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Article

Association of the Big Five Personality Traits with Training Effectiveness, Sense of Presence, and Cybersickness in Virtual Reality

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Abstract: Virtual reality (VR) presents numerous opportunities for training skills and abilities through the technology's capacity to simulate realistic training scenarios and environments. This can be seen in how newer research has emphasized how VR can be used for creating adaptable training scenarios. Nevertheless, a limited number of studies have examined how personality traits can influence the training effectiveness of participants within VR. To assess individual preferences in a virtual environment, the current study examines the associations of Big Five personality traits with training effectiveness from VR, as well as sense of presence and cybersickness. Our results show that traits of high agreeableness and low conscientiousness are predictors of training transferability in the VR environment in relation to the real world. Furthermore, the results also showed that trainees experiencing higher levels of cybersickness incurred worse training outcomes.

Keywords: personality traits; sense of presence; cybersickness; simulation sickness; training effectiveness; virtual reality; performance

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1. Introduction

Virtual reality (VR) has become increasingly recognized as a valuable training tool for its ability to provide a realistic and interactive virtual environment (VE) that would otherwise be impractical or expensive to recreate with other means [1]. Researchers have argued how the technology can be applied to create effective training scenarios that are tailored to individuals' specific individual factors [2].

Research on the effectiveness of VR training has generally focused on how the individual factors of sense of presence and cybersickness are influenced by the VR experience. Contrastingly, fewer studies have examined how individual characteristics that affect the VR experience compared with the effectiveness of VR training. Some studies have explored the impact of individual characteristics, such as cognitive and emotional patterns (e.g., [3,4]); however, few studies have directly assessed associations between personality traits and training effectiveness.

Within the framework of understanding how VR training can be tailored to individuals, the present study aims to explore how personality traits impact training effectiveness in VR. We believe that evaluating this rarely researched area will give insight into creating effective VR training, as well as why individuals interact and understand VEs differently. Ultimately, we believe this research could be applied to creating VR applications tailored to individuals' specific needs and preferences. Additionally, we believe that sense of presence and cybersickness are VR-specific phenomena integral to the experience. In keeping with the aim of understanding how VR training can be tailored to individuals, the current study will also explore these variables' impact on training effectiveness.

Specifically, the present study aims to answer the following questions: (1) How are the Big Five personality traits associated with training effectiveness in VR? (2) How are Big Five personality traits associated with cybersickness and sense of presence in a VR training experience? (3) How does sense of presence and cybersickness associate with training performance in VR?

2. Literature Review

2.1. Training Effectiveness of VR

Several studies have examined how VR technology enables trainees to improve real-life skills. Researchers have argued that VR's spatial abilities can accommodate a real-looking visualization of concepts that would otherwise be difficult to grasp [1]. Scholars have also argued that the spatial environments in VR and high intractability facilitate an active learning process [4]. Further, VR training can also accommodate learning by its easy repetition of a training scenario, and by the reception of direct feedback on how to improve [5,6]. Studies have found that VR training can help: to prepare workers to deal with emergencies or high-risk situations [7]; military personnel for the purposes of teaching fundamental skills [8]; teaching situational awareness in traffic [9]; provide the ability to practice surgery [10,11]; and in education, for example, by educating one on the properties of physics [12].

In comparison with video learning or other interactive 2D computer programs, VR technology promises more relevant and interactive training opportunities. Moreover, the technology allows for a more imbodied, tailored, and personalized experienced [8]. Nevertheless, the areas in which VR training can create positive training scenarios compared to more traditional learning methods are still not fully understood; furthermore, research on the area has been plagued by inconsistent results [4]. A recent meta-review by Kaplan et al. [13] finds that the use of VR training provides training transferability that is not significantly different from traditional training methods. The authors argue that the effectiveness of VR training, while generally assumed, has not yet been proven. Moreover, the authors postulate that the effectiveness of VR training might be dependent on whether the task is physical, cognitive, or spatial.

According to Makransky [14], VR training can be less effective (compared to a 2D monitor) when aspects of the VE produce extraneous cognitive load through aspects of the immersive environment that distract rather than enhance the VR training. Moreover, the advent of cybersickness, prevalent in immersive VEs, can hinder training performance [2].

2.2. Big Five Personality Traits

Personality traits are relatively enduring internal characteristics of people that are reflected in their responses, behaviors, attitudes, and feelings [15,16]. The theory postulates that five dimensions (Neuroticism, Extraversion, Openness to new experiences, Agreeableness, and Continuousness) account for underlying stable patterns of human behavior, emotions, and cognition.

Few studies have explored the effects of individual personality traits on VR training, and of the conducted studies few have found any notable associations. For example, a study that examined surgeons' technical performances and personality traits in VR found no correlation between personality traits and technical performance [11].

Related studies on training performance from 2D interactive games have found divergent associations. Correlations have been found between higher levels of openness to new experiences and training performance; and of the time that the video games are used with certain learning effects (e.g., [17]). Neuroticism have also been found to correlate with better performances in environments of increasing difficulty [18], while agreeableness has been found to be associated with feelings of proficiency [19]. Non-VR studies on the relationship between personality traits and training effectiveness have generally found positive associations with conscientiousness [20].

2.3. Sense of Presence

There have been several proposals regarding definitions of sense of presence. It has generally been explained as the degree of perceptual resources distributed towards the VE or simply as "being there" in the VE [21]. The term "immersion" is sometimes used interchangeably with sense of presence [22,23]; however, most research considering the human experience of VE operates with the differentiation that was proposed by Slater [24]: sense of presence regards the subjective experience of the VE, while immersion measures the objective properties of the VE.

Researchers have argued that the immersive and believable environments provided by modern HMDs promote a higher sense of presence [4]. The literature has also suggested that a high sense of presence enhances training effects by increasing the connection to the environment [25,26]. The meta-review by Mikropoulos and Natsis [27] found that sense of presence promoted positive learning effects in 12 out of 53 studies; further, 3 studies found adverse learning outcomes, while most did not find any significant effects. In newer studies using modern HMDs, positive correlations between skill development and sense of presence have, among others, been found in studies involving the administration of medication among nursing students [28], as well as for simulations used for psychomotor training [29] and in a block building task [30].

However, newer studies have also found negative associations. Bailey et al. [31] found a negative association between immersion and memory recalls, arguing that immersive properties add complexity to the VE that can overload the trainees' cognitive resources. This notion is supported by Makransky et al. [14], who found that immersive VR environments increase the sense of presence but result in worse training outcomes than 2D environments.

2.4. Cybersickness

Motion sickness-like symptoms experienced during a VR exposure are often called cybersickness. However, scholars have also been using the term "simulation sickness". Cybersickness is often defined as a specific subcategory of motion sickness (MS) applied to virtual environments [32]. Both cybersickness and MS share symptoms, such as vertigo, headache, nausea, and general discomfort [33,34]. A considerable proportion of participants in VR studies experience cybersickness during VR, with up to 80% of users indicating some degree of discomfort [35]. The sympathology can also negatively impact users' ability to complete VR training, with Brooks [36] reporting that 17% of their participants could not complete the training in a driving simulator.

The risk of cybersickness while observing or interacting in VR has been argued as a limiting factor for the use and adoption of virtual technologies [34]. Research has aimed to understand the causes of cybersickness symptoms in order to lessen the extent of negative symptoms and to, thus, improve usability (see [29]). While no complete scientific explanation exists, the most cited theory is that cybersickness is caused by the incongruity of sensory input, which is caused by the conflicting signals perceived from the visual stimuli of the VE in contrast to actual physical motion [36].

Cybersickness also has significant implications on performance in VR, as well as on the effectiveness of VR training [37]. Some results suggest cybersickness affects cognitive abilities in VR [38]. Cybersickness has been found to increase reaction time [39], a decline in working memory [40], and a decrease in performance [41].

2.5. Association of Big Five Personality Traits with Cybersickness and Sense of Presence

Research on the association between Big Five personality traits and sense of presence have seen inconsistent results, with most studies finding no association [30]. Kober and Neuper [42] found the correlations appeared to depend on the presence questionnaire that is used. A positive correlation was found using the short feedback questionnaire (SFQ) but not when using the more popular Slater–Usoh–Steed (SUS) questionnaire or the presence questionnaire (PQ). Among studies examining the Big Five personality traits, Weibel et al. [43] found participants with a high degree of neuroticism to have a higher sense of presence, whereas Sacau et al. [44] found openness to new experiences and extraversion to positively correlate with sense of presence.

Considering the relationship between personality and cybersickness could be important in helping understand why some individuals are far more suspectable to cybersickness than others. There is limited research between the Big Five personality traits and cybersickness [45]. However, Grassini et al. [30] reported a positive correlation between the neuroticism trait and the nausea subscale of the Simulation Sickness Questionnaire (SSQ).

Research on personality traits and MS have generally found few associations. Certain older studies have found extraversion to be negatively related to MS [33,46]. Certain other studies have also found MS to correlate with neuroticism [32,47]. Researchers have argued that this positive association may be explained by increased anxiety, a factor associated with neuroticism [30]. A recent Jasper [45] study found extraversion, agreeableness, and conscientiousness to be associated with recalled cybersickness severity.

The association between sense of presence and cybersickness has been argued for in the literature; however, the nature of the relationship appears complicated. A large body of research has attempted to determine whether cybersickness and presence are positively or negatively associated. The meta-review of Weech et al. [21] argues that the relationship is negative and that studies finding positive associations are explainable by the confounding variable of immersion. A recent study by [48] gave evidence for this theory. By continuously measuring the association of cybersickness and sense of presence, the authors found simultaneous measurements in time to explain the positive association. Nevertheless, the authors argue for a more nuanced explanation of the relationship than that which was concluded by Weech et al. [22].

3. Methods

3.1. Participants

In this study, 46 young adults between 18 and 30 years participated in the experiment. The participants were recruited from the student population at the Norwegian University of Science and Technology (Trondheim, Norway). The population consisted of 31 females and 15 males. The number of participants was established in consideration with previous similar studies (e.g., [11,30]. In order to maintain consistency with the research goals, only participants with less than 1 h prior experience using VR were recruited. All the participants received a description of the study and gave informed consent before the experiment.

3.2. VR Scenario

The virtual environment featured an assortment of colorful plastic block pieces set within an industrial warehouse. The blocks were floating in air above a metal table at sitting height. At experiment start participants were presented six-part instruction for assembling a model toy plane using the presented plastic blocks. We are unable to report specific images of the virtual environment due to the copyright of the utilized materials. Nevertheless, a visual recreation of the training environment is presented in Figure 1. The VE was chosen as it accommodates a controllable and spatially interactable task, well-fitted for the goal of examining the potential training transferability of VR. The application was developed specifically in our lab by BreachVR.

Participants used the HTC Vive Pro HMD while in a seated position. The HMD used two screens with a resolution of 1440 × 800 pixels per eye, a 110 degrees field of view, and a refresh rate of 90 Hz. A Vive controller was placed in the participants' preferred hand to interact with the block pieces.

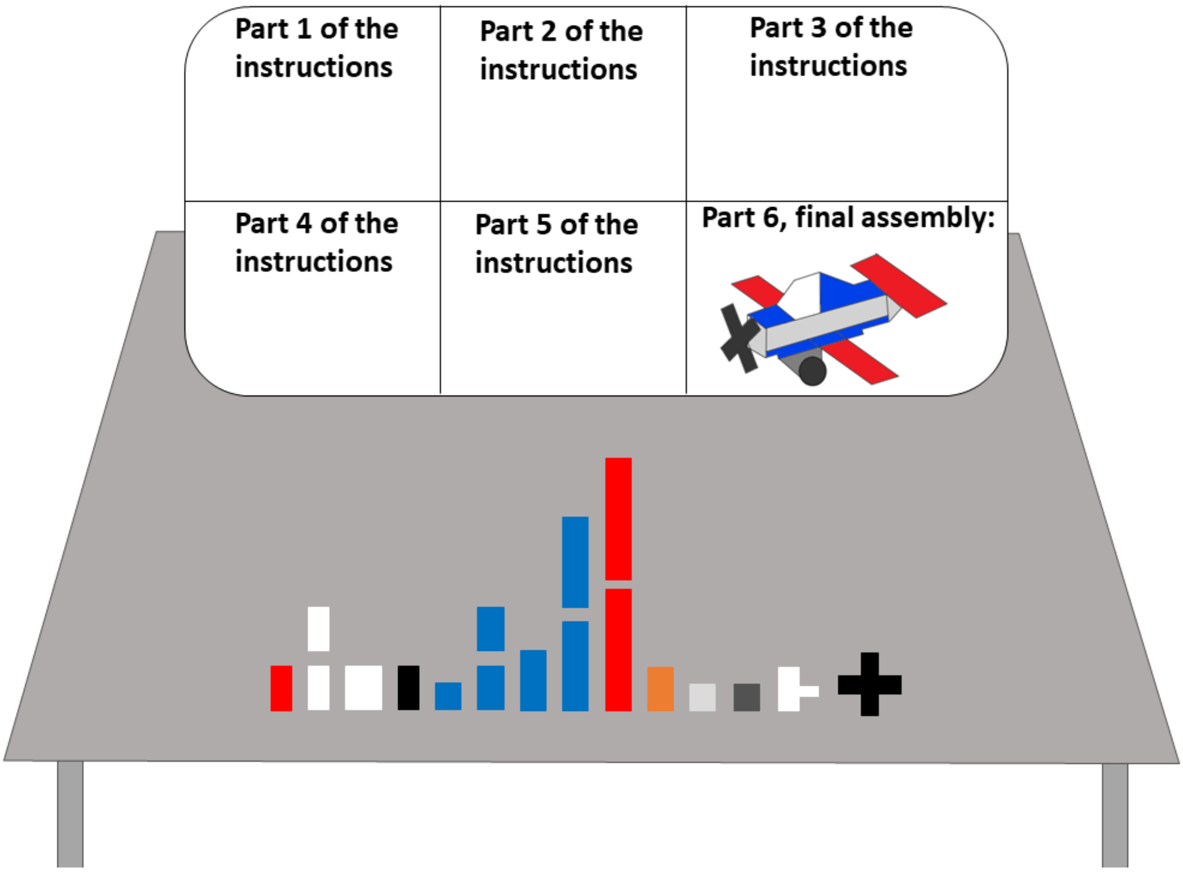

Figure 1. A recreation of the virtual training environment.

3.3. Procedure

Upon arriving at the laboratory, participants were given an experimental description, reported their age and sex, and signed the informed consent form. Next, the HMD was fitted, and participants were instructed how to use the controller to move and assemble the pieces in the environment. The experiment was performed in a sitting state as it more resembled the VR training environment which included a table at sitting height.

3.4. Study Design

The first part of the experimental task was conducting the VR training (see Figure 2). The task consisted of a 10 min session in which participants could freely train on assembling a model plane using the aforementioned building blocks. The duration of 10 min was based on the pilot study in order to provide most participants with enough time to finish building the plane at least once.

After the VR training session, participants were tasked with assembling the same model plane using actual blocks quickly and correctly in the real world. They were given the same 6-part instructions as in the VR training environment. Participants were explicitly informed prior to the experiment about this task.

After finishing the VR training session and the assembly of the actual model plane, participants were asked to complete the NEO Five-Factor Inventory (NEO-FFI), the presence questionnaire (PQ), and the simulation sickness questionnaire (SSQ).

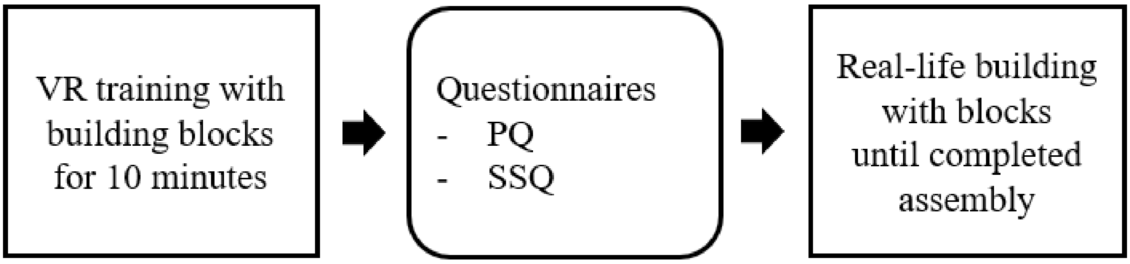

Figure 2. Study design of the current experiment.

3.5. Performance Measurements

The participants' hands were filmed using a mounted phone camera (Oneplus 8 pro, 48 MP-wide angel lens) in order to measure the number of mistakes during the assembly of the actual model plane. After a pilot test, it was decided that the timer should only be stopped after the correct assembly of the model plane. If participants assembled the model plane incorrectly, the observer would explicitly point out the mistakes in order to help participants complete the build.

Performance metrics were established as the speed of assembly (measured from experiment start until a correctly assembled model plane was achieved) and the number of errors made during assembly (counted by going through the video footage). A mistake was counted if participants misplaced a block such that the block would have to be reattached in order to assemble the model plane correctly. Only fully connected blocks in the wrong area would be counted as mistakes. If the model were disassembled and reassembled with the same errors, it would only be counted as one mistake. This was chosen as the misplacement of one of the blocks will inevitably lead to the displacement of the following blocks. In addition, it was only counted as one mistake if the following block had been correctly assembled, if not for the previously misplaced block.

3.6. Questionnaire Instruments

We used the validated Norwegian translation of the NEO-FFI. English versions of the SSQ and PQ were used because there do not exist any currently validated Norwegian versions.

The NEO-FFI is a shorter version of the NEO Personality Inventory Test 3 (NEO-PI-3) consisting of 60 items reported on a 5-point scale [49]. The scale presents a quick and reliable measurement of five domains of personality (neuroticism, extraversion, openness, agreeableness, and conscientiousness). In the current experiment, the final score was obtained using the average sample *t*-score (1 to 100) based on the normal distribution of the survey sample averaging both genders.

The SSQ was used to measure cybersickness as it is the most widely used measurement [47,50]. The questionnaire consisted of 16 items assessing cybersickness symptoms across three overlapping facets (oculomotor, disorientation, and nausea). Participants rated the symptoms from 0 (no symptoms) to 3 (severe). The final score was obtained by multiplying the facets using predetermined weights.

The PQ version revised by the l'Université du Québec en Outaouais Cyberpsychology Lab [35] was used to measure the participants' perceived sense of presence. This version of the PQ consists of 24 items, rated on a scale from 1 (low level of presence) to 7 (high level of presence). As sound was not present in the current virtual environment, the three items referring to sound were excluded from the questionnaire. The version of the PQ used in the current experiment has been found to have good internal reliability ($\alpha = 0.84$; [35]).

3.7. Data Analysis and Statistics

IBM SPSS Statistics (version 28) was used for the statistical analyses. Before conducting any analyses, the data were screened. Descriptive analyses indicated that four participants did not complete all 21 questions of the PQ measurement. Four items were missing in total

(0.42% of PQ items). Missing data were imputed using the mean method in SPSS. Pearson's correlation analyses were used to examine the relationship between the relevant variables.

4. Results

Descriptive Statistics

Table 1 shows the descriptive statistics obtained in the current study.

Table 1. Descriptive results for the questionnaires in the current study.

	Variable	M	SD
NEO-FFI	Neuroticism	54.83	11.01
	Extroversion	47.13	11.03
	Openness	48.85	0.89
	Agreeableness	53.04	0.97
	Conscientiousness	54.04	8.13
SSQ	Simulation sickness	130.36	127.27
Modified PQ	Sense of presence	4.76	0.59

Abbreviations—FFI: Five-Factor inventory; SSQ: simulation sickness questionnaire; and PQ: presence questionnaire.

The SSQ scores were higher than the average scores reported in similar studies using modern HMDs [30,51]. The mean values for the PQ were in line with the score of 4.49 reported by [52] and 4.65 by [35].

The average *t*-scores of the NEO-FFI were generally in line with the survey's normal distribution of 50. However, agreeableness and conscientiousness were somewhat above average. Similar personality tendencies were found in several other studies examining psychology students (see [43]).

The number of mistakes ranged from 0 to 28, averaging 2.74 (SD = 4.97). The average time for assembling the model plane was 142.65 s (SD = 104.61), with the fastest time of 42 s and the slowest time of 500 s. These results were in line with expectations. That is, most individuals will find the task suitably challenging; further, some will use significantly more time and make more mistakes.

5. Statistics

Correlations

Correlation analyses were performed in order to assess the relationship between cybersickness, sense of presence, and the Big Five personality traits with participants' training performance (see Table 2). Conscientiousness was negatively associated with both performance metrics, whereas agreeableness was positively associated with time used for assembly but not with the number of mistakes. No association with the performance metrics was found for cybersickness and sense of presence.

Table 2. Pearson's correlations between the analyzed NEO-FFI and performance metrics.

		Time Used for Assembly	Number of Mistakes
NEO-FFI	Neuroticism	−0.199	−0.217
	Extroversion	0.124	0.127
	Openness	0.129	0.127
	Agreeableness	−0.388 **	−0.231
	Conscientiousness	0.239 *	0.465 **
SSQ	Cybersickness	0.291	0.349 *
PQ	Sense of presence	0.009	−0.048

Note—Pearson's *r*. values are reported—* $p < 0.05$ and ** $p < 0.01$. Abbreviations—FFI: Five-Factor inventory; SSQ: simulation sickness questionnaire; and PQ: presence questionnaire.

Correlation analyses were also performed in order to examine the association of the Big Five personality traits with cybersickness and sense of presence (see Table 3). No significant correlations were found. Follow up analyses showed no association between SSQ and PQ ($r.$ = −278 and p = 0.075). Furthermore, the performance metrics correlated with each other ($r.$ = 0.870, p > 0.001).

Table 3. Pearson's correlations between the NEO-FFI, SSQ, and PQ.

		SSQ	PQ
NEO-FFI	Neuroticism	−0.242	0.012
	Extroversion	0.049	0.211
	Openness	−0.163	0.216
	Agreeableness	−0.012	0.230
	Conscientiousness	0.265	0.041

Abbreviations—FFI: Five-Factor inventory; SSQ: simulaaire; and PQ: presence questionnaire.

6. Discussion

In the framework of the present study, we aimed to explore how the Big Five personality traits associate with training effectiveness, cybersickness, and sense of presence. Secondarily, we sought to shed light on how sense of presence and cybersickness were associated with training performance.

In the present study, individuals high in conscientiousness were found to perform significantly worse on the training task. This finding was significant for the number of mistakes made but not on the time used for completing the assembly. A negative association between conscientiousness and training effectiveness is somewhat surprising. Most studies find conscientiousness beneficial in most general training tasks and in interacting with technology (e.g., [20,53]).

Individuals high in conscientiousness are characterized by a tendency to be organized, goal-directed, and good at planning [54]. An explanation for the negative association may lie in the specific VE used. The environment consisted of different types and colors of building blocks floating in space. During the assembly of the model plane, these building blocks must be manipulated and moved around in the 3D space. Conscientious trainees may have found the consequent working environment to be unorganized and difficult to navigate, thereby taking away cognitive resources that could be used to learn the task at hand. Moreover, some research has found that while individuals high in conscientiousness generally perform better on tasks, they do worse on novel or priorly unfamiliar tasks [43].

An explanation may lie in the tendency of conscientious individuals to be goal-directed [54]. Studies have indicated that a goal orientation can negatively affect training effectiveness, especially in tasks where the training task is closely related to the rewarded performance task [29]. As such, conscientious trainees may have overly focused on the end goal of completing the model plane assembly as correctly and quickly as possible to the detriment of first properly exploring and understanding how to assemble the plane in the VE effectively.

Another explanation for the negative relationship may be that conscientious individuals have a need for planning. The limited time for training in the simulation (10 min) may not have provided conscientious trainees with enough time to plan and explore how to build the model plane. Moreover, building a model plane is a complex process, whereby the placement of blocks depends on the placement of prior blocks in a step-by-step process. Recent research has indicated that learning process-based tasks are more effective when conducting a gradual step-by-step exploration rather than mentally planning how each part fits in the whole [55].

Another surprising finding of the present study is that individuals high in agreeableness fared better in the training task (for the time used, but not for the number of mistakes). Prior studies on personality and training performance in VR have found some positive correlations between agreeableness and training performance, but primarily for evaluations and feelings of proficiency [19,56]. To the authors' knowledge, no studies have found agreeableness to positively explain training effectiveness in tasks of interacting with technology. However, there is some evidence that exists indicating that agreeable individuals perform better at learning tasks. Large meta-studies have found agreeableness (in addition to conscientiousness and openness to new experiences) to be predictors of training performance [49,57]. Moreover, agreeable individuals have been found to get better grades in school compared to individuals who are low in agreeableness [58].

Based on their tendency to be collaborative, cooperative, and serving others [37], agreeable individuals may also have been more prone to dedicate effort to the laboratory training task and to be less distracted by the experimenter's presence in facilitating the training task.

The current investigation shows no relationship between individuals' sense of presence and their training performance. This result differs from research showing that sense of presence leads to more learning (e.g., [47,59]). However, this finding may be in line with recent research, which has shown that the higher sense of presence experienced in immersive environments can lead to a more engaging experience but worse learning outcomes than in low-immersive modularity [2,31]. According to Makransky [2], this discrepancy is explainable by the increased cognitive load experienced during immersive VE, taking away cognitive resources that could otherwise be used for learning [14].

In the current investigation, cybersickness was found to influence individuals' learning performance negatively. Logically, the negative symptoms of cybersickness should hinder participants' ability to train in a VE. This finding is in line with other studies examining the effect of cybersickness on training performance in VEs [41,57]. Solving the advent of cybersickness in VEs remains a significant challenge for the general adoption of VR technology. Studies have shown that up to 80% are negatively influenced by cybersickness; in addition, around 5–17% cannot endure prolonged exposure to VR [36].

The Big Five personality traits (neuroticism, extraversion, openness to new experiences, agreeableness, and conscientiousness) did not show any relationship with cybersickness. This finding is consistent with most studies (see [21]). However, the result contradicts some studies finding neuroticism to be associated with cybersickness (e.g., [21,37]). The Big Five personality traits were also unrelated to the sense of presence. This is in line with other studies that have found no association between sense of presence and personality. However, some studies have found sense of presence to relate to traits of neuroticism and extraversion [3,37]. Understanding the association of stable personality traits with sense of presence and cybersickness remains an essential line of research for understanding how to create and customize effective training experiences in VR.

Sense of presence and cybersickness were not found to be related in the current study. This finding is in line with several studies that have also not found an association [60]. However, the finding differs from the meta-review of Weech et al. [21], who reported the two phenomena as inversely related. As such, the relationship between sense of presence and cybersickness remains complicated. Recent studies have indicated that the relationship may be mediated by the technology used as well as the contents of the virtual environment [59]. In any case, more research is required in order to uncover how the two phenomena interact and are modulated.

Limitations

There are some limitations to the current study that should be considered. Mainly, the current training task might not be generalizable to all training. Specifically, the current VE gave individuals the task of learning how to assemble a model from its pieces. Other studies exploring VR training have focused on a wide area of tasks such as orthopedic surgery [11], fire training [7], and learning about physics objects [12]. Much like in real life, different tasks require different abilities. Thus, the current finding of conscientiousness to negatively associate and agreeableness to positively associate with training performance might not be generalizable to studies using different scenarios.

Secondly, the statistical analyses did not correct the use of multiple correlations. This was deliberately undertaken as the study examines associations that have not been adequately examined in earlier research. The current study could thus be viewed as exploratory. If a Bonferroni correction had been applied, the correlations between training performance, conscientiousness, and agreeableness would still be significant. However, cybersickness would not be significant with training performance.

A third limitation is in the performance measurements. Measuring the number of mistakes and time used means that most individuals performed the task quickly and with few mistakes, while some used significantly more time and incurred more mistakes. Thus, the performance measurements were highly skewed. It was decided to not conduct any outlier analyses due to the fact that the measurements were not normally distributed. If it were conducted, it would exclude participants having trouble with the task while only including participants who successfully conducted it. Consequently, it can be seen that some individuals disproportionately affected the results of the given correlations. Future studies should strive to create more normally distributed performance measurements and to consider using a larger sample.

A fourth limitation is in how the training scenario was set up. The study design gave each participant the same time for completing the training. This meant that trainees who quickly adapted to VR assembled the model plane several times, while there were others who did not get to finish the first assembly. This gave individuals who were proficient in assembling the model plane in VR an advantage in the performance task. Nevertheless, it was deemed that giving all participants the same time for training with the model plane assembly was more in line with the study's goal as we aimed to assess training efficacy in VR, which includes the factors of adaption and proficiency in using the VE.

A fifth limitation of the current study is the use of building blocks. Several participants indicated that they were well versed in using these types of blocks and could thus have an advantage when tasked with assembling the model plane. Thus, the results of the current experiment might be because of previous skills rather than the VR training. Future studies should strive to control for prior experience with building blocks or use a different type of skill training virtual environment.

Lastly, it should be noted that the present study used modern HMD equipment, while some older studies presented in this article generally did not use HMDs. This presents a difference in technical abilities between the equipment used in studies, meaning that the results of the current study may not be comparable or generalizable to older studies. Furthermore, the wide variety of simulations used in different studies may render the direct comparability of results problematic. Future studies should strive to understand better how individual factors are associated with specific training tasks and different VEs.

The findings of the present study shed light on the rarely studied association of Big Five personality traits and VR training effectiveness, finding a significant correlation between high agreeableness and low conscientiousness. However, more research is needed on the relationship of Big Five personality traits on effective VR training. The vast difference between VR technologies, VEs, and different training tasks might make it difficult to conclude on a general association between Big Five personality traits and training effectiveness. Future studies should strive to replicate the findings of this study using similar environments and training tasks, but also explore how different VR training scenarios might affect the relationship between personality traits and training effectiveness.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on reasonable request from the corresponding author. The data are not publicly available due to their containing information that could compromise the privacy of research participants.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Delgado, J.M.D.; Oyedele, L.; Demian, P.; Beach, T. A research agenda for augmented and virtual reality in architecture, engineering and construction. *Adv. Eng. Inform.* **2020**, *45*, 101122. [CrossRef]
2. Makransky, G.; Terkildsen, T.S.; Mayer, R.E. Adding immersive virtual reality to a science lab simulation causes more presence but less learning. *Learn. Instr.* **2019**, *60*, 225–236. [CrossRef]
3. Selivanov, V.V.; Selivanova, L.N.; Babieva, N.S. Cognitive processes and personality traits in Virtual Reality educational and training. *Psychol. Russ. State Art* **2022**, *13*, 16–28. [CrossRef]
4. Widyanti, A.; Hafizhah, H.N. The influence of personality, sound, and content difficulty on virtual reality sickness. *Virtual Real.* **2022**, *26*, 631–637. [CrossRef]
5. Jensen, L.; Konradsen, F. A review of the use of virtual reality head-mounted displays in education and training. *Educ. Inf. Technol.* **2018**, *23*, 1515–1529. [CrossRef]
6. Pagano, K.; Haddad, A.; Crosby, T. Virtual reality-making good on the promise of immersive learning: The effectiveness of in-person training, with the logistical and cost-effective benefits of computer-based systems. *IEEE Consum. Electron. Mag.* **2016**, *6*, 45–47. [CrossRef]
7. Freina, L.; Ott, M. A literature review on immersive virtual reality in education: State of the art and perspectives. *Health* **2015**, *1*, 10–1007.
8. Koźlak, M.; Nawrat, A.; Kurzeja, A. Virtual Reality simulation technology for military and industry skill improvement and training programs. *Szybkobieżne Pojazdy Gąsienicowe* **2014**, *2*, 5–12.
9. El Aeraky, S.; Dollfuss, M.; Kopciak, P.A.; Kolar, P.; Daniela, H. Virtual Reality Driving Simulator Prototype for Teaching Situational Awareness in Traffic. In Proceedings of the Forschungsforum der Österreichischen Fachhochschulen, Vienna, Austria, 30–31 March 2016.
10. Khanal, P.; Vankipuram, A.; Ashby, A.; Vankipuram, M.; Gupta, A.; Drumm-Gurnee, D.; Josey, K.; Tinker, L.; Smith, M. Collaborative virtual reality based advanced cardiac life support training simulator using virtual reality principles. *J. Biomed. Inform.* **2014**, *51*, 49–59. [CrossRef]
11. Rosenthal, R.; Schäfer, J.; Hoffmann, H.; Vitz, M.; Oertli, D.; Hahnloser, D. Personality traits and virtual reality performance. *Surg. Endosc.* **2013**, *27*, 222–230. [CrossRef]
12. Kim, J.-H.; Park, S.-T.; Lee, H.; Yuk, K.-C.; Lee, H. Virtual reality simulations in physics education. *Interact. Multimed. Electron. J. Comput.-Enhanc. Learn.* **2001**, *3*, 1–7.
13. Kaplan, A.D.; Cruit, J.; Endsley, M.; Beers, S.M.; Sawyer, B.D.; Hancock, P.A. The effects of virtual reality, augmented reality, and mixed reality as training enhancement methods: A meta-analysis. *Hum. Factors* **2021**, *63*, 706–726. [CrossRef]
14. Makransky, G.; Andreasen, N.K.; Baceviciute, S.; Mayer, R.E. Immersive virtual reality increases liking but not learning with a science simulation and generative learning strategies promote learning in immersive virtual reality. *J. Educ. Psychol.* **2021**, *113*, 719. [CrossRef]
15. Roberts, B.W. Back to the future: Personality and assessment and personality development. *J. Res. Personal.* **2009**, *43*, 137–145. [CrossRef]
16. Goldberg, L.R. The structure of phenotypic personality traits. *Am. Psychol.* **1993**, *48*, 26–27. [CrossRef]
17. deGraft-Johnson, C.; Wang, Y.-C.; Sutherland, M.B.; Norman, K.L. *Relating Five Factor Personality Traits to Video Game Preference*; Human-Computer Interaction Institute: Pittsburgh, PA, USA, 2013.
18. Lara, M.A. Personality Traits and Performance in Online Game-Based Learning: Collaborative Versus Individual Settings. Ph.D. Thesis, Indiana University, Bloomington, IN, USA, 2013.
19. Johnson, D.; Gardner, J. Personality, motivation and video games. In Proceedings of the 2010 Australian Computer Human Interaction Conference, Brisbane, Australia, 22–26 November 2010; pp. 276–279.
20. Meyer, R.D.; Dalal, R.S.; Bonaccio, S. A meta-analytic investigation into the moderating effects of situational strength on the conscientiousness–performance relationship. *J. Organ. Behav.* **2009**, *30*, 1077–1102. [CrossRef]
21. Weech, S.; Kenny, S.; Barnett-Cowan, M. Presence and cybersickness in virtual reality are negatively related: A review. *Front. Psychol.* **2019**, *10*, 158. [CrossRef]
22. Dalgarno, B.; Lee, M.J. What are the learning affordances of 3-D virtual environments? *Br. J. Educ. Technol.* **2010**, *41*, 10–32. [CrossRef]
23. Weibel, D.; Wissmath, B. Immersion in computer games: The role of spatial presence and flow. *Int. J. Comput. Games Technol.* **2011**, *2011*, 282345. [CrossRef]
24. Slater, M. Measuring presence: A response to the Witmer and Singer presence questionnaire. *Presence Teleoper. Virtual Environ.* **1999**, *8*, 560–565. [CrossRef]
25. Chuah, K.M.; Chen, C.J.; Teh, C.S. Incorporating Kansei Engineering in instructional design: Designing virtual reality based learning environments from a novel perspective. *Sci. Technol. Educ.* **2010**, *1*, 37–48.

26. Lee, E.A.-L.; Wong, K.W.; Fung, C.C. How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach. *Comput. Educ.* **2010**, *55*, 1424–1442.
27. Mikropoulos, T.A.; Natsis, A. Educational virtual environments: A ten-year review of empirical research (1999–2009). *Comput. Educ.* **2011**, *56*, 769–780. [CrossRef]
28. Dubovi, I.; Levy, S.T.; Dagan, E. Now I know how! The learning process of medication administration among nursing students with non-immersive desktop virtual reality simulation. *Comput. Educ.* **2017**, *113*, 16–27. [CrossRef]
29. Stevens, J.A.; Kincaid, J.P. The relationship between presence and performance in virtual simulation training. *Open J. Model. Simul.* **2015**, *3*, 41–48. [CrossRef]
30. Grassini, S.; Laumann, K.; Luzi, A.K. Association of Individual Factors with Simulator Sickness and Sense of Presence in Virtual Reality mediated by head-mounted displays (HMDs). *Multimodal Technol. Interact.* **2021**, *5*, 7. [CrossRef]
31. Bailey, J.; Bailenson, J.N.; Won, A.S.; Flora, J.; Armel, K.C. Presence and memory: Immersive virtual reality effects on cued recall. In Proceedings of the International Society for Presence Research Annual Conference, Philadelphia, PA, USA, 24–26 October 2012; pp. 24–26.
32. Shupak, A.; Gordon, C.R. Motion sickness: Advances in pathogenesis, prediction, prevention, and treatment. *Aviat. Space Environ. Med.* **2006**, *77*, 1213–1223.
33. Gordon, C.R.; Ben-Aryeh, H.; Spitzer, O.; Doweck, I.; Gonen, A.; Melamed, Y.; Shupak, A. Seasickness susceptibility, personality factors, and salivation. *Aviat. Space Environ. Med.* **1994**, *65*, 610–614.
34. Mazloumi Gavgani, A.; Walker, F.R.; Hodgson, D.M.; Nalivaiko, E. A comparative study of cybersickness during exposure to virtual reality and "classic" motion sickness: Are they different? *J. Appl. Physiol.* **2018**, *125*, 1670–1680. [CrossRef]
35. Knight, M.M.; Arns, L.L. The relationship among age and other factors on incidence of cybersickness in immersive environment users. In Proceedings of the 3rd Symposium on Applied Perception in Graphics and Visualization, APGV 2006, Boston, MA, USA, 28–29 July 2006; p. 162.
36. Brooks, A.L. Intelligent decision-support in virtual reality healthcare and rehabilitation. In *Advanced Computational Intelligence Paradigms in Healthcare 5*; Springer: Berlin/Heidelberg, Germany, 2010; pp. 143–169.
37. Wilmot, M.P.; Ones, D.S. Agreeableness and Its Consequences: A Quantitative Review of Meta-Analytic Findings. *Personal. Soc. Psychol. Rev.* **2022**, *26*, 242–280. [CrossRef]
38. Yörük Açıkel, B.; Turhan, U.; Akbulut, Y. Effect of multitasking on simulator sickness and performance in 3D aerodrome control training. *Simul. Gaming* **2018**, *49*, 27–49. [CrossRef]
39. Nesbitt, K.; Davis, S.; Blackmore, K.; Nalivaiko, E. Correlating reaction time and nausea measures with traditional measures of cybersickness. *Displays* **2017**, *48*, 1–8. [CrossRef]
40. Bos, J.E. Less sickness with more motion and/or mental distraction. *J. Vestib. Res.* **2015**, *25*, 23–33. [CrossRef]
41. Mittelstaedt, J.M.; Wacker, J.; Stelling, D. VR aftereffect and the relation of cybersickness and cognitive performance. *Virtual Real.* **2019**, *23*, 143–154. [CrossRef]
42. Kober, S.E.; Neuper, C. Personality and presence in virtual reality: Does their relationship depend on the used presence measure? *Int. J. Hum. Comput. Interact.* **2013**, *29*, 13–25. [CrossRef]
43. Vedel, A.; Thomsen, D.K.; Larsen, L. Personality, academic majors and performance: Revealing complex patterns. *Personal. Individ. Differ.* **2015**, *85*, 69–76. [CrossRef]
44. Sacau, A.; Laarni, J.; Hartmann, T. Influence of individual factors on presence. *Comput. Hum. Behav.* **2008**, *24*, 2255–2273. [CrossRef]
45. Jasper, A.; Doty, T.; Sepich, N.; Dorneich, M.C.; Gilbert, S.B.; Kelly, J.W. The relationship between personality, recalled cybersickness severity, and recalled cybersickness recovery time. *Proc. Hum. Factors Ergon. Soc. Annu. Meet.* **2021**, *65*, 206–210. [CrossRef]
46. Reason, J.T.; Brand, J.J. *Motion Sickness*; Academic Press: Cambridge, MA, USA, 1975.
47. Paillard, A.; Quarck, G.; Paolino, F.; Denise, P.; Paolino, M.; Golding, J.F.; Ghulyan-Bedikian, V. Motion sickness susceptibility in healthy subjects and vestibular patients: Effects of gender, age and trait-anxiety. *J. Vestib. Res.* **2013**, *23*, 203–209. [CrossRef]
48. Thorp, S.; Sævild Ree, A.; Grassini, S. Temporal Development of Sense of Presence and Cybersickness during an Immersive VR Experience. *Multimodal Technol. Interact.* **2022**, *6*, 31. [CrossRef]
49. Salgado, J.F. The Five Factor Model of personality and job performance in the European Community. *J. Appl. Psychol.* **1997**, *82*, 30–43. [CrossRef] [PubMed]
50. Stanney, K.M.; Kennedy, R.S. *Simulation Sickness*; CRC Press: Boca Raton, FL, USA, 2010.
51. Kim, H.K.; Park, J.; Choi, Y.; Choe, M. Virtual reality sickness questionnaire (VRSQ): Motion sickness measurement index in a virtual reality environment. *Appl. Ergon.* **2018**, *69*, 66–73. [CrossRef] [PubMed]
52. Grassini, S.; Laumann, K.; de Martin Topranin, V.; Thorp, S. Evaluating the effect of multi-sensory stimulations on simulator sickness and sense of presence during HMD-mediated VR experience. *Ergonomics* **2021**, *64*, 1532–1542. [CrossRef] [PubMed]
53. Oliveira, G.H.M.; Welch, E.W. Social media use in local government: Linkage of technology, task, and organizational context. *Gov. Inf. Q.* **2013**, *30*, 397–405. [CrossRef]
54. Colquitt, J.A.; Simmering, M.J. Conscientiousness, goal orientation, and motivation to learn during the learning process: A longitudinal study. *J. Appl. Psychol.* **1998**, *83*, 654–665. [CrossRef]
55. Yew, E.H.; Goh, K. Problem-based learning: An overview of its process and impact on learning. *Health Prof. Educ.* **2016**, *2*, 75–79. [CrossRef]

56. Kortum, P.; Oswald, F.L. The impact of personality on the subjective assessment of usability. *Int. J. Hum. Comput. Interact.* **2018**, *34*, 177–186. [CrossRef]
57. Ziegler, M.; Bensch, D.; Maaß, U.; Schult, V.; Vogel, M.; Bühner, M. Big Five facets as predictor of job training performance: The role of specific job demands. *Learn. Individ. Differ.* **2014**, *29*, 1–7. [CrossRef]
58. Laursen, B.; Pulkkinen, L.; Adams, R. The antecedents and correlates of agreeableness in adulthood. *Dev. Psychol.* **2002**, *38*, 591–603. [CrossRef]
59. Webster, R. Declarative knowledge acquisition in immersive virtual learning environments. *Interact. Learn. Environ.* **2016**, *24*, 1319–1333. [CrossRef]
60. Davis, S.; Nesbitt, K.; Nalivaiko, E. A systematic review of cybersickness. In Proceedings of the 2014 Conference on Interactive Entertainment, Newcastle, Australia, 2–3 December 2014; pp. 1–9.