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Mining players' experience in computer games: Immersion affects flow but not presence☆

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ABSTRACT

The aim of this study was to investigate whether different levels of immersion while playing a computer game affect the participant's experiences of flow and presence. Understanding how different levels of immersion influence the experiences of flow and presence can shed light on the intricate interplay between these constructs and provide valuable insights into the factors that contribute to engaging and immersive gameplay. The independent variable, immersion, was manipulated in three conditions (high, moderate, and low) in a between-subject design within the video game Minecraft. Participants were asked to complete 15 min of gameplay and then fill out the questionnaires concerning flow and presence. The experiment was conducted remotely on a video-sharing platform. Bayesian analysis revealed an effect of immersion level on flow, while no evidence of an effect was found for the experience of presence. This study provides evidence in favor of a relation between flow and immersion while supporting a presumed double dissociation of immersion from presence. Future research using a Bayesian approach is encouraged to build further knowledge on this research topic.

1. Introduction

In recent years, the popularity of video game playing has grown exponentially (Shi et al., 2019), and restrictions due to the COVID-19 pandemic have only accelerated this trend (Kim, 2021). Computer games represent one of the most popular forms of entertainment across the world (Liu et al., 2022). According to Gee (2006), computer games represent a unique form of art, and because of that, novel areas of research such as game studies will be challenged to develop new analytical tools to study the interaction between players and video games. Though the nature of this interaction has not yet been clearly defined, it seems to be the result of the influence of a game's technical aspects on players' experience of engagement and enjoyment (Caroux et al., 2015). Given the multidisciplinary nature of this interaction, research in both psychology and computer science has widely investigated the interaction between players and video games (Halbrook et al., 2019; Rienzo & Cubillos, 2020; Tondello & Nacke, 2019). As Ermi and Mäyrä (2005) suggested, the constructs of immersion, flow, and presence seem to represent fundamental components of the player experience (PX). However, previous definitions of immersion seemed to overlap with the concepts of flow and presence, as noted by other researchers (Agrawal et al., 2020; Grinberg et al., 2014; Michailidis et al., 2018; Modena & Parisi, 2021; Nacke & Lindley, 2008).

In the realm of psychological and cognitive research, the concepts of flow, immersion, and presence hold significant importance (Hookham & Nesbitt, 2019), but the lack of a unanimous consensus on a clear distinction between these concepts poses significant hurdles for researchers attempting to comprehensively investigate and understand the distinct nature of these constructs. Despite the prevalent treatment of these concepts as separate entities, with researchers assuming distinct boundaries between them in recent studies (Lackey et al., 2016; Modena & Parisi, 2021), the ongoing debate continues concerning their true conceptual independence. This study is intended to contribute to the present debate by providing new experimental data to shed some light on the relationship between the concepts. The absence of a common vocabulary is not only affecting gamers and game designers (Ijsselsteijn et al., 2007), but also cognitive scientists and neuropsychologists committed to identifying the neural correlates of immersion, flow, and presence (Ga et al., 2015; Katahira et al., 2018; Lim et al., 2019; Yun et al., 2017; Škola et al., 2020). Therefore, the aim of the present study is

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to investigate the relationship between levels of immersion and the constructs of flow and presence in the context of video game playing.

For this study, the video game Minecraft was chosen. Several possible outcomes could have been hypothesized. However, given the overall uncertainty around this research topic, the authors thought it would be appropriate not to formulate any hypothesis, but rather to investigate the issue openly. Therefore, the research question of this study was whether the level of immersion affects levels of flow and presence. Subjective self-report measures such as questionnaires were used to answer the question.

2. Theoretical considerations

2.1. Immersion

Research in PX has suggested evidence of immersion as an important element of the gameplay experience consistently sought by players (Denisova & Cairns, 2015). When people are involved in sustained interactions with computer games, they often report a sense of immersion in the digital world (Brown & Cairns, 2004). Murray (1997, pp. 98-99), wrote an elegant and clear definition of what is now commonly accepted as immersion:

"Immersion is a metaphorical term derived from the physical experience of being submerged in water. We seek the same feeling from a psychologically immersive experience that we do from a plunge in the ocean or swimming pool: the sensation of being surrounded by a completely other reality, as different as water is from the air, that takes over all of our attention, our whole perceptual apparatus …"

Notwithstanding the previous definition, immersion represents a complex and yet not clearly defined phenomenon. As pointed out in a literature review by Nilsson et al. (2016), the term immersion has been used inconsistently in a variety of different domains, including virtual environments (VE), film studies, music studies, and of course videogame studies. In the context of computer games, immersion has been widely used as an all-encompassing concept (McMahan, 2013), and it is unclear whether various researchers are using the same word consistently. In this study, we adopted Brown and Cairns' (2004) conceptualization of immersion, which defines it as the progressive state of involvement within a game encompassing the player's psychological experience. The authors (Brown & Cairns, 2004) identified three levels of immersion, each of them reachable only by overcoming certain barriers represented by game characteristics and human activity. In the first level of low immersion (*Engagement*), the player is willing to invest time and effort in playing the game. Although not completely absorbed in the game, the player is focused on the game's task. To reach the second level of moderate immersion (*Engrossment*), barriers related to game construction need to be removed, so that the player can be emotionally involved in the game. At this stage, emotions and attention are directly affected by the game, and awareness of time and surroundings start to gradually decay. The last level of immersion (*Total Immersion*) represents the highest degree of immersion that players can reach. To achieve total immersion, the player needs to overcome the barriers of empathy and atmosphere, thereby fostering emotional attachment and directing their attention toward elements within the game. This stage has been described as a fleeting experience, in which players report being totally detached from reality and fully immersed in the gaming experience. It is important to notice that Brown and Cairns (2004) defined the stage of Total Immersion as synonymous to presence.

2.2. Presence

Immersion and presence share a long history as concepts that have been often used interchangeably (Jang & Park, 2019; Johnson et al., 2018; Malbos et al., 2012; Psotka et al., 1993; Ryan et al., 2006; Witmer & Singer, 1998). For clarity, in the current study, we refer to presence as spatial presence, or "the extent to which one feels present in the mediated environment, rather than in the immediate physical environment" (Steuer, 1992, p. 75). Lombard and Ditton (1997) defined presence in the context of media studies as a psychological experience of non-mediation between user and media, which, in the case of computer games, consists of non-mediation between player and video game. Since its early definitions, presence has constituted an important concept for research in virtual environments (Skarbez et al., 2017), and it has been considered highly relevant for video game playing (Tamborini & Skalski, 2006).

As noted by McMahan (2013), the term presence has been often used interchangeably with immersion to refer to the sense of "being there" that players may experience when the design of a videogame satisfies certain criteria for allowing the psychological experience. Though presence and immersion have often been used interchangeably, other researchers have approached the two constructs as separate elements of the gameplay experience (Brockmyer et al., 2009; Ijsselsteijn et al., 2007; Wulansari et al., 2019). An early distinction was made by Slater and Wilbur (1997), who interpreted the two concepts as qualitatively different. Based on the argument from the two authors, while immersion ought to be considered as a quantifiable and objective property of the system (in our case the video game), presence represents the psychological feeling of being surrounded by the virtual environment, therefore a subjective and hardly quantifiable experience. Skarbez et al. (2017) suggested a possible connection between the concept of presence and the state of flow. Following Weibel et al. (2008), flow and presence may share similar components responsible for a deep feeling of involvement and immersive experience.

2.3. Flow

Within the scope of this study, we drew upon the concept of "flow," as originally introduced by the positive psychologist Csikszentmihalyi (1990). According to his framework, flow represents the optimal experience that emerges when the skills of the individual and the challenges of the task are equally distributed. When challenges surpass players' ability, anxiety may emerge, and when players' ability surpasses challenges, boredom may emerge. This definition of flow clearly overlaps with one of the categories of immersion given by Mäyrä and Ermi (2011), who differentiate the cognitive construct into three categories: sensory immersion, challenge-based immersion (comparable to Csikszentmihalyi's flow), and imaginative immersion. In the context of computer games, flow occurs when players are deeply immersed in the gameplay, losing track of time and feeling a sense of effortless control over the game challenges. Flow theory has been widely applied to the domain of computer games to investigate the process involved in the interaction between player and video game (Chen, 2007; Cowley et al., 2008). For instance, studies have shown that when players encounter challenges that are well-matched to their abilities, they are more likely to experience a state of flow (Sweetser & Wyeth, 2005; Nacke and Lindley, 2008). Additionally, the presence of clear and achievable goals within the game contributes to players' sense of flow (Sherry, 2004; Simões et al., 2013). Csikszentmihalyi identified eight major components responsible for the experience of flow: the task must be realistic, we must have the capacity to concentrate, the task has clear goals, the task provides immediate feedback, effortless involvement allows worries from everyday life to dissipate, we perceive a sense of control over our actions, sense of self disappears, and sense of time is altered.

Flow experiences in computer games are often associated with heightened levels of enjoyment and immersion. The conceptualization of flow and immersion has often shared common characteristics, such as loss of awareness and time perception, the role of attention, and balance between players' skills and game demands (Jennett, Cox, & Cairns, 2008; Michailidis et al., 2018). Players immersed in a state of flow tend to lose track of time and become fully absorbed in the gaming experience (Chen, 2007; Fu et al., 2009). This sense of immersion is further enhanced by the presence of interactive and dynamic game elements that challenge players' skills and maintain a sense of continuity in the gameplay (Nacke & Lindley, 2008). Nevertheless, most research on PX has treated flow and immersion as two separate elements of the gameplay experience (Borderie & Michinov, 2016; Brockmyer et al., 2009; Ijsselsteijn et al., 2007; Su et al., 2016).

2.4. A conceptual challenge

In summary, previous definitions of immersion seemed to overlap with the concepts of flow and presence, as noted by other researchers (Agrawal et al., 2020; Grinberg et al., 2014; Michailidis et al., 2018; Modena & Parisi, 2021; Nacke & Lindley, 2008). The overlap between immersion and flow centers around the state of deep engagement and absorption in a given activity or experience. Both concepts involve a sense of being fully immersed in the activity and experiencing a heightened state of focus and enjoyment (Brown & Cairns, 2004; Jennett, Cox, & Cairns, 2008; Mäyrä & Ermi, 2011; Michailidis et al., 2018). Likewise, we encounter intriguing convergence between immersion and presence. At the crux of this overlap lies the shared notion of "being there" in a mediated environment. As individuals become psychologically transported to the digital reality, they experience this transformative shift in perception and awareness (Witmer & Singer, 1998; Ryan et al., 2006; Malbos et al., 2012; Johnson et al., 2018; Jang & Park, 2019). Furthermore, we discern a fascinating union between presence and flow. United by a profound sense of involvement, both constructs offer a gateway to an experience of deep engagement and immersion. (Brockmyer et al., 2009; Ijsselsteijn et al., 2007; Skarbez et al., 2017; Wulansari et al., 2019).

Relying on experimental evidence, we will try to unveil the intricate dynamics of flow, immersion, and presence within the realm of computer gaming. A concise visual representation is presented in Fig. 1 to synthesize the conceptualization of the three examined constructs, as derived from the relevant literature incorporated in this study. This figure serves as an illustrative summary, encapsulating the key aspects of the concepts under investigation without being exhaustive.

3. Material and methods

3.1. Participants

To participate in the study, participants had to meet the following inclusion criteria: be over 18 years old, have significant previous experience with Minecraft, and have the PC game Minecraft installed on their PC. Following Brown and Cairns (2004), having previous experience with the game was considered essential to achieve a minimum level of immersion, defined by the authors as "Engagement". Participants were recruited online following a snowball procedure (Johnson & Gardner, 2010). The study was advertised via social media posts containing brief information about the study and a link to participate. Social networking sites such as Facebook, Reddit, Twitter, Discord, and Instagram were used to reach out to players from the Minecraft community. Information about the study and the informed consent were distributed via Google Forms.

A total of 135 participants agreed to participate and filled in the informed consent form. Of 135 participants, 74 showed up at the meeting sessions. Two participants were removed from the sample because they reported being under 18 during the meeting. Thus, the final sample consisted of 72 participants. All participants agreed to participate in the research as volunteers, and they were treated according to the Declaration of Helsinki (World Medical Association, 2001).

3.2. Experimental design

The present study was performed within the theoretical framework of the concept of immersion proposed by Brown and Cairns (2004), which facilitated the treatment of immersion as an independent variable in our study. A one-factorial multivariate design was used. The factor was the level of immersion experienced by the participants while playing the game, and it was manipulated at three levels (low vs. moderate vs. high). The dependent variables were the participants' experience of flow and presence as measured by questionnaires.

3.3. Pilot study

The present study followed a pilot study with a small number of participants ($N = 5$). During the pilot study, participants were instructed to complete the three conditions (low vs. moderate vs. high immersion) in a within-subject design. While playing the game, participants were asked to report their feelings and impressions following a think-aloud protocol (Knoll, 2018). Data from the pilot study were used to further elaborate on the three conditions of immersion used in the present study.

3.4. Procedure and manipulation

The experimental study was conducted remotely via the

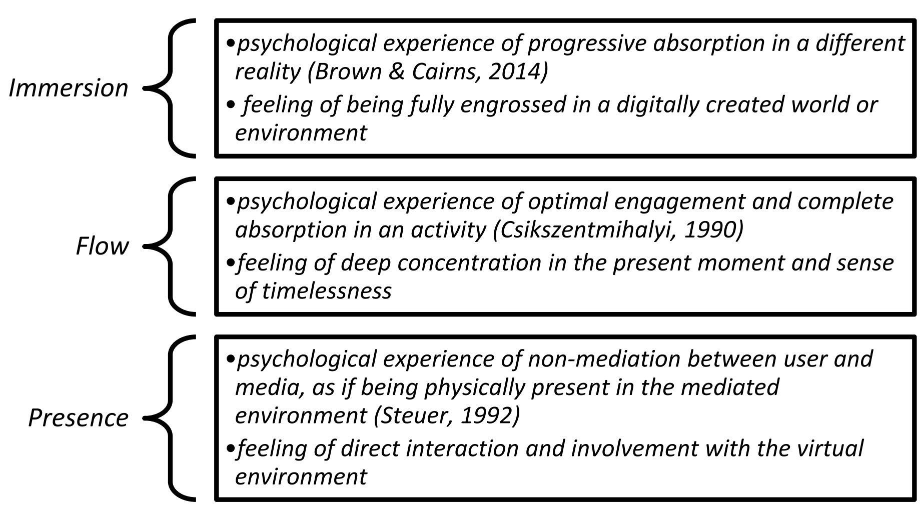

Fig. 1. Conceptualization of Immersion, Flow, and Presence. *Note:* The depicted figure presents a condensed representation of the examined constructs in this study and does not encompass all the diverse definitions found in the literature. Its purpose is to offer a succinct overview of the concepts investigated within the scope of this research.

videoconferencing platform Google Meet. Each participant was randomly assigned to one of the three experimental conditions (see Table 1). Participants were asked to wear headphones and share their screens while playing the computer game of Minecraft. Before receiving the instructions about the gameplay, they were once again informed about the details of the research and asked to confirm their age and willingness to participate as volunteers. However, the real aim of the study was not communicated to the participants to avoid them trying to anticipate the correct answer when completing the questionnaires (Field & Hole, 2002). Once done with the formalities, participants were asked to make themselves comfortable and get ready for the gameplay session. They were also carefully instructed to turn off any external audio devices and to turn their phone to silent mode, if possible, to avoid external distractions during the gameplay.

Once the game was loaded and the avatar was ready to move in the virtual environment (VE) of Minecraft, the experiment started. All the participants were assigned the same task, which consisted of collecting as many diamonds as possible within the virtual world of Minecraft. They were reassured that though sharing their screen, they did not have to feel as though they were observed because the researcher would have not be looking at their screen constantly; therefore, they could play the game naturally (Sanders & Paul, 2010). The players were then left to complete the quest in the game. Regardless of the number of diamonds collected, they were interrupted after 15 min of gameplay (Denisova & Cairns, 2015).

In the low-immersion condition (*Engagement*), they were asked to complete the task without being told about the time limit. They were ensured that the researcher would let them know when the gameplay was over (after 15 min, the researcher would interrupt the participant). Field of view (FOV) was set to the low level of 30°, and the sound was completely turned off. In the medium-immersion condition (*Engrossment*), they were instructed to complete the gameplay within 15 min. FOV was set to the normal level of 70, and the sound was still completely turned off. Finally, in the last condition of high immersion (*Total Immersion*), they were also instructed to complete the gameplay within 15 min, but FOV was set to 110, and they were asked to turn the sound up to an enjoyable level. A visual representation of the three conditions with different FOV settings is presented in Fig. 2.

After completing the 15 min of gameplay, participants were provided a link to the online questionnaires. They were asked to complete the questionnaires directly after the gameplay so that their memory would still be fresh and their answers most relevant (Cairns et al., 2014). The researcher was present while they answered the questions in case participants needed clarification. After completing the questionnaires, participants were first thanked for their participation and then asked if they had any questions or feedback before being orally debriefed.

Table 1
Gameplay manipulations (FOV, sound, and time pressure) for the three levels of immersion (engagement, engrossment, and total immersion).

	Low Immersion (Engagement)	Moderate Immersion (Engrossment)	High Immersion (Total Immersion)
FOV (Hirose et al., 2009; Lin et al., 2002)	30	70	110
Sound (Sanders & Paul, 2010)	Off	Off	On
Time pressure (Cox et al., 2012)	Off	On	On

Note. The three levels of immersion are inspired by Brown and Cairns (2004) and were tested in a pilot study with a total of five participants. During the pilot study, participants were asked to play the game in all three conditions using the think-aloud protocol. They were also interviewed afterward to understand their gaming experience.

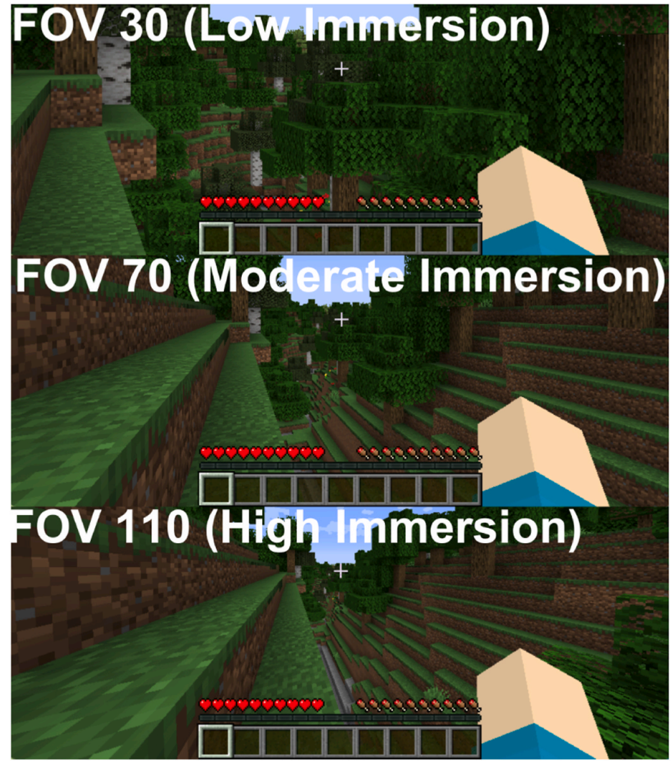

Fig. 2. Screen capture of Minecraft displaying the three FOV settings used in the gameplay session.

3.5. *Stimulus material*

The game used in this experiment was Minecraft, an open-world game published by Mojang in 2011. Minecraft consists of an open-world environment without predetermined objectives, allowing players the freedom to explore its limitless possibilities and interact with every constituent element of the virtual world. In contrast to previous games utilized in PX research, Minecraft stands out for its simple and direct manipulation of gameplay elements, including field of view (FOV) and sound. Previous research (Lin et al., 2002; Hirose et al., 2009; Sanders & Paul, 2010) has highlighted the significance of these elements in shaping the immersive experience. In the context of the current research, Minecraft was chosen because it seemed ideal in terms of the ability to manipulate its characteristics to induce various levels of immersion. Furthermore, the widespread usage of Minecraft in research settings presented a compelling opportunity to explore its application within our study. Participants were asked to start the game by creating a new world in single-player mode, using "2022" as a seed for the world generation. This allowed players to start all from the same location in the virtual generated world. The game mode was set to "survival" with normal difficulty. Other game settings were ensured to be the default. Most of the participants played the game in the latest version (1.18) of Minecraft.

3.6. *Measurement instruments*

Presence and flow were measured with a digitalized version of the IGROUP Presence Questionnaire (IPQ) (Schubert, 2003), and the Flow Short Scale (FSS) questionnaire (Rheinberg et al., 2003), respectively. The questionnaires were administered online through a link to their Google Form version. The digitalized version of the questionnaire had three sections: IPQ (see Appendix B), FSS (see Appendix C), and demographic questions (see Appendix D). While demographic questions were last, the IPQ and FSS were randomized to avoid order effects

(Schuman et al., 1981). The reason behind selecting these questionnaires stems from the findings highlighted by Denisova et al. (2016), where player experience questionnaires were observed to have conceptual overlaps. Considering this, we made a deliberate choice to use two separate and focused questionnaires specifically designed to measure our intended constructs. This decision ensures that we maintain clarity and accuracy in assessing our constructs of interest.

3.7. Presence

The IPQ was developed and used to measure the sense of presence experienced in a VE. The mean score on the IPQ was treated as a dependent variable. The questionnaire consists of 14 items on a 7-point Likert scale. The higher the score achieved on a positive scale, the higher the level of presence experienced (Rutrechtet al., 2021). The IPQ includes three components or subscales: spatial presence (SP), involvement (INV), and experienced realism (ER). SP describes the sense of being physically in the VE, INV represents the degree of awareness of the virtual world, and ER concerns the degree of realism felt in the virtual world. Furthermore, a single item assessing the general sense of presence (GP) as a sense of being in the virtual world was included (Schubert et al., 2001). The choice of this specific questionnaire was dictated by its reliability (internal consistency, $\alpha = .87$) and validity. Moreover, the questionnaire has already been used in video game research by its inventors (http://www.igroup.org/pq/ipq/index.php). Other research showed the reliability and validity of the IPQ in video game research (Panahi-Shahri, 2009). In the current study, the IPQ was found to have a high level of reliability ($\alpha = 0.85$). Since previous research used the IPQ subscales in addition to the total score for a more nuanced analysis (Berki, 2020; Bessa et al., 2016; Schwind et al., 2019), this study also included the components of SP ($\alpha = 0.77$), INV ($\alpha = 0.71$), and ER ($\alpha = 0.71$).

3.8. Flow

The FSS was used to measure the construct of flow. According to the nine components of flow proposed by Csikszentmihalyi (1990), the FSS considers all components with a 7-point Likert scale based on 10 items. Higher scores indicate higher levels of flow. The mean score on the FSS was treated as a dependent variable. Engeser and Rheinberg (2008) reported good internal consistency for the flow factor ($\alpha = 0.92$). The scale was validated by Rheinberg et al. (2003) and by Engeser and Rheinberg (2008). The wording of the items was slightly modified to better suit the experimental design, consistently using the past tense instead of the present tense across the 10 items. The FSS has been consistently used as a post-experience questionnaire in other game studies (Coppi et al., 2014; Rutrecht et al., 2021). In this study, Cronbach's alpha for the FSS was found to be acceptable ($\alpha = 0.74$).

3.9. Demographics

After participants completed the questionnaires for presence and flow, an additional six questions were added at the end of the questionnaires to account for age, sex, English level, and game expertise (hours per week spent gaming and number of years playing Minecraft) (Green & Bavelier, 2003). Following Green and Bavelier (2003), game expertise was controlled by asking the participants about their game habits. Thus, participants were asked to report the average hours per week spent playing Minecraft and the number of years spent playing the video game. Moreover, considering that Minecraft has different gameplay modes, participants were also asked to choose between survival, hardcore, creative, and online as their favorite game mode.

All statistical analyses were performed using JASP 0.16.1.0. Following van Den Berkman and Catak (2021), all the statistical analyses (except checking the difference between conditions regarding background variables) were conducted using Bayesian methods. Since the goal of this research was to ascertain the presence or absence of an effect of immersion on the constructs of presence and flow, Bayes factor hypothesis testing was considered suitable (van Doorn et al., 2021). A two-sided procedure was justified by the inconclusive evidence of previous research and conceptual confusion around the definitions of flow, immersion, and presence (Agrawal et al., 2020; Michailidis et al., 2018). In the model specification, due to vague and contradictory prior knowledge, a "default" prior distribution was used as the default option in JASP (van Doorn et al., 2021). The prior probability that the null hypothesis holds across all conditions was set to .50 (Westfall et al., 1997). A Bayesian ANOVA was conducted to learn about the candidate models and their condition-effect parameters (van Den Bergh et al., 2020). Bayesian factors (BFs) were interpreted according to the widely accepted classification proposed by Kass and Raftery (1995). BFs between 0.01 and 0.10 were considered strong evidence for the null model (M0); BFs between 0.10 and 0.31 were considered substantial evidence for M0; BFs between 0.31 and 1 were considered inconclusive; BFs between 1 and 3.2 were considered weak evidence for the alternative model (M1); BFs between 3.2 and 10 were considered enough evidence for an effect; and BFs between 10 and 100 were considered strong evidence for the effect. BFs of more than 100 were considered decisive evidence for M1, while BFs of less than 0.01 were considered decisive evidence for M0.

Before interpreting the results from the ANOVA, its main assumption of normality was assessed by controlling the quality of the data. All variables were checked for normality and equal variance across the experimental conditions. Normality was assured by looking at the Q-Q plots and computing skewness and kurtosis for all conditions (see Table 2). Homogeneity of variance was assessed by Levene's test for equality of variances. The Shapiro-Wilk test revealed a significant p-value for the high-immersion condition in the FSS variable ($p < .001$). One outlier was individuated and removed from the FSS total scores, given its score of 3.33 SD below the mean.

4. Results

There were no differences between the three conditions regarding the background variables (see Appendix E); thus, randomization seemed to be achieved. Descriptive statistics for the two dependent measures across conditions are displayed in Table 2. As can be seen, both questionnaires showed acceptable distribution properties for each of the conditions, except in the high condition for FSS scores.

4.1. Bayesian ANOVA

All Bayesian ANOVAs were performed using default prior settings in JASP 0.16.2.0 (Heo et al., 2020). Bayesian analysis was conducted to contrast the predictive performance of the null model M0 (absence of effect) to the alternative model M1 (presence of effect). The results from the Bayesian ANOVA showed evidence in favor of the alternative model for the FSS (see Table 3).

4.2. Strong evidence of an effect for FSS

Bayes factors revealed strong evidence for an effect of the independent variable, immersion, on the dependent variable, FSS, $BF10 = 15.03$. An error percentage of 0.014 indicated good robustness of the results (van Doorn et al., 2021). The support for M1 (there is a mean difference in flow across conditions) was about 15 times larger than for M0 (there is no meaningful difference across conditions). The results indicated that scores in the FSS differed between levels of immersion. A post hoc test was performed to further investigate which levels of immersion were responsible for the different FSS scores between conditions (see Table 4).

The adjusted posterior odds showed weak evidence (i.e., odds of about 3) that flow differed between low and medium immersion, with an

Table 2
Descriptive statistics for the IPQ and FSS questionnaires across conditions.

	FSS				IPQ			
	M	*SD*	Skewness	Kurtosis	*M*	*SD*	Skewness	Kurtosis
Low	4.56	0.88	0.10	−0.44	3.77	1.04	0.07	−1.07
Medium	5.23	0.89	−0.89	0.52	4.07	0.88	−0.17	−1.16
High	5.45	0.88	−1.59	2.78[a]	4.15	0.91	−0.10	−1.16

Note. $N = 72$. Low ($n = 24$), medium ($n = 24$), and high ($n = 24$) immersion.
[a] For the condition of high immersion, data from one participant were removed from the FSS scores (z-score = −3.33). The value displayed in the table reflects data after removing the participant.

Table 3
Model comparison for the alternative model compared to the null model for FSS scores.

Models	P(M)	P (M|data)	BF_M	BF_{10}	error %
M_0	.50	.06	0.07	1.00	–
M_1	.50	.94	15.03	15.03	0.014

Note. The abbreviations "M_O" and "M_1" stand for null and alternative models, respectively.

Table 4
Post hoc test for the FSS scores.

Level 1	Level 2	Prior Odds	Posterior Odds	$BF_{10,\ U}$	error %
Low	Medium	0.587	2.532	4.310	9.637e-7
	High	0.587	16.146	27.488	5.108e-7
Medium	High	0.587	0.228	0.388	0.007

Note. The first two columns indicate the levels of immersion being compared. The "U" in the Bayes factor denotes that it is uncorrected.

error percentage of 9.637×10^{-7}; strong evidence that flow differed between low and high immersion (i.e., odds of about 16), with an error percentage of 5.108×10^{-7}; substantial evidence (i.e., odds of about 0.20) that flow did not differ between medium and high immersion with an error percentage of 0.007. The model average posteriors showed that scores on FSS for the low-immersion condition are lower than the other conditions, while scores from the medium- and high-immersion conditions seem to differ only weakly.

4.3. Inconclusive evidence of an effect for the IPQ

Results from the Bayesian ANOVA regarding the IPQ are presented in Table 5. Bayes factors revealed inconclusive evidence to ascertain the presence of an effect, $BF_{10} = 0.27$. An error percentage of 0.008 indicated good robustness of the results. Results suggested greater support in favor of the null model. The model's average posteriors showed that IPQ scores across the three conditions of immersion seem to differ very weakly.

Following previous studies (Berki, 2020; Bessa et al., 2016; Schwind et al., 2019), a more in-depth analysis was conducted by running a Bayesian ANOVA for all the IPQ subscales. Results confirmed prior analysis for the total IPQ scores, resulting in overall inconclusive evidence across all subscales. Bayes factors revealed weak evidence in favor of M_1 for the subscales of GP ($BF_{10} = 1.30$), inconclusive evidence for SP ($BF_{10} = 0.60$), and substantial evidence in favor of M_0 for INV ($BF_{10} = 0.14$) and ER ($BF_{10} = 0.17$). The results from the Bayesian ANOVA for the IPQ suggested the absence of an effect on the dependent variable of presence.

Table 5
Model comparison for the alternative model compared to the null model for IPQ scores.

Models	P(M)	P (M|data)	BF_M	BF_{10}	error %
M_0	.50	.79	3.75	1.00	–
M_1	.50	.21	0.27	0.27	0.008

Note. The abbreviations "M_O" and "M_1" stand for null and alternative models, respectively.

5. Discussion

The study was intended to investigate the relationship between different levels of gameplay immersion and the constructs of flow and presence. The results suggested strong evidence for an effect of immersion on flow (see Table 3), while no evidence was found in favor of an effect of immersion on presence (see Table 5). Furthermore, the post hoc test revealed that flow differed across all conditions except between medium and high immersion (see Table 4).

In support of previous research (Michailidis et al., 2018; Weibel & Wissmath, 2011), the present study suggested that immersion has a considerable effect on the experience of flow. The Bayesian analysis provided strong evidence in favor of an effect of various levels of immersion on flow. Interestingly, the post hoc test revealed no evidence of an effect between the conditions of medium and high immersion. There could be several reasons for this. One possible explanation may come from the idea that immersion represents an experience antecedent to flow (Jennett, Cox, Cairns, et al., 2008; Sanders & Paul, 2010). According to Frochot et al. (2017), flow and immersion constitute two coexisting experiences, but while immersion is a more longitudinal state, flow is a particularly extreme experience. This may explain why the experience of flow did not vary between medium- and high-immersion conditions. If immersion precedes flow, and if flow is an extreme experience, it could be further hypothesized that we experience episodes of flow only when certain levels of immersion are reached. Considering the definition of flow given by Csikszentmihalyi (1992), medium and high levels of immersion may be capable of triggering what the author identified as deep flow episodes. It could also be further speculated that notwithstanding higher levels of immersion, the experience of flow does not vary once a certain immersive threshold is reached. Previous literature (Cheng et al., 2015) has indeed considered immersion as a suboptimal state and precondition of flow. Therefore, the hypothesis hereby proposed may fit well in the research area of PX. The video gameplay experience has often been described by the concept of immersion rather than flow, assuming that immersion better describes the degree of involvement in a game. However, the results from current study suggest that the flow state depends, at least partially, on immersion levels. According to the model proposed by Brown and Cairns (2004), it can be hypothesized that the experience of flow is likely to be triggered more often in the levels of engrossment and total immersion, not differentiating between them. Indeed, the authors suggested that immersion is somehow related but distinct from the definition of flow (Brown & Cairns, 2004). Researchers are encouraged to explore this hypothesis in greater depth. Other evidence in favor of the relation between flow and immersion comes from the gameplay experience model proposed by Ermi and Mäyrä (2005), which distinguishes between sensory immersion, challenge-based immersion, and imaginative immersion. Ermi and Mäyrä (2005) stated that the dimension of challenge-based immersion is particularly central for games and that it seems to share some important characteristics with the concept of flow (Ermi & Mäyrä, 2005). Although previous research has shown little evidence to support the distinction between flow and immersion (Michailidis et al., 2018), the results from this study suggest that though related, flow and immersion may represent different components of the gameplay experience, and that flow may arise only when a certain level of immersion is reached. However, this is mere speculation that should be tested in future research.

As for the concept of presence, this study did not provide evidence for the effect of immersion on presence. Instead, statistical analyses suggested substantial evidence in support of the null model of equal sense of presence across all gaming conditions. Following previous research (Berki, 2020; Bessa et al., 2016; Schwind et al., 2019), a more nuanced analysis was also performed on the IPQ subscales. The pattern of no effect was confirmed across all the subscales. Interestingly, for the subscale of GP, Bayes factors suggested weak evidence for an effect. However, given the small amount of evidence and the fact that the GP subscale is composed of a single item, this finding was irrelevant. Overall, the findings for the IPQ seemed to corroborate previous research from Jennett, Cox, Cairns, et al. (2008) and Cairns et al. (2014), which suggested a double dissociation of immersion from presence. In the study conducted by Cairns et al. (2014), immersion was successfully manipulated by altering music and time pressure, while the sense of presence remained unchanged. Similarly, Jennett, Cox, Cairns, et al. (2008) illustrated the possibility of being immersed in the game while not feeling present through the game Tetris. In the case of the present study, participants could have experienced various levels of immersion while playing Minecraft but may have not felt present due to the low-res graphics of the game and the limited spatial capabilities of the video game interface. This would explain why participants from this study did not experience different levels of presence between gameplay conditions. The findings of this study may therefore provide further evidence in support of the conceptual separation between immersion and presence. As noted by Jennett, Cox, Cairns, et al. (2008), when people report "being in the game," it does not necessarily mean that they experience a sense of presence, intended as "being there." It is important to remark that this study adopted a definition of presence commonly used in video game research, that of spatial presence (Lee, 2004). Other research has suggested that high levels of immersion may lead to high levels of social presence (Shi et al., 2019). It would be interesting to further explore how levels of immersion may have different impacts on spatial and social presence. In contrast with Brown and Cairns' (2004) suggestions, the results from this study did not show that the experience of presence was elicited by high levels of immersion. Indeed, if the double dissociation of immersion from presence were accurate, one would not expect higher levels of immersion to coincide with the experience of presence.

6. Limitations

There are a few limitations to the current study. Firstly, it's important to acknowledge that further research is needed to assess the generalizability of these findings beyond Minecraft. Furthermore, recruiting participants with previous experience in the game may limit the interpretation of the results to a certain kind of player. In the present study, experienced players were recruited to guarantee the experience of immersion (McMahan, 2013). Second, a defective manipulation of the immersion variable cannot be ruled out, though the pilot study suggested good evidence in favor of the manipulation of FOV, sound, and time to influence immersion. It is noteworthy to mention that the manipulation of FOV in our study may not have given the expected results. Some participants reported feeling "sea-sick" when the FOV was set at 30, while others felt that the game was moving "too fast" with an FOV of 110. This variability in responses highlights the individual differences in how participants experienced the FOV adjustments. In addition, a few participants reported not being used to playing the game with its original music. Altogether, these reports might suggest a defective manipulation of immersion for some players. Third, a potential limitation of our study could be the use of Bayesian ANOVA as the analytical method, as it is not commonly employed in similar studies. However, we see this choice as an opportunity to address the disputable and contradictory outcomes observed in previous research using standard statistics on this contentious topic. By adopting Bayesian statistics, we can quantify the strength of evidence supporting different hypotheses, providing more reliable and interpretable results. A recent systematic review revealed an increasing use of Bayesian statistics, especially in the fields of social science, psychology, and computer science (Van de Schoot et al., 2017). We believe that the adoption of Bayesian statistics can offer a promising avenue for future studies to explore and build upon. Another methodological limitation is that the experiment was conducted remotely via a video-sharing platform. Although players were carefully instructed before the experimental session to maintain similar environmental settings between participants, external elements such as room light (Cairns et al., 2014) or computer screen size (Hou et al., 2012) could have not been controlled. Furthermore, it must be noted that the two questionnaires used in this study (FSS and IPQ) were modified slightly from their original version. All FSS items were expressed in the past tense, while two questions from the IPQ had the anchors' order inverted (see Appendix B & C). Despite the good reliability, these changes may have indeed affected the content validity of the instruments. As the final point to consider, it is worth noting that this study is solely reliant on self-reported data, which may introduce a potential source of bias. Hence, in future research endeavors, the incorporation of corroborating measures is essential to fortify the robustness and credibility of our findings.

7. Future research

The insights from the current study provide strong evidence to further investigate the relation between flow and immersion in video games. While the construct of flow has already been identified as an important component of gameplay (Borderie & Michinov, 2016), its relation with immersion has not been explained clearly. Evidence from cognitive neuroscience research might provide further insights into the relations between flow and immersion. For example, a study conducted by Katahira et al. (2018) using electroencephalogram (EEG) suggested that the flow state may be related to high levels of cognitive control and immersion. These findings were further supported by a recent study conducted by Kannegieser and Ratz (2021), which specifically focused on measuring the constructs of immersion and flow through EEG. While the authors treated immersion and flow as separate entities, their analysis led them to conclude a specific correlation between the two constructs. We believe that future research employing EEG or other neuroscience methods could potentially offer even more objective evidence regarding the intricate relationship between flow and immersion.

A second avenue for research is the distinction between presence and immersion. This study suggested that the feeling of presence does not seem to vary in function concerning varying levels of immersion. As Cairns et al. (2014) suggested, though immersion seems to support a sense of presence, there is no evidence of a clear link between the two psychological constructs. Future research should avoid unnecessary overlapping between the two concepts and consider them separate components of the gameplay experience.

Besides the use of computer games for recreational purposes, future research may involve the results of this study in the context of educational games. For example, Georgiou et al. (2019) suggested that high levels of immersion in digital games may increase learning abilities, while a higher sense of presence may distract the subject and consequently decrease their learning capacities (Makransky et al., 2019). Considering the research question in this study—that medium and high levels of immersion may lead to deep flow experiences—it would be interesting to explore whether these flow experiences can enhance learning processes, as recently suggested (Erhel & Jamet, 2019; Kiili et al., 2021).

8. Conclusion

This research was driven by the desire to better understand the psychological constructs underlying the experience of immersion in the context of computer games. This study is interesting in that it provided more evidence in support of a relation between flow and immersion, rather than between presence and immersion. From a theoretical point of view, this study adds further knowledge for the future development of a shared framework to better understand the gameplay experience. From the practical perspective, these results point to the importance of gameplay immersion to elicit states of flow. The results could be seen as encouragement for game designers and media producers, for whom the experience of flow is a priority, to consider that inducing higher levels of immersion may not add much to the experience flow. A second practical implication concerns the design of video games and media technologies in which presence is prioritized. This study suggests that levels of immersion do not affect the perceived sense of presence. Therefore, usability tests should consider the two constructs distinct, as experiencing high levels of immersion does not necessarily mean feeling a sense of presence. Investigating the impact of immersion on flow and presence should also be considered beyond the field of computer games and PX. For example, Klasen et al. (2012) provided some evidence for specific neural activation patterns responsible for the experiences of flow, further suggesting that flow, immersion, and presence may share mutual neural correlates. Therefore, research on cognitive neuroscience could also benefit from the results of the current study to further investigate these experiences. In conclusion, a deeper understanding of the constructs of immersion, flow, and presence in computer games will help not only to create more engaging experiences but also to understand the cognitive processes underlying these psychological constructs.

Consent for publication

Not applicable.

Ethics approval and consent to participate

Not applicable.

Availability of data and materials

Not applicable.

Authors' contributions

SC conceived the study, designed the research, carried out experiments and data analysis. MN and PH coordinated this research and contributed to the draft of the manuscript.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Abbreviations

BF	Bayesian factor
FFS	flow short scale
FOV	field of view
IPQ	IGROUP presence questionnaire
PX	player experience

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.chbr.2023.100334.

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