# Exploring Presence in Virtual Reality

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I hope that you enjoy reading my thesis.

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**Executive Summary**

Virtual Reality (VR) has been around for many decades, and new applications are developed every day, but widespread acceptance and adoption has been notably slow. Part of this reluctance on the part of users may be due to the efficacy of VR in providing a genuine, impactful experience. One of the overarching goals of VR is to create “presence,” a concept that captures how deeply a user is immersed in a simulated world. The fundamental dimensions of presence are explored in this study to better understand it and its dynamics. Spatial presence, involvement, and perceived realism are the three dimensions of presence that were assessed. These were measured against the user variables of personality traits (extraversion, openness, neuroticism, conscientiousness, and agreeableness) and individuals’ familiarity with virtual reality. The key research question is: ‘Do personality traits or experience with virtual reality significantly relate with or affect the experience of spatial presence, involvement, and perceived realism among virtual reality users?’ A quantitative research design is used to address this primary question, incorporating data from 38 users. The BFI, which assesses participants’ personality, was used to gather data. The users then participated in two VR scenarios before completing the Igroup Presence Questionnaire to evaluate their sense of presence during the second simulation. To demonstrate coherence between the dimensions of presence, personality traits, and VR familiarity, correlation and regression analysis were used, along with two non-parametric tests. The findings of this study demonstrate the ways in which previous experience and personality traits influence each dimension of presence, and thus how they can help improve VR efficacy. Primarily, the findings demonstrated that experience with VR correlates in parts to a lower sense of presence, while the personality traits of extraversion and openness correlate in parts to a higher sense of presence. For VR to be successful, therefore, different types of simulations with varying levels of intensity need to be available for different types of people and applications.

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**Exploring Presence in Virtual Reality**

User response to a virtual reality (VR) experience, in terms of pleasure, satisfaction, and benefits, is heavily influenced by the sense of “presence.” Presence was best defined by Sheridan (1992), as a “sense of being physically present with visual, auditory, or force displays generated by a computer.” In other words, it is a psychological state that occurs when a user temporarily forgets that technology is creating the perceived media, or even temporarily feels that the media has become a functional or phenomenological extension of the body (Haans & IJsselsteijn, 2012; IJsselsteijn, 2005). A consequence of a strong sense of presence is that the user experiences and behaves in the virtual environment in the same way that they would in the real world (Frumau, 2016). Scholars have further divided the definition of presence into different types, including personal, social, and environmental (Schuemie et al., 2001). The first type, "personal" presence, simply refers to an individual sense of "being there." The other two types, "social" and "environmental" indicate an individual's sense of the virtual environment, whether there are other people or creatures in it, or whether the surroundings themselves are reactive, respectively. This research concerns itself with personal presence, as it is the most basic and universally applicable to all types of VR formats. Because presence is fundamentally a subjective experience, it has been an elusive concept to define and a complex condition to measure. Working toward a deeper understanding of presence is essential, however, as it is the foundation of the goal and success of virtual reality.

Decades of research on presence has revealed its multifaceted nature. Schubert et al. (1999), developed a self-reporting measuring tool for quantifying presence: the Igroup Presence Questionnaire. In so doing, his team identified three essential dimensions of personal presence: spatial presence, involvement, and realism. The primary aspect of presence is spatial presence, which is most commonly described as a “sense of being there.” It is related to the idea of bodily actions existing as possibilities in the VE (Schubert et al., 1999). The next dimension of presence, involvement, is described by Witmer and Singer (1998) as “a psychological state experienced as a consequence of focusing one’s energy and attention on a coherent set of stimuli or meaningfully related activities and events.” At its most basic, involvement signifies attention. If users are distracted or preoccupied, whether in the real world or a virtual world, involvement declines, and therefore so does presence. A third component of presence, identified by Schubert et al. (1999), is realness, here referred to as perceived realism or experienced realism. The authors suggest that the more comparable to reality a simulated environment is, the stronger a user’s sense of presence will be. Thus, it is easy for a person to feel they are actually in an environment if it doesn’t appear to be simulated. Some scholars have argued that concepts such as immersion and flow may be components of presence (Chen, 2007; Witmer and Singer, 1998), but it is more generally accepted that they are separate (Bohil et al., 2009; Lum, et al. 2018). They most likely, however, work together to enhance the sense of presence. Some who have examined presence as a single, unidimensional concept have found it difficult to measure (Frumau, 2016), and therefore it may be beneficial to view presence in a more nuanced way. This research has examined all three aspects of presence (spatial presence, involvement, and realism) in turn, to determine if they are impacted differently by the user variables. As discussed below, existing research into this question shows conflicting results.

Scholars have related the sense of presence to the effectiveness of VR, depending on its purpose. According to Slater and Wilbur (1997), a strong sense of presence in a VE helps users to more accurately complete tasks or approach certain difficult situations, because it causes their behavior in the simulation to closely resemble their behavior in the real world. Thus, VR is a useful tool for training or therapy. Additionally, there is agreement among scholars that in VR entertainment formats—games or other recreational simulations—presence positively impacts users' enjoyment and satisfaction with the activity (Shafer et al., 2018; Wheden et al., 2021). One study suggests that enjoyment in video games (not only VR) comes from interactivity, which is a form of involvement (Klimmt et al., 2007). Another study demonstrated that post-playing happiness and a sense of presence were both significantly higher for VR games compared to desktop computer games (Pallavicini et al., 2019). Presence, therefore, seems to be a factor in the emotional experience of gameplay. According to Wehden et al. (2021), gamers take steps to increase their presence, such as eliminating obstacles, including noise and real-world commitments, from their gaming experience and upgrading their hardware with faster graphics cards and processors. It is in the interest of virtual reality game developers to increase enjoyment and satisfaction among their consumers, as this will expand the market. Likewise, if presence increases the effectiveness of training or therapy VR systems, they will be more readily adopted by organizations. Designing simulations that increases presence for people with certain personality types or varying levels of VR experience will make them useful to a broader range of users.

## Applications of Virtual Reality

A basic definition of virtual reality is a real or simulated environment in which a perceiver experiences telepresence, and which includes features of interactivity and vividness (Steuer, 1992). VR employs computer-based technologies and techniques to build virtual environments, in which users move about, interact with objects, and have experiences resembling the real world (Seibert & Shafer, 2018). VR has wide applications including gaming, occupational training, and therapy.

According to Dani (2019), the incorporation of virtual reality into gaming has drastically increased in the past few years; it is now a $4 billion industry. The gaming world has been enriched by the expansion of virtual reality. Technological progress in VR gaming includes improved virtual world environments and more complex methods of interaction (De Paolis & De Luca, 2019). VR games exceed the limitations of conventional video games; while the latter require players to be seated in front of a computer or television screen for long periods of time, VR games allow users to move about and make a variety of physical exertions. (Kojić et al, 2019). One positive result of playing a VR-enabled game is that the player gets exercise. One example of a new interface technology is the omnidirectional treadmill, which allows users to walk naturally while using VR (Wehden et al, 2021). In the future, as the cost of VR hardware and software decreases, it will become more widely available to consumers, eventually becoming a commonplace entertainment product (Liebold et al., 2020). The possibilities created by virtual reality are numerous, and therefore it will likely become a highly sought-after product in the future.

People have been using artificially-generated scenarios for occupational training ever since the first commercial flight simulator was introduced in 1929 (Dani, 2019). Since then, simulators have progressed along with computing technology. Virtual reality is now regularly used in training for military drills, science experiments, machine maintenance, astronautic tasks, mining, and neurosurgery, to name but a few (Alaraj et al., 2011; Pstoka, 1995; van Wyk, 2009). Occupational training with VR simulators has repeatedly been proven to effectively transfer a user’s learned skills to the real world. While a less-than-perfect level of realism is sufficient for acquiring skills, there is also a positive correlation between a user’s sense of presence and their performance in trained tasks (Maneuvrier et al., 2020; Stevens & Kincaid, 2015). Thus, a better understanding of how different variables affect presence will aid in developing better VR training simulations.

Finally, a major new field for virtual reality applications is behavioral and cognitive therapy. Noteworthy applications have been demonstrated for treating phobias, such as acrophobia and fear of flying (Roy, 2003). Successful work has also been done in treating disorders such as anxiety, PTSD, and ADD (North & North, 2016). Beyond psychological therapy, medical applications for VR now include rehabilitation for brain injury and even pain relief (Romano, 2005). If increased presence can improve therapeutic treatments, it is worthwhile exploring.

**Problem Statement**

Virtual reality is underutilized. Research has shown that people are often uncomfortable with virtual reality, at times due to physical sickness (Raaen, 2015) or visual issues (Zhdanov, 2019), but also for unknown reasons. There are many benefits to VR, however; besides the seemingly countless applications, it has been shown to reduce costs for training and enable the execution of complex tasks in a secure, controlled environment (Stevens & Kincaid, 2015). While physical discomfort can be overcome with technology and repeated use, a lack of positive user experience in general may be the roadblock to widespread acceptance of VR. Thus, there is a need for a deeper understanding of the psychological and sensory experiences of users. The most enjoyable VR user experiences are rooted in the ability to feel present in the simulated world (Shafer et al., 2018). Presence is thus the key to positive VR encounters by bridging the virtual world and reality. To maximize the benefits of virtual reality experiences, it is important to understand how to enhance the sense of presence within a virtual environment. Since gaming is currently the most common use of VR, exploring presence in this area will pave the way for enhancing presence in other applications, thereby improving the impact and adoption of VR technology. While improved technology can reduce physical issues with VR, it is possible that increased presence in users may overcome emotional or psychological roadblocks to using it.

## Significance of the Study

The current study contributes to the understanding of presence in relation to two specific variables: user personality traits and amount of VR experience. By measuring and analyzing the degree of presence among people with diverse personalities and varying levels of VR experience, the researcher sought to gain a better understanding of why presence occurs. An important feature of this study is that instead of evaluating presence generally, the variables are measured against the three subordinate dimensions of presence: spatial presence, involvement, and perceived realism. As the understanding of presence becomes more complex, it is expected that the factors that shape presence will be equally complex. Rather than a unidimensional phenomenon, there is now clear evidence that multiple psychological sensations contribute to a user's overall experience of "being there" in a simulation (Scheumie, 2001). It is possible that these separate aspects of spatial presence, involvement, and perceived realism operate independently of each other, which would allow individual users to experience presence in unique ways; thus, the enjoyment or benefits derived from presence could look different for different users. Conversely, research may reveal that the three facets of presence are closely interrelated, and that all three are essential to extracting the full benefits of presence. This could mean that depending on a user's personal variables, he or she would sense certain aspects of presence more readily, and thus might prefer specific types of simulations or games. The expected result is a more nuanced understanding of presence and the factors that need to be taken into account during the development of presence. While the study tested the sense of presence in a recreational application, it will provide important insight into other applications of virtual reality, including occupational training and therapy.

Research on presence will be crucial to entertainment developers, organizations requiring personnel training, and medical professionals as virtual reality systems become cheaper, more accessible, and more effective. This study aims to provide insight into factors that should be considered when designing VR, in order to make it more pleasant and effective for a greater number of users.

## Theoretical Framework

### Presence in Virtual Reality

Many scholars have attempted to break down presence into types. One author defined three types of presence: personal, social, and environmental, relating to the self, other users, and the surroundings, respectively (Heeter, 1992). Another scholar defined presence as either subjective or objective. Subjective presence relates to a person's own sense of 'being there,' while objective presence signifies the ability to successfully interact with objects and induce effects in the virtual environment (Schloerb, 1995). Presence can also contain multiple facets within an overarching psychological experience. While some authors have pointed to realism as an attribute of VR that is separate from presence, Schubert et al. (1999), in creating a system for measuring presence, included the sense of realism as a necessary component of presence, along with spatial presence and involvement. The framework developed by Schubert et al. (1999) relies on the Igroup Presence Questionnaire, which has been successfully used to measure presence by numerous researchers (Hartmann et al., 2016; Lombard et al., 2009; Schuler et al., 2016; Schwind et al., 2019). It has further been found to successfully translate into other languages, such as Portuguese (Vasconcelos-Raposo et al., 2016). Because of its extensive validation, the tridimensional theory of presence is the framework that is used in this study.

***Spatial Presence***

The feeling of being present in a given space is known as "spatial presence" and is the most fundamental aspect of presence in general (Schuemie et al., 2001). The term applies equally to virtual or physical locations. Individuals discern a natural presence if the environment is actual and non-mediated, whereas they undergo a remote presence if the environment is actual but mediated, and a virtual presence if the environment is virtual (Schuemie et al., 2001).

Technological advances in recent decades have laid the foundations for a completely new VR spatial experience. According to Shu et al. (2019), technical interfaces give the impression of being spatially present at distant or imaginary locations. Mediated content takes on a life of its own, and one's self-awareness is submerged in a different universe. Spatial presence, as representing one's body in a place, is primarily shaped by mapping, both technological and mental (Shu et al., 2019). Controller technology in VR translates a user's input into action within the simulation. The way that a controller matches inputs to outputs is known as mapping, and the more that controller inputs reflect real-world bodily motions—such as moving one's arm rather than pressing a button—the more the controller is said to provide 'natural mapping' (Seibert & Shafer, 2018). Natural mapping can assist with spatial presence (Liebold et al., 2018). Mental, or cognitive, mapping is a continuous part of human daily life. The way people move around the real world, from their homes to highways, is based on often innate decisions about where they, and other things, are in space (Kitchin & Freundschuh, 2000). Cognitive mapping is necessary for participating in a virtual simulation. One must create a cognitive map of a VE, just as one would of the familiar real world, and most users do (Johns, 2003). Spatial presence occurs when users are able to develop a working mental model of a VE and also mentally place one's own body in that environment (Scheumie et al, 2001).

As spatial presence is a highly subjective phenomenon, it has been a complex concept to test and measure. Researchers have tried relating it to mapping memory, task performance, emotional or physical responses—such as a user feeling fear when standing at a dangerous height or moving one's body in response to physical features of the VE. Many of these forms of research have been inconsistent or inconclusive. The most repeatable method for measuring spatial presence—in fact, presence generally—has been questionnaires. The IPQ by Schubert et al. (1999) is the only to use spatial presence in particular as a criterion for measurement (Scheumie et al., 2001).

***Involvement***

Involvement is defined as the attention or awareness that a user devotes to a virtual environment (Witmer & Singer, 1998). It is a key feature to the success of every type of VR format, as it allows users to gain the most benefits or effects of the system; involvement makes video games more satisfying and training more useful. It is likely that involvement is a factor in users becoming return customers (Pallavicini & Pepe, 2019). Involvement is reduced by distractions in the real world, personal preoccupations, or unwieldy VR hardware; all of these take away a user's attention (Witmer & Singer, 1998). It has been shown that a strong indicator of enjoyment with a VR experience is the level of interactivity (Klimmt et al., 2007). Therefore, interactivity may be a valuable way in which to conceptualize and measure involvement. Virtual reality games offer users new forms of pleasure by simulating interactions not only with objects and environments, but even other people. To keep users coming back, VR developers are constantly increasing the scope and depth of possible interactions.

How humans and computers physically interact, specifically the available control devices, are a primary determinant of interactivity (Tang et al., 2020). Control pad-based console games have the lowest degree of interactivity due to the comparatively low level of bodily activity needed to operate them (Pallavicini & Pepe, 2019). Motion-based games have a higher degree of interactivity, as they necessitate a greater level of physical exertion. If players are able to choose the majority of the content they are exposed to, the interactivity increases, and the gameplay will be more or less realistic based on the gamer's ability and familiarity (Stevens & Kincaid, 2015). As a result, players with lower skill levels may find it difficult to navigate an environment or complete certain tasks, possibly making immersion in the game less likely and thus interactivity less beneficial. For example, certain simulations require practiced bodily movements: skill in a fishing game may require a particular flicking of the wrist, without mastery of which it would be difficult to excel in the game. Advanced and professional players, on the other hand, have highly developed conceptual familiarity with video games, which might allow them to reap greater rewards from interactivity.

***Perceived Realism***

As the name implies, perceived realism refers to how much a VE seems real in the mind of a user—whether its features reflect the physics, appearance, and other properties of the real world (Schubert et al., 1999). A significant result of recent developments in video game technology is increased realism. Perceived reality is a key variable for explaining the enjoyment of VR games (Shafer et al., 2019). The impact of perceived reality on presence has been clearly demonstrated.

Studies have found that high-definition images and high-quality sound induce a stronger sense of presence (Shafer et al., 2019).

The latest technological advancements include new screen displays and communication devices with improved bandwidth. VR systems can now model environments with a higher degree of audiovisual realism than previously possible (Shelstad et al., 2017). This means that not only should the scenery look real, but it should also change in realistic ways, sounds should come from multiple locations, and many objects should permit interaction (Bohil et al., 2009). Improved resolution and digital transmission provide sensory information through various channels. Larger display sizes and innovative formats can activate a greater proportion of the sensory field (Slater & Wilbur, 1997). To increase perceived realism, and thus the sense of presence, VR developers are looking at ways to provide feedback on multiple body parts (using tools such as haptics) and making sensory stimuli more complex (Coelho et al., 2006). Although simple measurements could previously be used to test televisual displays, the introduction of new technologies has necessitated the creation of universal standards for measuring the experience, in order to evaluate the overall effect of the display system on the observer (Shelstad et al., 2017). It is generally concluded that, as a result of these technical advancements, the observer's sense of presence in the displayed world has grown.

***Predictors of Presence***

It is well-established that certain variables impact a user's sense of presence. The head-mounted display (HMD) devices of most VR systems increase visual stimulation and the perception of motion; therefore, they create more presence than traditional computer screens (Shu et al., 2019). Additional technologies that improve the rendering of the visual or other sensory stimuli, such as system response time and multiple sensorial channels will also increase presence

(Coelho et al., 2006). On the other hand, new controller types, while often more intuitive and natural-feeling, can actually reduce presence because they require time to learn (Liebold et al., 2020).

A number of human factors have been investigated to assess their impact on presence. One variable that predicts both presence and enjoyment in VR games is players' talent. Low-skill or novice players may struggle to keep up with fast-paced games, while high-skill or experienced players are generally able to concentrate easily on the action and thus feel more present in a simulated world (Seibert & Shafer, 2018). Another factor that affects presence is gender, which for potentially both biological and cultural reasons, leads to a correlation between men and a higher sense of presence (Maneuvrier et al., 2020). Numerous studies have shown that cybersickness (motion sickness from a simulation) always reduces presence (Shafer et al, 2018; Wehden et al, 2021). It has been shown that women are more prone to cybersickness than men (Maneuvrier et al., 2020). Psychological factors that influence presence, but are more difficult to measure, include willingness to suspend disbelief, or to get lost in a task (Coelho et al., 2006). One study found that "immersive tendency" was highly correlated with presence (Ling et al., 2013), which almost seems self-evident, as the psychological condition allows for immersion, which is necessary for presence. There are further positive correlations between presence and "sensory avoidance," (Wallach et al., 2012) and between presence and high spatial intelligence (Alsina-Jurnet et al., 2005). Mental conditions that are constantly changing also affect presence, most notably attention. To feel involved in a virtual world, one has to give attention to it, and the level of attention can be affected by distractions, the meaning attached to the activity, or simply personal interest (Coelho et al., 2006; Oh et al., 2019). Thus, there are many factors and sociocultural conditions that likely interact with each other to shape the feeling of presence, and it may never be possible to isolate any single, reliable causal relationships for inducing presence.

**Personality Traits in Virtual Reality**

As a number of human factors have been investigated to assess their impact on presence, it makes sense to dive into how personality traits are generally being categorized. The Big Five is a commonly used typology for personality traits. The five primary personality variables that it includes are extraversion, neuroticism, openness, conscientiousness, and agreeableness (Dieris-Hirche et al., 2020). Extraversion refers to the propensity to be talkative and gregarious; neuroticism refers to a person's proclivity for depression, anxiety, and anger; and openness refers to a person's propensity to be unconstrained by their thoughts, emotions, or beliefs. (Wang et al., 2021). Conscientiousness indicates individual tendencies to be effective, cautious, and systematic, while tendencies to be altruistic and cooperative are represented by agreeableness (Dieris-Hirche et al., 2020). In relation to gaming, specifically multiplayer, online gaming, these five personality variables can be expanded to include certain personality characteristics. Extraversion is linked to active online socialization, while neuroticism is linked to online gaming addiction (Hufnal et al., 2019). Agreeableness is linked to problematic online gaming activity, such as unduly seeking to please other players. There are general indications that personality characteristics affect gaming behavior (Wang et al., 2021).

As research into presence has greatly expanded in recent years, a number of authors have sought to correlate it to various personality traits. One scholar confirmed that personality is indeed testable in a VE, because one's "virtual personality" remains true to one's "real personality" (Aas et al., 2010). A straightforward study by Samana, Wallach, and Safir (2009) tested five personality traits against the overall experience of presence after engaging in a simple VR simulation. Importantly, the team chose not to use the Big Five personality traits, but instead tested five separate traits with individual indices: empathy, imagination, immersive tendencies, dissociation tendencies, and locus of control. They found a positive correlation between presence and two traits, empathy and immersive tendencies. Another study (Sacau et al., 2005), did measure the Big Five personality traits against the experience of presence. In this case, presence referred only to spatial presence. The authors, however, did not consider spatial presence to be one of three presence dimensions; rather they viewed it as equivalent to the concept of presence itself. They found overall that personality traits did not contribute very much to the experience of spatial presence, although agreeableness did result in a positive correlation. Alsina-Jurnet et al. (2005), measured the Big Five personality traits, along with spatial intelligence and a tendency for test anxiety, against presence. They found that a low level of extraversion—in fact, introversion—correlated highly with presence, as did strong spatial intelligence and test anxiety.

Research has yet to tackle the issue of personality traits in terms of the three distinct facets of presence. As presence is becoming better understood, it will be valuable to understand if different types of users experience the phenomenon in different ways, or can benefit more from particular aspects of presence. The current research attempts to fill this gap.

### *Extraversion*

Extraversion refers to a person’s proclivity to be talkative and gregarious. Extraverted online gamers are more likely to send text or voice messages to other players (Huang et al., 2018). Gamers communicate their ideas, share their opinions, and provide knowledge to other gamers by sending messages (De Hesselle et al., 2021). Some individuals form exchange partnerships in which they reciprocate received behavior. For example, online gamers who receive their partners’ ideas, opinions, and information are likely to reciprocate, resulting in vigorous information exchanges (Huang et al., 2018). In this way, extraversion allows for the fulfillment of online gamers’ desire for association. Extraverts are known for having a high degree of confidence in their game partners, which strengthens their exchanges (De Hesselle et al., 2021). Extraversion encourages regular communication and the formation of trusting friendships, leading online gamers to rely on one another while making decisions (De Paolis & De Luca, 2019). Higher levels of extraversion in virtual reality greatly impacts interaction, which in turn is predicted to increase the level of presence (De Paolis & De Luca, 2019).

### *Openness*

Openness refers to a person’s proclivity to be unconstrained by thoughts, emotions, or beliefs (Gabana et al., 2017). It also includes a person’s tendency to be philosophically liberal, embracing or initiating change, and challenging authority. Individuals are more likely to participate in virtual activities if they are open, and thus mentally and emotionally available. According to De Hesselle et al. (2021), “open” people tend to carry a sense of wonder, which can inspire online players to experience enjoyment from game stories. Openness is therefore an important personality trait for explaining the actions of online gamers (Gabana et al., 2017). Online gamers with tendencies toward transparency feel secure or unrestricted in their conversations with other gamers and participate in regular interactions (De Paolis & De Luca, 2019). As a result, they make successful partners with whom other gamers can consult before making decisions. Thus, openness in virtual reality is an important indicator of involvement and presence.

***Neuroticism***

Neuroticism refers to a person's proclivity for depression, anxiety, and anger. Negative feelings take up space in one's working memory, at times preventing them from making positive choices, such as participating in exchanges that favor other gamers (Wang et al., 2021). Positive exchange influences other gamers to reciprocate by participating in similar interactions that favor both parties. As the need for reciprocity increases, highly neurotic gamers have difficulty finding partners, as others avoid working with them (Ke & Wagner, 2019). Furthermore, neuroticism obstructs the development of citizenship activity in gaming communities, which is linked to engaging in reciprocal exchanges. From the point of view of neurotic individuals, online players are less valuable to other gamers (Wang et al., 2021). Neuroticism thus decreases involvement and could affect overall presence in a virtual reality session.

***Conscientiousness***

Conscientiousness indicates individual tendencies to be effective, cautious, and systematic. Being conscientious is an established predictor of good job performance (John & Srivastava, 1999). Perhaps this is because highly conscientious people are known for their self-control, future orientation, industriousness, orderliness, and accountability (Witmer et al., 2005). Online gamers with high levels of conscientiousness tend to focus on their own advancement within a game and thus spend a limited amount of time on participating in exchanges that favor other gamers (Tang et al., 2020). Others will reciprocate with equally limited behavior, overall reducing the mutual benefits extracted from such exchanges and, in turn, the degree to which gamers depend on one another to make decisions (Tang et al., 2020). Furthermore, a lack of dedication to forming gaming friendships tends to deter other gamers from seeing them as beneficial. Strong traits of conscientiousness in virtual reality may therefore reduce a player's level of involvement and presence.

***Agreeableness***

The tendency to be altruistic and cooperative with others is known as agreeableness. Agreeable individuals are more likely to participate in pro-social conduct (John & Srivastava, 1999). In particular, agreeable people are more likely to assist others in games; thus, highly agreeable online gamers are willing to talk with other gamers to help them make decisions (Witmer et al., 2005). In return, the other online players will do the same. Likeability is fueled by agreeability, so it can be seen as a way to grow and add meaning to friendships (Dieris-Hirche et al., 2020). In virtual reality, agreeability has a significant impact on participation, which could have an impact on presence.

## Experience with Virtual Reality

Most people nowadays have plenty of experience using computer software for a variety of applications, from professional and personal to educational and recreational. Our technological age notwithstanding, use of virtual reality is not as consistently widespread as other digital formats. While VR technology and its applications are growing, only 19% of U.S. adults have tried VR at least once in the past year (Lin, 2020). It is an increase from the previous year, but it nevertheless indicates that the vast majority—81%—of adults in a major consumer economy like the U.S. have no experience with VR whatsoever. Of those people who have used VR, 55% are satisfied with it and become repeat users (Lin, 2020). While this is optimistic news for developers and marketers, what it means for researchers is that most prospective participants will have either no experience, or very much experience. Virtual reality was originally developed for training and other related simulations, yet in the past two decades it has become the province of video game players, and thus most of its development lies within the gaming industry (Zyda, 2005). What this means for VR familiarity is that the most experienced users are gamers. Many VR gamers are even professionals, playing in Esports tournaments for monetary prizes.

Expertise, or even basic familiarity with VR is a notable factor in how users perceive and enjoy simulated environments, including their sense of presence. One established correlation is a negative one between video game experience and cybersickness (Maneuvrier et al., 2020). It is not surprising that the more one engages in an activity, the more their body becomes used to it and is able to suppress side effects. Lack of cybersickness, in turn, allows for greater sense of presence in the simplest sense that it permits a user to continue engaging with a simulation and therefore may lead to more experience with VR. In the study by Maneuvrier et al. (2020), video game familiarity correlated to a greater sense of presence, which in turn correlated to better performance on a spatial cognition task. The cause-effect relationship between familiarity and presence is not clear; indeed, familiarity with video games may also bypass presence and directly relate to spatial cognition abilities. The relationship between video game experience and presence certainly needs to be tested further, however, as some studies in fact revealed no correlation (Alsina-Jurnet & Gutierrez-Maldonado, 2010). Also, no known studies measure the level of VR familiarity with the three distinct facets of presence, namely spatial presence, involvement, and perceived realism.

## Research Question

This research seeks specific correlations between six user variables—five distinct personality traits and level of VR experience—and the sense of each dimension of presence: spatial presence, involvement, and perceived realism. The study is expected to reveal which personality traits, if any, and whether VR familiarity can increase the amount of presence a user experiences in a simulation. The primary research question guiding the study is as follows:

*“Do personality traits or experience with virtual reality significantly relate with or affect the experience of spatial presence, involvement, and perceived realism among virtual reality users?”*

The research question was tested in terms of defined hypotheses. Classical hypothesis testing is “the formal statistical process used to evaluate the probability or likelihood a hypothesis is true” (Frey, 2018). Accordingly, this study comprises a null hypothesis, which indicates no influence of tested variables upon the sample, and an alternative hypothesis, which suggests a statistically significant influence of tested variables upon the sample. The hypotheses are as follows:

Null hypothesis: *Personality traits and individual familiarity with virtual reality are neither significantly related to nor affect the sense of spatial presence, involvement, and perceived realism among virtual reality users during a simulation.*

Alternative hypothesis: *Personality traits and individual familiarity with virtual reality are significantly related to or affect the sense of spatial presence, involvement, and perceived realism among virtual reality users during a simulation.*

## Methodology

### Research Design

The current research used a quantitative approach to investigate the impact of personality traits and familiarity with VR on the experience of presence. The focus was on seeking correlations to determine the relationship between personality traits or VR familiarity, and the three aspects of presence: spatial presence, involvement, and perceived realism. The personality traits and virtual reality experience were measured among a group of voluntary participants. Their sense of presence was also measured after using a VR simulation. The hypothesis was tested by seeking correlations between personality traits or VR familiarity and the participants' reported sense of presence.

## Participants and Equipment

There were 38 adult participants in total (23 male and 15 female). All were recruited from social media and gaming platforms and were individuals who frequently used video games recreationally and professionally, although not necessarily including games incorporating virtual reality. They all self-identified as “gamers.” All of the participants were Surinamese and lived in the city of Paramaribo, Suriname where the testing site was located. Their ages ranged from 18 to 54 and the educational level ranged from High School graduates to a Bachelor’s degree.

The VR equipment used was the 2019 Oculus Go headset, a product of Facebook Technologies in cooperation with Qualcomm and Xiaomi. It featured a 5.5" fast-switching LCD (RGB-stripe) display, with 2560×1440 resolution (1280×1440 per eye), and a 60 to 72 Hz refresh rate at 12.67 pixels per degree.

## Instrumentation

### *VR Familiarity Scale*

The researchers created a scale specifically for this analysis to gauge individual level of VR experience, which comprised three scores: 0 (*None*); 1 *(Occasional use)*; or 2 (*Very much*). This scale was subjective, according to a user's own opinion of his or her experience.

***Big Five Inventory***

The Big Five Inventory (BFI) was used to determine participants' personality traits. This is a personality assessment tool that evaluates individual degrees of the 'Big Five' personality dimensions (John & Srivastava, 1999). These comprise extraversion, neuroticism, conscientiousness, agreeableness, and openness. The BFI is a self-reporting questionnaire in which the participant scores the degree to which they believe assertions regarding themselves are valid on a 7-point Likert scale, with 1 indicating 'strong disagreement' and 7 indicating 'strong agreement.' The short form of the BFI, which contains 10 items, was used. This was due to Covid-19 restrictions, which limited the time available for testing to certain hours during the day. The BFI-10 was developed by two researchers especially for use in time-constrained situations, and was tested heavily for reliability and validity (Rammstedt & John, 2006). It is considered sufficient for research, although it may yield lower correlations than the standard BFI. However, to ensure enough time for participants during the Covid-19 time restraints to use the VR simulations and take all questionnaires, the procedure had to be shortened, where possible. The short form BFI took approximately 5 minutes to complete.

***Igroup Presence Questionnaire***

The Igroup Presence Questionnaire (IPQ) was used to measure presence. The IPQ consisted of 14 subjective items scored on a 7-point Likert Scale that assessed a participant's sense of presence within the virtual environment (Attride-Stirling, 2001). The version of the IPQ used included the three subscales of spatial presence, involvement, and perceived realism. Spatial presence was measured by the sense of being physically present; involvement was measured by the amount of attention paid to the virtual world and the quantity of interactions; and perceived realism was measured by the subjective view of realism. An example item from the IPQ is, *"How aware were you of the real-world surroundings while navigating in the virtual world? (i.e., sounds, room temperature, other people, etc.)"* A general item that measured an overall sense of 'being there' was also included in the questionnaire. In this research, this last item was incorporated during analysis into all three components: spatial presence, involvement, and perceived realism.

**Procedure**

Upon arrival at the study site, the participants were told of the study's intent and briefed on what they would be doing during the session. Then they were asked to read and sign an informed consent form. They were also free to inquire about any aspect of the research. All of the studies were conducted in the same manner and in the presence of the researcher. The study room was dim and quiet to prevent any distractions that might interfere with the virtual reality experience.

Before beginning the VR sessions, the participants completed a questionnaire that asked about their age and previous VR experience, as well as the BFI questionnaire, which measured their personality traits. After the personality questionnaire, participants engaged in two virtual reality simulations. The first simulation provided was "Jurassic World: Blue" (Universal Studios) in which minimum interaction was required from the participant. It gave the users five minutes to become comfortable with the headset and practice the controllers, while looking at dinosaurs in a calm setting. At the end of "Jurassic World," participants immediately began the second simulation, entitled "Bait!" (Resolution Games). This was a ten-minute interactive simulation in which participants needed to listen carefully to instructions for how to purchase fishing equipment and then use arm movements in order to hook fish on their fishing poles. They also had to interact with shop owners to upgrade their fishing equipment, and eventually improve their skills with body and wrist movements in order to catch more fish, or difficult-to-catch fish. This part of the simulation was quite interactive and the participants generally enjoyed it. None of the participants asked to stop or claimed to experience discomfort or cybersickness during the simulations.

Immediately after using the VR, the participants filled out the IPQ survey to rate the sense of presence experienced during the Bait! simulation. All data was gathered on a MacBook Pro laptop using Qualtrics, a well-known online survey platform. All information identifying participants remains confidential and will be disclosed only with individual permission or as required by law. Only the complete, anonymous data will be released. The testing sessions were severely restricted due to COVID-19 regulations. The time available was limited to standard business hours, and meant that interviewing the participants to obtain qualitative insights was not possible.

## Data Analysis

After conducting reliability and factor analysis, the Pearson correlation coefficient was employed to determine whether any of the user variables were positively or negatively correlated with any of the presence variables. This method was also utilized to identify correlations with the dimensions of presence and the familiarity with virtual reality. Pearson's correlation assesses whether any covariation exists among variables (Makarovs, 2020). Linear regression was used to evaluate the significance of the personality trait variables. Finally, two non-parametric tests, Kruskal-Wallis and Mann-Whitney, were conducted on the participant data, grouped by VR experience, to compare their reported sense of presence.

# Results

## Reliability Analysis

A standard method for examining the reliability and consistency of individual constructs in research is Cronbach's alpha (Goforth, 2015). A larger Cronbach's α value indicates internal consistency among the constructs. In this case, Cronbach's α value for the IPQ items concerning spatial presence is 0.82. The α value for the item's concerning involvement is 0.75; and for the items concerning perceived realism it is 0.71. All α values are above the acceptable standard for reliability (>0.60).

The items used for the BFI personality questionnaire were also measured for reliability using Cronbach's alpha. The α value for Extraversion is 0.75; for Agreeableness α it is 0.72; for Conscientiousness it is 0.76; for Neuroticism it is .75; and for Openness α is .81. These are also all higher than the acceptable standard for reliability (>0.60).

## Factor Analysis

The latent dimensions of presence, comprising spatial presence, involvement, and perceived realism, were examined using Principal Axis Factoring (PAF) with Oblique rotation. The Kaiser-Mayer-Olkin (KMO) index is used to judge the adequacy of a data set (Kaiser, 1970). Values higher than 0.60, indicate that factor analysis could be useful for the sample size. The KMO of the dataset is 0.65, exceeding the recommended value of 0.6 (Kaiser, 1970). Bartlett's Test of Sphericity (Bartlett, 1954) reached statistical significance ($\chi_2$=124.13, p<.005), indicating that the data was suitable for factor analysis.

The results of the analysis revealed three factors with Eigenvalues over 1, explaining the cumulative % of Rotation Sums of Squared Loadings and 68.47% of the variance, respectively. However, no items were found that have high loadings thus indicating different factors that may cause high multi-collinearity. Following the best practices of item retention outlined at the outset, five items were retained for Spatial Presence (factor 1), four items loaded on Involvement (factor 2), and four items loaded on Perceived Realism (factor 3) as shown in Table 1, and then Table 2 shows the descriptives.

**Table 1**

*Items loadings in the related factors (spatial, involvement, real experience)*

| | Factor | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| SP5 | .814 | | |
| SP1 | .723 | | |
| SP3 | .677 | | |
| SP4 | .656 | | |
| SP2 | .614 | | |
| INV2 | | .836 | |
| INV1 | | .644 | |
| INV3 | | .793 | |
| INV4 | | .737 | |
| REAL3 | | | .658 |
| REAL1 | | | .525 |
| REAL2 | | | .460 |
| REAL4 | | | .745 |

*Note*. Extraction Method: Principal Axis Factoring.
Rotation Method: Direct oblimin with Kaiser Normalization.[a]

a. Rotation converged in 8 iterations.

**Table 2**

*Descriptive Statistics for predictors of presence*

| | Mean | Std. Deviation | Analysis N |
|---|---|---|---|
| INV1 | 4.32 | 1.76 | 38 |
| INV2 | 3.92 | 1.73 | 38 |
| INV3 | 4.08 | 1.84 | 38 |
| INV4 | 6.03 | 1.22 | 38 |
| REAL1 | 4.18 | 1.78 | 38 |
| REAL2 | 4.92 | 1.58 | 38 |
| REAL3 | 5.16 | 1.50 | 38 |
| REAL4 | 3.82 | 1.59 | 38 |
| SP1 | 5.71 | 1.23 | 38 |
| SP2 | 2.08 | 1.50 | 38 |
| SP3 | 5.79 | 1.17 | 38 |
| SP4 | 5.45 | 1.47 | 38 |
| SP5 | 5.82 | 1.01 | 38 |

When the Kaiser-Mayer-Olkin (KMO) index was applied to the personality trait data, as depicted in Table 3, the result was 0.69, exceeding the recommended value of 0.6. Bartlett's Test of Sphericity reached statistical significance ($\chi_2$=132.06, p<.001), indicating that our data were suitable for factor analysis. The results of the analysis revealed five factors with Eigenvalues over 1, explaining 79.12% of the overall variance. However, no items were found to have high loadings, which may indicate high multi-collinearity. Following the best practices of item retention outlined at the outset, two items were retained for all the factors related to the Big Five personal traits. The included descriptives are thus also shown in Table 4.

**Table 3**

*Items loadings in the related factors (Extra version, Agreeableness, Conscientiousness, Neuroticism, Openness)*

| | Factor | | | | |
|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 |
| AGR1 | 0.91 | | | | |
| AGR2 | 0.65 | | | | |
| CON1 | | 0.81 | | | |
| CON2 | | 0.73 | | | |
| EXTR1 | | | 0.60 | | |
| EXTR2 | | | 0.90 | | |
| NRO1 | | | | 0.58 | |
| NRO2 | | | | 0.91 | |
| OPEN1 | | | | | 0.84 |
| OPEN2 | | | | | 0.56 |

*Note.* Extraction Method: Principal Axis Factoring. Rotation Method: Direct Oblimin with Kaiser Normalization.[a]

a. Rotation converged in 11 iterations.

**Table 4**

*Descriptive Statistics for personality traits*

| | Mean | Std. Deviation | Analysis N |
|---|---|---|---|
| I see myself as someone who is reserved | 3.24 | 1.15 | 38 |
| I see myself as someone who is generally trusting | 4.24 | 0.88 | 38 |
| I see myself as someone who tends to be lazy | 2.50 | 1.33 | 38 |
| I see myself as someone who is relaxed, handles stress well | 3.79 | 1.17 | 38 |
| I see myself as someone who has few artistic interests | 3.61 | 1.41 | 38 |
| I see myself as someone who is outgoing, sociable | 3.87 | 1.04 | 38 |
| I see myself as someone who tends to find fault with others | 2.71 | 1.43 | 38 |
| I see myself as someone who does a thorough job | 4.21 | 0.81 | 38 |
| I see myself as someone who gets nervous easily | 3.18 | 1.23 | 38 |
| I see myself as someone who has an active imagination | 4.39 | 0.82 | 38 |

**Correlation Analysis**

To assess the relationship between the scores of the Big Five personality traits and the sense of presence (spatial, involvement, and perceived realism), a bivariate Pearson's product-moment correlation coefficient (*r*) was calculated, as shown in Table 5. The bivariate correlation between five personal traits and experienced presence was statistically non-significant, $p > 0.05$.

**Table 5**

*Relationship among Extraversion, Agreeableness, Conscientiousness, Neuroticism, Openness, spatial, involvement and realism.*

| | Extrav. | Agree. | Conscient. | Neurotic. | Openness | Spatial | Involv. | Realism |
|---|---|---|---|---|---|---|---|---|
| Extraver. | 1 | | | | | | | |
| Agreeable. | .54** | 1 | | | | | | |
| Conscient. | .53** | .54** | 1 | | | | | |
| Neurotic. | -.29 | -.30 | .22 | 1 | | | | |
| Openness | .44** | .72** | .44** | -.24 | 1 | | | |
| Spatial | .23 | -.10 | -.09 | -.06 | .19 | 1 | | |
| Involv. | .20 | .02 | -.03 | -.23 | .29 | .28 | 1 | |
| Realism | .15 | -.04 | .12 | -.10 | .19 | .44** | .34* | 1 |

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

To assess the relationship between the levels of virtual reality experience and the sense of presence (spatial, involvement, and perceived realism), a bivariate Pearson's product-moment correlation coefficient (*r*) was calculated, as shown in Table 6. The bivariate correlation between experience with VR and spatial presence was statistically significant, $r$ (48) = -.381, $p < 0.05$.

**Table 6**

*Relationship among spatial, involvement, realism and experience with VR*

| | Spatial | Involvement | Realism | Experience with VR |
|---|---|---|---|---|
| Spatial | 1 | | | |
| Involvement | .28 | 1 | | |
| Realism | .44** | .34* | 1 | |
| Experience with VR | -.38* | -.08 | -.04 | 1 |

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

**Regression Analysis**

The effects of personality traits on the experience of spatial presence are shown in Table 7. In combination, the five personality traits accounted for 28.8% of the variability in Spatial Presence; $R^2$= .29, adjusted R2= .18, $F$ (5, 38) =19.98, .045<0.05, with Agreeableness recording a higher beta value ($\beta$ = –.560, $p < .05$) than Extraversion ($\beta$ = .383, p <. 05) and Openness ($\beta$ = .533, $p < .05$). If the Agreeableness scores were increased by one standard deviation, the Spatial Presence scores would likely decrease by .56 standard deviation units. If the Extraversion and Openness scores were increased by one standard deviation, the Spatial Presence scores would likely increase by .38 and .53 standard deviation units, respectively. The effects of Conscientiousness and Neuroticism were statistically non-significant (p value > 0.05).

**Table 7**

*Coefficients*[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | |
|---|---|---|---|---|---|
| | | a | Std. Error | Beta | t |
| 1 | (Constant) | 3.19 | 1.39 | | 2.304 |
| | Extraversion | .77 | .32 | .38 | 2.378 |
| | Agreeableness | -.74 | .33 | -.56 | -2.230 |
| | Conscientiousness | -.34 | .27 | -.29 | -1.299 |
| | Neuroticism | .08 | .17 | .10 | .524 |
| | Openness | .72 | .29 | .53 | 2.450 |

*Note.* Dependent Variable: Spatial Presence

Table 8 shows the results of the test of the effects of personality traits on the experience of involvement within presence. In combination, the five personality traits accounted for 24.2% of the variability in Involvement: $R^2$= .242, adjusted $R^2$= .124, F (5, 38) =11.91, $p$<.0.05, with Openness recording the only significant beta value (β = .563, $p < .05$). If the Openness scores were increased by one standard deviation, the Involvement scores would likely increase by .56 standard deviation units. The effects of the other four personality traits were statistically non-significant ($p$ value > 0.05).

**Table 8**

*Coefficients*[a]

| Model | | Unstandardized Coefficients | | Standardized Coefficients | |
|---|---|---|---|---|---|
| | | a | Std. Error | Beta | t |
| 1 | (Constant) | 3.84 | 1.10 | | 3.478 |
| | Extraversion | .28 | .26 | .23 | 1.077 |
| | Agreeableness | -.53 | .26 | -.52 | -1.986 |
| | Conscientiousness | -.07 | .21 | -.08 | -.338 |
| | Neuroticism | -.12 | .13 | -.17 | -.856 |
| | Openness | .59 | .23 | .56 | 2.509 |

*Note.* Dependent Variable: Involvement

Table 9 shows the results of the test of the effects of personality traits on perceived realism within presence. In combination, the five personality traits accounted for 16.9% of the variability in Perceived Realism: $R^2$= .169, adjusted $R^2$= .040, F(5, 38)=39.17, *p*<.0.05, with Agreeableness recording the only significant beta value (β = –.596, *p* < .05). If the Agreeableness scores were increased by one standard deviation, the Perceived Realism scores would likely reduce by .59 standard deviation units. The effects of the other four traits were statistically non-significant (*p* value > 0.05).

**Table 9**

*Coefficients[a]*

| Model | | Unstandardized Coefficients | | Standardized Coefficients | | |
|---|---|---|---|---|---|---|
| | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | 4.23 | 2.09 | | 2.017 | .052 |
| | Extraversion | .20 | .49 | .090 | .410 | .685 |
| | Agreeableness | -1.10 | .50 | -.59 | -2.196 | .035 |
| | Conscientiousness | .41 | .41 | .25 | 1.021 | .315 |
| | Neuroticism | -.26 | .26 | -.21 | -.998 | .326 |
| | Openness | .79 | .44 | .42 | 1.803 | .081 |

*Note.* Dependent Variable: Realism

**Kruskal-Wallis Test**

A Kruskal-Wallis is a non-parametric test used (As the assumption of normality was violated) to assess the difference in means of several sample groups (Kruskal & Wallis, 1952). In this study it was used to investigate the difference in the sample groups for each level of VR experience in relation to the three dimensions of presence (i.e., spatial presence, involvement and perceived realism). As shown in Table 10, this analysis revealed a statistically significant difference among the three experience levels at the p < .05 level for spatial presence: Kruskal-Wallis H (2, 38) = 7.99, *p* = .018. The mean rank of spatial presence was highest for the "None" group (M = 23.33). For the "Occasional use" group, M = 19.70 and for the "Very much" experience group, (M = 7.20).

**Table 10**

*VR Experience Group Ranks for Spatial Presence*

| Level of experience | N | Mean Rank |
|---|---|---|
| None | 15 | 23.33 |
| Occasional use | 18 | 19.72 |
| Very much | 5 | 7.20 |
| Total | 38 | |

As can be seen in Tables 11 and 12, there was no statistically significant difference at the *p* < .05 level for Involvement or Perceived Realism in relation to the three groups of VR experience: Kruskal-Wallis H (2, 38) = .812, *p* = .666 and Kruskal-Wallis H (2, 38) = .438, *p* = .803 respectively.

**Table 11**

*VR Experience Group Ranks for Involvement*

| Level of experience | N | Mean Rank |
|---|---|---|
| None | 15 | 19.90 |
| Occasional use | 18 | 20.31 |
| Very much | 5 | 15.40 |
| Total | 38 | |

**Table 12**

*VR Experience Group Ranks for Perceived Realism*

| Level of experience | N | Mean Rank |
|---|---|---|
| None | 15 | 20.60 |
| Occasional use | 18 | 18.25 |
| Very much | 5 | 20.70 |
| Total | 38 | |

**Mann-Whitney Test**

Finally, a Mann-Whitney U test (Mann & Whitney, 1947) was conducted for the three VR experience groups in relation to the three dimensions of presence. The test only revealed a significant difference between the groups regarding spatial presence. Between the “None” experience with VR group (n =15) and the “Very much” experience with VR group (n = 5), the outcome was significant: $U = 7.50$, $z = -2.628$, $p = 0.009$, with a large effect size $r = 0.58$. Between the “Occasional use” experience group (n = 18) and the “Very much” experience (n = 5), the outcome was also significant: $U = 13.50$, $z = -2.360$, $p = 0.018$, with a medium effect size $r = 0.49$. There was no significant difference between the “None” experience group (n =15) and the “Occasional use” group (n = 18): $U = 107.5$, $z = -1.001$, $p = 0.317$. The effect size was small: $r = 0.17$. There were no significant differences found among the three VR experience groups in terms of involvement or perceived realism.

# Discussion and Conclusions

## Discussion

The study aimed to measure the effects of VR users' personality traits (Extraversion, Agreeableness, Conscientiousness, Neuroticism and Openness) on the three dimensions of presence (Spatial Presence, Involvement, and Perceived Realism). The analysis also revealed the relationship between having past experience in VR and the sense of presence. The null hypothesis claimed that personality traits and individual familiarity with virtual reality are not significantly related to or affect the sense of spatial presence, involvement, and perceived realism among virtual reality users during a simulation.

In terms of Pearson's correlation hypothesis testing, we found the absence of a significant relationship between the five personality traits and the three facets of presence, indicating that the null hypothesis cannot be rejected. A comparable study by Sacau et al. (2005), found that of the Big Five personality traits, only agreeableness correlated with presence. The authors suggest that personality traits may not be extremely impactful in an individual's VR experience. While the correlational test in the current study did not reveal agreeableness to be significant, the regression analysis did uncover a relationship between agreeableness and spatial presence, yet in this case a negative one. At the same time, agreeableness was also negatively correlated to perceived realism. Thus, the current study showed agreeableness to reduce two components of presence, while the 2005 study suggested that it increased presence. Another discrepancy between the study by Sacau et al. and the current study is the issue of openness. While the earlier researchers expected a correlation between openness and presence, but found none, this study did indeed find a positive relationship between openness and two components of presence—spatial presence and involvement. Finally, the current study revealed an opposite result to an earlier study regarding extraversion. Research by Alsina-Jurnet et al. (2005; 2010) concluded that extraversion was negatively correlated with both spatial presence and realness; indeed, the authors describe introverts as more sensitive to presence. In contrast, the regression analysis in the current study provided evidence that extraversion relates to a higher level of spatial presence. The discrepancy with Sacau et al. can perhaps be explained by the fact that in their work, presence is a singular concept. It is defined as “spatial presence” alone. It is not that the authors rejected the other two dimensions per se; rather spatial presence is commonly equated with “being there” and thus often comprises the full definition of presence itself (Sheridan, 1992). Thus, this discrepancy may be evidence that research into presence requires a more nuanced conceptualization. Looking at presence generally will not be able to return the more complex, detailed results that arise when it is separated into multiple components. For Alsina-Jurnet et al., however, presence is defined in the same way as it is for the current study: the three-faceted concept of spatial presence, involvement, and realism, as proposed by Schubert et al. (1999). As Alsina-Jurnet et al. (2010) also used the IPQ to assess presence, it is notable that their results for extraversion were opposite to ours. This indicates that personality, considered as a user variable, is quite complex. Perhaps certain personality traits, when combined in particular ways, may have unique impacts on behavior or psychology. It is conceivable that certain personality traits, when combined with other individual, demographic traits, such as age or culture, may have unexpected behavioral or psychological results, as shown in the study done by Allik et al. (2018). Without knowing and accounting for these other combining factors, the measurement of presence could be inconsistent in different studies.

The second user variable tested was past experience with virtual reality. The results demonstrated a statistically significant relationship with spatial presence, based on the Pearson’s correlation, the Kruskal-Wallis test, and the Mann-Whitney test, thus indicating that the null hypothesis can be partially rejected, in terms of spatial presence. Interestingly, the relationship between VR experience and spatial presence is inverse, meaning that individuals with more experience seem to have a lesser sense of spatial presence. There were important differences in the perception of spatial presence among the three experience groups in VR; the group with no experience at all felt the highest level of spatial presence, while the group with very much experience felt the lowest amount of spatial presence. Earlier research in this area did not produce the same result. The 2010 study by Alsina-Jurnet et al. found no correlation at all between the sense of presence and computer experience. A study by Maneuvrier et al. (2020) found that video game experience significantly predicted a greater sense of presence, which is opposite to the findings of the current study. The lack of consistency in these results may be due to the type of experience that was tested; the earlier study measured “computer experience,” in general, while the 2020 study measured “video game” experience. While both are forms of digital media, neither of these are the same as virtual reality. It is possible that virtual reality, as it is designed especially to be immersive and sensory-intensive, has a stronger impact on novice users; while novice computer and video-game users are less amazed by and less drawn-in to their devices. Some research suggests that the “novelty effect” plays a role in virtual reality experiences (Huang, 2020). Maneuvrier et al. (2020) suggested that their participants with frequent video game experience sensed high levels of presence because of user selection—those who naturally experience presence easily are attracted to video games. The result of the current study, that experienced VR users feel less presence, leads to an alternate perspective. Repeated use of VR may dull the novelty, surprise, and awe induced by an immersive, multi-sensory medium, thus weakening the sense of presence. In other words, VR users need new and exciting stimuli to feel deeply engaged with a simulation.

Experience with virtual reality as a user variable certainly needs to be researched further to create a body of consistent results.

**Limitations**

The general lack of significant results in correlating the five personality traits with the sense of presence, and in some cases, results that opposed earlier studies, suggests a limitation in the Big Five personality instrument. It may be that the Big Five, while sufficiently describing most individuals, does not accurately describe all individuals. A study by Allik et al. (2018) demonstrates that the Five Factor Model is indeed not universal. While covariance of particular personality traits tends to group into usual patterns, they found that at least 20% of individuals expressed, through both self and external assessment, personality traits that configured differently than the norm. There are no clear reasons as yet why some people's personality traits combine in unusual ways, but they could be the result of life events, environments, or cultures. Allik et al. (2018) reported on cases of notable deviations to the FFM being present among African nations and also within more traditional societies. An in-depth study into the FFM among Africans by Zecca et al. (2012) found that while the FFM usually held true, there were some particular differences in personality trait covariance, especially relating to Extraversion. Zecca et al. also confirmed previous studies that more "collectivist" cultures deviate more from the FFM. One of the largest studies of the Big Five personality traits across cultures involved 50 nations (McCrae et al., 2005). Suriname is not included in the study, nor are the other small countries of northeast South America, Central America, or the Caribbean, except Puerto Rico. The only South American nations in the list of 50 participants are Argentina, Brazil, Chile, and Peru (pp. 549). It cannot be said that Surinamese people or the participants of this study necessarily deviate from the standard

Big Five model, however there may be unknown cultural factors that limit the reliability of the BFI. There be non-cultural factors as well among this specific group of participants, perhaps related to their interest in playing video games, that affect the fit of the Big Five model. Results notwithstanding, the BFI is currently the best, most reliable instrument available for measuring personality traits.

This study was limited in large part by available participants and time restrictions. The participants were all recruited from an online gaming forum, and all self-identified as “gamers.” Even though some had no experience with virtual reality, they all had experience with video games. This experience may have influenced the participants’ sense of presence. For example, as described, a study by Maneuvrier et al. (2020) correlated video game experience with presence. Especially as virtual reality is being developed for wide applications beyond recreation, it could have been insightful to test participants who had experience using VR for training or therapy, or individuals who had no familiarity whatsoever with video games, or even computers.

Time restrictions due to COVID-19 policies in the city in which the study took place meant that the procedure was truncated. The testing location could only be open for a short period, so the researchers were not able to interview the participants. This would have provided valuable qualitative data and supplemented the quantitative data from the questionnaires. Even though the IPQ is well-established, self-reporting remains subjective and individuals’ answers can be influenced by what they believe the researcher wants to find, or other unpredictable personal feelings. Another option would have been to administer the IPQ within a simulated environment. One interesting study, for example, found that presence questionnaire results were more consistent when the questionnaire was given inside a VE (Schwind et al., 2019); at the very least, it can help participants stay focused on their answers (Haas, 2017).

**Future Research**

To further supplement the self-reporting of presence, it has been shown to be beneficial to combine presence questionnaires with observations and questions about physical behaviors (Frumau, 2016). This can include a person moving in real life to avoid virtual objects, or reporting that they wished to avoid those objects. There are even more visceral ways in which presence can be measured. Research by Dey and colleagues (2020) used a neurophysiological approach, assessing participants' heart rates, visual stress, and neurological activity in certain sections of the brain during a virtual reality experience. If this type of research becomes validated through frequent experimentation, it could eventually replace self-reporting questionnaires altogether, as they are inherently dependent on participants' honesty, biases, distractions, and other factors.

As more advanced VR systems become available, it will be fruitful to test the role of immersive technologies on the sense of presence, in comparison to user variables. Recent innovations in virtual reality, such as the Feelreal products, (Feelreal.com, 2018), dispense aromas, mist, wind, and heat onto users' faces. Other innovations are moving toward recreating the sensation of touch in virtual reality, through synthetic skins (Yu et al., 2019) and magnetic fields that can push against the hand (Zhang et al., 2016). If these types of immersive features are able to significantly increase the sense of presence among users, then user variables, including personality traits and VR experience, might become less influential. The sense of presence seems to occur as a balance between technological variables and user variables. It is important that researchers maintain awareness of that balance and take notice when it shifts.

Another avenue for future research could be the effect of the type of simulation on the experience of presence. The current study used simulations (Jurassic World and Bait!) that were recreational, and therefore were designed to be fun. As attention is an important aspect of presence, and it is reasonable to assume that people pay attention to things they are enjoying, presence could have been higher than it otherwise might be due to participant enjoyment. It could be insightful to conduct further research on the sense of presence during simulations that are boring, stressful, or discomforting. After all, this may be the nature of simulations that are used for occupational training or therapy.

Finally, it must be remembered that other user variables can also impact the sense of presence. These include simple physical factors like visual ability (Ling et al., 2013), psychological factors like sensory sensitivity (Wallach et al., 2012), and simply being distracted (Oh et al., 2019). There are also numerous psychological factors, willingness to suspend disbelief, immersive tendencies, and sensory-seeking tendencies (Coelho et al., 2006; Ling et al., 2013; Wallach et al., 2012). There may be many more factors that researchers have not yet considered. Naturally, all possible user variables cannot be tested at the same time, but to gain the fullest possible understanding of presence, future research should tackle as many different potential predictors of presence as possible.

## Theoretical and Practical Implications

Overall, the results of this study within the body of presence research demonstrate an urgent need to define presence clearly and consistently for all future studies. While it was necessary and useful to separately examine the three facets of presence—spatial presence, involvement, and perceived realism—it is possible that spatial presence is, in fact, the most important of the three. Hartmann et al. (2015) suggest that while involvement and realism are closely tied to spatial presence, they may be contributing determinants of it, rather than components of an overarching presence. It is notable that in the current study, out of the six significant findings, four of them related to spatial presence. Research into presence could be simplified if the focus stays on spatial presence, while the role of involvement and realism may benefit from reassessment.

The ultimate goal of research into technology like virtual reality is to be useful in improving that technology. Virtual reality is designed with the intention of inducing immersion and a sense of presence. Thus, for developers to improve VR simulations, whether for entertainment, occupational, or therapeutic applications, they need to understand the variables that shape presence, in order to attempt to increase it for users. As this study has demonstrated, at least certain aspects of an individual's personality can predict an increase or decrease in experienced presence, as can his or her familiarity with virtual reality. The latter is a more straightforward problem to address. Because more experience with VR decreases a user's sense of presence, recreational simulations and games that are marketed to advanced users need to include technological and content features that will aid in increasing presence. This means the technology has to produce high-level immersion, by enhancing the appearance of being surrounded or intensifying and varying the sensory stimuli. Simulation content might need to include more interactions for advanced users, and more realistic imagery. Games could even increase the degree of immersion, interaction, and realism as players achieved higher levels. In the case of simulations used for occupational training and therapy, a similar approach needs to be taken by developers. Different types of simulations need to be made available for new users and more experienced users, respectively. As individuals progress through the stages of their training or therapy, they should be introduced to more immersive simulations that will help increase their sense of presence.

Targeting virtual reality to people based on personality traits is a complex problem, as many people don't know their personality type, or don't wish to be labeled by one. The variations in the experience of presence suggest, however, that different types of simulations would appeal more, or be more effective, to different types of people. In the case of recreation, VR developers could, in both the design and marketing phases, administer personality tests in consumer focus groups. Based on the personality profiles of those who enjoy certain game aspects, different types of games could be designed and marketed to certain types of people, or different versions of the same game with various presence enhancements could be developed. In general, to keep the most users, and potential users, interested and coming back, it is important for VR creators to ensure the availability of a wide variety of games and simulated environments—whether with high- or low-intensity immersion, high-action or relaxed interactions, realistic or cartoonish scenery. In this way, there will be something to appeal to everyone. When VR is used for training or therapy, users could easily be given a personality assessment. Those with high scores for agreeableness may experience less spatial presence and realism, and thus would need to be administered simulations with more intensive and realistic features to extract the desired benefits. Individuals scoring high on openness are predicted to sense more spatial presence and involvement, and extroverts more spatial presence. Therefore, such users could attain benefits from training and therapy simulations that are relatively basic.

## Conclusion

The research question for this study was: *Do personality traits or experience with virtual reality significantly relate with or affect the experience of spatial presence, involvement, and perceived realism among virtual reality users?* The results were only partially positive, with most of the relationships involving spatial presence. Three out of five personality traits affected the experience of at least one of the dimensions of presence. Familiarity with virtual reality also clearly affected the sense of spatial presence. This study has further shown that these user variables are both valid and useful for understanding presence. Further work needs to be done to attain consistency in results, especially regarding personality traits. The dimension of spatial presence seems to be an especially promising focal point for discovery. The results of this study, especially the demonstrated connection between familiarity with virtual reality and the sense of presence, will be valuable for simulation developers in creating virtual environments that are engaging and beneficial for all users.

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**Appendix 1: Informed Consent Form**

# Informed Consent

## Exploring presence in virtual reality

This study aims to investigate the level of presence achieved amongst gamers in virtual reality. You will participate in a study in where immersion in virtual environments is investigated against contributing factors such as previous experiences and individual's personality traits.

We will gather information by letting you participate in two short virtual reality games. Before the games you will fill out a personality trait survey and a short questionnaire regarding your previous experience with virtual reality. Once you have completed the virtual sessions you will be asked questions about yourself and what you were experiencing during the games. You don't have to answer questions that you don't want to answer. Your participation is voluntary, and you can stop at any time.

Is important to know that there are physical risks associated with participation in this study. Some users might experience nausea or headaches due to the realistic scenario, if you do not feel comfortable you can stop at any time. Regarding to coronavirus, safety measures will be present all the time, every device will be disinfected before you use it. This project has been revised and approved by the BMS Ethic Committee.

Your personal data, records and findings will be collected as part of the investigation, then it might be processed in an anonymized form for presentation. Participants have the right to request access to and rectification or ensure their personal data. If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), you can contact the Secretary of the Ethics Committee of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-bms@utwente.nl

We protect your privacy as well as possible. We safeguarding your personal information maintaining confidentiality. All information taken from the study will be coded to protect each subject's name. No names or other identifying information will be used when discussing or reporting data.

The investigator(s) will safely keep all files and data collected in a secured locked cabinet in the KCS Technology Lab. All data registrations of personal information must be recorded across the University of Twente. Research data should be stored for at least 10 years.

This research is executed by the master student Rohan-Dhoenand Budhram, of the faculty of Behavioural, Management and Social Sciences at the University of Twente.

## Consent Form for exploring presence in virtual reality

**Appendix 2: Experience with VR Question**

# Experience with Virtual Reality

Start of Block: How much experience do you have using Virtual Reality

Q1 How much experience do you have using Virtual Reality?

| | None at all (1) | A few experiences (2) | I am a frequent user of Virtual Reality (3) |
|---|---|---|---|
| Click to write Statement 1 (1) | ○ | ○ | ○ |

End of Block: How much experience do you have using Virtual Reality

**Appendix 3: BFI-10 Questionnaire**

# The BFI-10 Personality Traits

Start of Block: Default Question Block

Q1 I see myself as someone who is reserved

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q2 I see myself as someone who is generally trusting

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little. Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q3 I see myself as someone who tends to be lazy

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q4 I see myself as someone who is relaxed, handles stress well

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little. Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q5 I see myself as someone who has few artistic interests

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q6 I see myself as someone who is outgoing, sociable

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q7 I see myself as someone who tends to find fault with others

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q8 I see myself as someone who does a thorough job

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q9 I see myself as someone who gets nervous easily

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

Q10 I see myself as someone who has an active imagination

| | Strongly disagree Point 1 (1) | Disagree a little Point 2 (2) | Neither agree nor disagree Point 3 (3) | Agree a little Point 4 (4) | Agree Strongly Point 5 (5) |
|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ |

**End of Block: Default Question Block**

**Appendix 4: Igroup Presence Questionnaire**

# IPQ Questionnaire

Start of Block: Default Question Block

Q1 How aware were you of the real world surrounding while navigating in the virtual world? (i.e. sounds, room temperature, other people, etc.)?

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q2 How real did the virtual world seem to you?

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q3 I had a sense of acting in the virtual space, rather than operating something from outside.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q4 How much did your experience in the virtual environment seem consistent with your real world experience ?

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q5 How real did the virtual world seem to you?

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q6 I did not feel present in the virtual space.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q7 I was not aware of my real environment.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q8 In the computer generated world I had a sense of "being there"

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

Q9 Somehow I felt that the virtual world surrounded me.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | o | o | o | o | o | o | o |

Q10 I felt present in the virtual space.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | o | o | o | o | o | o | o |

Q11 I still paid attention to the real environment.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | o | o | o | o | o | o | o |

Q12 The virtual world seemed more realistic than the real world.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | o | o | o | o | o | o | o |

Q13 I felt like I was just perceiving pictures.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | o | o | o | o | o | o | o |

Q14 I was completely captivated by the virtual world.

| | -3 (1) | -2 (2) | -1 (3) | 0 (4) | 1 (5) | 2 (6) | 3 (7) |
|---|---|---|---|---|---|---|---|
| 1 (1) | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

**End of Block: Default Question Block**