



HAL
open science

Presence in video games: A systematic review and meta-analysis of the effects of game design choices

Loïc Caroux

► **To cite this version:**

Loïc Caroux. Presence in video games: A systematic review and meta-analysis of the effects of game design choices. *Applied Ergonomics*, 2023, 107, pp.103936. 10.1016/j.apergo.2022.103936 . hal-03852663

HAL Id: hal-03852663

<https://hal.science/hal-03852663>

Submitted on 15 Nov 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

PRE PRINT

Caroux, L. (2023). Presence in video games : A systematic review and meta-analysis of the effects of game design choices. *Applied Ergonomics*, 107, 103936.

doi:10.1016/j.apergo.2022.103936

NOTICE: this is the author's version of a work that was accepted for publication in "Applied Ergonomics". Changes resulting from the publishing process, such as peer review, editing, corrections, structural formatting, and other quality control mechanisms may not be reflected in this document. Changes may have been made to this work since it was submitted for publication. The definitive version will appear in "Applied Ergonomics".

Presence in video games : A systematic review and meta-analysis of the effects of game design choices

Author: Loïc Caroux

Affiliation: CLLE laboratory, University of Toulouse and CNRS, 5 Allées Antonio Machado, 31058

Toulouse Cedex 9, France.

Corresponding author:

Loïc CAROUX

Laboratoire CLLE - Maison de la Recherche

Université Toulouse Jean Jaurès

5 Allées Antonio Machado

31058 Toulouse Cedex 9

France

E-mail: loic.caroux@univ-tlse2.fr

Abstract

Sense of presence is a widely assessed dimension of video game player experience. A systematic literature review and a meta-analysis were conducted to provide a more comprehensive view of the elements of game design that have an effect on the sense of presence, as well as its different dimensions studied and assessment techniques. The review revealed that many major categories of game design aspects were well represented. The meta-analysis revealed that several game design factors have significant effects on different dimensions of presence. The largest revealed effects were that playing games with a head-mounted display and motion controller rather than a monitor display and non-motion controller has a large effect on global presence. Also, playing with human co-players rather than computer-controlled co-players and playing cooperatively rather than competitively have a very large and large effect on social presence, respectively. Implications for future research are discussed, such as investigating the effects of design factors on presence in a more targeted manner, systematically assessing presence with its most relevant sub-dimensions, and using more similar rating scales. Design recommendations, with their expected impact on players' sense of presence, are proposed.

Keywords

Game user research, player experience, visual display, multiplayer, questionnaire, scale.

1. Introduction

Presence is the feeling of being inside a virtual environment (see for reviews Felton & Jackson, 2022; Wilkinson et al., 2021). This psychological concept is a widely assessed dimension of a user's experience interacting with a computer-generated environment. The sense of presence is usually described as a three-dimensional construct (Felton & Jackson, 2022; Terkildsen & Makransky, 2019). Spatial presence (or physical presence) is the dimension of presence that describes the user's feeling of being physically in the virtual environment and the ability to interact with that environment and the objects in it as if it were real. Social presence is the dimension that describes the feeling of coexistence with other beings in the virtual environment. Self-presence is the dimension that describes the feeling of extension and prolongation of the user's body in the avatar displayed in the virtual environment as if it were their own body.

Presence can be particularly experienced by players interacting with video games (Terkildsen & Makransky, 2019). Video games are interactive systems in which users interact with a virtual environment for the primary purpose of fun and entertainment (Caroux et al., 2015). This virtual environment is usually displayed via an audio-visual terminal. The player sends commands to the environment via an artifact (gamepad, motion controller, etc.) and the environment evolves according to these commands. The sense of presence is one of the dimensions that can be assessed when studying the player experience (Caroux et al., 2015; Terkildsen & Makransky, 2019). Player experience is the individual, personal experience held by the player during and immediately after playing the game (Wiemeyer et al., 2016). Player experience includes dimensions related to enjoyment, such as flow and emotions, and engagement, such as immersion and presence. Note that presence and immersion are two concepts that are frequently studied to assess player experience and may be still used interchangeably in some studies. However, several authors have made efforts to differentiate these constructs (see for example Cairns et al. (2013) or Nilsson et al. (2016)). For example, immersion can be defined as "the sensation of being surrounded by the virtual

environment that increases proportionally with the number of modalities provided with artificial stimuli” (McMahan, 2003; Nilsson et al., 2016). Immersion is primarily relative to sensory perception, while presence, a feeling of being “in the game”, is a more mental, psychological perception.

Although presence is a widely used construct for assessing player experience, it is not always clear how the sense of presence is influenced by game design choices. A previous systematic review of the literature by Caroux et al. (2015) showed that player experience can be influenced by various hardware and software aspects of video games. Three main categories of game design were highlighted in this previous review: input/output information (i.e. display and control modes), in-game contents (i.e. gameplay mechanics, narrative and challenge), and multiplayer aspects (i.e., nature of the co-player, co-playing mode, and online gaming techniques). Presence was addressed in this previous review, but along with several other dimensions and without quantitative evidence on the specific impacts of game design factors. Therefore, the results may be of limited use to researchers and designers who wish to know the specific effect of each design choice on presence. In addition, the number of studies that have investigated presence in video games has increased significantly over the past decade. For example, the impact of recent technological innovations in video games, such as virtual reality (VR) systems (e.g., Marre et al., 2021), was investigated in a rather embryonic fashion in this previous review, due to the small number of published studies at that time. Some of these have subsequently been addressed in more empirical studies published in the interim.

Furthermore, the effects of game design choices on player experience, including the dimension of presence, have been investigated in numerous experimental studies over the past two decades (Caroux et al., 2015). Several published articles have provided state of art, literature surveys or reviews of what we know about the influence of various design choices on a given dimension of player experience, such as enjoyment (Mekler et al., 2014; Schaffer & Fang, 2019; Segundo Díaz et al., 2022), flow (Khoshnoud et al., 2020), engagement (Boyle et al., 2012) or emotions (De Byl, 2015),

or on the influence of a given design characteristic on the overall player experience, such as affective-based game adaptation (Bontchev, 2016; Ng & Khong, 2014), personalization techniques (Karpinskyj et al., 2014), brain-computer interfaces (Marshall et al., 2013), or game accessibility (Spiel & Gerling, 2021). Their contribution is of course of great interest to the game user research community, including researchers and practitioners, but remains limited due to their solely descriptive nature. Their usefulness decreases when it comes to knowing the precise effect of each design choice or helping a game designer choose an element that would have a specific desired impact on dimensions of player experience like presence. We believe that the size of the body of experimental game user research literature is now large enough to allow more comprehensive and in-depth analyses of the data from this research such as meta-analyses.

The purpose of the present study is to focus in depth on the concept of presence in the player experience in video games. The main objective is to provide a more comprehensive view of the elements of game design that have an effect on the sense of presence in video games. This study is based on a systematic review of literature that described the different categories of game design elements that have been studied, but also explored the different studied dimensions of presence and the different techniques to assess it. In addition, a meta-analysis was conducted to assess the impact of the specific game design elements that were evaluated in these studies. The goal is to quantify the effect of these game design choices on the sense of presence based on a combination of data from different experimental studies. The results of the meta-analysis can help to better understand the specific effect of each design choice on presence and thus optimize the player experience when designing video games.

2. Methods

2.1. Literature search

The literature search and selection were performed in major online databases (Web of Science Core Collection, PsycInfo, Medline) to identify relevant studies for inclusion in this review. The search

covered published research articles written in English and published through 2021, with no minimum year. The first step of the literature search was to use keywords related to video games and player experience. The search topic was intentionally broader than just the concept of presence. The search also included other main dimensions of player experience in order to capture as many articles in this area as possible. Some articles might have studied presence as a secondary dimension and therefore did not mention it in the title or abstract. Similarly, this approach allowed for the inclusion of studies in which presence was assessed among other dimensions but did not show a significant effect.

Therefore, the search query was performed with the following keywords related to video games (video games, digital games, computer games, electronic games, or videogames), player (play, player, or playing), and experience (experience, enjoyment, engagement, immersion, presence, flow, or emotion). A few articles were added manually after checking the databases of previous published literature reviews on player experience. The database search yielded 5,360 published articles after duplicate removing.

The articles were included according to the following inclusion criteria. The articles had to investigate the influence of game design factors (software and/or hardware) on player experience. Because the main objective of the present study was to focus on the elements of game design that have an effect on the sense of presence in video games, this review was based on studies that compared one given modality of game design factor to another (e.g., a rather recent display mode such as head-mounted display vs. a more traditional mode such as a monitor display). Thus, the articles were required to include controlled experiments (i.e. randomized controlled trials or within-participant experiments) that assessed the efficacy of these design factors on player experience compared to a “control condition”. In addition, the objective of this review was to study player experience in a situation where entertainment was not competing with another user goal such as learning, training, etc. Games for which entertainment is not the primary goal (e.g., serious game, game-based learning, rehabilitation game, physical training exergame) are designed to help the user achieve a primary goal (e.g., academic learning, training, cognitive rehabilitation, skill enhancement, behavioral change, etc.)

that is not inherently related to the player-video game interaction (e.g., Krath et al., 2021; Shahmoradi et al., 2022). The present review aimed to focus on player experience data (including presence) collected in situations uniquely designed to achieve optimal player experience. Mixing data from studies with different user goals could bias the results of the review and meta-analysis. Thus, an excluding criterion was articles that studied games for which entertainment is not the primary goal.

Each abstract in the search database was reviewed for compatibility between the article and the inclusion criteria. When the abstract was ambiguous, the whole text was screened. This review was done independently by two persons, including the author of this article. The two reviewers then compared their results. If there was a disagreement about an article, the two reviewers discussed their choice and together decided to include or exclude the article. A total of 215 articles, published between 2000 and 2021¹, met the inclusion criteria.

The next step was to limit the search to articles that investigated the influence of game design factors on presence. Articles reporting studies that assessed presence, alone or among other dimensions of player experience, were included in the final database of this review. A total of 55 articles, published between 2004 and 2021, met the final inclusion criteria and were included in this review.

2.2. Data extraction

The data extracted from the studies reported in the remaining 55 articles concerned the type of game design characteristic studied and the modalities manipulated, the different measures (presence and other dimensions of player experience), and the type of technique for measuring presence.

¹ Note that while the first year of publication (e.g., online) of some of the included articles was 2021 or earlier (hence their inclusion in the literature search databases and in the current review), their final year of publication may be 2022.

2.3. Meta-analysis

Next, another selection was made from the studies reported in the included articles to further quantitative analyses. The studies were selected based on the categories of game design factors and presence dimensions. A study was included if there were at least two studies in the database that investigated the effect of the same game design factor on the same presence dimension, and for which corresponding data were available. The data were generally directly available in the article. Where data were not directly available, the authors of the article were contacted to provide the data in question. If data were not available from the authors or if there was no response from them (mainly for older articles), the study was not included in the meta-analysis. A total of 38 studies, from 31 articles, were included in the meta-analysis.

2.4. Statistical analysis

The means and standard deviations (SD) for dependent variables were used to calculate effect sizes (ES; Hedges' g) for each outcome in the experimental and control conditions. The experimental condition typically involved the primary modality of the game design factor studied, and the control condition involved the classic modality of the game design factor or its absence (see the results section for the details of the different groups compared). Data were standardized using post-intervention SD values. A random-effect model was chosen to analyze the effect of game design factors because the studies included in this meta-analysis used similar but not identical methods of measurement of presence (Deeks et al., 2019). The ES values are presented with 95% confidence intervals (CI). Calculated ES were interpreted using the following scale: < 0.2, trivial; 0.2–0.6, small; > 0.6–1.2, moderate; > 1.2–2.0, large; > 2.0–4.0, very large; > 4.0, extremely large (Hopkins et al., 2009). Heterogeneity was assessed using the I^2 statistic (Higgins & Thompson, 2002). Statistical significance was set at $p \leq 0.05$. The analysis was performed with Review Manager 5.4.1 software (The Cochrane Collaboration, 2020).

3. Results

3.1. Dimensions of presence assessed

The systematic review revealed that presence was assessed as a global concept (global presence) or according to one or more of its dimensions (spatial presence, social presence, self-presence). Table 1 shows the repartition of the articles included in the systematic review according to the dimension(s) of presence assessed. Most articles (58%) studied presence as a global concept. Spatial presence was studied by 33% of the articles. Social presence (16%) and self-presence (7%) were studied by fewer articles. It should be noted that an article may aim to assess global presence and a specific dimension of presence, but also more than of one dimension at a time. The complete list of articles included in the systematic review is detailed in Appendix.

Table 1. Number of articles included in the systematic review database by game design factor and presence dimension assessed.

Game aspect	Game design factor	Presence dimension assessed				Total number of articles
		Global presence	Spatial presence	Social presence	Self-presence	
Input/output information	Display mode	10	6	1	1	16
	Control mode	6	8	-	1	14
	Combined display & control device	3	-	1	-	4
	Visual interface	3	1	-	1	3
	Auditory interface	1	1	-	-	2
	<i>Sub-total</i>	<i>20</i>	<i>15</i>	<i>2</i>	<i>3</i>	<i>35</i>
Multiplayer	Co-player nature	5	2	3	-	9
	Co-playing mode	2	-	3	-	5
	Online playing	-	-	3	-	3
	<i>Sub-total</i>	<i>6</i>	<i>2</i>	<i>7</i>	<i>-</i>	<i>14</i>
In-game contents	Avatar	4	-	-	-	4
	Narrative	2	2	1	1	3
	Gameplay	2	1	-	-	3
	Reward	2	-	-	-	2
	Difficulty	1	-	-	-	1
	<i>Sub-total</i>	<i>10</i>	<i>3</i>	<i>1</i>	<i>1</i>	<i>12</i>
Total number of articles		32	18	9	4	55

Note. An article that studied more than one dimension of presence, and/or more than one game design factor was counted in multiple cells. Therefore, the total or sub-total numbers are not the sum of the corresponding column or row.

3.2. Techniques used to measure presence

All the articles included in this review studied presence using questionnaires and scales. Table 2 presents the details of the questionnaires and scales used according to the dimension of presence assessed. Most articles used standardized scales. A very small proportion used *ad hoc* questionnaires (i.e. designed by the article authors without prior validation). Some scales were designed entirely to study presence (e.g., Slater-Usoh-Steed Presence Questionnaire (SUS) (Slater et al., 1994)), while others are only sub-dimensions of a more general scale, which is designed to assess the whole user experience for example (e.g., Presence-Immersion dimension of the Player Experience of Need Satisfaction Scale (PENS) (Ryan et al., 2006)). Another discriminating feature of these scales is that

some are specific to video games (e.g., Social Presence in Gaming Questionnaire (SPGQ) (De Kort et al., 2007)), while other are designed to assess presence (or user experience) in more diverse systems than video games (e.g., Independent Television Commission-Sense of Presence Inventory (ITC-SOPI) (Lessiter et al., 2001)).

It should be noted that presence is rarely the only one dimension of player experience that has been assessed in the included articles. Enjoyment, flow, or emotions are examples of other dimensions that may have been assessed in some articles. This review does not attempt to detail these elements since its purpose is to focus solely on presence.

Table 2. Questionnaires and scales used in the included articles to assess presence

Presence dimension assessed	Instrument	Specific to presence assessment	Sub-dimension of a more general instrument	Specific to video game player experience	Number of articles
Global presence	Presence-Immersion dimension of the Player Experience of Need Satisfaction Scale (PENS) (Ryan et al., 2006)		X	X	5
	Slater-Usuh-Steed Presence Questionnaire (SUS) (Slater et al., 1994)	X			4
	Presence dimension of the Game Engagement Questionnaire (GEQ) (Brockmyer et al., 2009)		X	X	4
	Verbal presence measure (Schneider et al., 2004)	X		X	4
	Telepresence scale (Kim & Biocca, 1997)	X			3
	Presence questionnaire (Witmer & Singer, 1998)	X			1
	Igroup Presence Questionnaire (IPQ) (Schubert et al., 2001)	X			1
	Independent Television Commission-Sense of Presence Inventory (ITC-SOPI) (Lessiter et al., 2001)	X			1
	Pictorial Presence Self-Assessment-Manikins (SAM) questionnaire (Weibel et al., 2015)	X			1
	Multimodal Presence Scale (Makransky et al., 2017)	X			1
	Presence Scale (Persky & Blascovich, 2008)	X		X	1
	Ad-hoc questionnaire				5
Spatial presence	Spatial presence dimension of the Independent Television Commission-Sense of Presence Inventory (ITC-SOPI) (Lessiter et al., 2001)	X	X		7
	Measurement, Effects, Conditions - Spatial Presence Questionnaire (MEC-SPQ) (Vorderer et al., 2004)	X			4
	Spatial Presence dimension of the Temple Presence Inventory (TPI) (Lombard & Ditton, 2000)	X	X		3
	Spatial presence dimension of the Igroup Presence Questionnaire (IPQ) (Schubert et al., 2001)	X	X		1
	Spatial Presence Experience Scale (SPES) (Hartmann et al., 2016)	X			1
	Spatial presence dimension of the Multimodal Presence Scale (Makransky et al., 2017)	X	X		1
	Physical presence dimension of the Sense of presence questionnaire (Lee et al., 2005)	X	X		1
	Ad-hoc questionnaire				1
Social presence	Social Presence in Gaming Questionnaire (SPGQ) (De Kort et al., 2007)	X		X	9
Self-presence	Self-presence dimension of the Sense of presence questionnaire (Lee et al., 2005)	X	X		2
	Self-presence dimension of the Multimodal Presence Scale (Makransky et al., 2017)		X		1
	Ad-hoc questionnaire				1

Note. An article that studied more than one dimension of presence, and/or used more than one questionnaire or scale was counted in multiple cells.

3.3. Game design factors studied

Table 1 shows that presence has been studied in articles that involve many different game design factors. These game design factors fall under the major aspects of video games studied in game user research, namely information input/output techniques (32 articles), multiplayer aspects (14 articles), and in-game contents (12 articles). The following paragraphs detail the different game design factors that were studied in the articles included in the review.

3.3.1. Information input/output techniques

Sixteen articles studied the effects of visual display type. These articles focused on innovative methods of visual information display, such as HMDs (7 articles) and 3D-stereoscopic displays (6 articles). Other less studied concepts (one article) included screen size, fidelity, and image display quality. Fourteen articles studied the effects of control mode. Most of these articles studied motion-based controllers (9 articles). These controllers include tangible controllers (e.g., Wiimote, PS Move, or steering wheel controllers) or full body controllers (e.g., Kinect sensor). Other means of control, through speech or brain activity, and concepts related to control, such as control fidelity or aiming type in a shooting game, were also studied, but in only one article. Four articles investigated the effects of systems that combine an HMD with motion-based controllers, such as in VR game systems. Other input/output information game design factors were studied by only one article per concept. Regarding visual interfaces, point of view (1st or 3rd person), diegesis (how contextual information is presented), and graphical fidelity were studied. Regarding auditory interfaces, the presence of music and the fidelity of sound were studied.

3.3.2. Multiplayer aspects

Nine articles investigated the effects of the nature of the co-players. The co-players are other players in a same game environment, which can be controlled by another human being or by the computer. Five articles studied the effect of the co-playing mode. In multiplayer games, the main goal may be shared among players and they must achieve the goal together (collaboration and cooperation), or

players may have to act against their rivals to achieve victory (competition). Three articles investigated the effect of online playing (i.e. interacting in the same game environment without being in the same physical location).

3.3.3. In-game contents

Four articles investigated the effect of avatar appearance (representation of the player in the game environment). Two of them focused on the possibility to customize the appearance of the avatar. One of them was about the choice between pre-defined appearances. The last one was about the possibility of having an avatar that physically resembles the player. Three articles investigated the effects of narrative in video games, which concerns how a context is included in the game environment. Two articles studied the effect of contextual in-game story on presence. One article studied the effect of a virtual agent (computer-controlled social entity) in the game environment. Several other aspects of in-game contents were studied, but in only one article each. The effects of the type and variety of rewards, which were given to players after completing an objective for example, the level of difficulty, and the game mechanics (e.g., rules, main goal, or social aspect of the game) were also studied.

3.4. Meta-analysis

The meta-analysis was conducted based on the influence of different game design factors on global presence, and on each sub-dimension of presence. A total of 16 analyses were conducted: 6 analyses for global presence, 7 analyses for spatial presence, 2 analyses for social presence, and 1 analysis for self-presence. Table 3 provides a summary of all effect sizes calculated in this article, which are detailed in the following paragraphs. Note that the values of all effect sizes reported in the following paragraphs and tables are positive, meaning that if there is a statistically significant effect, it means that the feeling of presence is greater in the experimental condition than in the control condition.

Table 3. Summary of effect sizes of the influence of different game design factors on each dimension of presence

Game design factor	Experimental condition	Control condition	Effect size and 95% interval confidence			
			Global presence	Spatial presence	Social presence	Self-presence
Display mode	HMD	Monitor display	.42 [.04, .80] *	.80 [.60, 1.01] *	-	-
	3D-stereoscopic display	2D display	.10 [-.20, .40]	.21 [-.24, .65]	-	-
Control mode	Motion-based control	Classic control	.22 [-.13, .58]	.12 [-.05, .30]	-	-
	Motion-based tangible controller	Classic controller	-	.06 [-.12, .23]	-	-
	Body motion-based control	Motion-based tangible controller	-	.23 [-.22, .68]	-	-
Combined display & control device	HMD & motion-based control device	Classic display and control device	1.64 [.89, 2.40] *	-	-	-
Auditory interface	Music presence	Music absence	-	.20 [-.28, .68]	-	-
Co-player nature	Human co-player	Computer co-player	1.04 [.38, 1.70] *	-	2.17 [1.62, 2.73] *	-
Co-playing mode	Cooperation/collaboration mode	Competition mode	-	-	1.59 [-.04, 3.22] *	-
Avatar	Avatar choice	Default avatar	.33 [-.01, .66] *	-	-	-
Narrative	Story presence	Story absence	-	.80 [.24, 1.36] *	-	1.05 [.47, 1.62] *

Note. * denotes a statistically significant effect

3.4.1. Effects of game design factors on global presence

Table 4 presents the results of the meta-analyses of the influence of game design factors on global presence. There was a significant small effect of HMDs vs classic monitor displays on global presence. There was a significant large effect of combined HMD & motion-based control devices vs classic devices (monitor display and classic controller, i.e. gamepad or keyboard/mouse set) on global presence. There was a significant moderate effect of human co-players vs computer co-players on global presence. There was a significant small effect of avatar choice vs no avatar choice (i.e. default avatar) on global presence.

There were non-significant effects of 3D-stereoscopic displays vs classic 2D displays, and motion-based control (i.e. with a tangible or full body controller) vs classic control (i.e. with a gamepad or a keyboard/mouse set) on global presence.

Table 4. Meta-analysis of effects of game design factors on global presence

Game design factor	Experimental condition	Control condition	Number of studies	Effect size	95% confidence interval Lower limit	95% confidence interval Upper limit	z-value	p-value	I ²
Display mode	HMD	Monitor display	3	.42	.04	.80	2.16	.03	36%
	3D-stereoscopic display	2D display	3	.10	-.20	.40	.66	.51	28%
Control mode	Motion-based control	Classic control	2	.22	-.13	.58	1.24	.21	17%
Combined display & control device	HMD & motion-based control device	Classic display and control device	3	1.64	.89	2.40	4.25	<.001	61%
Co-player nature	Human co-player	Computer co-player	5	1.04	.38	1.70	3.08	.002	90%
Avatar	Avatar choice	Default avatar	2	.33	-.01	.66	1.92	.05	0%

3.4.2. Effects of game design factors on spatial presence

Table 5 presents the results of the meta-analyses of the influence of game design factors on spatial presence. There was a significant moderate effect of HMDs vs monitor displays on spatial presence. There was a significant moderate effect of the presence of a contextual story vs the absence of story on spatial presence.

There were non-significant effects of 3D-stereoscopic displays vs 2D displays, motion-based control vs classic control, motion-based tangible controllers vs classic controllers, body motion-based control vs motion-based tangible controllers, and in-game music presence vs music absence on spatial presence.

Table 5. Meta-analysis of effects of game design factors on spatial presence

Game design factor	Experimental condition	Control condition	Number of studies	Effect size	95% confidence interval Lower limit	95% confidence interval Upper limit	z-value	p-value	I ²
Display mode	HMD	Monitor display	3	.80	.60	1.01	7.77	<.001	0%
	3D-stereoscopic display	2D display	2	.21	-.24	.65	.91	.36	70%
Control mode	Motion-based control	Classic control	6	.12	-.05	.30	1.36	.17	50%
	Motion-based tangible controller	Classic controller	5	.06	-.12	.23	.63	.53	42%
	Body motion-based control	Motion-based tangible controller	5	.23	-.22	.68	1.00	.32	82%
Auditory interface	Music presence	Music absence	2	.20	-.28	.68	.81	.42	49%
Narrative	Story presence	Story absence	2	.80	.24	1.36	2.82	.005	0%

3.4.3. Effects of game design factors on social presence

Table 6 presents the results of the meta-analyses of the influence of game design factors on social presence. There was a significant very large effect of human co-players vs computer co-players on social presence. There was a marginally significant large effect of multiplayer cooperation/collaboration mode vs competition mode on social presence.

Table 6. Meta-analysis of game design factors on social presence

Game design factor	Experimental condition	Control condition	Number of studies	Effect size	95% confidence interval Lower limit	95% confidence interval Upper limit	z-value	p-value	I ²
Co-player nature	Human co-player	Computer co-player	2	2.17	1.62	2.73	7.65	<.001	0%
Co-playing mode	Cooperation/collaboration mode	Competition mode	2	1.59	-.04	3.22	1.92	.06	93%

3.4.4. Effects of game design factors on self-presence

Table 7 presents the single result of the meta-analysis of the influence of a game design factor on self-presence. There was a significant moderate effect of the presence of a story vs the absence of a story on spatial presence.

Table 7. Meta-analysis of game design factors on self-presence

Game design factor	Experimental condition	Control condition	Number of studies	Effect size	95% confidence interval Lower limit	95% confidence interval Upper limit	z-value	p-value	I ²
Narrative	Story presence	Story absence	2	1.05	.47	1.62	3.56	<.001	0%

4. Discussion

4.1. Main findings and research implications

The first objective of the present research was to provide a more comprehensive view of the elements of game design that have an effect on the sense of presence in video games. The results showed that many major categories of game design aspects are well represented in the literature

that was reviewed. The impact of input/output information techniques, in-game contents, and multiplayer aspects on player presence have been investigated in numerous articles. However, the proportion of articles is not homogeneous within these categories. The most studied factors are mainly related to input/output information techniques and multiplayer aspects. The factors related to the in-game contents have been studied in a more disparate way.

Regarding input/output information techniques, the way visual information is displayed was particularly studied. The meta-analysis showed that displaying visual information via an HMD (as opposed to a classic monitor display), had a small effect on global presence and a moderate effect on spatial presence. Interestingly, in combination with motion controllers in a VR game system, the effect size on global presence was larger, while the effect of motion controllers alone did not reach significance.

In terms of the multiplayer aspects, the nature of co-player and the mode of co-playing were extensively studied and had some of the largest effects on presence in the meta-analysis. Playing with a human co-player (vs a computer-controlled co-player) had a moderate effect on global presence, and even a very large effect on social presence. The cooperation/collaboration mode (as opposed to competition mode) in a multiplayer game had a large effect on social presence.

Factors related to in-game contents are much less represented in the included articles. Only the effects of in-game story presence and choice of avatar appearance were investigated in the meta-analysis (intermediate effect of story presence on spatial presence and self-presence; small effect of player avatar choice on global presence).

While the most essential game design factors have been addressed in this present research regarding input/output information and multiplayer aspects, this is not the case for in-game contents.

Important elements of in-game contents, such as challenge and difficulty (e.g., Denisova et al., 2020; Vahlo & Karhulahti, 2020), have not been well addressed in the included articles. Other elements related to gameplay, such as game rules, game mechanics and functionality (e.g., Segundo Díaz et al.,

2022) were also not addressed. Future research needs to study game design factors more broadly in order to gain a more comprehensive view of their influence on the sense of presence in video games.

The second objective of this research was to explore the different dimensions of presence studied in player-computer interaction, as well as the different techniques used to assess it. The results showed that presence has mainly been studied as a global construct. Few articles have studied the separate dimensions of presence. Of the three dimensions of presence, spatial presence has been the most studied, primarily in relation to input/output information techniques. Social presence has been less studied, primarily in relation to aspects of multiplayer games. Self-presence has been studied even less.

The fact that global presence was the most studied concept in the reviewed literature may be related to the fact that many articles have not focused on presence solely for the purpose of studying player experience. Global presence may be considered a sufficient assessment item when studying the overall player experience. However, this could be a real problem if the goal is to get a clear picture of the impact of a game design choice on presence. It may be crucial to know which dimension of presence is specifically impacted by a given design choice. As an example, the meta-analysis showed that the choice of avatar appearance has a significant effect on global presence. But it would have been more informative to study each specific dimension of presence. In particular, we could hypothesize that self-presence would be particularly enhanced in such a case since an avatar is a prolongation of the self in the virtual environment. Studies on multiplayer aspects illustrate this point perfectly. They showed that global presence was positively impacted by the nature of the co-player with a moderate effect size. However, when social presence is specifically studied, which could be considered as a naturally relevant dimension for this game design factor, the studies showed a very large effect size. In the same line, the meta-analysis did not reveal a significant effect of control mode on global presence or spatial presence. Given the nature of the different dimensions of presence, it would have been interesting to study the impact of these design factors on self-

presence. It can be hypothesized that the mode of control is a type of prolongation of the self in the virtual environment and therefore has an impact on the sense of self-presence. Specific dimensions of presence should be studied more in future research, instead of, or at least in addition to, global presence. Targeting a specific dimension in relation to the nature of the game design factor would be particularly relevant. More generally, studies on social presence and self-presence are lacking and should be further explore in future research.

In terms of techniques for measuring presence, this review found that numerous questionnaires and scales were used in the included articles. While it is good that validated scales were widely used, it is unfortunate that there are very diverse. Given their heterogeneity, this may limit the validity of the comparison of results to some extent. The results of meta-analyses may be more robust when the measurement instruments are homogeneous. Future research should attempt to use similar scales to assess presence in video games. For example, the use of some global, presence-specific scales, such as the MPS (Makransky et al., 2017), have the advantage of assessing global presence and each sub-dimension at the same time. Unfortunately, the review did not reveal any such scales constructed specifically for video games.

Finally, the results of the literature review showed that presence was exclusively assessed with subjective questionnaires and scales. This is not surprising given that presence is primarily a concept that the player can experience when playing video games. Declarative instruments seem to be the best for collecting the player's impressions of their experience during their interaction with a game. However, other techniques based on the player's behavior or physiological state exist and have been validated, included for video game situations (e.g., Terkildsen & Makransky, 2019). It may be worthwhile for future studies to include these techniques, instead of or in addition to subjective techniques, in order to have more varied data to characterize presence in video games.

4.2. Design recommendations

One of the benefits of this meta-analysis is that the effects of game design choices on the sense of presence were quantified and their size calculated based on the combination of data from different experimental studies. Therefore, these results may help to better optimize player experience in video game design than the results from isolated studies. Some design recommendations with their expected impact on the players' sense of presence, based on these results, are provided to game designers in Table 8.

Table 8. Design recommendations based on significant effects from the meta-analysis.

Game design factor	Design recommendation	Expected impact on presence dimensions (based on effect sizes of the meta-analysis)			
		Global presence	Spatial presence	Social presence	Self-presence
Display mode	Display the virtual environment in an HMD device (vs. a monitor display)	Small	Moderate	-	-
Combined display & control device	Display the virtual environment in a VR device, i.e. an HMD combined with a motion controller (vs. a classic monitor display and controller)	Large	-	-	-
Co-player nature	Allow players to play with human co-players (vs. computer co-players) in a multiplayer game	Moderate	-	Very large	-
Co-playing mode	Allow players to play cooperatively or collaboratively with other players (vs. competitively) in a multiplayer game	-	-	Large	-
Avatar	Allow players to choose their avatar in the game (vs. imposing a default avatar)	Small	-	-	-
Narrative	Introduce a contextual story in the game (vs. no story)	-	Moderate	-	Moderate

4.3. Limitations

As with many systematic reviews and meta-analyses, the results of this study may be limited by the body of literature reviewed, while the total number of articles included in this review was quite large given the relative recency of the field of game user research.

The limitations of this review are reached when it comes to exploring some specific game design factors or presence dimensions in more detail. For example, several game design factors described in the review were not included in the meta-analysis because they were unique in their research question (e.g., visual interface or online playing). Similarly, the meta-analysis includes comparisons with a small number of studies (2 or 3 studies), while other included a large number (5 or 6 studies). This may limit the validity of the findings.

In addition, as noted above, the variety of comparisons may be considered as a limitation of the meta-analysis. While many game design factors were investigated in the included studies, not all existing factors explored in the literature on player-computer interaction were investigated in relation to the sense of presence (e.g., challenge, game rules, etc.). Similarly, the influence of included game design factors has not been studied on all dimensions of presence (e.g., the effect of control mode on self-presence). This may also limit the validity of the results.

4.4. Perspectives

The present research focused solely on presence, which is only one dimension of player experience in video games. The goal was to isolate this concept to specifically study the effects of game design factors on it. Future research should then focus on other dimensions of player experience. Two directions can be explored by these future studies.

First, future meta-analyses should be conducted on the other main dimensions of player experience, namely immersion, flow, and enjoyment for the most important ones. Some literature reviews already exist, such as general reviews on player-computer interaction (e.g., Caroux et al., 2015), but also more specific reviews on enjoyment (e.g., Segundo Díaz et al., 2022) or flow (e.g., Khoshnoud et al., 2020). But none of them provide quantitative evidence of the effects of game design choices on these essential dimensions of player experience.

Second, the concept of presence should be studied in relation to these other dimensions of player experience. The connection between presence and other dimensions have sometimes been studied,

but mostly in a theoretical manner, such as the connection between flow and immersion (Michailidis et al., 2018). Most of the articles included in this review have studied each dimension in isolation. Future studies should examine the links between presence and other dimensions when investigating the effects of game design choices.

5. Conclusion

The present article reports a systematic review and meta-analysis of the effects of game design factors on the sense of presence. The systematic review showed that many major categories of game design aspects are well represented in the reviewed literature. The most studied factors are mainly related to input/output information techniques and multiplayer aspects. Factors related to in-game contents have been studied in a more disparate manner. The meta-analysis showed that the way visual information is displayed, as well as the nature of the co-player and the mode of co-playing in multiplayer games have the largest effects on presence. The systematic review also showed that presence was primarily assessed using subjective questionnaires and scales, but that the wide variety of these instruments limits comparison across studies. This study revealed that future research should focus on investigating game design factors in a more targeted manner, systematically assessing presence with its most relevant sub-dimensions, and using more similar scales to assess presence. Finally, one of the benefits of this meta-analysis is that the effects of game design choices on the sense of presence were quantified and their size calculated based on combining data from different experimental studies. Therefore, these results can help to better understand the specific effect of each game design choice and thus optimize player experience in video game design than the results of isolated studies.

Acknowledgements

The author thanks Anastasia Passemar for her help in reviewing the articles in the search database.

The author also thanks Noé Monsaingeon and Jean-Christophe Sakdavong for their comments on earlier drafts of this paper.

References

- Aymerich-Franch, L. (2010). Presence and emotions in playing a group game in a virtual environment: The influence of body participation. *Cyberpsychology, Behavior, and Social Networking, 13*, 649–654. <https://doi.org/10.1089/cyber.2009.0412>
- Balakrishnan, B., & Sundar, S. S. (2011). Where am I? How can I get there? Impact of navigability and narrative transportation on spatial presence. *Human–Computer Interaction, 26*, 161–204. <https://doi.org/10.1080/07370024.2011.601689>
- Birk, M. V., Atkins, C., Bowey, J. T., & Mandryk, R. L. (2016). Fostering intrinsic motivation through avatar identification in digital games. *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*, 2982–2995. <https://doi.org/10.1145/2858036.2858062>
- Bontchev, B. (2016). Adaptation in affective video games: A literature review. *Cybernetics and Information Technologies, 16*(3), 3–34. <https://doi.org/10.1515/cait-2016-0032>
- Boyle, E. A., Connolly, T. M., Hainey, T., & Boyle, J. M. (2012). Engagement in digital entertainment games: A systematic review. *Computers in Human Behavior, 28*, 771–780. <https://doi.org/10.1016/j.chb.2011.11.020>
- Bracken, C. C., & Skalski, P. (2009). Telepresence and video games: The impact of image quality. *PsychNology Journal, 7*, 101–112.
- Brockmyer, J. H., Fox, C. M., Curtiss, K. A., McBroom, E., Burkhart, K. M., & Pidruzny, J. N. (2009). The development of the Game Engagement Questionnaire: A measure of engagement in video game-playing. *Journal of Experimental Social Psychology, 45*, 624–634. <https://doi.org/10.1016/j.jesp.2009.02.016>
- Brondi, R., Alem, L., Avveduto, G., Faita, C., Carrozzino, M., Tecchia, F., & Bergamasco, M. (2015). Evaluating the impact of highly immersive technologies and natural interaction on player engagement and flow experience in games. In K. Chorianopoulos, M. Divitini, J. Baalsrud Hauge, L. Jaccheri, & R. Malaka (Eds.), *Entertainment Computing—ICEC 2015* (Vol. 9353, pp. 169–181). Springer International Publishing. https://doi.org/10.1007/978-3-319-24589-8_13

- Cairns, P., Cox, A. L., Day, M., Martin, H., & Perryman, T. (2013). Who but not where: The effect of social play on immersion in digital games. *International Journal of Human-Computer Studies*, 71, 1069–1077. <https://doi.org/10.1016/j.ijhcs.2013.08.015>
- Caroux, L., Isbister, K., Le Bigot, L., & Vibert, N. (2015). Player–video game interaction: A systematic review of current concepts. *Computers in Human Behavior*, 48, 366–381. <https://doi.org/10.1016/j.chb.2015.01.066>
- Chanel, G., Kivikangas, J. M., & Ravaja, N. (2012). Physiological compliance for social gaming analysis: Cooperative versus competitive play. *Interacting with Computers*, 24, 306–316. <https://doi.org/10.1016/j.intcom.2012.04.012>
- Chung, J., & Gardner, H. J. (2012). Temporal presence variation in immersive computer games. *International Journal of Human-Computer Interaction*, 28, 511–529. <https://doi.org/10.1080/10447318.2011.627298>
- De Byl, P. (2015). A conceptual affective design framework for the use of emotions in computer game design. *Cyberpsychology: Journal of Psychosocial Research on Cyberspace*, 9(3), Article 4. <https://doi.org/10.5817/CP2015-3-4>
- De Kort, Y. A., IJsselsteijn, W. A., & Poels, K. (2007). Digital games as social presence technology: Development of the Social Presence in Gaming Questionnaire (SPGQ). *PRESENCE 2007, Proceedings of the 10th Annual International Workshop on Presence*, 195–203.
- De Simone, J. J., Verbruggen, T., Kuo, L.-H., & Mutlu, B. (2012). Is cheating a human function? The roles of presence, state hostility, and enjoyment in an unfair video game. *Computers in Human Behavior*, 28, 2351–2358. <https://doi.org/10.1016/j.chb.2012.07.005>
- Deeks, J. J., Higgins, J. P., Altman, D. G., & on behalf of the Cochrane Statistical Methods Group. (2019). Analysing data and undertaking meta-analyses. In J. P. T. Higgins, J. Thomas, J. Chandler, M. Cumpston, T. Li, M. J. Page, & V. A. Welch (Eds.), *Cochrane Handbook for Systematic Reviews of Interventions* (1st ed., pp. 241–284). Wiley. <https://doi.org/10.1002/9781119536604.ch10>

- Denisova, A., Cairns, P., Guckelsberger, C., & Zendle, D. (2020). Measuring perceived challenge in digital games: Development & validation of the challenge originating from recent gameplay interaction scale (CORGIS). *International Journal of Human-Computer Studies*, 137, 102383. <https://doi.org/10.1016/j.ijhcs.2019.102383>
- Emmerich, K., & Masuch, M. (2016). The Influence of virtual agents on player experience and performance. *Proceedings of CHI PLAY 2016*, 10–21. <https://doi.org/10.1145/2967934.2968092>
- Felton, W. M., & Jackson, R. E. (2022). Presence: A review. *International Journal of Human-Computer Interaction*, 38, 1–18. <https://doi.org/10.1080/10447318.2021.1921368>
- Gábana Arellano, D., Tokarchuk, L., & Gunes, H. (2017). Measuring affective, physiological and behavioural differences in solo, competitive and collaborative games. In R. Poppe, J.-J. Meyer, R. Veltkamp, & M. Dastani (Eds.), *Intelligent Technologies for Interactive Entertainment* (Vol. 178, pp. 184–193). Springer International Publishing. https://doi.org/10.1007/978-3-319-49616-0_18
- Gajadhar, B. J., de Kort, Y. A. W., & IJsselsteijn, W. A. (2008). Shared fun is doubled fun: Player enjoyment as a function of social setting. In P. Markopoulos, B. de Ruyter, W. IJsselsteijn, & D. Rowland (Eds.), *Fun and Games* (Vol. 5294, pp. 106–117). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-88322-7_11
- Gajadhar, B. J., Nap, H. H., de Kort, Y. A. W., & IJsselsteijn, W. A. (2010). Out of sight, out of mind: Co-player effects on seniors' player experience. *Proceedings of the 3rd International Conference on Fun and Games - Fun and Games '10*, 74–83. <https://doi.org/10.1145/1823818.1823826>
- Gerling, K. M., Birk, M., Mandryk, R. L., & Doucette, A. (2013). The effects of graphical fidelity on player experience. *Proceedings of International Conference on Making Sense of Converging Media - AcademicMindTrek '13*, 229–236. <https://doi.org/10.1145/2523429.2523473>
- Gürkök, H., Hakvoort, G., & Poel, M. (2011). Evaluating user experience in a selection based brain-computer interface game a comparative study. In J. C. Anacleto, S. Fels, N. Graham, B.

- Kapralos, M. Saif El-Nasr, & K. Stanley (Eds.), *Entertainment Computing – ICEC 2011* (Vol. 6972, pp. 77–88). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-24500-8_9
- Hartmann, T., Wirth, W., Schramm, H., Klimmt, C., Vorderer, P., Gysbers, A., Böcking, S., Ravaja, N., Laarni, J., Saari, T., Gouveia, F., & Maria Sacau, A. (2016). The Spatial Presence Experience Scale (SPES): A short self-report measure for diverse media settings. *Journal of Media Psychology, 28*, 1–15. <https://doi.org/10.1027/1864-1105/a000137>
- Higgins, J. P. T., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. *Statistics in Medicine, 21*, 1539–1558. <https://doi.org/10.1002/sim.1186>
- Hogue, A., Kapralos, B., Tawadrous, M., Stanfield, B., & Hogue, U. (2012). Stereoscopic 3D video games and their effects on engagement. In A. J. Woods, N. S. Holliman, & G. E. Favalora (Eds.), *Proceedings Volume 8288, Stereoscopic Displays and Applications XXIII* (p. 828816). <https://doi.org/10.1117/12.906762>
- Hopkins, W. G., Marshall, S. W., Batterham, A. M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine & Science in Sports & Exercise, 41*, 3–12. <https://doi.org/10.1249/MSS.0b013e31818cb278>
- Hou, J., Nam, Y., Peng, W., & Lee, K. M. (2012). Effects of screen size, viewing angle, and players' immersion tendencies on game experience. *Computers in Human Behavior, 28*, 617–623. <https://doi.org/10.1016/j.chb.2011.11.007>
- Johnson, D., Wyeth, P., Clark, M., & Watling, C. (2015). Cooperative game play with avatars and agents: Differences in brain activity and the experience of play. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 3721–3730. <https://doi.org/10.1145/2702123.2702468>
- Karpinskyj, S., Zambetta, F., & Cavedon, L. (2014). Video game personalisation techniques: A comprehensive survey. *Entertainment Computing, 5*, 211–218. <https://doi.org/10.1016/j.entcom.2014.09.002>

- Kätsyri, J., Hari, R., Ravaja, N., & Nummenmaa, L. (2013). The opponent matters: Elevated fMRI reward responses to winning against a human versus a computer opponent during interactive video game playing. *Cerebral Cortex*, *23*, 2829–2839.
<https://doi.org/10.1093/cercor/bhs259>
- Khoshnoud, S., Alvarez Igarzábal, F., & Wittmann, M. (2020). Peripheral-physiological and neural correlates of the flow experience while playing video games: A comprehensive review. *PeerJ*, *8*, e10520. <https://doi.org/10.7717/peerj.10520>
- Kim, T., & Biocca, F. (1997). Telepresence via television: Two dimensions of telepresence may have different connections to memory and persuasion. *Journal of Computer-Mediated Communication*, *3*(2), JCMC325. <https://doi.org/10.1111/j.1083-6101.1997.tb00073.x>
- Klimmt, C., Possler, D., May, N., Auge, H., Wanjek, L., & Wolf, A.-L. (2019). Effects of soundtrack music on the video game experience. *Media Psychology*, *22*, 689–713.
<https://doi.org/10.1080/15213269.2018.1507827>
- Krath, J., Schürmann, L., & von Korfflesch, H. F. O. (2021). Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. *Computers in Human Behavior*, *125*, 106963.
<https://doi.org/10.1016/j.chb.2021.106963>
- Lee, K. M., Jin, S. A., Park, N., & Kang, S. (2005). *Effects of narrative on feelings of presence in computer/video games*. Annual Conference of the International Communication Association (ICA), New York, NY.
- Lemmens, J. S., Simon, M., & Sumter, S. R. (2022). Fear and loathing in VR: The emotional and physiological effects of immersive games. *Virtual Reality*, *26*, 223–234.
<https://doi.org/10.1007/s10055-021-00555-w>
- Lessiter, J., Freeman, J., Keogh, E., & Davidoff, J. (2001). A cross-media presence questionnaire: The ITC-Sense of Presence Inventory. *Presence: Teleoperators and Virtual Environments*, *10*, 282–297. <https://doi.org/10.1162/105474601300343612>

- Lim, S., & Reeves, B. (2009). Being in the game: Effects of avatar choice and point of view on psychophysiological responses during play. *Media Psychology, 12*, 348–370.
<https://doi.org/10.1080/15213260903287242>
- Lim, S., & Reeves, B. (2010). Computer agents versus avatars: Responses to interactive game characters controlled by a computer or other player. *International Journal of Human-Computer Studies, 68*, 57–68. <https://doi.org/10.1016/j.ijhcs.2009.09.008>
- Limperos, A., Waddell, T. F., Ivory, A. H., & Ivory, J. D. (2014). Psychological and physiological responses to stereoscopic 3D presentation in handheld digital gaming: Comparing the experiences of frequent and infrequent game players. *Presence: Teleoperators and Virtual Environments, 23*, 341–353. https://doi.org/10.1162/PRES_a_00204
- Lombard, M., & Ditton, T. (2000). *Measuring presence: A literature-based approach to the development of a standardized paper-and-pencil instrument*. Presence 2000: The Third International Workshop on Presence.
- Makransky, G., Lilleholt, L., & Aaby, A. (2017). Development and validation of the Multimodal Presence Scale for virtual reality environments: A confirmatory factor analysis and item response theory approach. *Computers in Human Behavior, 72*, 276–285.
<https://doi.org/10.1016/j.chb.2017.02.066>
- Marre, Q., Caroux, L., & Sakdavong, J.-C. (2021). Video game interfaces and diegesis: The impact on experts and novices' performance and experience in virtual reality. *International Journal of Human-Computer Interaction, 37*, 1089–1103.
<https://doi.org/10.1080/10447318.2020.1870819>
- Marshall, D., Coyle, D., Wilson, S., & Callaghan, M. (2013). Games, gameplay, and BCI: The state of the art. *IEEE Transactions on Computational Intelligence and AI in Games, 5*(2), 82–99.
<https://doi.org/10.1109/TCIAIG.2013.2263555>
- Mayer, S., Lischke, L., Grønbaek, J. E., Sarsenbayeva, Z., Vogelsang, J., Woźniak, P. W., Henze, N., & Jacucci, G. (2018). Pac-Many: Movement behavior when playing collaborative and

- competitive games on large displays. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–10. <https://doi.org/10.1145/3173574.3174113>
- McGloin, R., Farrar, K. M., & Krcmar, M. (2011). The impact of controller naturalness on spatial presence, gamer enjoyment, and perceived realism in a tennis simulation video game. *Presence: Teleoperators and Virtual Environments*, 20, 309–324. https://doi.org/10.1162/PRES_a_00053
- McMahan, A. (2003). Immersion, engagement, and presence: A method for analyzing 3-D video games. In M. J. P. Wolf & B. Perron (Eds.), *The Video Game Theory Reader* (pp. 67–86). Routledge.
- Mekler, E. D., Bopp, J. A., Tuch, A. N., & Opwis, K. (2014). A systematic review of quantitative studies on the enjoyment of digital entertainment games. *CHI '14 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, 927–936. <https://doi.org/10.1145/2556288.2557078>
- Michailidis, L., Balaguer-Ballester, E., & He, X. (2018). Flow and immersion in video games: The aftermath of a conceptual challenge. *Frontiers in Psychology*, 9, 1682. <https://doi.org/10.3389/fpsyg.2018.01682>
- Ng, Y. Y., & Khong, C. W. (2014). A review of affective user-centered design for video games. *2014 3rd International Conference on User Science and Engineering (i-USEr)*, 79–84. <https://doi.org/10.1109/IUSER.2014.7002681>
- Nilsson, N. C., Nordahl, R., & Serafin, S. (2016). Immersion Revisited: A review of existing definitions of immersion and their relation to different theories of presence. *Human Technology*, 12(2), 108–134. <https://doi.org/10.17011/ht/urn.201611174652>
- Pallavicini, F., Ferrari, A., Pepe, A., Garcea, G., Zancchi, A., & Mantovani, F. (2018). Effectiveness of virtual reality survival horror games for the emotional elicitation: Preliminary insights using Resident Evil 7: Biohazard. In M. Antona & C. Stephanidis (Eds.), *Universal Access in Human-*

- Computer Interaction. Virtual, Augmented, and Intelligent Environments* (Vol. 10908, pp. 87–101). Springer International Publishing. https://doi.org/10.1007/978-3-319-92052-8_8
- Pallavicini, F., Pepe, A., & Minissi, M. E. (2019). Gaming in virtual reality: What changes in terms of usability, emotional response and sense of presence compared to non-immersive video games? *Simulation & Gaming, 50*, 136–159. <https://doi.org/10.1177/1046878119831420>
- Park, N., Lee, K. M., Jin, S.-A. A., & Kang, S. (2010). Effects of pre-game stories on feelings of presence and evaluation of computer games. *International Journal of Human-Computer Studies, 68*, 822–833. <https://doi.org/10.1016/j.ijhcs.2010.07.002>
- Peña, J., & Chen, M. (2017). Playing with power: Power poses affect enjoyment, presence, controller responsiveness, and arousal when playing natural motion-controlled video games. *Computers in Human Behavior, 71*, 428–435. <https://doi.org/10.1016/j.chb.2017.02.019>
- Peng, X., Huang, J., Li, L., Gao, C., Chen, H., Tian, F., & Wang, H. (2019). Beyond horror and fear: Exploring player experience invoked by emotional challenge in VR games. *Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems - CHI EA '19*, 1–6. <https://doi.org/10.1145/3290607.3312832>
- Persky, S., & Blascovich, J. (2008). Immersive virtual video game play and presence: Influences on aggressive feelings and behavior. *Presence: Teleoperators and Virtual Environments, 17*(1), 57–72. <https://doi.org/10.1162/pres.17.1.57>
- Phillips, C., Johnson, D., Klarkowski, M., White, M. J., & Hides, L. (2018). The impact of rewards and trait reward responsiveness on player motivation. *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play*, 393–404. <https://doi.org/10.1145/3242671.3242713>
- Rachevsky, D. C., Souza, V. C. de, & Nedel, L. (2018). Visualization and interaction in immersive virtual reality games: A user evaluation study. *2018 20th Symposium on Virtual and Augmented Reality (SVR)*, 89–98. <https://doi.org/10.1109/SVR.2018.00024>

- Rajae-Joordens, R. J. E. (2008). Measuring experiences in gaming and TV applications. In J. H. D. M. Westerink, M. Ouwerkerk, T. J. M. Overbeek, W. F. Pasveer, & B. de Ruyter (Eds.), *Probing Experience* (Vol. 8, pp. 77–90). Springer Netherlands. https://doi.org/10.1007/978-1-4020-6593-4_7
- Ravaja, N. (2009). The psychophysiology of digital gaming: The effect of a non co-located opponent. *Media Psychology*, 12, 268–294. <https://doi.org/10.1080/15213260903052240>
- Ravaja, N., Saari, T., Turpeinen, M., Laarni, J., Salminen, M., & Kivikangas, M. (2006). Spatial presence and emotions during video game playing: Does it matter with whom you play? *Presence: Teleoperators and Virtual Environments*, 15, 381–392. <https://doi.org/10.1162/pres.15.4.381>
- Roettl, J., & Terlutter, R. (2018). The same video game in 2D, 3D or virtual reality – How does technology impact game evaluation and brand placements? *PLOS ONE*, 13(7), e0200724. <https://doi.org/10.1371/journal.pone.0200724>
- Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and Emotion*, 30(4), 344–360. <https://doi.org/10.1007/s11031-006-9051-8>
- Schaffer, O., & Fang, X. (2019). Digital game enjoyment: A literature review. *HCI in Games. HCII 2019. Lecture Notes in Computer Science*, 11595, 191–214. <https://doi.org/10.1007/978-3-030-22602-2>
- Schild, J., LaViola, J., & Masuch, M. (2012). Understanding user experience in stereoscopic 3D games. *Proceedings of the 2012 ACM Annual Conference on Human Factors in Computing Systems - CHI '12*, 89. <https://doi.org/10.1145/2207676.2207690>
- Schmierbach, M., Limperos, A. M., & Woolley, J. K. (2012). Feeling the need for (personalized) speed: How natural controls and customization contribute to enjoyment of a racing game through enhanced immersion. *Cyberpsychology, Behavior, and Social Networking*, 15(7), 364–369. <https://doi.org/10.1089/cyber.2012.0025>

- Schneider, E. F., Lang, A., Shin, M., & Bradley, S. D. (2004). Death with a story: How story impacts emotional, motivational, and physiological responses to first-person shooter video games. *Human Communication Research, 30*(3), 361–375. <https://doi.org/10.1111/j.1468-2958.2004.tb00736.x>
- Schubert, T., Friedmann, F., & Regenbrecht, H. (2001). The experience of presence: Factor analytic insights. *Presence: Teleoperators and Virtual Environments, 10*(3), 266–281. <https://doi.org/10.1162/105474601300343603>
- Segundo Díaz, R. L., Rovelo Ruiz, G., Bouzouita, M., & Coninx, K. (2022). Building blocks for creating enjoyable games—A systematic literature review. *International Journal of Human-Computer Studies, 159*, 102758. <https://doi.org/10.1016/j.ijhcs.2021.102758>
- Seibert, J., & Shafer, D. M. (2018). Control mapping in virtual reality: Effects on spatial presence and controller naturalness. *Virtual Reality, 22*, 79–88. <https://doi.org/10.1007/s10055-017-0316-1>
- Shafer, D. M. (2021). The effects of interaction fidelity on game experience in virtual reality. *Psychology of Popular Media, 10*, 457–466. <https://doi.org/10.1037/ppm0000298>
- Shafer, D. M., Carbonara, C. P., & Popova, L. (2011). Spatial presence and perceived reality as predictors of motion-based video game enjoyment. *Presence: Teleoperators and Virtual Environments, 20*, 591–619. https://doi.org/10.1162/PRES_a_00084
- Shafer, D. M., Carbonara, C. P., & Popova, L. (2014). Controller required? The impact of natural mapping on interactivity, realism, presence, and enjoyment in motion-based video games. *Presence: Teleoperators and Virtual Environments, 23*, 267–286. https://doi.org/10.1162/PRES_a_00193
- Shahmoradi, L., Mohammadian, F., & Rahmani Katigari, M. (2022). A systematic review on serious games in attention rehabilitation and their effects. *Behavioural Neurology, 2022*, 2017975. <https://doi.org/10.1155/2022/2017975>

- Skalski, P., Tamborini, R., Shelton, A., Buncher, M., & Lindmark, P. (2011). Mapping the road to fun: Natural video game controllers, presence, and game enjoyment. *New Media & Society*, *13*(2), 224–242. <https://doi.org/10.1177/1461444810370949>
- Slater, M., Usoh, M., & Steed, A. (1994). Depth of presence in virtual environments. *Presence: Teleoperators and Virtual Environments*, *3*, 130–144. <https://doi.org/10.1162/pres.1994.3.2.130>
- Spapé, M. M., Kivikangas, J. M., Järvelä, S., Kosunen, I., Jacucci, G., & Ravaja, N. (2013). Keep your opponents close: Social context affects EEG and fEMG linkage in a turn-based computer game. *PLoS ONE*, *8*(11), e78795. <https://doi.org/10.1371/journal.pone.0078795>
- Spiel, K., & Gerling, K. (2021). The purpose of play: How HCI games research fails neurodivergent populations. *ACM Transactions on Computer-Human Interaction*, *28*(2), 1–40. <https://doi.org/10.1145/3432245>
- Terkildsen, T., & Makransky, G. (2019). Measuring presence in video games: An investigation of the potential use of physiological measures as indicators of presence. *International Journal of Human-Computer Studies*, *126*, 64–80. <https://doi.org/10.1016/j.ijhcs.2019.02.006>
- The Cochrane Collaboration. (2020). *Review Manager (RevMan)* (5.4.1).
- Vahlo, J., & Karhulahti, V.-M. (2020). Challenge types in gaming validation of videogame Challenge Inventory (CHA). *International Journal of Human-Computer Studies*, *143*, 102473. <https://doi.org/10.1016/j.ijhcs.2020.102473>
- Vella, K., Koren, C. J., & Johnson, D. (2017). The impact of agency and familiarity in cooperative multiplayer games. *Proceedings of the Annual Symposium on Computer-Human Interaction in Play*, 423–434. <https://doi.org/10.1145/3116595.3116622>
- Vorderer, P., Wirth, W., Gouveia, F. R., Biocca, F., Saari, T., Jäncke, F., Böcking, S., Schramm, H., Gysbers, A., Hartmann, T., Klimmt, C., Laarni, J., Ravaja, N., Sacau, A., Baumgartner, T., & Jäncke, P. (2004). *MEC Spatial Presence Questionnaire (MEC-SPQ): Short Documentation and Instructions for Application*. <http://www.ijk.hmt-hannover.de/presence>

- Wauck, H., Lucas, G., Shapiro, A., Feng, A., Boberg, J., & Gratch, J. (2018). Analyzing the effect of avatar self-similarity on men and women in a search and rescue game. *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*, 1–12.
<https://doi.org/10.1145/3173574.3174059>
- Weber, S., Mast, F. W., & Weibel, D. (2020). Experiencing presence in a gaming activity improves mood after a negative mood induction. *International Journal of Gaming and Computer-Mediated Simulations*, 12(4), 1–22. <https://doi.org/10.4018/IJGCMS.2020100101>
- Weibel, D., Schmutz, J., Pahud, O., & Wissmath, B. (2015). Measuring spatial presence: Introducing and validating the pictorial presence SAM. *Presence: Teleoperators and Virtual Environments*, 24(1), 44–61. https://doi.org/10.1162/PRES_a_00214
- Weibel, D., Wissmath, B., Habegger, S., Steiner, Y., & Groner, R. (2008). Playing online games against computer- vs. Human-controlled opponents: Effects on presence, flow, and enjoyment. *Computers in Human Behavior*, 24, 2274–2291. <https://doi.org/10.1016/j.chb.2007.11.002>
- Wiemeyer, J., Nacke, L., Moser, C., & Mueller, F. 'Floyd.' (2016). Player experience. In R. Dörner, S. Göbel, W. Effelsberg, & J. Wiemeyer (Eds.), *Serious Games* (pp. 243–271). Springer International Publishing. https://doi.org/10.1007/978-3-319-40612-1_9
- Wilkinson, M., Brantley, S., & Feng, J. (2021). A mini review of presence and immersion in virtual reality. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, 65, 1099–1103. <https://doi.org/10.1177/1071181321651148>
- Williams, K. D. (2013). The effects of video game controls on hostility, identification, and presence. *Mass Communication and Society*, 16, 26–48.
<https://doi.org/10.1080/15205436.2012.661113>
- Williams, K. D. (2014). The effects of dissociation, game controllers, and 3D versus 2D on presence and enjoyment. *Computers in Human Behavior*, 38, 142–150.
<https://doi.org/10.1016/j.chb.2014.05.040>

Witmer, B. G., & Singer, M. J. (1998). Measuring presence in virtual environments: A presence questionnaire. *Presence: Teleoperators and Virtual Environments*, 7(3), 225–240.

<https://doi.org/10.1162/105474698565686>

Yildirim, C., Carroll, M., Hufnal, D., Johnson, T., & Pericles, S. (2018). Video game user experience: To VR, or not to VR? *2018 IEEE Games, Entertainment, Media Conference (GEM)*, 1–9.

<https://doi.org/10.1109/GEM.2018.8516542>

Appendix: List of articles included in the systematic review according to the game design factor studied and the presence dimension assessed

Game aspect	Game design factor	Presence dimension assessed			
		Global presence	Spatial presence	Social presence	Self-presence
Input/output information	Display mode	Chung & Gardner, 2012; Emmerich & Masuch, 2016; *Hogue et al., 2012; Hou et al., 2012; *Limperos et al., 2014; *Pallavicini et al., 2018; Rajae-Joordens, 2008; *Roettl & Terlutter, 2018; Weber et al., 2020; *Yildirim et al., 2018	Bracken & Skalski, 2009; Emmerich & Masuch, 2016; *Lemmens et al., 2022; *Schild et al., 2012; *Seibert & Shafer, 2018; *Williams, 2014	Emmerich & Masuch, 2016	Hou et al., 2012
	Control mode	*Aymerich-Franch, 2010; Chung & Gardner, 2012; Gürkök et al., 2011; Peña & Chen, 2017; *Rachevsky et al., 2018; *Schmierbach et al., 2012	*McGloin et al., 2011; *Seibert & Shafer, 2018; *Shafer, 2021; *Shafer et al., 2011, *2014; Skalski et al., 2011; *Williams, 2013, *2014	-	Williams, 2013
	Combined display & control device	*Pallavicini et al., 2019; *Peng et al., 2019; *Rachevsky et al., 2018	-	Brondi et al., 2015	-
	Visual interface	Gerling et al., 2013; Lim & Reeves, 2009; Marre et al., 2021	Marre et al., 2021	-	Marre et al., 2021
	Auditory interface	Chung & Gardner, 2012	*Klimmt et al., 2019	-	-
Multiplayer	Co-player nature	*Johnson et al., 2015; *Lim & Reeves, 2010; Ravaja et al., 2006; *Vella et al., 2017; *Weibel et al., 2008	Ravaja, 2009; Ravaja et al., 2006	*Cairns et al., 2013; Gajadhar et al., 2008; *Kätsyri et al., 2013	-
	Co-playing mode	Gábana Arellano et al., 2017; Lim & Reeves, 2010	-	Chanel et al., 2012; *Mayer et al., 2018; *Spapé et al., 2013	-
	Online playing	-	-	Cairns et al., 2013; Gajadhar et al., 2008, 2010	-
In-game contents	Avatar	Birk et al., 2016; *Lim & Reeves, 2009; *Schmierbach et al., 2012; Wauck et al., 2018	-	-	-
	Narrative	Emmerich & Masuch, 2016; Schneider et al., 2004	Emmerich & Masuch, 2016; *Park et al., 2010	Emmerich & Masuch, 2016	*Park et al., 2010
	Gameplay	Chung & Gardner, 2012; Wauck et al., 2018	Balakrishnan & Sundar, 2011	-	-
	Reward	Johnson et al., 2015; Phillips et al., 2018	-	-	-
	Difficulty	De Simone et al., 2012	-	-	-

Note. * denotes an article for which one or more studies are included in the meta-analysis. An article may be cited more than once in the table based on the game design factor and the presence dimension assessed.