Is Anxiety-Inducing VR Experienced Differently Depending on Personality? The Mediating Role of Presence

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ABSTRACT This study attempted to investigate the role of presence in an anxiety-inducing virtual reality (VR) experience and explain possible individual differences in the feeling of presence. More specifically, it was investigated if the feeling of presence (a) differed by personality and (b) affected individual levels of anxiety. This study utilized the psychobiological model of the Temperament and Character Inventory (TCI) to study personality in the context of virtual reality exposure therapy (VRET). In total, thirty six individuals participated in a lab experiment in which anxiety-inducing VR content was experienced through a head-mounted display. The results suggested that individuals with high levels of cooperativeness and self-transcendence experienced increased levels of presence, which further enhanced cognitive anxiety levels. On a physiological level, cooperativeness and reward dependence enhanced somatic anxiety (respiration), but presence was not a significant mediating factor.

INDEX TERMS Presence, virtual reality exposure therapy, personality, TCI.

I. INTRODUCTION

Exposure therapy is used in treating patients with excessive feelings of anxiety. It intentionally makes patients confront their feared but safe objects, situations, feelings, thoughts and memories to diminish fear, anxiety and associated negative responses to the equivalent or similar stimuli in the future [1]. In exposure therapy it is important to provide corrective information; therefore, patients do not have to worry about their feared stimulus. Thus, for the exposure to be successful, the stimulus must be something that the patients fear, yet is not dangerous [2]. In this regard, VR can be an efficient tool for exposure therapy because it is a mere replica of the real world, thus no harm can be inflicted upon the patients. Indeed, exposure therapy using VR technology has been widely studied and recognized as a useful approach. VRET illustrated its usefulness across various domains including mental health [3], phobias [4], post-traumatic stress disorders [5], social anxiety disorders [6], and general anxiety disorders [7]. Most studies demonstrate that VRET produces compatible clinical outcomes when compared to in-vivo exposure.

Anxiety is a feeling of agitation and worry, characterized as an overreaction to circumstances seen as dangerous only in a subjective way [8]. Anxiety is often accompanied by certain physiological arousal [9] and manifested as increased respiration, heart rate and perspiration as the sympathetic nervous system is stimulated.

The assumption inherent to VRET is that virtual objects and environments are perceived as real, therefore eliciting similar levels of anxiety. In VRET, it is important that the patients actually feel anxiety. If the patients perceive the VR to be unreal, thus feeling no anxiety, the therapy is unlikely to be successful [2].

Perceiving virtual objects and environments as real is related to the construct of presence [10]–[12], which is defined as a ''psychological state in which virtual objects are

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experienced as actual objects in either sensory or nonsensory ways.' ' [12] To be specific, the believability of phobic elements experienced during VR is positively related to feelings of presence or the perception of a virtual environment as real [12]. Although the feeling of presence is a crucial factor in virtual reality experiences, the role of presence in VRET has often been just assumed and has not been examined comprehensively [6].

We surmise that failing to consider the concept of presence in the study of VRET may be problematic given the important role of presence in virtual reality that has already been demonstrated in the literature [10], [13]–[16]. It is possible that neglecting the concept of presence and its contributing factors can adversely affect the effectiveness of VRET. For example, Krijn *et al.* [17] found a negative association between VRET patient drop-out rates and the level of presence experienced by patients.

In addition, because of individual differences in experiencing the feeling of presence, there may be individual differences in the results of VRET as well. In that sense, it would be helpful to know the contributing factors of presence to identify patients who may need additional support or more careful consideration. Individual differences exert a substantial influence on the extent to which one feels a sense of presence [18]. For example, individual personality traits can impact a sense of presence [17], [19]. Thus, it is reasonable to expect that the experience and the effectiveness of VRET may differ depending on personality and propensity to feel presence. With this knowledge, VRET could be better designed to align with individual differences in order to facilitate a greater sense of presence—thereby improving the effectiveness of therapy.

This study, thus, has three purposes. The first is to investigate if there are any individual differences in experiencing VR. More specifically, the feeling of presence in VR experience will be compared across individuals with different personalities. If the level of presence differs at all depending on individuals' personality, it would mean that personality should be considered in planning VRET to better serve the patients. Second, this paper intends to highlight the important role of presence in anxiety-inducing VR experience. That is, it tries to reveal the underlying mechanism of how personality affects VR experience by systematically investigating the mediating role of presence. The third purpose it to showcase the Temperament and Character Inventory (TCI) as a measure of personality in the context of VRET. In doing so, we tested both cognitive and somatic anxiety (mental and physical manifestation of anxiety) to consider both psychological and physiological processes.

II. LITERATURE REVIEW

The feeling of presence is an essential aspect of VR experiences [20]. The definition of presence varies in the literature, but it is generally conceptualized as a psychological state in which virtual experiences are perceived as real without the individual noticing the existence of technology [12].

According to Lee [12]'s explication of the concept, three types of presence exist based on the three domains of virtual experiences: social, physical, and self-presence. Social presence concerns the extent to which a user perceives virtual interactants to be actual social beings. Physical presence conjures the feeling that virtual (para-authentic or artificial) physical objects are actual physical objects. Finally, self-presence concerns the extent that one's virtual self is perceived as the actual self. When the user makes no distinction between the virtual and actual self, a high level of self-presence is experienced.

Considering the importance of presence in virtual experience, identifying the factors contributing to presence becomes critical. Lombard and Ditton [11] identify three primary causal factors for social presence (or presence): media content, media form, and user factors. Presence is largely based on form factors [21]. Media form refers to a medium's vividness, such as the number of co-presented sensory modalities or the resolution of the sensory channel. The content of the medium delivered within the media form – including characters, tasks, messages, and narratives etc. – also affects the feeling of presence [11]. Finally, the characteristics of users can also influence the experience of presence. The media form and contents generate different experiences and feeling of presence for each user. Compared to media content and form, however, user factors have been relatively understudied [11]. Thorough and systematic investigation is necessary to determine the individual characteristics that engender feelings of presence in virtual spaces.

Several studies have found individual differences in virtual experiences across personality types. However, the measures used to assess personality vary across these studies; thus, the results are inconsistent. For example, Laarni *et al.* [22] demonstrated positive associations between presence and extraversion. Conversely, Alsina-Jurnet and Gutiérrez-Maldonado [19] and Thornson *et al.* [23] found that introversion enhanced presence, while Sacau *et al.* [24] found no relationship between presence and introversion/extroversion.

In this study, we used the Temperament and Character Inventory (TCI) developed by Robert Cloninger to measure personality. Derived from a psychobiological model, this inventory has been proven to be adaptable to clinical situations [9] and has been applied widely in psychotherapy. The TCI examines how two factors, temperament and character, collaborate to establish the dimensions of personality. Temperament focuses on "emotional drives" and consists of the following personality dimensions: (a) novelty seeking, (b) harm avoidance, (c) reward dependence, and (d) persistence [25]. Character emphasizes individual "goals, beliefs, and values" and consists of the following personality dimensions: (e) self-directedness, (f) cooperativeness, and (g) self-transcendence. While temperament corresponds to relatively heritable, percept-driven, and unconscious traits, character derives from concept-based traits and conscious memories [9].
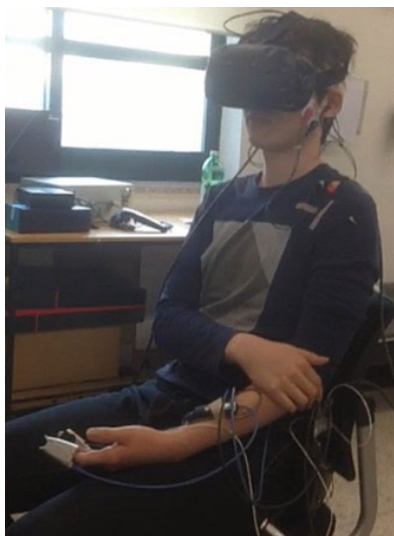
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FIGURE 1. The Scene of Experiment. Participants were watching three-minute-long anxiety-inducing video clip (The teaser of American horror movie *The Conjuring 2*) with VR HMD, VIVE. During the experiment, physiological responses (e.g.,heart rate, skin conductance, skin temperature) were also measured using NeXus-10 M.

There are several reasons for using TCI rather than other personality measures in the context of VRET. First, TCI is based on the unified psychobiological theory of personality which includes both social-psychological and biological components [26]. TCI has been used in various areas in medical and neurobiological domains, and its related research can provide both psychological and biological evidence in VRET research.

Second, TCI is widely used in psychotherapy. The result of TCI may be readily available, as there is a good chance that TCI may have already been conducted for the purpose of psychotherapy. For this reason, additional tests of personality would be unnecessary.

Third, Cloninger suggests that TCI assessment may point to or support a psychiatric disorder diagnosis [9]. As TCI has been demonstrated as a powerful diagnostic tool for medical professionals, the relationship between TCI and presence can provide more accurate diagnosis and further refinement and improvement of VRET processes and outcomes.

Therefore, We propose the following research question to investigate if there are any specific group of people who have propensity to feel a higher or lower level of presence:

RQ1 Do any dimensions of personality correlate significantly with feelings of presence? If so, which ones?

The feeling of presence in virtual experience plays an important role in understanding the effect of media. A strong body of literature consistently suggests the important role of presence in facilitating the virtual experience [13], [27], [28]. Specifically, it can function as a mediator connecting the predictor and the media experience outcome variable. For example, Adachi et al. [29] found that media type to view a VR tourism advertisement significantly affected the

TABLE 1. Demographic and neuropsychological characteristics of participants.

Characteristics	All participants (N = 36)
Age(years)	22.00 (3.50)
Gender (M:F)	19:17 (52.78%:47.22%)
Education Year	14.51 (1.13)
TCI: Harm Avoidance	40.69 (28.28)
Novelty Seeking	49.64 (24.40)
Reward Dependence	57.47 (27.65)
Persistence	43.44 (27.58)
Self-Directedness	57.67 (26.77)
Cooperativeness	61.97 (32.72)
Self-Transcendent	30.53 (28.06)

user's positive image about the destination. Compared to those who used a computer, those who used a head-mounted display (HMD) to view the VR tourism advertisement experienced a higher level of presence, which further enhanced the formation of a positive destination image. In fact, presence has often been identified as a significant mediator promoting effective virtual experiences [13], [14], [29]–[32]. That is, presence has been demonstrated as the key factor explaining why and how technology use affects user experiences [33].

Experiencing presence in VR is associated with physiological measures such as increased heart rate and, to a lesser extent, skin conductance. No significant relationship has been detected between presence and skin temperature [26]. Therefore, in addition to measuring cognitive anxiety, we also captured data on heart rate and skin conductance to analyze any potential correlation between somatic anxiety (physical manifestation of anxiety) and the TCI. According to the multidimensional view of anxiety [34], [35], physical and mental anxiety should be differentiated. While cognitive anxiety includes negative concerns and disrupted attention, somatic anxiety includes autonomic arousal or bodily symptoms of anxiety. Studies have found that cognitive and somatic anxiety are deferentially associated with other variables. For example, cognitive, compared to somatic anxiety, was shown to be more highly related to performance [36]. Skin temperature and respiratory rate were also measured concurrently to identify other manifestations of anxiety. The following research question is proposed.

RQ2 Does presence operate as a mediator in the relationship between personality and anxiety ?

III. METHODS
A. PARTICIPANTS

Forty participants, aged 19 to 38 (see Table 1) completed the experiment. Four participants were ultimately excluded from data analysis due to problematic physiological signals leading to incomplete data. Thus, a total of thirty six participants were included in the data analysis. Exclusion criteria included illiteracy, a history of neuropsychiatric disorders - dementia, alcohol abuse, head trauma, visual or hearing difficulties - and motor impairment affecting test scores.

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B. APPARATUS AND MATERIALS

VIVE head-mounted displays (HMD; HTC Corp.) were used to present the virtual reality content. The HMD presented the visual and auditory content as a 360-degree video. The digital operation was using a GT73VR 7RE Titan gaming laptop (MSI Corp.). During the VR experience, a three-minute teaser video for *The Conjuring 2*, an American horror movie released in 2016 utilized. The movie was specifically designed to be viewed with a 360-degree VR devices. Thus, the users could have a 360-degree view and they had to simply turn their heads to look around. Participants were well instructed on how to view the VR content and encouraged to look around to enjoy the full perspective. The movie was in the first-person perspective and the body of the self was not provided. To monitor and capture the physiological change in heart rate, skin conductance, and skin temperature during the VR practice, NeXus-10 MK2 equipment (MindMedia Corp.) and BioTrace+ software were used.

C. PROCEDURE

Before exposure to the video, participants were asked to answer questionnaire about their personality and baseline cognitive anxiety. To measure baseline somatic anxiety, physiologic state was measured for three minutes. Afterward, each participant watched the anxiety-inducing video for three minutes using the HMD while their physiological state was recorded. Participants were asked to be seated while watching the video. It is actually quite common to experience VR while sitting in a chair. As the Head Mounted Display (HMD) completely blocks the view of the physical world, it can be dangerous to walk around. After watching the video, participants were again asked to rate their cognitive anxiety and the presence during the VR experience.

D. MEASURES

All psychological indicators were self-reported via questionnaire. Personality was measured using the standardized TCI-RS (revised-short) [37] consisting of 140 items based on a 5-point scale. TCI scores are converted into T-scores. T-scores are based on a normal distribution with a mean of 50 and a standard deviation of 10. Each of the categories has a varying number of sub scales. The result of TCI determines each dimension. Cognitive anxiety was measured with the State-Trait Anxiety Inventory (STAI) [38] before and after the VR experience. Presence (physical, social, and self) was measured using a 10-point Likert scale adapted from the ITC-SOPI for the virtual reality environment [39].

In addition to the self-reported measures, physiological data for somatic anxiety were also measured using Nexus-10. Heart rate was measured by the flow of blood volume to the tip of the index finger, while skin conductance was measured using the palm side of the third and fourth finger. Skin temperature was measured via the skin of the thickest part of the fifth finger, and the respiratory rate was measured using a flexible belt worn around the abdomen. All data were gathered on the non-dominant hand (e.g., for right-handed individuals, all measures were taken on the left hand) [40]. The data were automatically recorded in real time and converted to text files afterward. Physiological signals were measured for three minutes in resting state before the VR intervention, thereby extracting a background signal.

E. STATISTICAL ANALYSIS

SPSS (*PASW statistics 18*) software was used for statistical analysis. For physiological signals, the average value during the running time of the virtual content screening (three minutes) was used for analysis.

IV. RESULTS

A. DEMOGRAPHIC CHARACTERISTICS

The demographic and neuropsychological characteristics of the participants are shown in Table 1. The average age of participants was 22 years ($SD = 3.5$), with the sample being 52.8% males and 47.2% females (see Table 1).

Addressing RQ1, Pearson's correlation analysis indicated that individuals with high levels of cooperation were likely to feel high levels of physical presence ($r = 0.38$, $p = 0.02$) and social presence ($r = 0.34$, $p = 0.05$). Self-transcendence showed marginally positive associations with physical ($r = 0.32$, $p = 0.056$) and self-presence ($r = 0.30$, $p = 0.080$) (see Table 2).

Multiple regression analysis was conducted to test whether personality dimensions significantly predicted the level of presence felt during the VR experience. The results indicated that cooperativeness explained 13% of the variance, $F(1, 33) = 4.96$, $p = 0.033$, and significantly predicted the level of presence ($\beta = .36$, $p = .033$). Self-transcendence was also found to significantly affect the level of presence ($\beta = 0.33$, $p = 0.055$) and R^2 was 0.107, $F(1, 33) = 3.961$, $p = 0.055$.

B. RELATIONSHIP BETWEEN TCI AND ANXIETY

To address RQ2, the association between TCI and physiological signals of anxiety (i.e., somatic anxiety) was analyzed using multiple regression. Four types of physiological signals were analyzed: skin conductance, temperature, heart rate, and respiration. While most bio markers did not show differences across the seven dimensions of TCI, we found some interesting results related to respiration. Specifically, individuals with high levels of cooperativeness showed a significantly greater change in respiration between the pre and posttest, ($\beta = 0.413$, $p = 0.012$) and R^2 was .171, $F(1, 34) = 7.004$, $p = 0.012$. Those with high levels of reward dependence showed similar patterns of significantly increased respiration, ($\beta = 0.392$, $p = 0.018$) and R^2 was 0.153, $F(1, 34) = 6.160$, $p = 0.018$ (see Table 3).

C. MEDIATION EFFECT OF PRESENCE

Next, mediation analysis was conducted using PROCESS [41] to investigate if the effect of personality

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TABLE 2. Pearson's correlation analysis between personality (TCI) and presence.

Dimesions		Physical presence	Self-presence	Social presence	Presence
Temperament	Novelty Seeking	0.092	0.078	0.136	0.105
	Harm Avoidance	0.143	0.239	0.094	0.164
	Reward	0.215	0.130	0.283	0.243
	Persistence	-0.124	-0.043	-0.049	-0.107
Character	Self-Directedness	-0.053	-0.033	0.026	-0.016
	Cooperativeness	0.377 *	0.210	0.335 *	0.362 *
	Self-Transcendence	0.321 +	0.295	0.232	0.327 +

Note. $^{+}p < 0.01$, $^{*}p < 0.05$ (2-tailed).
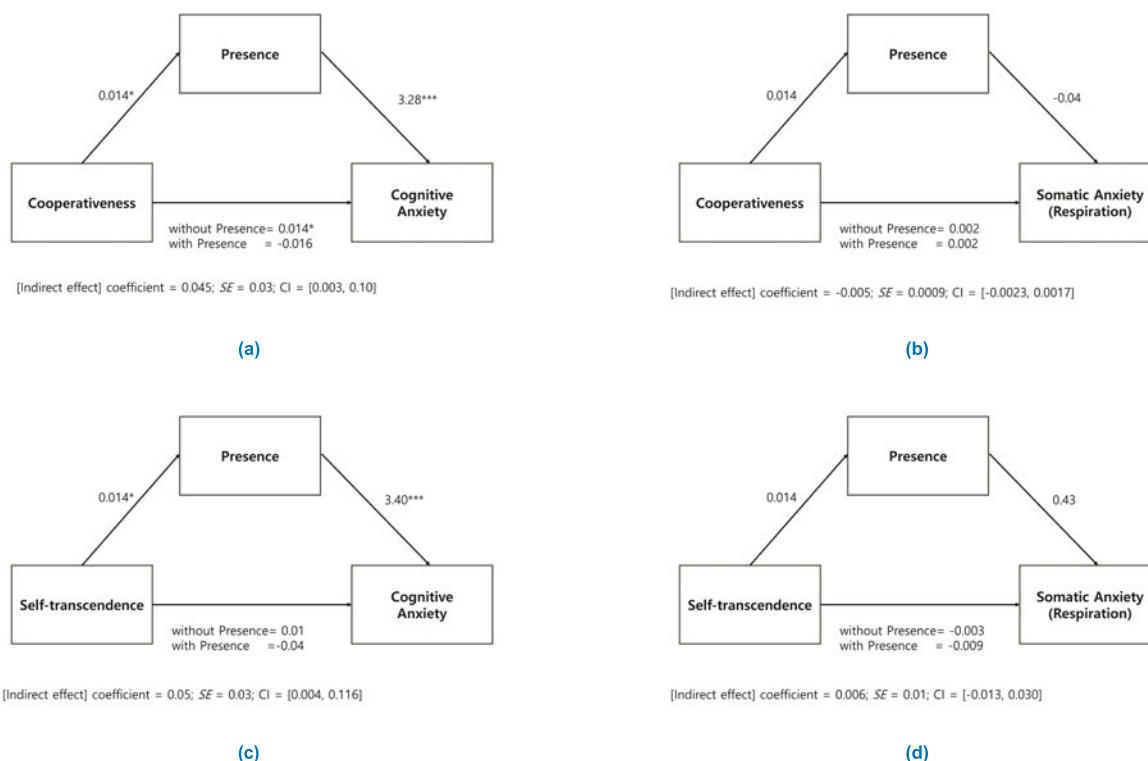

(a)

(b)

(c)

(d)

FIGURE 2. The mediating role of presence between (a) cooperativeness and cognitive anxiety, (b) cooperativeness and somatic anxiety, (c) self-transcendence and cognitive anxiety, and (d)self-transcendence and somatic anxiety. Indirect effects shown in (a) and (c) were significant, while the ones in (b) and (d) were not. Significance level: $*p < 0.05$, $**p < 0.01$, $***p < 0.001$.

TABLE 3. Relationship between TCI and the change of respiratory rate.

Personality	Respiratory Rate			
	β	R^2	F	p
Novelty Seeking	-0.049	0.002	0.081	0.777
Harm Avoidance	0.086	0.007	0.252	0.619
Reward Dependence	0.392	0.153	6.160	0.018
Persistence	-0.064	0.004	0.141	0.709
Self–Direcetedness	-0.036	0.001	0.043	0.837
Cooperativeness	0.413	0.171	7.004	0.012
Self-Transcendence	-0.014	0.0	0.007	0.934

on the level of VR-induced anxiety was mediated by the feeling of presence. PROCESS is based on a bootstrapping approach and indicates both direct and indirect effects. In this study, the procedure was based on 5000 bootstrap samples.

Given that cooperativeness and self-transcendence were significantly associated with presence, two mediation analyses were conducted for each variable (see Fig 2).

The mediating role of presence between cooperativeness and anxiety was first tested. Two separate analyses were conducted for two different types of anxiety: cognitive and somatic. For cognitive anxiety, regression analysis showed that cooperativeness was significantly associated with anxiety when it was the only predictor ($\beta = 0.014$, $p = 0.0328$) and R^2 was 0.13, $F(1, 33) = 4.963$, $p = 0.033$. When presence was added as another predictor, presence was significant ($\beta = 3.280$, $p = 0.0002$) controlling for cooperativeness and R^2 was 0.364, $F(2, 32) = 9.17$, $p = 0.0007$. However, cooperativeness was no longer significant ($\beta = -0.016$,

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$p = 0.591$), suggesting a full mediation effect [33]. The effect score of the indirect effect was 0.045, ($SE = 0.03$); $CI = [0.003, 0.10]$. On the hand, the mediation model using somatic anxiety as the dependent variable turned out to be insignificant.

Second, mediation analysis was conducted to test the mediating role of presence between self-transcendence and anxiety. With cognitive anxiety as the dependent variable, regression analysis showed that the relationship between self-transcendence and anxiety was not significant ($\beta = 0.01$, $p = 0.76$). When both self-transcendence and presence were included as the predictor of anxiety, the effect of presence was significant ($\beta = 3.400$, $p = 0.0001$), while self-transcendence was not significant ($\beta = -0.036$, $p = 0.285$). The coefficient of the indirect effect was 0.05, ($SE = 0.03$); $CI = [0.004, 0.116]$ suggesting a significant indirect effect [42]. On the other hand, the mediation model predicting somatic anxiety with reward dependence turned out to be insignificant.

V. DISCUSSION

This study investigated the potential individual personality differences in VRET by inducing cognitive and somatic anxiety in a virtual environment. Specifically, we demonstrated the importance of presence as a mediator between personality dimensions and anxiety. Our findings suggest that individuals with high levels of cooperativeness and self-transcendence experience increased levels of presence, which then increased cognitive anxiety. Physiological evidence indicates that self-transcendence and reward dependence also enhance somatic anxiety as evidenced by increased respiration, but presence did not operate as a mediator in this relationship. Although future studies should be conducted to reveal the exact reason behind the different result between psychological and somatic anxiety, we suspect that as presence is a type of cognitive process: it may be more likely to manifest in the cognitive realm rather than the physiological.

This study is one of the first to use TCI to investigate the role of personality and VR experience. It is interesting that individuals with high levels of cooperativeness and self-transcendence are more likely to feel virtual objects as real and thus experience a high level of anxiety. According to the TCI measure and the theoretical explanation behind it, cooperativeness is comprised of five factors: social acceptance, empathy, helpfulness, compassion, and pure-hearted conscience. The concept of self-transcendence is comprised of three sub-categories: self-forgetfulness, transpersonal identification, and spiritual acceptance. In fact, it may be reasonable to expect that people with high empathy, compassion, self-forgetfulness, and transpersonal identification are likely to experience high levels of presence in virtual reality. VR is often called "the ultimate empathy machine", as it provides a realistic experience of being in someone else's shoes. In virtual reality, one can be a chile, a criminal, or a disabled person and have a direct experience, albeit

mediated, to understand what it is like to live as someone else. A project like 'The Machine to be Another' at 'Be Another Lab' (http://beanotherlab.org/home/work/tmtba/) attempts to promote open-mindedness toward different races by providing a virtual experience to become someone in different race. In addition, Bailenson's VR experiment showed that experiencing being an old man in VR via a virtual-self body prompted participants to save more for retirement [43]. Although there is mounting evidence that VR enhances empathy, our study is one of a few that demonstrates that empathy enhances VR experience. Given the fact that VR experience is, in essence, about being someone else, people with high ability and tendency for empathy and compassion are likely to feel that VR is more realistic. Future studies should be conducted to obtain more empirical evidence to clearly show the relationship between personality and presence.

This study provides multiple implications. We believe that it suggests important guidelines for the practitioners who develop or use VRET as well as the researchers of VRET in that it identifies the important factors affecting VRET experience in general. First, our findings suggest that the level of anxiety experienced via VR content can differ based on personality. Specifically, individuals possessing tendencies for cooperativeness and self-transcendence experienced higher levels of presence. These results suggest that VRET may be more effective among these individuals. Presence was demonstrated to be a full mediator between cooperativeness and anxiety. This implies that presence fully explains why individuals with tendencies toward cooperativeness are likely to be sensitive to anxiety-inducing VR.

Second, TCI was used in investigating the effects of anxiety-inducing VR experience for the first time in this study. Previous studies relied on the Big Five personality traits (neuroticism, extraversion, openness, agreeableness, and conscientiousness) or other related measures such as absorption, immersive tendencies, or empathy [19], [44]. TCI, on the other hand, integrates social and biological components in a unified psychobiological theory of personality and has been used in conjunction with other research modalities (e.g., molecular neuroimaging, structural neuroimaging, and genetics) to investigate the neurobiological foundations of personality [9]. Given that TCI is often utilized in psychotherapy, patients with anxiety may have their TCI data readily available before commencing with VRET.

Third, this study demonstrates the importance of presence in VRET. We found a significant mediating role of presence in anxiety-inducing VR; specifically, presence demonstrated a significant mediating effect between personality and anxiety. Individuals with high levels of cooperation and self-transcendence were more likely to become more immersed in the virtual space; this feeling of presence further enhanced anxiety. Moving forward, we suggest that VRET should be examined alongside the concept of presence. As Lombard and Ditton [11] argue, personality as an individual factor, together with media-related factors affect the level

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of presence a person experiences. In this study, we demonstrated that presence may be a reason why anxiety-inducing VR experiences differ across personality dimensions.

Fourth, this study investigated anxiety through two different methods focusing on both cognitive and somatic anxiety. Interestingly, presence was related to cognitive but not somatic anxiety. Although the reason behind this result is not clear, we suspect that as presence is a type of cognitive process: perhaps presence is more likely to manifest in the cognitive realm rather than the physiological. We believe future studies should examine the relationship between anxiety and presence more closely.

VI. LIMITATIONS AND FUTURE STUDIES

This study has several limitations that suggest directions for future studies. First, this study was not conducted in a clinical setting investigating clinical outcomes. Future studies should examine if the results of this study apply to health outcomes among patients managing anxiety disorders. Second, this study utilized anxiety-inducing VR material. Therefore, it has boundary conditions; it is not clear if VR content that induces other emotions will show comparable results to those in this study. Furthermore, we used only one form of VR content to induce anxiety among participants. Moving forward, we posit that other forms of anxiety-inducing VR content might lead to other relationships across variables. Finally, although significant results were detected, the number of participants was rather small. Future studies should further collect evidence from a larger sample to confirm the relationship between personality and presence.

VII. CONCLUSION

This study demonstrated the important role of presence across TCI personality dimensions in anxiety-triggering VR experiences. We hope more VRET studies will utilize TCI to study personality, presence, and anxiety so that individuals with anxiety disorders can receive VR treatments in ways that resonate with their individual differences, thereby making treatment more effective.

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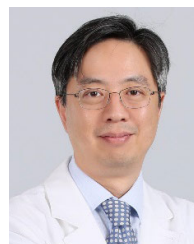
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