AMCIS 2023 Proceedings

SIG HCI - Human Computer Interaction

Aug 10th, 12:00 AM

Emotion in Motion: Experiment on Affective Responses to Virtual Realities

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Completed Research Full Paper

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Abstract

The rise of metaverse platforms pave the path for a future where many human activities will be conducted in a virtual reality (VR). Therefore, it is necessary to investigate whether and how users emotionally respond to fully digitalized realities when conducting daily activities. In this study, we focus on two core features: immersion and sense of embodiment through self-motion. We conduct a large-scale experiment to examine the effects of virtual realities on emotional traits (PANAS). We use high (VR head-mounted-display) and low (PC monitor) immersive environments, as well as different levels of self-motion (high/low), compared to a 2D control. Students (N=183) were randomly assigned in one of 5 virtual conditions to complete a daily non-emotionally charged task. Two analyses were conducted based on the same experiment. The findings indicate that immersion and embodiment are not direct emotional elicitors on their own, and affect valence and arousal are likely content related.

Keywords

Metaverse, extended reality, emotion, physical movement, immersive, 3D, 2D, data representation

Introduction

The technological progress of virtual technologies, represented by virtual reality (VR) and economic development of metaverse platforms, is approaching a new reality where most human daily activities including e.g. education, business, work, and health, will be conducted withing it. From information searching to information evaluation, and from problem solving to decision-making, there is an urgent need in metaverse mediated realities, for redefining and repositioning emotionality to facilitate the efficiency of humans' information-management skills. Emotions are frequently at the epicenter of research, and justifiably explored from various perspectives. They play a detrimental role on human daily behavior, on a conscious and unconscious level. The hedonic value of information systems and technologies is a core characteristic of the metaverse, consisting of different virtual realities highly associated with emotional arousal both negatively and positively (Markowitz & Bailenson, 2021; Somarathna et al., 2022; Riva et al., 2007). Through numerous studies VR has been well-established as a suitable tool for emotion elicitation, often even referred to as the 'empathy machine' (e.g. Bujić et al., 2020).

There is a particular interest in current literature focusing on understanding how individuals emotionally respond to VR environments. Some studies have used VR as the research context for examining emotions, rather than a research question itself e.g. Felnhofer et al. (2015); Chirico et al. (2018). However the majority of studies investigating emotional responses to VR are highly relied on specifically designed content for inducing, manipulating, or managing emotions (Markowitz & Bailenson, 2021; Somarathna et al., 2022) rather than the inherited attributes of head-mounted display (HMD) VR. There are two detrimental attributes in effective VR experiences, immersion and embodiment. Immersion refers the technological capabilities along with feelings of presence and being in the virtual world. Embodiment refers to how users perceive themselves and have multimodally connected themselves with the virtual world (Wiederhold, 2020). In this study we operationalize embodiment through motion, a sense of body existence (da Silveira Coêlho et al., 2022), and the subjective experience of using and 'having' a body (Blanke & Metzinger, 2009). Overall, the effects of immersion and sense of embodiment have not been comprehensively investigated regarding how they consciously, or not, adjust our emotional perception. To be more specific, it is still unknown whether negative and positive emotions would be differentially elicited in virtual realities constructed with different levels of immersion and self-motion, especially when conducting daily activities.

The aim of this study is to experimentally investigate the effects of immersion and embodiment on emotion in metaverse. More specifically, we use a daily scenario involving tasks of information gathering, processing, and decision-making. We conduct an experiment with 2 levels of embodiment operationalized by sense of motion: self-motion vs. self-anchored, and 2 levels of immersion operationalized by display type: high (HMD VR) vs. low (PC monitor) and a 3D virtual environment demonstrating financial data on a graph (study 1: N = 183; study 2: N = 173). The design includes a control group (using a 2D graph) and considers the same virtual environment and amount of information in all conditions.

This study benefits future designs and applications intended to take place in the metaverse. It contributes to understanding emotional perceptions regarding high and low immersive environments in pragmatic, applicable, and non-emotionally charged settings. Our study also provides insights regarding the use of actual self-motion and emotional influences while exploring metaverse environments. The structure of the current paper begins with a background section presenting existent literature regarding immersive environments, emotions, and virtual motion. It continues with methods, where the experimental design, apparatus, and procedures are provided. We proceed with the results section, where we use the same experiment to conduct two separate analyses (study 1 and 2) for which we present the findings. Finally, we conclude by discussing our results, contribution, study limitations, and future research directions.

Background

The term and concept of metaverse are not new. Science fiction has been a core avenue for metaverse representations, with early works from 1992 already using the term. In Snow Crash the metaverse is a parallel virtual reality where users can connect to and with each other, while recent representations portray technologies resembling our current capabilities, incorporating advanced VR headsets, with audio and haptic feedback providing users with a full-body experience (Mystakidis, 2022). Metaverse, as an umbrella term represents the artificially generated extended realities built on the convergence of virtual technologies and multimodalities (Pamucar et al., 2022; Rauschnabel et al., 2022; Mystakidis, 2022; Xi et al., 2022). It is a post-reality universe allowing real-time multisensory and dynamic interactions with VR environments, objects, and users (Mystakidis, 2022). VR has been defined as a digital replica of the "real reality" (Dincelli & Yayla, 2022; Xi & Hamari, 2021; Xi et al., 2022). It can create realistic digital worlds and generate the illusion of "being there" (Heeter, 1992). Such immersive experiences can successfully influence our cognition, behavior, and emotional state, bringing forth concerns regarding a users' physical and psychological autonomy and well-being (Mystakidis, 2022; Han et al., 2022).

When discussing fully immersive experiences there are two contributing qualities, technological immersion and presence. VR is characterized by technological immersion, the capacity to cover one's field of view and replace it with a digitally generated one. Immersion refers to a description of technology and the capability of computer displays to trigger inclusive (physical reality removal), extensive (multisensory), and vivid (resolution, fidelity) features (Slater & Wilbur, 1997; Somarathna et al., 2022). Another core characteristic of VR is psychological immersion, typically referred to as presence, a sense of feeling like "being there", part of the graphically synthesized environment (Heeter, 1992; Markowitz & Bailenson, 2021). Technological immersion and presence are closely linked, and while either of them has the capability to generate immersive experiences, the results will only be partial if one is neglected. For example, a monitor experience displaying a 2D environment is less immersive (technologically and psychologically) than a 3D using a VR HMD. Research suggests VR experiences with good stereoscopic visuals and tracking (tech. immersion) are perceived as more psychologically rich (tele-presence), than less immersive experiences (Cummings & Bailenson, 2016). Further findings indicate that the two qualities enhance emotional intensity of virtual experiences as users connect more deeply with the world, and experience enhanced psychological effects and emotional states (Baños et al., 2004; Riva et al., 2007).

Embodiment and Self-Motion in VR

Embodiment as the other core concept in VR refers to the subjective experience and sense of 'having' and using a body (Blanke & Metzinger, 2009). Sensorimotor, often in the form of locomotion, has been employed as a crucial modality in many VR applications. Locomotion is used for two main tasks, the action of self-motion, and perceptual sensory awareness (Hettinger et al., 2014). Self-motion is easily incorporated in VR because it utilizes visual ques and landmarks appearing stable as we move (Harris et al., 2002). VR users can activate their entire body and perform physical motions which are updated synchronously to the virtual environment (Mystakidis, 2022). The use of 1-to-1 body motions engaging with a scene, and reception of perceptual updates to those movements in a congruent way to our sensorimotor system, results in a qualitatively different experience to traditional media (Markowitz & Bailenson, 2021; Han et al., 2022).

Self-motion in virtual and real environments can be achieved in two ways, self-propulsion (e.g. walking, swimming), or passive movement (e.g. on a vehicle observing surrounding motion) (Campos & Bülthoff, 2012). While the later has been often utilized in VR environments (e.g. Harris et al., 2002), studies have shown a strong link between physical motion or walking and increased feelings of immersion (Slater et al., 1995), and cognitive performance (Friedrich et al., 2021; Campos & Bülthoff, 2012). This is because physical motion can provide users with multisensory information regarding the extend, speed, and direction of egocentric movements, by utilizing a multitude of sources such as dynamic visuals, efference motor signals, and vestibular and proprioceptive cues (Campos & Bülthoff, 2012).

In practice however, natural motion is not always possible in full scale due to the physical limitations, versus the unlimited virtual ones. For this reason, immersive applications typically employ alternatives with an anchored or minimal physical movement approach. One method used by several current applications is motion with key-binds to the controllers, which can result in challenges like feelings of vection and cyber-sickness (motion sickness). An alternative method for VR motion while the physical body remains still, is using teleportation systems, which generates less vection but decreases presence and realism (see Boletsis & Chasanidou, 2022 for VR locomotion review). An adaptation of teleportation addressed the problem by developing a wrap-feeling around the user with visuals indicating fast movement before placing them to their pre-selected location. Similarly to the key-bind motion, this method results in higher vection occurrences. At the same time, many of the newly developed applications available to the public bypass motion completely, designing spaces not meant for movement (i.e. seated environments, office spaces), or they bring the environment to the user instead, manipulating elements while keeping the user at the epicenter of the scene (e.g. beat saber). In this study our embodied VR condition, allows users to physically move and interact with the environment thus getting a strong sense of self-motion, while the low embodiment VR condition only allows them to manipulate objects via controller key-binds.

Emotions in VR

Emotions are complex mental states or contracts, directly influenced by neurophysiological changes, thoughts, feelings, and behaviors. Neuroscientific research has established this is not solely a one-way relationship, and affective states play a detrimental role in regulating cognitive, behavioral, and physiological functions, just as much as vice versa (Somarathna et al., 2022). Affective structure is typically categorized in positive and negative valence dimensions, as well as degrees of activation and arousal (Thompson, 2007; Somarathna et al., 2022). The emotional valence defines the range from positive to negative, while arousal determines the intensity, ranging from very active to passive (see Somarathna, 2022 for valence-arousal depiction and more details).

Most affect VR studies focus on passive environments (Somarathna et al., 2022) frequently centering parks (Markowitz & Bailenson, 2021) or clinical and therapeutic applications (Macey et al., 2022). Emotional incitement and regulation studies are among the most common in the field (e.g. see reviews Somarathna et al., 2022; Macey et al., 2022; Markowitz & Bailenson, 2021), with much of the research focusing on influencing user interactions, transmitting emotion, or inducing a particular state or mood (Markowitz & Bailenson, 2021; Han et al., 2022). Multiple studies have successfully evoked targeted emotions such as anxiety, boredom, relaxation, fear, joy, sadness, or anger (e.g. Felnhofer et al., 2015; Baños et al., 2006; Herrero et al., 2014; Baños et al., 2012; Ding et al. 2018). Recent studies have also demonstrated stronger emotions being evoked in video-games using VR compared to traditional platforms (Lavoie et al. 2020). Other studies comparing VR to traditional monitors, elucidated negative emotions before a decision-making task, conclude that VR as a more immersive experience induced stronger emotions (Susindar et. al. 2019).

Nevertheless, there is not much research regarding immersive experiences and their effects on emotional states while in non-emotionally charged or affective-inducing environments. This can be a challenge due to the nature of emotions being invoked in all daily aspects. However, it is important to investigate the effects of immersive experiences in casual settings, that are not directly aimed at evoking or manipulating emotional states, before using them effectively in channeled contexts. And while we know that immersive experiences may influence the affective traits of users (Calvert & Tan, 1994), it is only assumed that a more physically embodied experience may influence our emotional and psychophysiological states further (Kim & Biocca, 2018). It is difficult to predict how self-motion might influence emotional traits in immersive environments not targeted at emotional elicitation. The limited prior literature conducted in VR shopping context with physical self-motion, demonstrated no significant affective changes compared to a teleportation method, or compared to a physical store experience (Bujić et al., 2021; Schnack et al., 2021). It is therefore unclear how embodiment represented by self-motion will influence affective traits in the metaverse. For this reason, the current study aims at investigating the emotional effects of self-motion in different immersive realities.

Methods

Design

A 2 × 2 between-subjects, factorial experiment including a control group were designed for investigating emotional changes in different virtual realities. The level of immersion was operationalized as a 3D experience either mediated by VR HMD (virtual reality head-mounted display) or PC flat-monitor. The sense of embodiment was related to perceived self-location and operationalized as the perception of self-motion (self-motion vs. self-anchored while moving the graph) as shown in Table 1. In the high immersion conditions (VR: Group 3 and 4), participants were required to either physically move in the 3D space or stand still while using controllers to manipulate the graph (object of interest). In the low immersion conditions (monitor-based: Group 1 and 2), participants could interact by using a mouse and keyboard. In the high sense of embodiment conditions (Group 2 and 4), participants could freely navigate within the 3D space (either physically or with key-binds), move surrounding the object and even place themselves inside the large 3D graph. In the low embodiment conditions (Group 1 and 3), movement was restrained with participants anchored in one spot, and they could instead only move the object/graph for inspection (not their selves). This study adhered to the Finnish National Board on Research Integrity TENK Guidelines 2019 and acquired research permission from the university.

In order to examine emotions in the daily life transactions of metaverse, a relatively easy decision-making task was carefully designed. Participants were shown a 3D or 2D (for control) graph containing information of 4 different financial assets, including prices and periods (Figure 1). Each asset had a different colored graph line with prices changing on all periods. During a 10-minute experiment, participants had to carry out activities autonomously, including information gathering, processing, and decision-making. The financial tasks and simply designed room were considered of low emotional charge, yet relevant to daily life practices and cognitive computations one would encounter in the metaverse or the physical world.

Group (N = 183)	**Immersion (Environment & Device)**	**Embodiment (Motion)**	**Input interaction**
Group 1 (n = 36)	**Low**: (3D) Monitor (24.5”, 60 Hz, 1080p)	**Low**: Self-anchored	Keyboard and mouse (graph control)
Group 2 (n = 35)	**Low**: (3D) Monitor (24.5”, 60 Hz, 1080p)	**High**: Self-motion	Keyboard and mouse (key-bind for self-movement)
Group 3 (n = 37)	**High**: (3D) HMD VR (Oculus quest 2)	**Low**: Self-anchored	Controllers (graph control)
Group 4 (n = 35)	**High**: (3D) HMD VR (Oculus quest 2)	**High**: Self-motion	Physical self-movement
Group 5 (n = 40)	**Control**: (2D) Monitor (24.5”, 60 Hz, 1080p)	**Control**	Mouse

Note. Sample size of each group for study 1. In study 2, ten outliners were identified, leaving final sample at 173.

Table 1. The Experimental and Control Conditions

Participants

During July-November 2022, a total of 216 non-color-blind volunteers were recruited from Tampere university in Finland. The final sample consists of 183 student participants, excluding pilots (N = 33). The mean age was 26.26 (18-48, SD=5.98), and 92 of them declared male (50.3%) as their gender, 88 female (48.1%) and 3 non-binary/did not declare (1.6%). The students were 53% MSc, 38.3% BSc, 8.2% PhD, and 0.5% other. The majority of them (80.9%) had no or very minimal prior VR experience. Participants were from more than 40 countries and diverse cultural backgrounds, including Finland (26.8%), India (6.6%), Pakistan (5.5%), Vietnam (4.4%), Germany (4.4%), and others.

Materials

Measures: Demographic information including age, gender, education, etc. were acquired before the experiment. The 10-item international Positive and Negative Affect Schedule (PANAS) Short Form (I-PANAS-SF) was adopted (Thompson, 2007) and was given immediately prior and after the experiment. Five items were used for measuring negative affect including *upset, hostile, afraid, ashamed, nervous,* and the other 5 items were used for measuring positive affect, including *determined, inspired, attentive, alert, and active*. Right before and after the experiment, participants were asked to indicate to what extent they felt each of the items "right now", at this moment, ranging from 1= *not at all* to 7= *extremely.*

Physical Environment: The experiment was conducted at LUDUS research laboratory of Tampere University, Finland. For the two VR conditions, we utilized an Extended Reality dedicated space (6m×8m). For the other three PC conditions (including control), we used a research cubicle in the same laboratory. The same cubicle was also used by all participants when completing the pre- and post-surveys.

Virtual Environment: Participants were asked to interact with a 3D or 2D graph in the same virtual environment (Figure 1). We developed and provided the same 3D room used in all 4 groups, while the control group used a 2D web-based interface with an image of the room as its background. The virtual environment was intentionally plain in order to avoid visual noise and distractions to the participants. A timer was visible on all conditions, with a notification when 5 minutes had passed to remind participants their tasks were now displayed and available on a canvas.

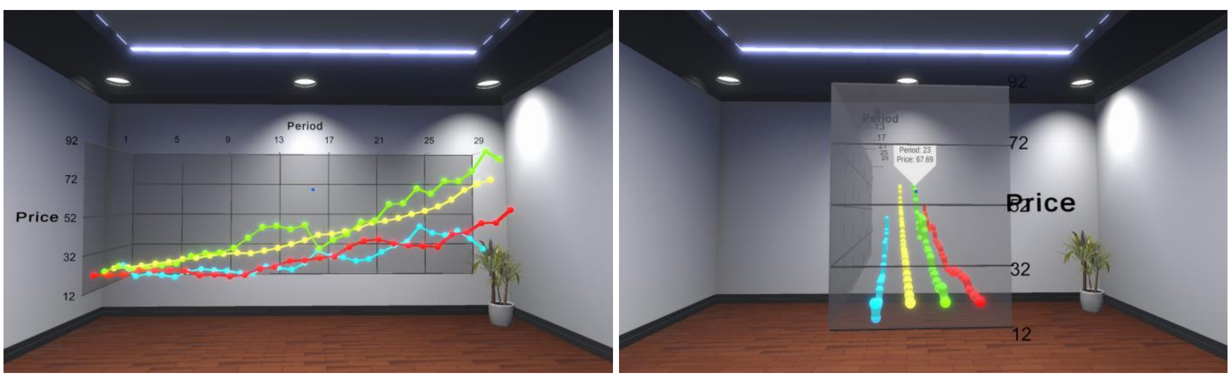

Figure 1. The Environment and 3D Graph (available to the 4 experimental conditions)

Procedure

Before the formal experiments, a series of pilot studies (N= 33) for all conditions was conducted for improving the experiment design, instructions, and measures. University students were recruited via campus advertisements. Participants completed an online presurvey before self-booking their experiment time. Two experimenters were responsible for running all the participants. Upon arrival to the lab, participants completed the PANAS 10-item questionnaire, and were then pseudorandomized in one of the five conditions. Before starting the formal procedure, participants were required to complete tutorial tasks under the guidance of experimenters. The experimenters only started the formal experiment after ensuring participants understood all procedures and had no difficulties of using their devices.

During the formal 10-minutes experiment, participants could explore their graph for the first 5 minutes, and complete tasks based on the period and price information of the graph within the remaining time. Once 10 minutes run out, the program would prompt the subject to finish, to ensure control over the experiment duration. Participants were then guided to complete the post PANAS measures. In the beginning all participants provided consent forms, and in the end, all received performance-based compensation (always guaranteed a fair minimum) in the form of digital coupons redeemable at local grocery stores.

Results

In order to provide more rich and granular results, two separate studies were conducted based on different data-analysis approaches. Study 1 examined if the PANAS items presented differences in regards to immersion and embodiment levels, while study 2 examined the same regarding positive and negative valence. Both studies were based on the same between-subject experiment presented in the previous section.

Study 1: Ten Dimensions of Affect

The first study examines all PANAS items for each condition using a two-way MANOVA. Pre scores were subtracted from post, leaving only the difference between each item's before and after. Table 2 describes the dataset's mean differences (scores in post test minus score in pre test) and standard deviations. The analysis was run using SPSS, with the 10 items placed as fixed factors, and *immersion* and *embodiment* as independent factors. No participants were excluded in this analysis, therefore our sample remains N=183. The assumption of normality was not met, but our large and even samples provide sufficient robustness to proceed. There was no multicollinearity found among the 10 items. Levene's test was good with $p > .05$ but Box's test value was $p < .05$, and we therefore interpret Pillai's trace.

	Upset	Hostile	Ashamed	Nervous	Afraid	Inspired	Active	Attentive	Determined	Alert
Group1	-.11 (1.21)	-.05 (.33)	.05 (.86)	-.08 (1.79)	-.44 (.96)	.58 (1.48)	.13 (1.43)	-.05 (1.09)	.11 (1.23)	-.02 (1.96)
Group2	.22 (1.23)	.17 (1.04)	.37 (1.19)	-.25 (1.35)	-.02 (1.31)	.17 (1.17)	.05 (1.30)	.17 (1.12)	-.14 (1.11)	.25 (1.70)
Group3	.18 (1.22)	-.02 (.89)	.51 (1.09)	-.05 (1.52)	.02, (.60)	.72 (1.64)	.21 (1.25)	.05, (1.66)	.54 (1.55)	.35 (1.31)
Group4	.05 (1.05)	-.08 (.65)	.34 (.87)	.05 (1.66)	-.11 (.96)	.40 (1.47)	.17 (1.50)	-.20 (1.84)	-.20 (1.41)	.54 (1.50)
Group5	.07 (.47)	-.05 (.22)	.10 (.70)	-.05 (2.11)	-.25 (1.00)	-.30 (1.45)	.25 (1.33)	-.02 (1.29)	-.15 (1.57)	-.20 (1.80)

Note. Group 1: 3D+ Monitor+ Self-anchored; Group 2: 3D+Monitor+ Self-motion; Group 3: 3D+ VR + Self-anchored; Group 4: 3D+ VR+ Self-motion (physical); Group 5: 2D Control

Table 2. Descriptive Information of Ten Dimensions of Affect (Mean differences and Standard Deviations)

The results of the MANOVA analysis show no main effects of immersion levels ($F = .76$, $p = .66$), or sense of embodiment ($F = .93$, $p = .50$) on any of the ten aspects of emotions. There is also no interaction ($F = 1.1$, $p = .36$) between immersion and embodiment. However, the follow-up ANOVA test between-subject effects showed a significant negative effect of embodiment on *determined* ($F = 4.52$, $p = .03$). In addition, Tukey HSD pairwise comparisons for immersion showed *inspired* was significantly higher in VR compared to control group (M_{vr}-$M_{control}$ = 0.87, $p = 0.008$). Similarly for embodiment, pairwise comparisons for *inspired* were significantly higher in self-anchor conditions compared to control ($M_{self\text{-}anchor}$ - $M_{control}$ = 0.96, $p = 0.03$).

Study 2: Negative vs. Positive Affect

The second study performed a second MANOVA, examining differences between negative and positive emotions for each condition. Pre and post data were used to identify their mean differences which are reported in Table 3. The differences for *hostile, upset, afraid, nervous,* and *ashamed* were added to each other and divided by 5 to form the *Negative* scores. The same was done for *inspired, alert, active, determined,* and *attentive*, to form the *Positive* scores. Single and multi-factor extreme outliers were removed from the dataset resulting in N = 173. No multicollinearity was found between the factors.

Normality was not met in all conditions, however our groups are even providing additional robustness. Using SPSS a MANOVA was run with Positive and Negative scores as the dependent variables, and immersion and motion levels as the independent.

Group	**Positive (+) (post-pre)**		**Negative (-) (post-pre)**	
	Mean Difference	Std.	Mean Difference	Std.
Group 1	.14	.716	.01	.489
Group 2	.13	.769	-.03	.469
Group 3	.49	.784	.06	.474
Group 4	.21	1.006	.08	.477
Group 5	-.07	.782	.02	.483
Total	.17	.827	.03	.475

Table 3. Descriptive Information of Positive and Negative Affect

Both Levene's and Box's reports tested well with $p > .05$. The descriptive results (Table 3) show higher mean difference and standard deviations reported for the Positive cluster compared to Negative in all conditions with a total $M = .17$ and $M = .03$ respectively. The MANOVA results however report no statistically significant main effect of immersion with Wilk's Lambda ($F = 1.8$, $p = .16$), or embodiment ($F = .55$, $p = .57$). There was no interaction effect detected ($F = .53$, $p = .58$) between the two. Tukey HSD pairwise comparisons were also non-significant with the exception of VR and Control ($p = .03$) for Positive scores of immersion ($M_{vr} - M_{control} = 0.42$).

Discussion and Conclusions

According to the results of study 1, there was no significant effect of the different immersion levels (VR vs. monitor), and no significant effect of the different embodiment levels (self-motion vs. self-anchored) on the 10 affect items. While prior research has indicated a higher emotional activation for both positive and negative affect in immersive environments (e.g. Felnhofer et al, 2015), this is not necessarily an unexpected finding as there is very little research exploring emotional influences of non-emotionally charged experiences. Similarly for embodiment, we can assume from our results that self-motion or self-anchor, does not impact our emotional perception in casual digital interactions. This reenforces the notion that metaverse is not perceived emotionally different at its core, and it is in fact of more importance the intentionality of its contents that shape and influence how we feel in it (Somarathna et al., 2022; Markowitz & Bailenson, 2021). This supports the perception of highly immersive technologies as tabula rasa tools, inducing no more or less of any emotion, and any emotional shifts are likely a direct result of the administered content. These inferences from our results assume a more casual and daily interaction that could take place in metaverse, with simple and close to realistic experiences where the user is enabled by the virtual world benefits, and not attempted to be distracted from their primary task in need of their cognitive resources (e.g. a user checking their bank status). It is however possible that more visually rich, or otherwise enhanced environments, could influence the emotional perception of users as demonstrated by prior studies.

Looking closer at the means on the descriptive Table 2, as well as the pairwise comparisons, we see that *inspired* is an item of interest. To begin with, the means show an increase of the post measure compared to pre for all conditions except Control which resulted in a negative score, meaning the post score was rated lower than the pre. Most importantly immersion played a role in how *inspired* people felt after their experience, with the highest scores in VR conditions ($p = .008$ compared to the control condition). Even though we observed no main effect of immersion this individual finding could still be explained. Financial situations, similar to the tasks provided in our experiment, tend to be somewhat uneventful, involving several mental computations. Providing an immersive and interactive environment could ignite one's imagination on how other daily tasks could be changed in the future. The *inspired* item also shows a statistical difference comparing 2D control to self-anchored ($p = .003$), with their means being increased by the VR anchored condition the most. These results combined indicated that the affective trait of feeling *inspired* was particularly sensitive to our independent variables compared to the rest of PANAS items. It is likely that the VR anchored condition was perceived as the most novel interaction as it brings forth two state-of-the-art and concepts, high immersion and object control. Similar experiences have been demonstrated in pop-culture (e.g. in Iron-Man movies Tony Stark rotates and manipulates 3D schematics in front of him), but are hard to imagine and experience in real life. These experiences are less common than self-motion equivalents, as a large object could easier and more realistically be implemented in space (e.g. large scale statues), with the user having to physically move their body to experience it.

In study 2, we investigated the effects of immersion and embodiment on affect valence, focusing on positive and negative emotions as two collectives. The results indicate no main effect or interaction, which implies that the level of immersion and self-motion are not granted by default what constitutes a metaverse experience as positive or negative. However, similarly to other studies (Susindar et. al., 2019; Lavoie et al., 2020), we see from the means on Table 3 an overall trend for emotional increase, with both positive and negative scores being on the plus side (instead of minus), meaning participants reported higher emotional activation during their post-experience measure. Notably, the increase is higher for the positive valence cluster, while negative means remained closer to their original scores. Reflecting the same relationship, immersive pairwise comparisons demonstrate a significant difference (p = .03) of the positive scores between the 2D control and VR conditions. This indicates participants experienced more positive feelings after VR exposure even though the context was not designed to evoke them. This brings forth the notion that users might adopt immersive over non-immersive environments, even for casual tasks. Therefore, it is possible that users may prefer and enjoy more conducting their daily activities and transactions in the metaverse instead of traditionally computerized environments.

Aiming to explore the roles of immersion and embodiment in eliciting emotions in the metaverse, this study conducted a large-scale laboratory experiment consisting of 4 experimental conditions and 1 control condition. In conclusion, immersion and self-motion did not significantly influence emotional perception. We can therefore hypothesize that it is not immersion or sense of embodiment directly which alter our emotional perception of metaverse experiences, but likely the environment and contents channeled for individual applications. Similar to prior studies we do see a tendency for an increase of emotional arousal especially of positive ones in VR conditions.

Limitations and Future Agendas

Even though the experiment was carefully designed and implemented, there are still a few limitations which can be considered for future research. To begin with, even though PANAS scale is a relatively mature measurement tool it still has some disadvantages. The 10 items and self-reported scores may not be able to fully reflect the emotional variance participants experienced during the experiment and may also portray participants' biases. Other psychophysiological measures such as electroencephalogram (EEG), electromyography (EMG), and facial expression analysis could be combined with or replace PANAS scale. Furthermore, the daily life decision-making task provided in this study involved data and graph information processing. Thus, our findings might be more applicable to virtual realities requiring more cognitive resources and mental effort (e.g. finance context of this study). Lastly, only students (M_{age} = 26.26) were recruited as the participants of the experiment. As young users they are likely to have higher immersive tendencies compared to middle-aged or older adults and are therefore more likely to accept virtual technologies like VR for daily-life decisions. It would be worth investigating emotional phenomena with diverse age groups in future metaverse studies.

Acknowledgments

This work has been supported by the OP Ryhmän Tutkimussäätiö, under Grant No. 20200040 [INVESTUAL]; the Nasdaq Nordic Foundation [Promoting Financial Literacy and Pro-Environmental Choices Using Game-Based Pedagogy and Virtual Reality]; the KAUTE Foundation under Grant No. 20200531 [VIRTUMER]; the Academy of Finland Flagship Programme under Grant No. 337653 [UNITE | Forest-Human-Machine Interplay]; the Foundation for Economic Education under Grant No. 210301

[GAMETH]. This work was carried out with the support of LUDUS research lab in Tampere University, Finland. Special thanks to Ans Ahmad, Filipe Gama, Zampeta Legaki, Panu Kalmi, and Gökhan Buturak's contribution to the project. The authors would also like to thank all volunteer participants from Tampere University.

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