, and growing awareness for the need for safety and security at public places" (Business, 2018) are the major driving factors for growth in the 360-degree camera market. A system of multiple cameras facing different directions are used to 'stitch' a 360-degree footage.

2.3 Stress

2.3.1 Definition of Stress

Though it seems quite simple, stress is defined in various ways, and the definition is rather inconsistent, thus creating confusion. The term "stress" was first introduced in 1930 by Hans Selye, who defined it as "the non-specific response of the body to any demand for change" (The American Institute of Stress, 2017) Cohen & Ronald & Kessier defined stress as "the general process through which environmental demands result in outcomes deleterious to health"(1997). According to the findings of Salo & Pirkkalainen & Koskelainen, stress is created when the "demands encountered by an individual exceed the individual's resources for dealing with them"(2018). Cohen & Ronald & Kessier (1997) emphasized that one's interpretation of an event and their evaluation of coping resources both influence one's perception of the stress received.

2.3.2. Stress Relief

How best we can alleviate our stress is the question we constantly ask ourselves. When a group of university students who identified studying as their main source of stress completed 4 randomly ordered sessions of exercise only, exercise/study, exercise only, and control(sitting quietly), stress level was reduced after the exercise only session (Breus, 1998). Visiting an urban forest also showed a reduction in the stress level of the visitors. The recovery ratio for stress showed a positive correlation with the length of visit and the strenuosity of the activity practiced by the individual (Hannsman, 2007). Low level of school-related stress was associated with high level of leisure time physical activity in a study conducted with a sample of 15-year-old Norwegian students. It was suggested that the leisure time physical activity moderates the school-related stress (Haugland, 2003).

2.3.3 Measuring Stress Through Heart Rate

Physical and mental stress load affects cardiovascular response (Hjortskov et al, 2004). A study by Sinyor, Golden, Steinert, & Seraganian (1986) shows that aerobic exercise (a form cardiovascular exercise) change people's response to psychosocial stress. A meta-analysis by Thayer, Ahs, Frederikson, Sollers, & Wager (2012) found that heart rate variability serves as a proxy for vertical integration of brain mechanism that control our behavior with peripheral psychology and serve as an important marker to understand our stress and health. The findings

of these studies show that heart rate variability can be an indicator of stress level changes.

2.4. Zipline (Zipwire) Trolley System

Now serving a recreational purpose, zipline trolley system borrowed ideas from aerial ropeways--also called as aerial tramways or cable ways. The use of ropeways dates back to 250 B.C. People used rope to cross ravine and river (Decker, n.d.). In modern history, the ropeway had been used primarily to transport cargoes and minerals in mining industry (Trennert, 2001). The zipline system is comprised of a trolley the rolls along a suspended length of cable, and a pair of vertical rings--rings are used to engage braking mechanism--extending away from the trolley from the trolley can be found at its front (Smith, 2010). The zipline trolley is the frame with the pulleys known as sheaves that run along the cable (Wikipedia). While the zipline offered various braking mechanisms, the one used in this experiment employed a spring braking system, which absorbed the momentum at the arrival point. For the zipline, participants rode it to enter an island, a tourist attraction in South Korea, as an alternative to taking a ferry.

3. METHODS

3.1 Procedure

360-degree video of the zipline ride was taken before the testing started. Participants were categorized into 3 groups: Real group, VR gear group, and controlled group. Participants in all three groups had to wear a wearable device on their wrist and their heart rate data during the 'activity' was collected. The first group rode an actual zipline that lasted for 90 seconds. The zipline located in Gapyeong was chosen. The second group wore a VR gear and viewed a 360 video of the same zipline for same amount of time. They had a fan in front of them to make the experience as similar to the real experience. The third group rested for the same amount of time, also with a fan in front of them. Immediately after the 'activity', all three groups filled out a questionnaire to measure their stress level.

3.2 Data Collection

Because the participants were not easy to control in outdoor area, randomly assigning people to three different groups was not feasible. Therefore, data of all three groups had been collected within 150 meter radius. After experiments were complete, the participants in all three groups had filled out a survey asking about their demographic information and Global Assessment of Recent Stress (GARS) scale translated into Korean--Koh and Park (2000) had confirmed the reliability and the validity of the translated GARS. The first group consisted of those who were willing to ride zipline, or zipwire, and their heart rate was measured through Fitbit, which they were asked to put on before they set off. In the second group, a total of 35 people had participated in an experiment using heat-mounted display (HMD). They put on the same Fitbit and the HMD. For the same duration (1.5 min.), they experienced the same zipline ride, which was filmed and compiled prior to the experiment. Lastly, 35 participants were asked to put on the fitbit and their heart rate was measured for the same duration. This research had employed quasi-experimental design. Though the pretest-posttest design for the zipline group and HMD group would have been sufficient, giving the same questionnaire with short intervals would not capture the effects of zipline and the immersive technology accurately. In other words, on account of the participants' short-term memory, they may remember their answers they had provided in the pretest and will not change their response in the posttest with the same question items. Because of this, the third group that experienced neither zipline ride nor HMD zipline ride provides the baseline information.

3.3 Results

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Table 1: The Number Of Officially Reported Plague Cases

	Group	Gender	SES	Exerc.	Glutton	Confl.	Not Stress	Hypert..	Medicat	VR	BPM
Genders	-.10										
SES	-.12	-.03									
Exercise hrs.	-.16	.09	.10								
Glutton	.00	.01	-.08	-.16							
Conflict	**.28****	-.06	**-.25****	-.10	.03						
Not Cope w/ Stress	**.24****	.10	-.18	.05	.07	**.43****					
Hypertension	.06	**-.37****	**-.25****	-.06	.12	.18	**.25****				
Medication	.01	.07	-.06	-.09	**.27****	.15	**.23***	**.41****			
VR Experi.	.07	-.06	.01	**.20***	**.22***	.08	.03	.11	**.23***		
BPM	**-.45****	**.21***	.01	.16	.10	-.09	-.09	-.06	-.01	-.09	
GARS	**.34****	**-.25****	**-.29****	-.17	.10	**.28****	**.48****	**.31****	.03	.05	**-.19***

* $p < .05$ ** $p < .01$ *** $p < .001$

Group is moderately correlated with the participants' interpersonal conflict within 24 hours, r = .28, p = .002. (People who had conflicts with others were found more in an order of zipline, VR and Inactive.) Group is also moderately correlated with the participants' inability to cope with stress, r = .24, p = .008. Group is also moderately correlated with the participants' BPM, r = .45, p = .000. Group is also moderately correlated with the participants' GARS, r = .34, p = .000. Gender is moderately correlated with the participants' hypertension, r = .37, p = .000(women have less hypertension) Gender is also moderately correlated with the participants' BPM, r = .21, p = .023. Gender is moderately correlated with the participants' GARS, r = -.25, p = .008. SES is moderately correlated with the participants' interpersonal conflict within 24 hours, r = -.25, p = .006. SES is also moderately correlated with the participants' hypertension, r = -.25, p = .007. SES is moderately correlated with the participants' GARS, r = -.29, p = .002. Exercise is moderately correlated with the participants' VR experience, r = .20, p = .033. Glutton is moderately correlated with the participants' condition whether or not they are taking medication, r = .27, p = .004. Glutton is also moderately correlated with the participants' VR experience, r = .22, p = .017. Interpersonal conflict within 24 hours is moderately correlated with the participants' inability to cope with stress, r = .43, p = .000. Interpersonal conflict within 24 hours is also moderately correlated with the participants' GARS, r = .28, p = .003. Inability to cope with stress is moderately correlated with participants' hypertension, r = .25, p = .007. Inability to cope with stress is also moderately correlated with participants' condition whether or not they are taking medicine, r = .23, p = .014. Inability to cope with stress is also moderately correlated with participants' GARS, r = .48, p = .000. Hypertension is moderately correlated

with the participants' condition of being under medication, r = .41, p = .000. Hypertension is also moderately correlated with the participants' GARS, r = .31, p = .001. Taking medicine is moderately correlated with the participants' VR experience, r = .23, p = .014. BPM is moderately correlated with the participants' GARS, r = .19, p = .046. Whether or not people in each group share similar demographic characteristics is the question that must be addressed before making a comparison because similarity lays the baseline justifying the comparability of the groups. If one group has notably different characteristics compared to others, a selection bias must be examined.

Table 2: ANOVA for Demographic Differences

Variable	Groups	*N*	Mean	SD	F	*p*-value
Gender	Zipline	38	.79	.41	2.80	.07
	VR	39	.54	.51		
	Comparison	40	.68	.47		
Age	Zipline	38	42.45	14.23	1.72	.18
	VR	40	36.88	12.84		
	Comparison	40	39.10	12.94		
Married	Zipline	38	.58	.50	1.80	.17
	VR	39	.77	.43		
	Comparison	40	.73	.45		
SES	Zipline	36	5.89	1.29	1.54	.22
	VR	40	5.99	1.17		
	Comparison	39	5.50	1.43		

As illustrated in Table 2, no statistically significant demographic difference was found. Based on this result, it was assumed that all three groups shared characteristics similar enough to compare.

Table 3: ANOVA for Heartbeat per Minutes (BPM) of the three groups

Variable	Groups	N	Mean	SD	F	Post-hoc Test
BPM	Zipline	38	97.95	10.69	30.76***	1 > 2*** 1 > 3***
	VR	40	81.80	9.31		
	Comparison	40	84.55	9.04		

The heart beat per minute (BPM) of the zipline group showed a statistically significant difference compared to two other groups. The mean difference of VR group and the comparison group was not statistically significant.

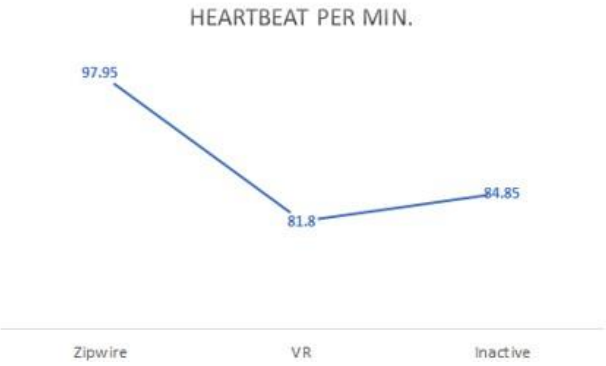

Fig. 1. BPM difference across 3 groups

Table3: ANOVA for perceived stress levels of 3 groups

Variable	Groups	N	Mean	SD	F	Post-hoc Test
BPM	Zipline	38	2.12	.99	7.35***	1 < 3** 1 < 2
	VR	40	2.66	1.29		
	Comparison	39	3.19	1.35		

When the effects of an actual sports activity on people's perceived stress level was compared against VR group and the reference group, there was a statistically significant difference, F = 7.35, p < .01. However, no statistically significant stress level difference between zipline and VR groups was found, p = .001.

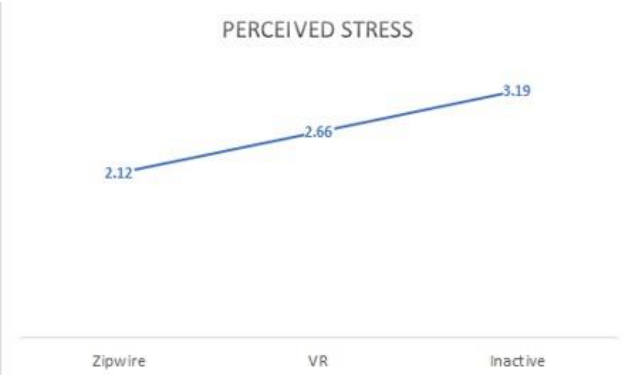

Fig. 2. Perceived Stress Level Differences

4. CONCLUSIONS

When compared the three groups (Zipline, VR, and reference) using the HMD, the evidence of zipline ride increasing the test subjects' heartbeat was visible. The heartbeat average of zipline group was greater than VR group and Inactive group. When interviewed a few

participants from the zipline group during the experiment, they responded that they were most nervous just before they launched off from a launch pad on the top of a zipline tower which was 80m high (equivalent to a 25-story building). Therefore, the highest heartbeat average of the zipline group can be accounted for by the fear of height. An interesting discovery that can be drawn from this research was that people's perceived stress level difference was not statistically significant when compared zipline group and VR group because heartbeat change was evident as explained above. The virtual experience through immersive technology could offer stress-relieving effects not notably different from a real zipline ride. However, one should take caution when generalizing the results to all the other sports because of zipline's unique features. Also, one should investigate to see if there's a threshold for a certain degree of heartbeat to take effect on the change of stress level. Therefore, based on the findings, future research must further investigate the heartbeat change and its effects on people's perceived stress level in different settings and different media.

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