virtual worlds

MDPI

Systematic Review

Ludic and Narrative Immersion in Virtual Reality Exposure Therapy to Animal Phobias: A Systematic Literature Review

Silvino Martins * and **Mário Vairinhos**

DigiMedia, University of Aveiro, 3810-193 Aveiro, Portugal; mariov@ua.pt
* Correspondence: silvinomartins@ua.pt

Abstract: In the context of therapeutic exposure to phobias, virtual reality (VR) offers innovative ways to motivate patients to confront their fears, an opportunity not feasible in traditional non-digital settings. This systematic literature review explores the utilization of narratives and digital games in this context, focusing on identifying the most common ludic and narrative immersion features employed in studies dedicated to animal phobias. Via a search on the Scopus and Web of Science scientific databases, twenty-nine studies were selected for in-depth analysis. The primary objective was to evaluate the presence of ludic and narrative elements in each study to understand their immersive potential across both dimensions. Findings suggest that ludic elements are more commonly used than narrative elements, which are notably scarce, and the exploration of the emotional dimension of narrative immersion is limited. An essential takeaway is that features fostering narrative immersion are invariably linked to the ludic dimension, often functioning as secondary components. This study provides a guiding framework for developing therapeutic interventions in VR, emphasizing the incorporation of ludic and narrative aspects. Additionally, it identifies untapped research opportunities, particularly the integration of autonomous narratives that are less reliant on ludic elements.

Keywords: ludic immersion; narrative immersion; virtual reality; exposure therapy; animal phobia; gamification; storytelling

Citation: Martins, S.; Vairinhos, M. Ludic and Narrative Immersion in Virtual Reality Exposure Therapy to Animal Phobias: A Systematic Literature Review. *Virtual Worlds* **2023**, *2*, 303–325. https://doi.org/10.3390/virtualworlds2040018

Academic Editor: Carina Soledad González

Received: 8 August 2023
Revised: 9 September 2023
Accepted: 25 September 2023
Published: 4 October 2023

1. Introduction

Exposure therapy, a cognitive–behavioral therapy (CBT) technique, is considered the treatment of choice for specific phobias, as there is a consensus that exposure to feared objects and situations is essential and highly effective in treating the vast majority of patients with this condition [1–3]. In recent years, virtual reality (VR) exposure therapies have gained attention as viable alternatives to traditional "in vivo" exposure due to their ability to create realistic and highly customizable simulations [4–6].

The digital medium not only allows for realistic exposure to fears but also provides unique opportunities for presenting phobic stimuli and facilitating controlled confrontations with these triggers, which may be impractical or impossible in real-world scenarios [7]. However, optimizing patient engagement and motivation to tolerate high levels of anxiety during exposure sessions remains crucial for successful outcomes [8]. In response to this challenge, researchers have explored the incorporation of game elements (gamification) to frame the presentation of phobic stimuli within VR environments (VREs) [9–12]. By integrating gamification approaches, therapy sessions become more interactive and captivating, providing patients with a more rewarding space to confront their fears.

While gamification approaches have received attention, the specific role of narratives and storytelling in VR-based exposure therapy for phobias has yet to be explored. The immersive potential of digital narratives and storytelling has been recognized as a key contributor to engagement and motivation [13,14]. Previous studies have indicated that incorporating narratives into educational games sustains player motivation [15–17], and their persuasive power in behavior change is well known [18]. Narrative transportation, a form of immersion, has been proposed as a mechanism through which narratives impact an individual's attitudes, perceptions, or beliefs [19], which is relevant in therapy as it can serve as a way to challenge irrational beliefs associated with phobias [8]. Integrating ludic and narrative elements in exposure therapy can immerse patients not only perceptually, via VR technologies, but also emotionally via captivating narratives and enjoyable ludic activities. Therefore, narratives have the potential to enhance therapy experiences by incorporating engaging storylines, characters, and storytelling techniques, providing compelling ways to challenge irrational beliefs.

However, according to some views, maintaining the individual's focused attention on the phobic stimulus, free from distractions, is paramount in the context of exposure therapy [20]. Although this idea has been debated [21], our approach diverges from the inclusion of narrative elements during exposure to stimuli as a distraction maneuver. Instead, our objective is to explore the utilization of narrative elements as a deliberate strategy to contextualize the individual's focus and guide them towards the primary therapeutic goal—addressing the phobic stimulus.

In recent literature on gamification approaches, often the narrative dimension is either absent or considered secondary to the ludic dimension. To investigate this further, this review aims to understand how digital narratives and games have been utilized in therapeutic exposure to animal phobias in VR. The review focuses on the following questions:

(a) Which studies go beyond perceptual immersion by incorporating digital game elements and narratives to engage patients?
(b) What ludic and narrative elements are typically integrated into VR-based exposure therapies for phobias?
(c) How are different dimensions of narrative immersion explored?

This review is conducted as part of a research project that aims to identify the characteristics that promote narrative immersion in the context of therapeutic exposure to phobias in VR. By emphasizing the narrative dimension, this research aims to open new avenues for investigation in the fields of communication and interaction design, ultimately enhancing the effectiveness of VR-based therapies for phobic conditions.

2. Beyond Perceptual Immersion in Virtual Reality: Factors That Contribute to Ludic and Narrative Immersion

In the realm of VR, two fundamental concepts, immersion and presence, hold significant importance [22–24]. Immersion is often regarded as an inherent and objective characteristic of VR systems, representing the system's ability to engage the user's senses in a perceptual manner [25]. It depends on the VR system's capacity to deliver realistic and multi-modal sensory stimuli [24]. On the other hand, presence, a closely related concept, delves into the psychological sensation of being fully absorbed in a virtual environment [23,24]. In essence, immersion in VR is commonly understood to result from the system's ability to captivate the user's sensory faculties, contributing to the sense of presence in the virtual world.

However, beyond sensory stimulation, immersion also encompasses psychological aspects such as mental involvement and absorption [13,14,26]. In the realm of video games, different dimensions of immersion have been identified, including narrative immersion, ludic immersion, spatial immersion, and social immersion [13,14,27–29].

In the context of this study, our aim is to promote user engagement with narrative and ludic elements during VR-based exposure to phobias. Therefore, we focus on the multidimensional nature of immersion, considering not only its perceptual aspects but also the ludic and narrative dimensions, drawing on the contributions of Murray [13] and Ryan [14] to inform the exploration of these dimensions.

Ryan [14] describes narrative immersion as a type of immersion that results from engagement with a fictional world through imagination. It involves mentally constructing elements of a story, anticipating its development, and emotionally responding to the characters. It can be categorized into spatial, temporal, and emotional dimensions, each related to specific aspects of the narrative.

Ludic immersion, on the other hand, refers to involvement and absorption in gameplay activities, which can be independent of the presence of a narrative. It is characterized by the challenges provided by a game and the passion brought by the player to overcome those challenges [14].

In VREs, various characteristics play a significant role in users' mental engagement with narratives and game challenges. To better understand and classify these aspects of ludic and narrative immersion, we have developed an analysis model (Table 1) based on the foundational work of Murray and Ryan [13,14], as well as self-determination theory (SDT) [30]. This model offers various indicators, or criteria, that facilitate the differentiation and assessment of VREs concerning their potential for immersive experiences.

Table 1. VR non-perceptual immersion analysis model: dimensions and indicators for assessing ludic and narrative aspects of VREs.

Type of Immersion	Dimension	Indicator
Ludic		Competence
		Autonomy
Narrative	Spatial	Freedom of navigation
		Believability
	Temporal	Narrative tension
		Time as a mechanic
	Emotional	Empathy
		Dramatic agency

2.1. Ludic Immersion: Competence and Autonomy

According to SDT, games are intrinsically motivating as they fulfill three fundamental psychological needs—autonomy, competence, and relatedness—that are essential for individual well-being and functioning [30,31]. Huizinga's description of games aligns with the principles proposed by SDT, portraying them as joyful and tension-filled activities that contribute to intrinsic motivation and satisfaction. Additionally, the cooperative nature and group participation in many games satisfy the need for relatedness, while elements such as competition, decision-making, and voluntary engagement foster competence and autonomy [32,33].

Fulfilling these psychological needs can lead to a state of flow [34], characterized by complete immersion, pleasure, and satisfaction. Studies have shown that self-determined motivation and perceptions of autonomy, competence, and relatedness are positively associated with optimal experiences [35].

In the context of VR experiences, understanding the potential for ludic immersion requires examining an experience's ability to provide perceptions of competence and autonomy. While ludic characteristics are associated with hedonic gratifications, providing pleasure and enjoyment, narrative and non-ludic elements relate to eudaimonic gratifications, offering opportunities for understanding of and reflection on the human condition [36].

In the realm of SDT, autonomy refers to feelings of will and control during a task [30,31]. Play, being a spontaneous, voluntary, pleasurable, and flexible activity [37], fulfills the need for autonomy and is, therefore, potentially immersive. However, the autonomy experienced in formal game activities may differ from play, as it is dictated by the game's design. In games, the degree of autonomy is determined by the player's choices, actions, tasks, and goals, rather than following a predefined script. Autonomy is perceived when tasks are pursued out of personal interest, accompanied by choice, positive feedback, and empowering instructions [31].

Ermi and Mäyrä [27] propose that achieving a balance between challenges and abilities is crucial for ludic immersion. This characteristic not only enhances the optimal gaming experience but also fosters a sense of mastery and efficacy, which is closely linked to the perception of competence [31]. In games, other factors contributing to the perception of competence and flow include clear goals, immediate feedback, and a sense of control over the outcome and the situation [27,34].

2.2. Narrative Immersion: Spatial, Temporal and Emotional Dimensions

Narrative immersion entails complete absorption and engagement in a story, where the reader or viewer feels like an integral part of the fictional world presented to them [14]. Ryan [14] identifies three types of narrative immersion: spatial immersion, involving the connection with the setting and environment; temporal immersion, encompassing engagement with the plot; and emotional immersion, which relates to the involvement with characters.

Narrative immersion goes beyond passive observation, as individuals mentally immerse themselves in the plot and environment, experiencing the actions and emotions alongside the characters. This concept aligns with Walton's thesis of "Mimesis as Make-Believe" [38] and the theory of narrative transportation [19]. Walton argues that readers create an illusion of reality, actively participating in the narrative. This immersive experience extends to various representational media and is rooted in the human capacity to imagine and engage with fictional worlds, a skill fostered in childhood with imaginative play. Narrative transportation, on the other hand, suggests that narratives have the power to transport individuals, shaping their thoughts and actions to align with the presented story. When individuals fully engage with a story, their attitudes and beliefs can be transformed, highlighting the persuasive potential of narratives [19].

2.2.1. Spatial Immersion: Freedom of Navigation and Believability

Spatial immersion refers to the immersive experience that arises from the setting of a narrative, creating a sense of being present in that space [14]. In its purest form, spatial immersion occurs when the individual develops a deep connection with the depicted setting, feeling intimately involved within it [14].

Unlike non-digital and non-interactive media such as books or movies, digital media have the unique capability to present navigable spaces, enhancing the poetics of exploration [13].VR, in particular, enables users to not only observe and imagine spaces but also explore and interact with them in a more realistic manner.

Although Murray does not explicitly mention spatial immersion, space plays a central role in her characterization of immersion: the experience of being transported to an "elaborately simulated space". The level of detail in this simulated space, referred to as its "encyclopedic extent", and the possibility of coherent spatial navigation are key factors contributing to immersion. When an environment is highly detailed and immersive, we feel engaged and influenced by it, offering an alternative to the chaotic real world. This holds true for both non-interactive and interactive environments, but it is particularly powerful when users can freely navigate the digital space.

In this regard, two specific affordances of digital media contribute to the sense of spatial immersion: spatial affordance, which enables the creation and representation of virtual spaces for user exploration and interaction, and encyclopedic affordance, which allows for the storage and retrieval of vast amounts of digital information [13].

Considering Murray's perspective, the freedom of navigation (spatial affordance) and the level of detail (encyclopedic affordance) provided by a digital environment serve as criteria for assessing the potential of a virtual environment for spatial immersion. These affordances enhance the poetics of exploration in VR, as environments with greater detail and openness offer higher immersive potential in terms of space.

Freedom of Navigation (Spatial Affordance)

Navigation is an inherently interactive task in VREs, encompassing orientation and locomotion [39]. The user's ability to spatially recognize, analyze, plan, and decide on paths within the virtual world (orientation) and to move through the space (locomotion) are crucial aspects, as any difficulties in these tasks can disrupt the state of immersion [39].

Freedom of navigation refers to the navigation possibilities provided by the virtual environment, the user's degree of freedom (DOF) in three-dimensional space, and their agency over movements. The amount of DOF appears to be directly linked to the degree of spatial immersion [40]. An environment that allows users to freely move in a three-dimensional space (6DOF) offers a more immersive experience, both perceptually and narratively, compared to an environment where they can only look around (3DOF). Similarly, an environment enabling panoramic views and the ability to look in all directions creates a more immersive experience than one with a fixed and limited viewpoint.

In essence, the user's level of control over movements and the freedom to explore the virtual environment influence the sense of spatial narrative immersion. The freedom of spatial exploration enhances the feeling of presence in the virtual environment, contributing to a greater sense of being in the fictional world and increasing engagement with the story.

Believability: Level of Detail and Coherence

The encyclopedic affordance of digital media allows for the creation of highly detailed and complex virtual environments that can be perceptually indistinguishable from reality [13]. However, the level of detail alone does not guarantee spatial immersion within a narrative. Coherence between the virtual environment and the fictional world of the narrative is essential.

While high detail and realism can make users feel physically present in a virtual environment, inconsistencies or errors can disrupt the suspension of disbelief and hinder deep immersion. On the other hand, coherence alone is insufficient without an appropriate level of detail. This relationship between "level of detail" and "coherence" can be likened to a puzzle, where the number of puzzle pieces represents the level of detail, and their proper arrangement represents coherence. A puzzle with many pieces but poor fitting results in an unclear and incoherent image. Similarly, a puzzle with few pieces lacks depth and complexity.

The level of detail refers to the realism and complexity of a virtual environment, made possible by the encyclopedic affordance of digital media. This affordance allows for the storage and retrieval of vast amounts of information, enabling the representation of a richly detailed fictional world. From a narrative perspective, it provides the opportunity to tell stories from multiple perspectives and create a dense and complex web via intersecting narratives [13].

Highly detailed and realistic virtual environments contribute to the sense of spatial immersion [13]. However, this level of detail extends beyond visual aspects. Games such as Civilization and SimCity exemplify the encyclopedic affordance of digital narratives. These games allow players to interact with spaces based on complex information systems by constructing and managing virtual civilizations or cities. They provide players with an encyclopedic experience, offering access to and manipulation of vast amounts of rich information about the systems they are engaging with. Civilization and SimCity demonstrate how digital media can create an immersive experience by leveraging extensive encyclopedic scope.

Coherence is a crucial characteristic that, combined with the level of detail, contributes to spatial immersion. It refers to the conformity of the virtual environment to the fictional world expressed by the narrative and the user's expectations. Coherence can be determined by logical, visual, cultural, and narrative consistency. Any lack of coherence within these categories affects the believability of the virtual environment and subsequently diminishes the sense of spatial immersion (Table 2).

Table 2. Coherence types and incoherence examples capable of undermining the sense of immersion in VR narratives.

Coherency Typology	Examples of Incoherence
Logical	Elements in the environment violate the laws of physics.
Visual	Elements in the environment have inconsistent visual styles, such as a mix of cartoonish and photorealistic elements. Graphical representation does not align with the fictional world. Visual continuity issues occur between different narrative moments.
Cultural	Inconsistent or inappropriate elements appear in relation to the culture or context of the story.
Narrative	The story lacks coherent development, with abrupt changes in the plot or characters.

Since the level of detail and coherence are inseparable and should be considered together, we propose "believability" as a comprehensive criterion for evaluating the potential of a virtual environment for spatial immersion. When a virtual environment is believable, users are more likely to become fully immersed in the story and feel as though they are truly within the depicted setting.

2.2.2. Temporal Immersion: Narrative Tension and Time as a Mechanic

Temporal immersion is a form of narrative immersion that arises from the plot of a story. It stems from the uncertainty surrounding narrative events, both past and future, and the sensation of time progression within the narrative [14]. This deliberate uncertainty serves to engage the audience by manipulating their expectations [41], thus generating tension, anticipation, and what Ryan refers to as temporal immersion [14].

Narrative tension, achieved via strategies such as surprise, curiosity, and suspense, plays a crucial role in manipulating audience expectations [14,41–43]. In interactive environments such as VR, temporal immersion can also be facilitated by utilizing time as a mechanic, e.g., introducing time limits for completing actions or overcoming challenges [14,44].

Narrative Tension: Surprise, Curiosity, and Suspense

Surprise triggers a quick and momentary reaction to an unexpected event. In contrast, curiosity and suspense create a longer-lasting desire for knowledge [14]. While surprise may be the most basic form of narrative tension, its fleeting effects make it less conducive to immersion. However, considering temporal immersion as a means of manipulating expectations [41], surprise can still be immersive. It can occur when there is a revelation of past events that reshapes what was previously known, engaging attention in a prolonged temporal context [14].

Curiosity can be likened to suspense, as both involve a desire for knowledge [14]. Curiosity is related to wanting to know about past events (diagnosis), while suspense revolves around anticipating future events (prognosis). Unlike surprise, these forms of temporal tension have a more enduring impact on the audience due to information gaps or uncertainties regarding the story's outcome [14,42].

Suspense encompasses several types, categorized by the focus of uncertainty that captures the audience's attention. Ryan describes the most common types as "what" suspense, "how" suspense, and "who" suspense [14]. "What" suspense, typical of action movies and thrillers, centers on the question of what will happen next. "How" suspense already provides an outcome, shifting the focus to understanding how a particular state was reached. This type of suspense involves converging possibilities toward a single point, unlike "what" suspense, which presents a choice between two possibilities. Finally, "who" suspense, often used in crime stories and police investigations, centers on identifying the responsible party for a specific event. This type is less intense, as it does not necessitate emotional involvement; instead, the audience derives satisfaction from intellectually solving the problem.

Time as a Mechanic

Temporal immersion can also be enhanced via the inclusion of time limits in interactive environments. This mechanic adds pressure to decision-making within a specified timeframe or requires players to defeat enemies before being killed [44]. For example, in Minecraft, survival mode offers greater potential for temporal immersion compared to creative mode. Narrative temporal immersion can be heightened by incorporating puzzles and time-limited challenges that have narrative consequences. These elements directly contribute to narrative tension. Time-based achievements, where players must complete tasks or reach specific story points within designated timeframes, introduce additional challenges and tension to the narrative.

2.2.3. Emotional Immersion: Empathy and Dramatic Agency

Emotional immersion is a type of narrative immersion that arises from the feeling of emotional connection with characters and events in a story [14]. In a VRE, emotional immersion can be promoted via strategies aimed at generating empathy, such as role-play [45] or dramatic agency [13].

Empathy

Empathy, a complex and multifaceted construct, is commonly conceptualized as comprising two primary dimensions [46–48]. These dimensions, known as affective empathy and cognitive empathy, represent distinct facets of our ability to understand and connect with others. Affective empathy involves experiencing emotional responses to the feelings of others, allowing us to share in their emotional states. On the other hand, cognitive empathy focuses on an intellectual understanding of another person's perspective, encompassing the comprehension of their emotions, desires, and intentions [46,47]. Perspective-taking is a form of cognitive empathy that, unlike affective empathy, does not involve sharing the emotional state of the other person [49].

On the other hand, identification refers to "the adoption of the identity and perspective of a character", a process that culminates in a cognitive and emotional state where the audience member is not aware of themselves as an audience member but instead imagines being one of the characters in the narrative [50]. Identification is a term used when referring to empathy with media characters [50,51] and involves both cognitive and affective components of empathy. Identification can lead to a deeper emotional connection with the story and its characters and may even result in behavioral changes. The study by Bal and Veltkamp [52] provides an example of how fictional narrative experiences involving emotional immersion can improve individuals' empathic abilities.

A VRE offers the opportunity for role-play, which has proven to effectively establish cognitive empathy by fostering perspective-taking [53]. Role-playing in a virtual environment also has emotional advantages, as it can evoke positive emotions such as confidence, self-esteem, and a sense of achievement. Assuming the role of another person can elicit these positive emotions [45].

Dramatic Agency

Dramatic agency refers to the sense of control over the outcome of the story and occurs when users are given the ability to intentionally influence aspects of storytelling [45,54]. Due to the procedural nature of digital media, designing narratives for VR involves authoring characters, worlds, and events, as well as a range of narrative possibilities and the ways these possibilities respond to user actions [13]. When these elements are combined, users experience the satisfaction of dramatic agency.

In addition to dramatic agency, the more closely the VR experience approximates real-life interaction and freedom of choice, the greater the potential for emotional immersion. More realistic experiences allow for embodied interactions and choices with moral consequences, making users feel that their behavior has repercussions and thus enhancing the formation of empathic connections with the characters and world of the story [53].

Fisher [51] conducted an analysis of various VR experiences, aiming to identify strategies that evoke empathy in users. Among these experiences, "Gnomes and Goblins" was considered to have the highest potential for generating empathy. In this VR experience, users have a sense of agency and control over the virtual environment and the events that occur within it. The character in the experience, the goblin, offers immediate feedback to user actions, reacting by running away if users get too close and coming out of hiding if offered an acorn. Building trust with the goblin becomes a gradual process, leading to the formation of an emotional and cognitive connection. Moreover, at a certain point, there is a direct perspective-taking as the user is reduced to the size of the goblin, enhancing the empathic experience.

On the other hand, the experience with "Henry" was considered to have lower potential for emotional immersion. Interactions with the character are non-existent, and strategies for generating empathy are adapted from traditional cinema, such as the use of close-ups. In this scenario, the user is relegated to a passive observer role with no ability to move or interact with the character, limiting the empathic engagement.

3. Methods

Our review aimed to examine the utilization of digital narratives and games in VR-based therapeutic exposure to animal phobias. To address this, we employed a structured analysis model that drew upon the theoretical concepts introduced earlier. Our inquiry revolved around key questions: identifying studies that transcended mere perceptual immersion, exploring the integration of ludic and narrative elements in VR-based phobia therapies, and investigating diverse dimensions of ludic and narrative immersion.

The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [55] for methodology and communication.

3.1. Keywords and Database

An initial search for articles was conducted using two scientific databases, Scopus and Web of Science, using the keywords "virtual reality", "therapy", and "phobia" to identify potential studies for screening and assessment in the review. The requirement incorporated was for these terms to appear simultaneously in the title, abstract, or keywords of the results. To ensure the exclusion of review articles, specific conditions were used in each database query. The search covered articles published in the English, Portuguese, or Spanish languages from 2012 to the current year (2023).

In Scopus, the advanced search query consisted of the following keywords and conditions:

> (TITLE-ABS-KEY (*phobia AND therapy AND "virtual reality" OR vr) AND NOT TITLE ("systematic review" OR "systematic literature review" OR "meta-analysis" OR "scoping review" OR "narrative review" OR "overview of reviews" OR "umbrella review" OR "rapid review")) AND PUBYEAR > 2011 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE, "English") OR LIMIT-TO (LANGUAGE, "Portuguese") OR LIMIT-TO (LANGUAGE, "Spanish"))

A similar search query was conducted in Web of Science, with the addition of manually limiting the publication date from 2012 until 31 May 2023:

> ((TS = (*phobia AND therapy AND ("virtual reality" OR vr))) NOT TI = ("systematic review" OR "systematic literature review" OR "meta-analysis" OR "scoping review" OR "narrative review" OR "overview of reviews" OR "umbrella review" OR "rapid review")) AND LA = (English OR Portuguese OR Spanish)

3.2. Inclusion and Exclusion Criteria

Studies published between 2012 and 2023 in Portuguese, Spanish, or English were included. Review articles and meta-analyses were excluded. Additional inclusion criteria were as follows:

- Description of VR-based exposure therapy interventions targeting patients with specific phobia of the animal subtype.
- Reporting of VR-based exposure, where the user's field view is fully immersed through the use of head-mounted displays (HMDs), either with computer-synthesized environments or 360-degree panoramic captures of the real world.

Exclusion criteria:

- Studies where the exposure environments were primarily designed for experimental manipulation of variables rather than specifically for exposure therapy purposes.

3.3. Search Strategy

To narrow the search, studies focusing on a single subtype of phobia were selected. This focused approach reduced the number of results and allowed for a deeper analysis of a single specific phobia type. Animal phobias were chosen due to the preliminary hypothesis implying their higher potential for instrumentalization in narratives, particularly in generating emotional engagement.

To capture a wide range of relevant studies, the search term "phobia" was used instead of "animal", as not all studies explicitly used the term "animal" and might use specific phobia names (e.g., arachnophobia or fear of snakes).

The choice for selecting studies published between 2012 and 2023 was made to focus on recent advancements in VR technology and its use in phobia treatment. Although examples of VR interventions have existed in the scientific literature since the 1990s (e.g., [56–58]), the accessibility of commercial VR equipment increased significantly around 2012 with the emergence of commercial and affordable equipment from companies such as Oculus.

The review specifically focused on VR, excluding studies involving augmented reality (AR) or other monitor-based (non-immersive) displays, in order to analyze unique narrative characteristics specific to the VR medium.

4. Results

4.1. Included Studies

A flowchart in Figure 1 illustrates the selection process leading to the final inclusion of 29 studies for analysis. Initially, 870 studies were identified in the databases, and after removing duplicates, 639 remained for screening. The screening process involved reviewing titles and abstracts to apply the inclusion/exclusion criteria. Review articles were excluded, along with studies focusing on non-animal phobias or anxiety disorders (e.g., acrophobia, dentophobia, claustrophobia, social anxiety disorder, generalized anxiety disorder, etc.), qualitative studies involving interviews, and studies explicitly reporting AR or monitor-based environments.

Afterwards, 89 studies were assessed for eligibility by thoroughly reviewing the articles, particularly focusing on their Methods sections. This assessment led to the exclusion of four studies because the target phobia in the intervention was not specific to the animal subtype. Additionally, 28 studies were excluded as they did not use VR for exposure (e.g., AR, CAVE, non-immersive monitor-based approaches, or in vivo exposure).

Six studies were excluded because they either lacked sufficient details about the VRE or did not provide any information at all, such as studies involving dataset comparisons or technical system descriptions. One study was a short communication related to another study in the screening list.

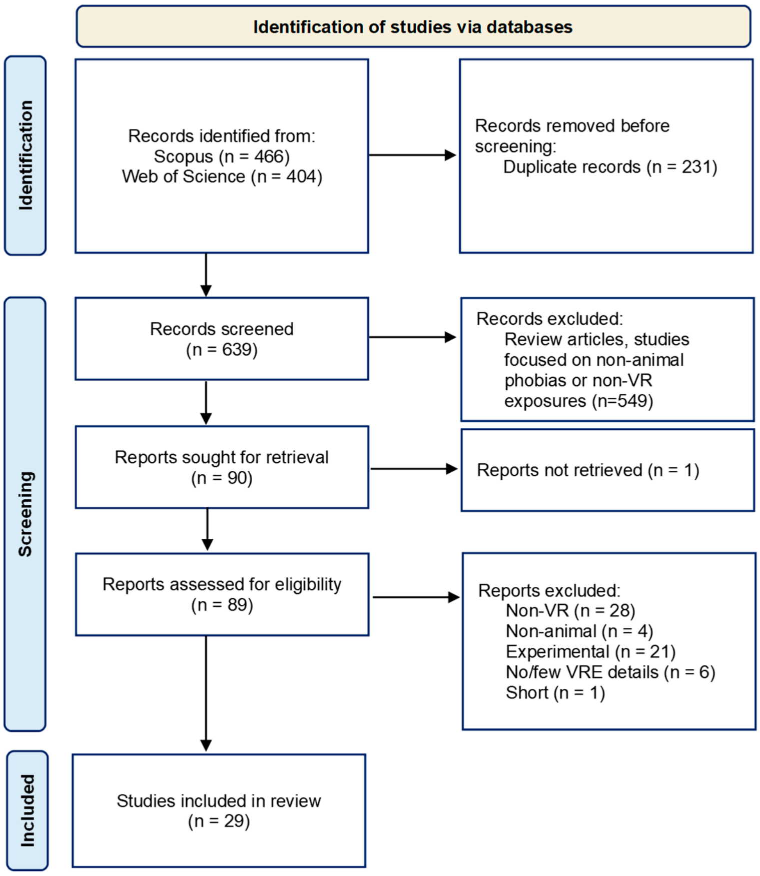

Figure 1. PRISMA flow diagram [55].

The remaining 21 studies were excluded as they did not involve exposure interventions but rather focused on eliciting fear reactions within the VRE as part of their experimental studies. It is worth noting that not all experimental studies were excluded; rather, the exclusion mainly targeted those with a single exposure scenario and minor variations, or studies that provided limited details about the VRE.

4.2. Overview

Figure 2 provides an overview of the articles considered for review, showing the frequency of articles by phobia type (Figure 2a) and publication year (Figure 2b).

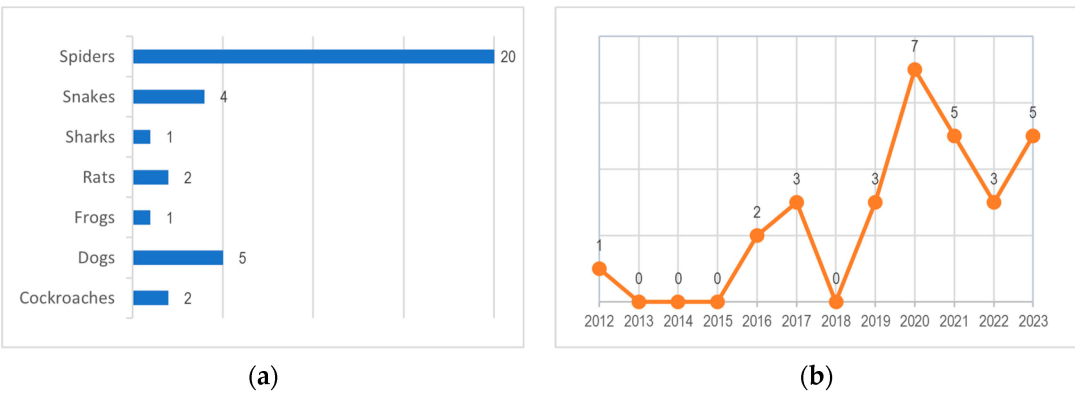

Figure 2. (**a**) Frequency of studies per phobia type; (**b**) Frequency of studies per publication year.

Among the 29 articles included, seven distinct types of phobias were identified: cockroaches, dogs, frogs, rats, sharks, snakes, and spiders. The total number of phobias addressed (35) exceeds the total number of articles (29) because some studies propose interventions for different animals. For instance, in some studies, the VRE allowed for exposure to snakes or spiders [59,60].

Spiders were the most frequently addressed animal, appearing in 20 articles, which corresponds to 57% of the studies. This significant representation can be attributed to the high prevalence of arachnophobia compared to other types of phobias in the general population [61,62]. On the other hand, less common phobias, such as sharks and frogs, were represented only once. Squalophobia, the fear of sharks, appears to have no epidemiological reports regarding its prevalence in the general population [63]. The study investigating this phobia is a case study involving a 30-year-old woman who self-referred to the VR exposure program without any prior official diagnosis.

In terms of publication years, most studies (79%) were published between 2019 and 2023, reflecting what seems to be a recent surge in research in this area.

The increased number of articles published after 2016 can be attributed to the advancement and wider accessibility of consumer-oriented VR technologies. This period witnessed the introduction of more affordable and higher-quality equipment, enabling a more immersive and comfortable user experience. The commercial release of the Oculus Rift CV1 in 2016 marked a significant milestone in the availability of VR devices for research purposes.

4.3. Analysis of Non-Perceptual Immersion in VR-Based Exposure to Animal Phobias

We sought to obtain an overview of the immersive potential of VREs designed for therapeutic exposure to animal phobias, focusing on non-perceptual, ludic, and narrative forms of immersion. The analysis followed the analysis model built and presented in Table 1. Each study's VR experience was evaluated for immersion potential (none, low, moderate, high) in each of the dimensions. An overview of the results is summarized in Table 3, which includes citations and their corresponding ratings based on potential for immersion across the various dimensions. Additionally, Figure 3 visually represents the frequency of these ratings for the different types of immersion, allowing for a better sectorial and intersectoral analysis.

Table 3. Summary of included studies by potential for immersion.

	No Potential	Low Potential	Moderate Potential	High Potential
Ludic Immersion	[64,65]	[60,66–82]	[59,63,83]	[12,84–88]
Spatial Immersion	-	[59,60,64–67,71,75,81,82]	[12,68–70,72–74,76–80,83–86,88]	[63,87]
Temporal Immersion	[59,60,64,66,67, 74,75]	[65,68–73,76–83]	[12,63,84–88]	-
Emotional Immersion	[59,60,63–84,87]	[12,85,86,88]	-	-

It is important to mention that this analysis does not aim to be exhaustive regarding the examined details, as that would not be possible. Not all articles provide prototypes for in-depth inspection, so the analysis was primarily based on textual descriptions of the environments and the observation of screenshots included in some of the articles. Nonetheless, it is believed that there is enough detail to obtain a general idea by identifying patterns and trends. At the same time, it is an opportunity to test the use of the analysis model and reflect on it. In the discussion section, the limitations of the analysis and the obtained results will be presented in greater detail.

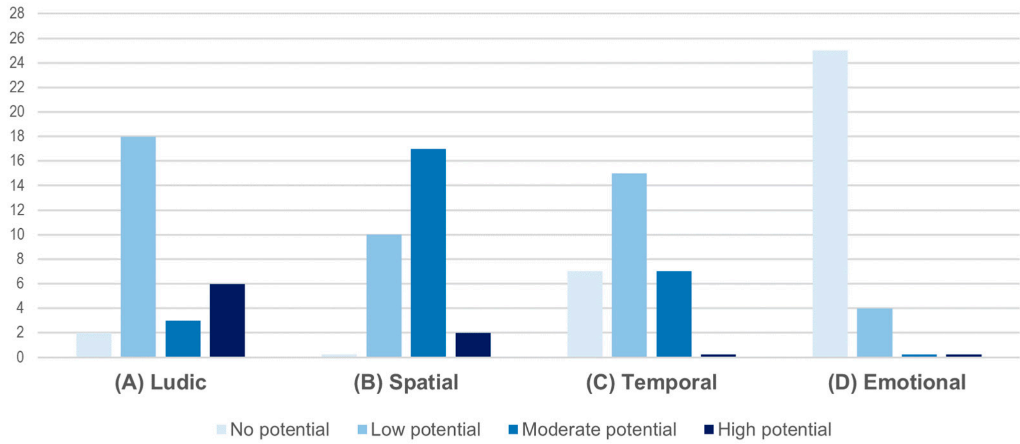

Figure 3. Overview of the results for each dimension: article frequency by potential for immersion.

4.3.1. Ludic Immersion

The analysis of ludic immersion potential in each VRE was based on the criteria established in Table 1. In each study, we aimed to identify characteristics that could promote users' sense of competence and autonomy. These included the presence of gradually adjustable challenges based on individual abilities and environments that allowed users to define their own path, engaging in tasks and challenges at their own pace.

Based on the analysis, two of the virtual environments were found to lack features that could promote a sense of competence or autonomy. Among the remaining studies, 18 were classified as having "low" ludic immersion potential, while three had "moderate" potential, and the remaining six demonstrated "high" potential (Figure 3A).

More than half of the analyzed studies (approximately 69%) had low or nonexistent potential for ludic immersion. This can be attributed to the prevalence of studies that use virtual environments replicating in vivo exposure without incorporating ludic or narrative elements to frame phobic stimuli, thus missing the ludic potential of the medium. Exemplary of this approach are the studies by Farrell et al. [67] and Leehr et al. [68], which are based on Öst's [8] technique of brief and intensive therapy for specific phobias, consisting of a single session's exposure to the feared object or situation.

Only 7 out of the 29 studies mediate phobia exposure via gaming elements and activities. However, this does not imply that the remaining studies lack ludic immersion potential, as this type of immersion is not limited to games or entertainment-focused activities. As mentioned in Section 2.1, ludic immersion can be achieved via experiences that offer engaging challenges and activities, resulting in feelings of involvement and task efficacy. When an experience offers various levels of challenges that adjust to the user's capabilities, the user can engage in tasks that are within their abilities, contributing to a sense of efficacy, a fundamental characteristic of ludic immersion.

No Potential for Ludic Immersion

Both studies which were found to have a VRE lacking ludic immersion potential involve non-interactive 360° videos. In one of the studies, the feasibility of a multimodal internet-based exposure approach is evaluated, incorporating images, videos, games, and 360° videos [64]. While the entire intervention holds potential for ludic immersion, particularly during the digital game phase, the only VR component is present when the user watches 360° videos, which were not described as possessing the characteristics associated with ludic immersion. In the other study [65], there is an increase in spider intensity as the video progresses; however, the user lacks control over this intensity, and there is no task that could provide a sense of mastery, thus limiting any sense ludic immersion.

Low Potential for Ludic Immersion

The existence of gradual challenges, where each task is presented only when the user feels comfortable with the level of challenge offered in the previous task, promotes feelings of competence and contributes to a minimum ludic immersion potential. All studies classified as having low ludic immersion potential had some form of difficulty variation, either adaptively based on individual anxiety levels [81] or via predefined tasks and environments with different difficulty levels [60,66–80,82].

In some studies, difficulty levels were established beforehand using a fear hierarchy, sometimes in collaboration with the individual. In Farrell et al. [67], children are exposed to various dog breeds following a hierarchy of situations ranging from task one (observing a dog on a leash with an assistant entering and sitting on the opposite side of the room) to task ten (observing a dog off-leash without an assistant).

In addition to variable difficulty, the use of voice cognition (VC) was believed to contribute positively to the sense of efficacy. VC refers to voice-overs that accompany the user during the experience, simulating their inner voice. These narrations can provide positive reinforcement and contribute to the user's perceived competence. Ding et al. [60] investigated the use of dynamic VC, which varies according to the user's gaze direction. It was found that this feature not only positively influences the feeling of ownership of VC but also influences user behavior, increasing the frequency of gaze shifts towards different elements of the scenario after receiving instructive VC.

Moderate Potential for Ludic Immersion

In Malbos et al. [63], a case study on shark phobia, the existence of different difficulty levels is combined with high autonomy. It involves an open-world virtual environment that users can explore freely, where contact with phobic stimuli is not forced and only occurs when the user feels prepared. Moreover, immediate contact with sharks is avoided until the third and final environment, which is an ocean. However, the patient is instructed, but not coerced, to enter the virtual ocean, swim, and stay in the water until their anxiety level decreases before being confronted with a shark.

In the remaining studies, in addition to gradually intensifying the phobic stimuli, there are simple mechanics designed to guide users toward exposure to these stimuli in a playful manner. In Go et al. [59], the objective is to collect coins placed throughout the environments while simultaneously encountering phobic stimuli. The number of coins is related to the level of challenge: more demanding tasks yield greater rewards.

High Potential for Ludic Immersion

The remaining six studies, classified as having high potential for ludic immersion, describe more formal gaming experiences. These experiences have in common the existence of different levels with progressively increasing difficulty, where phobic stimuli become more realistic [84,88] or more numerous [87]. In some applications, the phobic stimulus starts out having a cartoon-like appearance before evolving into more realistic versions.

In Lindner, Rozental et al. [85], various challenges are present. One challenge involves helping a spider by preventing it from being washed away from a wall by rain. To accomplish this, users must fix their gaze on the moving spider, causing an accompanying umbrella to shield it from the rain. Other tasks include maintaining gaze on the spider to keep it moving or to earn more points.

In the study conducted by Fajar et al. [84], the designed game comprises five different levels, each with a specific challenge of moving a spider to a designated target within a set time limit. As the game progresses through these levels, the difficulty increases, and the appearance of the spider becomes more realistic.

4.3.2. Spatial Immersion

All VR experiences provide a minimum level of spatial immersion as they transport the user to a digital environment that completely replaces their perception of the real-world space they are in. Therefore, none of the evaluated studies were classified as having no potential for spatial immersion. However, according to the analysis model, only studies that offered a greater variety of scenarios or allowed user movement in space were classified as having moderate or high degrees of spatial immersion. Thus, in addition to 10 studies with low potential for ludic immersion, 17 were classified as having moderate potential, and 2 as having high potential (Figure 3B).

Low Potential for Spatial Immersion

Many studies with low potential for spatial immersion shared a similar type of navigation freedom, limited to three degrees of movement where users could only rotate their heads in the virtual environment but not move within it [59,60,64–67,71,75,81]. Although Farrell et al. [67] and Minns et al. [65] had high realism due to high-definition video captures of real environments and animals, they lacked sufficient navigational freedom as they were non-interactive videos that didn't allow users to explore the presented environment spatially. Brice et al. [82] utilized a HMD capable of providing 6DOF; however, the freedom of movement was not explored in the study. The participants were seated during the VRE experimentation, and the extent of the space was confined to a box where the exposure stimuli were presented.

Moderate Potential for Spatial Immersion

The analysis of navigation freedom was a key criterion. The possibility of moving in the VRE with 6DOF alone is generally sufficient to provide a moderate sense of spatial immersion. A majority of the studies allowed a navigation with 6DOF, encompassing three degrees of rotation and three degrees of translation [68–71,73,74,76–80,83,84,87].

However, even with 3DOF, a moderate sense of spatial immersion can still be achieved, depending on the believability of the VRE. Certain studies presented visually coherent and well-crafted scenarios in terms of aesthetics and detail, even though locomotion was not allowed [12,85,86,88]. These studies also presented variations in the realism of spiders, ranging from cartoon-like to more realistic appearances, while consistently maintaining visual and logical coherence.

High Potential for Spatial Immersion

The two studies classified as having high potential for spatial immersion offered both high navigational freedom and a high level of believability. They provided spatial locomotion with 6DOF in open environments that allowed users to freely explore vast spaces. In Malbos et al. [63], a study related to shark phobia, users could walk and swim in expansive areas. Both studies paid special attention to constructing environments that closely resembled reality, aiming for a high level of spatial immersion.

Toma et al. [87] mentioned the use of high-quality textures and visual and sound effects related to wind and water. However, Malbos et al. [63] demonstrated a greater concern for aspects of spatial immersion. They implemented different situations (namely pool, lake, and ocean) and various phobic elements (e.g., dark rocks, moving fish, and algae) to provide multiple exposure contexts. They aimed to engage multiple senses simultaneously, including visual cues (e.g., landscape, ocean, fish, and sharks), auditory cues (e.g., footsteps, seagulls, water splashes, and underwater movements of the shark), and proprioceptive and vestibular cues induced by motion sensors. Different types of interactions were also incorporated to enhance realism, such as object collisions, observable water, and terrain reactions based on physical laws, and the ability to interact with elements in the environment, such as stones and crabs.

4.3.3. Temporal Immersion

The analyzed VR experiences lack a plot, since they do not have a sequence of events forming a story [89]. Although most experiences include different phobia exposure situations, these situations are not organized in a narrative structure.

The absence of a plot hinders the potential for temporal immersion in the analyzed experiences, as narrative tension, which arises from the story's plot, is a primary source of this immersion. However, phobia exposure experiences can still generate feelings of tension and uncertainty due to the contact with phobic stimuli, like the feelings evoked by narrative tension. In this regard, the unpredictability associated with the animals' behavior was believed to provide a minimal sense of temporal immersion.

Among the analyzed studies, 7 were classified as having no potential for temporal immersion, 15 as having low potential, and 7 as having moderate potential (Figure 3C). Environments with more realistic animal behaviors were evaluated as having a higher degree of temporal immersion. Realism was assessed based on the animal's movement, dynamic behavior, and its ability to react to the user. For example, an animal whose movement responds to the user's actions would be more immersive than a static or predictable animal.

No Potential for Temporal Immersion

Studies classified as having no potential for temporal immersion are those where virtual animals either have no movement or their movement is not dynamic [59,60,64,66,67,74,75]. In some cases [67,75], the animals move, which can create some tension. However, as they are non-interactive pre-recorded video sequences, they lack the same tension that would be present in a simulation where the animal "acknowledges" the user's presence, as observed in other studies. In a similar case, the animal exhibits pre-defined behavior that does not respond to the user's presence [60].

Low Potential for Temporal Immersion

The 15 studies classified as having low potential for temporal immersion present animals with minimally dynamic movements and behaviors that can generate some tension or anxiety related to anticipating the animal's movements [65,68–73,76–83].

In one of the studies [81], boxes are scattered throughout the scenario, from which spiders emerge. This technique prevents spiders from instantly appearing in the user's field of view in an unrealistic manner. However, it also serves as a strategy to generate anticipation, as the user does not know when spiders will emerge from behind the boxes.

Examples of studies with animals exhibiting dynamic behavior include a study where the spider moves when the user touches it [70] and where the dog wakes up and moves when the user approaches at a certain distance [72]. In the study conducted by Oxley et al. [78], a dog can exhibit up to 10 different aggressive behaviors, which vary based on the participant's distance from the dog and the speed of approach

In the study by Taffou et al. [83], addressing cynophobia, besides virtual animals exhibiting dynamic behavior in response to the user's proximity, a strategy was employed to create a sense of anticipation in the user. The user's task is to follow a frog, which creates a desire to know where the frog is leading and what will happen next, similar to the moment when Alice follows the rabbit in *Alice in Wonderland*.

In one study, animals exhibit non-interactive behavior, but techniques are used to generate tension, such as in a high-definition stereoscopic video experience where the spider approaches the user as if aware of its presence [65].

Moderate Potential for Temporal Immersion

In many of the studies classified as having moderate potential for temporal immersion, in addition to animals displaying dynamic movements and behaviors, the use of time as a game mechanic is present, which is one of the criteria capable of generating temporal immersion according to the analysis model employed (Table 1).

The use of time as a game mechanic is observed in 6 studies with game-like characteristics [12,84–88]. In one of the studies, temporal immersion is generated via the "kill or be killed" mechanic [87]. Users traverse a path where snakes appear, and they must eliminate the snakes since the snakes will chase the user when they approach. Additionally, tension is heightened by strategically placing snakes along the path, with some snakes being highly visible while others are positioned to be observed later, making them more challenging to eliminate. In Fajar et al. [84], all the challenges involve performing a task within a set time.

In the other 4 studies with game-like characteristics where time is utilized as a mechanic, users are challenged to perform tasks involving maintaining visual contact with spiders. One task involves protecting the spider from objects that could harm it, ensuring its safety, while another task requires maintaining visual contact to prevent the spider from turning away and leaving. In addition to the use of time, the spiders' movements and animations are dynamic, meaning they interact with the user's behavior [12,85,86,88].

In Malbos et al. [63], tension gradually builds via contact with clues related to the phobia, leading up to an encounter with a shark. From the pool environment to the ocean environment, the user encounters different aquatic elements increasingly related to the phobic stimulus. This is achieved via the implementation of an open, highly detailed environment and strategically placed visual and auditory cues along the path to the shark encounter.

4.3.4. Emotional Immersion

No study includes characters or narrative elements that could create a sense of empathy or identification. The closest resemblance to characters is found in 4 studies where spiders are present [12,85,86,88]. These studies showcase a gradual evolution of the spider's appearance, ranging from a more anthropomorphized, cartoon-like representation to a realistic one. The challenges in these studies involve maintaining visual contact with the spiders and, in some cases, protecting them. Consequently, these studies were categorized as having low potential for emotional immersion (Figure 3D).

In studies with low potential for emotional immersion, the tasks primarily focus on saving the spiders and maintaining visual contact with them. These tasks are believed to foster a minimal emotional connection with the animals. Additionally, the VR experiences provide information about spiders and their species, enhancing knowledge and understanding of their biology and ecological significance. This informational component aims to reduce fear or disgust toward spiders, promoting a better appreciation of their importance in ecosystems.

5. Discussion

Overall, the reviewed articles covered a diverse range of phobias and therapeutic approaches, with a particular emphasis on spider phobia. A significant number of the studies were published in the last five years, indicating a potential recent growth in research on VR-based exposure therapy.

Based on the overall results overview (Figure 3), it is apparent that narrative immersion in VR-based exposure therapy to animal phobias has received less attention compared to ludic immersion. Among the three categories related to narrative immersion (Figure 3B–D), only two studies achieved maximum immersion potential, while ludic immersion, as a standalone category, had six articles with maximum potential and almost none with the lowest potential (Figure 3A). On the lowest level, spatial immersion is the dimension with the fewest studies evaluated with no potential, which can be explained due to the spatial nature of the medium.

The limited inclusion of narrative elements, such as plot or characters, explains the lower ratings of narrative immersion. Emotional immersion received relatively low ratings in terms of potential, likely due to the creative effort required for its conception and integration with other categories. Creating an engaging and empathetic plot for emotional immersion proves more challenging than developing ludic scenarios and tasks that can be easily generalized across various phobias.

An intersectional analysis reveals that features promoting ludic immersion are intrinsically linked to those facilitating narrative immersion. The six studies with high ludic immersion potential also received positive ratings in the narrative immersion categories. Notably, four of these studies [12,85,86,88] had the higher potential for emotional immersion compared to other studies. Additionally, these studies demonstrated medium potential in the spatial and temporal immersion categories. Another study [87] showed high potential for spatial immersion and medium potential for temporal immersion while having high potential for ludic immersion.

Similarly, the seven studies with the highest potential for temporal immersion also had positive ratings in the ludic immersion category, reinforcing the connection between ludic and narrative immersion. Six of these studies demonstrated high ludic immersion potential [12,84–88], while the remaining study [63] showed medium potential.

These findings indicate that characteristics conducive to narrative immersion are consistently subordinate to those that enhance ludic immersion. Narratives tend to serve as secondary elements in virtual experiences with game-like or ludic features. The decision to concentrate on phobias related to animals was driven by the belief that such phobias offer better opportunities for using narratives to evoke emotional engagement during virtual reality exposure therapy. However, this review reveals that such utilization is not yet fully realized.

The absence of studies where the use of narrative elements is disengaged from gaming strategies highlights an opportunity to investigate their independent use. This prompts a reflection on the potential of narrative, separate from gaming, by leveraging its own dimensions such as spatial navigation freedom, narrative tension, or dramatic agency as motivational factors.

The review emphasizes the immersive potential of VR-based exposures across all the analyzed dimensions. Notably, ludic immersion is evident in games that align challenges with exposure therapy objectives, showcasing how VR can effectively merge entertainment with therapeutic goals. Moreover, spatial immersion, which is inherent to the medium, can be further enhanced through well-crafted and coherent scenarios, as demonstrated in the study by Malbos et al. [63], where multiple senses are engaged simultaneously in an open-world environment.

While temporal immersion is also addressed implicitly in some studies, with dynamic and unpredictable stimuli inducing tension and anticipation, its full potential could be unlocked by combining fear-induced tension with narrative tension via a plot framing the phobic stimuli, an aspect that has not been explored yet.

Additionally, emotional immersion shows promise but remains relatively unexplored. Establishing a deeper connection between the user and the virtual animal could foster identification, though it is currently only lightly implemented in the game where the user must protect the spider [86]. Thus, exploring and harnessing emotional immersion, in conjunction with the other dimensions, may pave the way for novel approaches to VR-based exposure therapy, presenting an exciting avenue for future research.

Lastly, it is essential to underscore that while this study is primarily centered around the exploration of ludic and narrative features, we acknowledge the indispensable role of perceptual cues, or perceptual immersion, in the context of exposure therapy. Research has shown that perceptual cues are fundamental in inducing higher fear activation and facilitating greater fear habituation when compared to conceptual cues [90]. Therefore, the utilization of non-perceptual cues should not be regarded as a replacement for their perceptual counterparts. Moreover, within the scope of our broader study, one of our research hypotheses revolves around the notion that ludic and narrative features can serve as motivational tools, encouraging users to tolerate higher levels of anxiety, while contextualizing the phobic stimuli, fostering a synergy between perceptual, ludic, and narrative immersion in the therapeutic process.

Several limitations should be noted. The VREs described in the studies varied in maturity, ranging from experimental prototypes to functional prototypes evaluated in clinical trials, and may not fully represent the final product. Consequently, certain aspects considered essential for immersion may not have been thoroughly developed and may only be included in advanced implementation stages. It is worth emphasizing that the lack of experimental studies investigating the impact of narrative elements signifies a research opportunity that may require additional time for integration into clinical trials.

To assess the VREs, the review process relied on the information provided by authors in their respective articles, which varied in level of detail. While this approach allowed for a broad evaluation, it may not fully exploit the potential of the analysis model, which is specially intended for comprehensive inspection through empirical observation or experimentation. As a result, the findings should be considered a general indication of the immersive potential of the analyzed studies rather than an absolute measurement.

6. Conclusions

Within the context of therapeutic exposure to phobias, VR stands as a medium with the potential to motivate patients to confront their fears in a controlled environment. This systematic literature review has explored the use of digital narratives and games in these therapeutic contexts, with a primary focus on uncovering the main ludic and narrative features in studies dedicated to animal phobias. Our analysis, driven by a selection of twenty-nine studies, evaluated those features, shedding light on the relationship between ludic and narrative immersion. Moreover, this study goes beyond the scope of these findings. Drawing upon established theoretical foundations, we provide a framework that can inform the analysis and design of VR-based therapeutic interventions, with a specific emphasis on the incorporation of ludic and narrative aspects.

Via a comprehensive analysis of the reviewed studies, several key findings have emerged. First, it is evident that narrative immersion has received notably less attention compared to its ludic counterpart. The limited inclusion of narrative elements, such as plot and characters, has contributed to the lower ratings of narrative immersion. Additionally, emotional immersion, a critical dimension, remains relatively unexplored, which can be attributed to the creative challenges involved in its integration. Furthermore, an intersectional analysis has revealed a consistent link between features promoting ludic immersion and those facilitating narrative immersion. Studies with high potential for ludic immersion also tend to exhibit positive ratings in the narrative immersion categories, highlighting the subordinate role of narrative elements in virtual experiences dominated by game-like or ludic features.

This review is aligned with our broader project's goals, which aim to explore the essential factors that enhance narrative immersion in VR-based exposure therapy for phobias. By emphasizing the narrative dimension, we seek to open up new avenues for research in communication and interaction design, bridging the gap between psychology, communication and interaction design. In our future work, we intend to delve deeper into some of the discussed uncharted territories, such as the integration of narratives less dependent of ludic features, by leveraging its own dimensions such as spatial navigation freedom, narrative tension, or dramatic agency, as well as the exploration of models able to adapt narratives to the unique needs and fears of individual users. We also plan to conduct empirical studies to evaluate the impact of ludic and narrative elements on treatment outcomes, bridging the gap between theory and practice.

Author Contributions: Conceptualization, S.M. and M.V.; methodology, S.M. and M.V.; validation, S.M. and M.V.; formal analysis, S.M. and M.V.; investigation, S.M. and M.V.; resources, S.M. and M.V.; data curation, S.M.; writing—original draft preparation, S.M.; writing—review and editing, S.M. and M.V.; visualization, S.M.; supervision, M.V.; funding acquisition, S.M. and M.V. All authors have read and agreed to the published version of the manuscript.

Funding: This work is financially supported by national funds through FCT—Foundation for Science and Technology, I.P., under the project UIDB/05460/2020, and under the Ph.D. grant 2021.08437.BD.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data generated in this systematic literature review have been made publicly accessible in an archive. The archive includes a spreadsheet file containing data from both the screening and review processes. Additionally, there are three. BIB files containing all the bibliographic citations, organized as records identified from databases, records checked for eligibility, and records included in the review. The archive can be assessed at: https://drive.google.com/drive/folders/1hdfHbYdsm_Xrc_0B2pRwAOd7p-fkGFWd (accessed on 2 October 2023).

Acknowledgments: S.M. would like to acknowledge the financial support provided by FCT—Foundation for Science and Technology and express gratitude for the research facilities, resources, and support provided by DigiMedia research unit.

Conflicts of Interest: The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

Abbreviations

The following abbreviations are used in this manuscript:

AR	Augmented Reality
CAVE	Cave Automatic Virtual Environment
CBT	Cognitive Behavioral Therapy
DOF	Degrees of Freedom
HMD	Head-Mounted Display
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SDT	Self-Determination Theory
VC	Voice Cognition
VR	Virtual Reality
VRE	Virtual Reality Environment

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