Much Realistic, Such Wow! A Systematic Literature Review of Realism in Digital Games

Katja Rogers
katja.rogers@acm.org
Stratford School of Interaction Design and Business
University of Waterloo
Waterloo, Canada

Sukran Karaosmanoglu
sukran.karaosmanoglu@uni-hamburg.de
Universität Hamburg
Hamburg, Germany

Maximilian Altmeyer
maximilian.altmeyer@dfki.de
German Research Center for Artificial Intelligence (DFKI)
Saarland Informatics Campus
Saarbrücken, Germany

Ally Suarez
ally.suarez@uwaterloo.ca
University of Waterloo
Waterloo, Canada

Lennart E. Nacke
lennart.nacke@acm.org
Stratford School of Interaction Design and Business
University of Waterloo
Waterloo, Canada

ABSTRACT

Researchers reference *realism* in digital games without sufficient specificity. Without clarity about the dimensions of realism, we cannot assess how and when to aim for a higher degree of realism, when lower realism suffices, or when purposeful unrealism is ideal for a game and can benefit player experience (PX). To address this conceptual gap, we conducted a systematic review using thematic synthesis to distinguish between types of realism currently found in the digital games literature. We contribute qualitative themes that showcase contradictory design goals of realism/unrealism. From these themes, we created a framework (i.e., a hierarchical taxonomy and mapping) of realism dimensions in digital games as a conceptual foundation. Our themes and framework enable a workable specificity for designing or analyzing types of realism, equip future work to explore effects of specific realism types on PX, and offer a starting point for similar efforts in non-game applications.

CCS CONCEPTS

• **Human-centered computing** → **HCI theory, concepts and models**; • **Software and its engineering** → **Interactive games**.

KEYWORDS

realism, fidelity, systematic literature review, thematic synthesis

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1 INTRODUCTION

Realism is an essential and ubiquitous building block in the fabric of games [92, 98, 127]. Realism has a long history of being sought after in many different art forms and media, and games are no different. The concept of realism is widespread in game design and games research [2, 58, 149]. The side effects attributed to realistic games include being considered more intuitive and more immersive [50, 92, 106]. Thus, realism frequently appears to be an implicit or explicit goal in games user research.

However, applied definitions of realism are often ambiguous and vague, despite its multi-faceted complexity. Proclaiming a game should be realistic is nearly useless because of this clear lack of synthesized understanding of all existing realism concepts. Without a qualifier of *what kind* of realism people refer to, discussing realism currently holds little to no value for game designers or researchers. Across research on digital games and human-computer interaction (HCI), there are multiple different typologies of realism, which we will introduce below. However, these frequently consider only a subset of realism dimensions (e.g., only realism relating to visual vs. behavioural aspects of virtual characters [169]) or they originate from the study of particular game genres (e.g., first-person shooters [137]). This has created a fragmented foundation for realism and its dimensions in digital games. Without a clearer overview of the dimensions of realism in digital games, it is almost impossible to systematically explore the design, measurement, and research on contributing factors to realism in games, and its effects on player experience (PX). This is the research gap we aim to bridge: building a framework of realism dimensions in digital games, to provide a foundation for future work on effects of realism on PX.

In particular, the goal of this paper is to answer the following research question: *What dimensions of realism in games are present in the literature?* By answering this question, we develop a first overview of the different types of realism in digital games, based on the current state of the literature. This informs our understanding of realism as a construct in digital games, and provides theoretical grounding for talking about and researching realism in its different facets. Further, we not only identify the dimensions of realism in

current discourse, but also contribute a first illustration of how these different types of realism relate to one other (in a hierarchical taxonomy), and how they fit into a prototypical model of player-game interaction. For the latter, we chose Adams' game model [2]; thus mapping the dimensions into the domains of player, game input, game output, and core mechanics.

Our approach to developing this framework consisted of a systematic literature review with rigorous methodology that adheres to guidelines (e.g., developing an a priori protocol) and using a formal synthesis method for qualitative data. As our synthesis method, we applied thematic synthesis [164] to develop qualitative themes and initial realism types. These were based on occurrences of realism terms within the literature, in a corpus of 205 papers. Through a series of affinity mapping and card sorting activities within our research team, we then refined the initial realism types into a hierarchical taxonomy of 29 realism dimensions with different abstraction levels (see Figure 6). Further, we charted the realism types within Adams' model of player-game interaction [2].

Our contributions are thus as follows: 1) a two-part framework of realism dimensions in digital games, and 2) qualitative themes that showcase the dichotomous and contradictory function that realism holds in games research. Our two-part framework of realism dimensions consists of the hierarchical taxonomy of realism dimensions, and the mapping of realism dimensions within Adams' game model. It represents a first comprehensive vocabulary of the dimensions that realism can encompass in digital games. We believe that it will aid the field in being more specific when talking about, when designing, and when researching aspects of realism, and thus systematize future work. With this conceptual foundation, our field will be able to more systematically explore specific dimensions of realism to determine when high realism, moderate realism, or a lack of realism is most beneficial for PX. Further, we hope that it will spark discussion about which dimensions of realism prevalent in digital games may also generalize to non-game applications, such as virtual reality (VR) (and its cousins mixed reality [108] and cross reality [173]), as a vantage point for similar research efforts in non-game HCI.

2 BACKGROUND

We venture from a general definition: *realism* as "the quality or fact of representing a person or thing in a way that is accurate and true to life" [131]. In the context of games, realism can be upheld in many ways: graphics and character animation are commonly discussed in terms of realism [152, 156], as well as storylines [55, 127], sound effects [47], or how the game allows players to physically manipulate virtual objects [92]. Yet we note that outside of games, the term"realism" is used broadly and can also refer to the foundation of multiple artistic movements [11, 69, 115, 117], schools of philosophy [110], and concepts in international politics [109].

Another term that is sometimes used synonymously[1] with realism is *fidelity*, which can be defined as: "the degree of exactness with which something is copied or reproduced" [130]. Based on these two definitions, fidelity is the broader, overarching term. For the purposes of this paper, we thus conceptualize realism as a sub-type of fidelity in which the thing being signified in the reproduction process is the real world. For example, a game with mythical creatures like dragons as virtual characters cannot be considered realistic at least in some regards—because no matter how sophisticated the graphics, there is no true-to-life way to portray a dragon. However, the game may still have high fidelity with regards to existing portrayals of dragons in games, or other mediums.

However, as we will see in our thematic synthesis, this is not the only definition of fidelity: for some, it relates only to technical aspects like resolution or field of view [81], or to the completeness or quality of a prototype [146].

The construct of realism in games is difficult to narrow down in particular because it relates to so many different aspects (narrative, visuals, mechanics, etc.), and can be paradoxical in terms of player perception. For example, sound effects are often designed to be much more "crunchy" than they would be in real life [73, 90]. Yet they can be perceived as more realistic than the "real" sound effect would be (e.g., Foley effects for footsteps vs. footsteps recorded from real-life movements).

2.1 Realism in HCI

In HCI, designs for interaction techniques and interfaces have long drawn on realism as a design goal and affordance. By offering and signaling interaction possibilities that are similar to real-world equivalents, researchers and designers hope that users should be able to intuitively know how to perform actions, and know what functionality to expect in return from the system.

Skeuomorphism in design [36, 118] is one example of this principle: employing visual cues that relate to real-world objects, but also interaction principles [61]. For instance, an interface text field might be designed to look concave to imply they can be filled with input, and a tablet or e-reader might employ a swiping gesture reminiscent of turning pages in a real book. Skeuomorphism relates to the concepts of affordances, signifiers, and metaphors, which are commonly prescribed in design guidelines [18] and echoed by movements towards including a material lens in interaction design research [176]. It places realistic aspects—design that is in some way accurate and true to life—on a continuum with abstraction at the other end. Modern designs trend towards the latter, with minimal or "*flat*" designs that broaden the potential design space and simplify information content [157]. Yet there are mixed results regarding benefits of either design approach. Skeuomorphic design has been criticized for its potential to result in visual clutter and cognitive load [157, 165]. In contrast, flat design can oversimplify semantics [157], negatively affect older adults' performance or accuracy [165], and cause "*click uncertainty*" even among young adults [165]. New trends combine the two [100].

Reality-based interaction is a second example, referring to a framework in HCI that was first articulated by Jacob et al. [76] (see also [75]). This has become an established term used by designers and researchers to justify and generate design choices [57]. According to Jacob et al. [76], reality-based interaction is a trend in HCI that aims to "*bas[e] interaction on the real world*" to reduce cognitive effort. The goal is that "*these new interaction styles draw strength by building on users' pre-existing knowledge of the everyday, non-digital*

[1]Yet another term that is sometimes framed synonymously to realism or fidelity is the Aristotelian concept of *mimesis*, however this equivalence has also been called into question in humanities research [25].

world to a much greater extent than before" [75]. The framework suggests that there are four themes by which reality-based interaction can be applied: (1) naïve physics, and users' awareness of and skills with regards to (2) their body, (3) environment, and (4) social factors [75]. However, they also acknowledge that almost all interfaces will necessarily include unrealistic features. They discussed tradeoffs between reality-based design and power [76], or more specifically, between realism and expressive power, efficiency, versatility, ergonomics, accessibility, and practicality [75]. Similar trade-offs to realism have also been echoed by researchers like Bowman and McMahan [20] and Shneiderman [153].

Perhaps unsurprisingly given these trade-offs, alternatives to reality-based interaction have also been discussed at length in the HCI field. For example, Kulik [88] suggested a framework of imagination-based interaction to escape limitations of reality-based designs ("*'magic' techniques,*" such as enabling reversing of actions, fast and easy creation and manipulation of objects, and disabling constraints based on time or distance). Further, Jetter et al. [79] have proposed that the distinction between reality-based and digital-based interaction cannot be drawn neatly: "*When interacting with new technology, users apply all their preexisting knowledge, regardless of whether it stems from the physical or digital realm [...] some concepts from the digital world have been adopted and deeply internalized by the user population and are applied almost as effortlessly as if it were basic-level sensorimotor experiences*" [79]. Bowman et al. [21] have suggested the design of hyper-natural or magic techniques that reduce naturalness or realism or "*enhance natural interactions to make them more powerful*". Similar perspectives have been reflected in what Lehtonen et al. [91] term movement empowerment: exaggerated, "*superhuman abilities*" in movement-based digital games (e.g., [59, 66, 80, 178]).

All of the above reflect a deep dichotomy in the field of HCI: we can increasingly develop virtual interactions and worlds that closely emulate the real one we inhabit, but also some of the greatest strengths of virtual worlds stem from intentional abstraction and a purposeful *lack* of realism: allowing users to bend the laws of reality and experience something more imaginative, more interesting, and more engaging.

2.2 Types of Realism Types: A Primer

The multi-dimensional nature of realism is long established across the literature [39, 65, 127, 129]. However the field does not agree on an exhaustive list of the dimensions that realism covers. This section showcases the different typologies put forth in various domains of HCI. Specifically, we introduce typologies of realism put forth in research on CAVE systems and VR, on simulators, on non-interactive but dynamic media (e.g., movies and television shows), and finally, within games research. For reasons of scope, we exclude realism types in non-dynamic media like books. Yet we acknowledge that non-interactive but dynamic media studies in particular of course draw from this area of research.

For this part, the first author conducted an informal literature review of typologies of realism. This was based on a series of Google Scholar searches, using keyword combinations of realism/fidelity and types/dimensions; this search was continued until a full page of results was not relevant. Additionally, they applied a snowballing approach using the references of the papers found through the keyword searches. The collection was augmented further via a personally collected reading list on the topic, curated over three years of reading papers on the topic and with feedback from researchers in several research groups. An overview of this is available on request. We note that despite employing some minor aspects of systematic methodology, this is an informal review of the literature and the result cannot be considered exhaustive. Instead, it is meant as a theoretical primer to the topic of realism typologies.

The resulting overview of the literature is illustrated in Figure 1. Prior research on types of realism were roughly classified into four fields of research from which they originated: as mentioned, these are non-interactive media studies (e.g., TV shows), games research, simulator research, and CAVE systems/virtual reality research. For most of these strands of realism research, their origin can be traced back to the 70s. We identify four major domains of realism dimensions: relating to narrative, perceptual, interactive, and psychological aspects. Table 1 shows how each of the research strands covers these four domains.

In the following paragraphs, we briefly introduce existing types of realism addressed in each strand of the literature, beginning with non-interactive media studies, and ending with realism typologies in games research. As will be seen from the terms, sometimes the same term is used by different authors to refer to different things, or a term is used more broadly by some authors than others. Further, the terms realism and fidelity themselves are often used interchangeably. We provide a list of original quotes as descriptions of each type of realism in the supplementary materials.

2.2.1 Realism Typologies in Non-Interactive Media Studies. Non-interactive media studies as a field of research itself draws on realism in non-dynamic and non-interactive media studies (e.g., realism in books). Unsurprisingly, this strand has a distinct focus on narrative subtypes of realism. One of the earliest realism dimensions results from an exploration of realism in TV media: a *magic window* type of realism [29, 30, 68, 129], which refers to the medium's ability to "*allow[...] one to observe ongoing life in another place*" [29, 30]. Another early type of realism resulting from this strand conferred a higher degree of realism to media experiences that contain "*information or events [...] useful to the viewer in real life*" [29, 30] (*usefulness of social expectations* [68], *utility* [29, 30, 129]). The third type of realism ranging from the earlier decades of this strand refers to *identity* [29, 30, 129]: "*a feeling of closeness to characters*" [129]. Hall [65] instead terms this *(emotional) involvement*, but similarly relate it to "*[whether] the audience could either feel the characters' emotions or have an affective response to the characters as they would to a real person*". This type of realism should however not be confused with Grodal [60]'s *emotional realism* within this strand, which refers to media's ability to elicit any kind of affective response, regardless of the involvement of characters (e.g., "*inducing the viewer to experience the nervous, stressful situations*"). This more general emotional response type of realism is more closely related to more recent perspectives like those of Rooney et al.'s [143, 144] *apparent realism*: they consider a type of realism that is experienced "*online*" as a kind of "*experiential authenticity or the 'illusion of non-mediation'*" [144] that includes presence, narrative consistency, and perceptual persuasiveness.

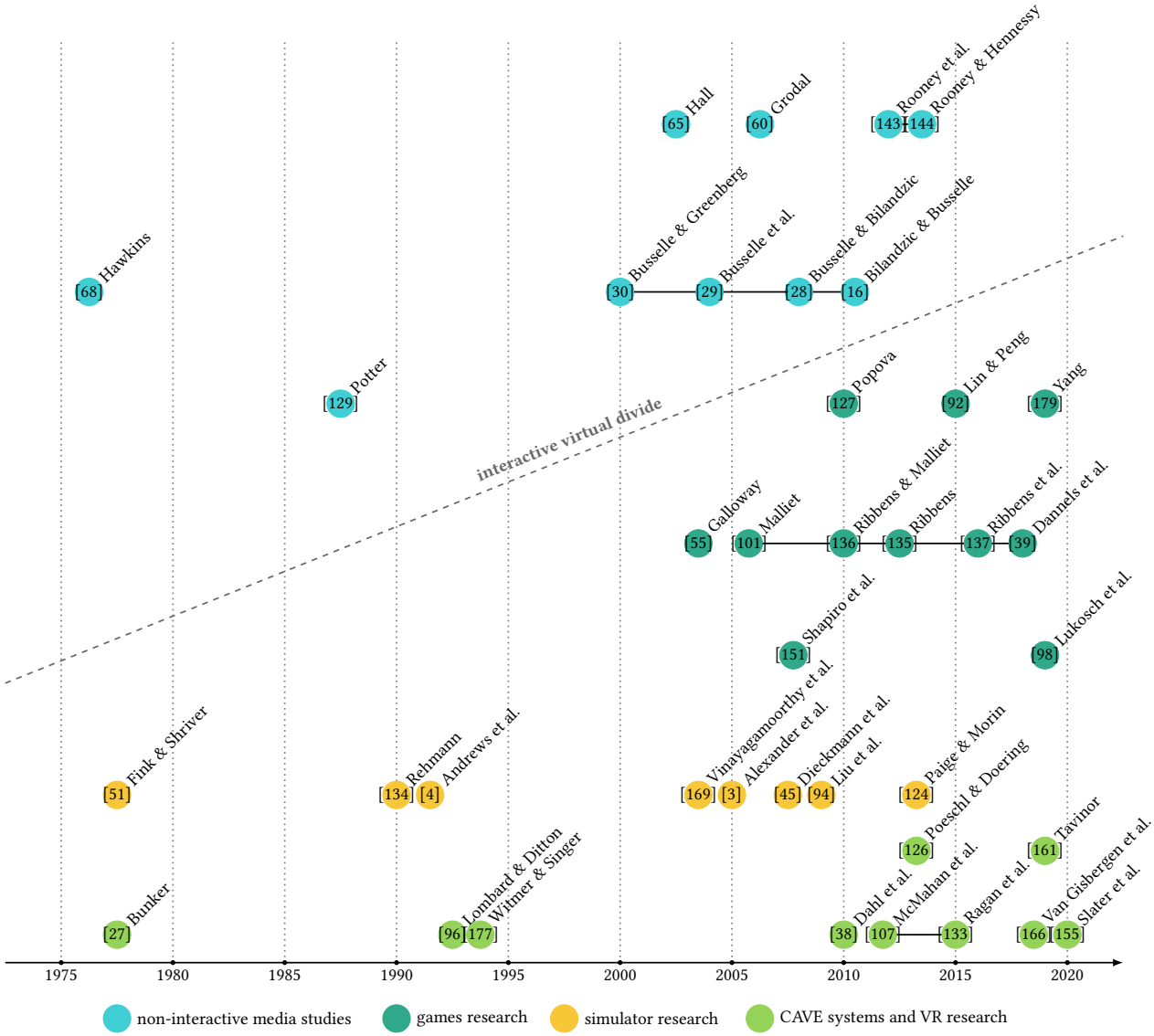

Figure 1: Realism strands: typologies of realism can be assigned to one of four fields of research: non-interactive media studies (e.g., TV shows), games research, simulator research, and CAVE systems/virtual reality research. They are presented here based on their year of publication; publications sharing a common author were connected by a line. Additionally, we draw a dashed line to distinguish between the typologies of realism referring to non-interactive media, and those referring to interactive media (games, simulators/simulations, CAVE and VR applications).

Narrative consistency is seen as a separate dimension by Hall [65], yet termed *narrative realism* by others [16, 28]. This is closely related to many other types of realism that focus on whether events portrayed in the mediated world could occur in real life, have occurred in real life, are similar to events in real life, or have a high likelihood of happening: *plausibility* [29, 30, 65], *probability* [29, 30], *typicality* [29, 65], *factuality* [65], and *social realism* [29, 30]. Busselle and Bilandzic [28] later also define the dimension of *fictionality*: "*information that the story is fictional*". Some authors have also referred to these types of realism with a higher level of abstraction (e.g., *external realism* [16, 28])—however the two uses of the same term must be distinguished: one refers to similarity with the real world [28], whereas the other also refers to consistency of narrative and the influence of expectations based on the real world [16]. Similarly at a high level of abstraction, Rooney and Hennessy [144] posit *relative realism* as "*similarity [...] to one's own lived experiences; the relative plausibility, typicality or factuality of the viewed events.*" They further contrast this as a type of realism that results from active appraisal or assessment (opposite to their more experiential *apparent realism*) [143].

● non-interactive media studies			
narrative ✔ *magic window* [29, 30, 68, 129]; *usefulness of social expectations* [68] / *utility* [29, 30, 129]; *narrative consistency* [65] / *narrative realism* [16, 28]; *plausibility* [29, 30, 65], *probability* [29, 30], *typicality* [29, 65], *factuality* [65], *social realism* [29, 30]; *fictionality* [28]; *external realism* [16, 28]; *relative realism* [144]; *apparent realism* [143, 144]	perceptual ✔ *perceptual persuasiveness* [65], *perceptual specificity / realism* [60], and *perceptual realism* [144]; *schematic typicality and familiarity*[60]; *categorical realism*[60]; *genuineness, seriousness & pain* [60]; *apparent realism* [143, 144]	interactive (✔) (*realism through interactivity* [60])	psychological ✔ *identity* [29, 30, 129] / *(emotional) involvement* [65]; *emotional realism* [60]; *apparent realism* [143, 144]
● CAVE systems and VR research			
narrative (✔) *social realism* [96]; *meaningfulness of experience* [177]	perceptual ✔ *perceptual realism* [96]; *display realism* [107, 126]; *scene realism* [177]; *simulation realism* [126]; *scenario fidelity* [133]; *resemblance* [166]; *depictive realism* [161]; *visual realism / fidelity* [133]; *pictorial / image realism / fidelity* [27]; *scene realism* [126]); *sound realism* [126]; *display fidelity* [133]; *visual fidelity* [155]; *virtual realism as (technological) immersion* [161]; *physical realism* [155]; *ontological realism* [161]; *consistency of information* [177]; *audience behaviour* [126]	interactive ✔ *dynamic / interactive realism / fidelity* [27]; *interaction fidelity* [107, 126, 133]; *functional realism* [161]	psychological (✔) *psychological realism* [155, 161]
● simulator research			
narrative ✖	perceptual ✔ *physical fidelity* [3, 4, 38, 51, 94, 124]; *physical simulation realism* [45]; *equipment fidelity* [38, 51, 94, 124]; *environment fidelity* [3, 38, 124]; *objective fidelity* [134]; *motion fidelity* [94]; *visual-audio fidelity* [94]; *visual realism* and *behavioural realism* [169]	interactive ✔ *functional fidelity* [3, 4, 38, 51, 94]; *semantical simulation realism* [45]; *task fidelity* [38, 94]; *conceptual fidelity* [124]	psychological ✔ *perceptual fidelity* [134]; *phenomenal simulation realism* [45]; *psychological fidelity* [3, 38, 124]; *psychological-cognitive fidelity* [94]
● games research			
narrative ✔ *typicality* [127] / *conceptual / imaginative realism* [151]; *magic window* [127, 137] / *factuality* [101]; *utility* [127, 137]; *identity* [127]; *realistic narrative* [55]; *social realism* [55] / *absolute perceived realism* [151] / *authenticity* [101, 135, 136]; *relative (imaginative) perceived realism* [151]; *internal realism* [137]; *external realism* [92]; *social realism* [39, 135–137]; *social fidelity* [98]; *narrative realism* [179]	perceptual ✔ *perceptual fidelity* [127]; *realistic representation* [55]; *HCI realism* [179]; *graphic realism* [92]; *visual realism / realistic representation* [55]; *perceptual pervasiveness* [39, 101, 135–137, 179]; *sensory realism* [151]	interactive ✔ *virtual experience* [101, 127]; *freedom of choice* [39, 135, 136, 179]; *functional fidelity* [98]; *simulation realism* [179] / *simulational realism* [39, 135, 136]; *physical fidelity* [98]; *enactive realism* [92]; *HCI realism* [179]	psychological ✔ *character involvement* [39, 101, 135, 136] / *identity / (character) involvement* [137]; *psychological fidelity* [98]

Table 1: An overview of our primer on which domains are covered by realism typologies in different research strands.

Like other strands, this type of realism also has dimensions relating to perceptual aspects: *perceptual persuasiveness* [65], *perceptual specificity/realism* [60], and *perceptual realism* [144]. The latter also talk of *stereoscopic realism* as tying different degrees of perceptual realism to specific viewing formats (3D vs. 2D). Finally, Grodal [60] further distinguishes between *schematic typicality and familiarity* and *categorical realism*, and even briefly mentions the possibility of *realism through interactivity* in games. (All his other types of realism remain firmly within non-interactive media. Thus, for the purposes of this informal review we situate this paper within the non-interactive strand.) He also points out that our perception of realism is also tied to our evaluations of *genuineness, seriousness, & pain* which could be seen as another dimension of realism: "*'realism' is more often attributed to those representations that portray negative emotions than those that portray positive emotions*" [60].

2.2.2 Realism Typologies in CAVE Systems and Virtual Reality. Here the most common domain of realism concerns perceptual aspects: *perceptual realism* [96], *display realism* [107, 126], *scene realism* [177], *simulation realism* [126], *scenario fidelity* [133], and what van Gisbergen et al. [166] refer to as *resemblance*. Sometimes this more strictly focuses on visual aspects (e.g., *depictive realism* [161], *visual realism/fidelity* [133], *pictorial/image realism/fidelity* [27], *scene realism* [126]), or—more rarely—auditory aspects (i.e., *sound realism* [126]). In other cases, realism in perceptual aspects is tied to the device with which media is being portrayed (*display fidelity* [133], *visual fidelity* [155], *virtual realism as (technological) immersion* [161]), or is interacted with (*physical realism* [155]). We note that Witmer and Singer [177]'s *consistency of information* could also be considered a narrative realism type. However, from context, this seems to relate more to behavioural physics.

Narrative-focused types of realism are represented less commonly (e.g., Lombard and Ditton [96]'s *social realism*—drawn from

non-interactive media studies—refers to how plausible virtual events are). Further, Witmer and Singer [177]'s *meaningfulness of experience* might be considered related to concepts like *utility*.

Another domain of realism in this strand focuses on aspects of how people interact with the virtual environment, due to the interactive nature of CAVE system and VR applications: this has been termed *dynamic/interactive realism/fidelity* [27], *interaction fidelity* [107, 126, 133], or *functional realism* [161].

Finally, a few types of realism in this research strand refer to psychological aspects: *psychological realism* [155, 161, 166]. This is described as a subjective realism that does not depend on any resemblance to the real world [166], and instead is contingent only on the user's response and perceived realism.

2.2.3 Realism Typologies in Simulator Research. Simulation/simulator research largely neglects narrative aspects, but features the perceptual, interactive, and psychological domains. Perceptual types of realism are referred to with different adjectives: most commonly this is *physical fidelity* [3, 4, 38, 51, 94, 124] or *physical simulation realism* [45]. Sometimes this is referred to as *equipment fidelity*, which is considered the same as physical fidelity by Fink and Shriver [51], but a subcomponent of physical fidelity by others [38, 94, 124]. *Environment fidelity* is often closely focused on the different senses (e.g., [3, 38, 124]). Rehmann et al. [134] refers to *objective fidelity* to encompass "*both equipment and environmental cues*". Liu et al. [94] further includes *motion fidelity* as an additional subcomponent of physical fidelity. They also separate out *visual-audio fidelity* as another own subcomponent of physical fidelity. In contrast, Vinayagamoorthy et al. [169] instead distinguish between only *visual realism* and *behavioural realism*, likely because they focus primarily on virtual characters.

The interactive domain focuses on interaction with the system, and how the system reacts to input. This is largely referred to as *functional fidelity* with differing but closely related definitions [3, 4, 38, 51, 94], but also *semantical simulation realism* [45]. The types of realism focusing on whether tasks performed by users or players are portrayed authentically are closely related: *task fidelity* [38, 94] or *conceptual fidelity* [124]. (While echoing narrative types like *authenticity*, these are not described in terms of narrative.) The difference is that functional realism provides realistic output to player input, while task/conceptual realism is more abstract: borrowing Paige and Morin [124]'s example: "*A patient simulator [...] is programmed to display a drop in blood pressure and reduction in pulse strength with the intent to represent a patient in a state of shock [...] the simulation activity has high conceptual fidelity if the information offered to the learner is interpretable as representing the concept of a shock state.*" Whether this information is portrayed with high functional realism is irrelevant for conceptual realism: for the latter, the system can simplify the exact blood pressure levels to something like "high vs. low" to only maintain conceptual realism.

This strand also features psychologically focused realism types, alternatively termed *perceptual fidelity* [134], *phenomenal simulation realism* [45], *psychological fidelity* [3, 38] or *psychological-cognitive fidelity* [94]. Somewhat confusingly, Paige and Morin [124] also refer to *psychological fidelity*, but focus this heavily on how this is influenced by *task* and *functional fidelity* attributes. Overall, this branch of research more commonly uses the term fidelity than realism, perhaps due to its earlier origins focusing strongly on technical factors.

2.2.4 Realism Typologies in Games Research. Games are complex, and it is perhaps unsurprising that realism typologies in games research have similarities with all the previously presented strands and cover all four domains. In particular we note the instances where realism typologies crossed the "*interactive virtual divide*" presented in Figure 1: Malliet [101] and Popova [127] both prove the original citational "hubs" through which realism typologies originating in non-interactive media studies have made their way to games studies. Like non-interactive media studies, games research thus has a strong set of realism types that relate to narrative aspects. Popova [127] distinguished between *typicality*, *magic window*, *perceptual fidelity*, *virtual experience*, *utility* (see also Ribbens et al. [137]), and *identity*. Magic window was interpreted as *factuality* by Malliet [101], but later again termed magic window realism by Ribbens et al. [137]. Typicality is also echoed by Shapiro et al. [151]'s *conceptual/imaginative realism*. Galloway [55] distinguishes between *realistic narrative* and *realistic representation*, but for the former also emphasizes *social realism*: this refers to the congruence of the portrayed events with the specific player's life and experience (e.g., "*The Sims is most probably closer to the narratives of normal life than is storming an enemy base in [a first-person shooter]*" [55]). This aspect is also considered by Shapiro et al.'s *absolute perceived realism* [151] ("*the judged likelihood that a depicted event could happen in the real world [...] indexed by the event's [...] likelihood to happen to the viewer*") and Malliet [101]'s *authenticity*. Interestingly, in Malliet's later work with Ribbens and Malliet [136] (and Ribbens [135]'s follow-up) authenticity is then more closely aligned with a consistency definition: "*the credible and consistent integration of mechanics, narrative elements and visual elements within the digital game world*". This focus on consistency is in turn closely aligned with Shapiro et al. [151]'s *relative (imaginative) perceived realism* and Ribbens et al. [137]'s even later *internal realism*. A combination of plausibility, accuracy, typicality, and likelihood was in contrast termed *external realism* by Lin and Peng [92]—drawing on Busselle and Bilandzic [28]'s work in non-interactive media. Further, games research also places more focus on realism relating to virtual characters: *social realism* [39, 135–137] and *social fidelity* [98].

Unsurprisingly, this strand also has interactivity-focused dimensions (*virtual experience* [101, 127], *freedom of choice* [39, 135, 136, 179], *functional fidelity* [98], *simulation realism* [179], *simulational realism* [39, 135, 136], *physical fidelity* [98], *enactive realism* [92]).

The perceptual domain is covered by the visuals-focused *graphic realism* [92] and *visual realism/realistic representation* [55], as well as the more expansive *perceptual pervasiveness* [39, 101, 135–137, 179] and *sensory realism* [151].

Finally, this research strand also explores the psychological domain, particularly in relation to players' embodiment as an avatar (termed *character involvement* [39, 135, 136]) and emotional response to virtual characters—also termed *character involvement* by Malliet [101], or *identity/(character) involvement* by Ribbens et al. [137]. Lukosch et al. [98] propose a more general concept for players' emotional responses (i..e, not tied to characters): *psychological fidelity*. These in some ways relate to and extend the *psychological realism* in CAVE systems and VR research (adding considerations of embodiment and connection to characters), but should not be

confused with the *psychological fidelity* of simulator research which focuses more on a user's responses to completing a task.

2.3 Research Gap

As demonstrated with this informal primer to realism typologies, the term "*realism*" is broad and can refer to many overlapping or even entirely different aspects. In many cases, even the use of the same term for a specific dimension of realism does not necessarily mean that it overlaps exactly (even between papers that share authors). There is substantial potential for confusion given the overlapping and contradictory use of realism types. This emphasizes the importance of clarity when writing about specific types of realism, because merely saying something should be or is "*realistic*" can mean and include so many things. Further, it emphasizes a research gap: a need to systematically explore how researchers write about and conceptualize realism dimensions.

We focus our efforts on games, because many types of realism are suggested to be a crucial factor for PX. Further, games are ideal for exploring realism, as they heavily feature all four initial domains of realism dimensions from the primer: narrative, perceptual, interactive, and psychological.

3 SYSTEMATIC LITERATURE REVIEW WITH THEMATIC SYNTHESIS

We conducted a literature review to systematically map the kinds of realism in games addressed and understood by researchers in our broader community. Starting with 1455 initial unique records, we arrived at a sample of 206 papers. Our methodology for the search, screening, and data extraction stages of the review were based on several guidelines for systematic literature reviews: the JBI manual for evidence synthesis [7], PRISMA [123] (largely for its focus on clear reporting of the search process, including the use of a PRISMA flow diagram [122], see Figure 3), and best practice guidelines such as those by Siddaway et al. [154]. (This has resulted in a comprehensive reporting style uncommon in the CHI community, which we both advocate and apologize to our readers and reviewers for.) We then explored and synthesized the data through *thematic synthesis* [164], to answer our key research question: *What dimensions of realism in games are present in the literature?*

Thematic Synthesis: Rationale and Methodological Foundation. While not previously used in the CHI community, thematic synthesis is well established as a methodology for the data synthesis step of systematic reviews particularly in health research (e.g., Manning et al. [103]). We chose this particular approach of thematic synthesis because of its inclusivity with regards to qualitative data: it can synthesize both quantitative and qualitative data. Additionally, existing typologies of realism in games are often specific to particular genres or a narrow domain within games. This precludes more theory-driven methods (e.g., framework synthesis [9, 32]) that require established, grounded theoretical models which can then be applied. Further, while we had originally considered thematic analysis for the synthesis step, this has been criticized for use in literature review synthesis because of a lack of transparency in whether its aim is descriptive or interpretive [46].

We therefore chose thematic synthesis, which was developed to mitigate some weaknesses of thematic analysis for synthesis in literature reviews, by clearly separating the process into data-driven and theory-driven steps [164]. Thematic synthesis consists of three steps: 1) line-by-line coding, 2) developing descriptive themes, and 3) generating analytical themes [164]. With this clear separation of the descriptive, close-to-data stage (steps 1 and 2) and the interpretive, theory-oriented stage (step 3), it thus clearly delineates which findings are descriptive and which are interpretive (i.e., "*'go beyond' [to] generate new interpretive constructs, explanations or hypotheses*" [164]). Within the classification spectrum of Dixon-Woods et al. [46], we thus consider it well-balanced between more integrative synthesis methods for literature reviews (i.e., closer to the data) and more interpretive methods (i.e., closer to the theory). Figure 2 illustrates the process of thematic synthesis, and how it resulted in themes and initial realism types. The latter were then used in an affinity mapping activity, detailed in a later section, to develop a comprehensive hierarchical taxonomy of realism dimensions in digital games as part of our framework.

3.1 Approach

Protocol and Search. Our literature review began with the development of a review protocol which we make available in our supplementary materials, and an iterative process of identifying an appropriate search query. In multiple iterations, we tested keyword combinations and looked over results to ensure their thematic fit, with accompanying discussions among the authors. Through this process, we arrived at the search queries described in Table 2. We excluded papers addressing boardgames and mathematical game theory in their abstract (we also excluded the latter as a keyword), because of our focus on digital games played by human players.

With the query, we targeted two databases as recommended by guides to systematic reviews [154]: Scopus[2] (see [48]) and the The ACM Guide to Computing Literature[3]. The ACM digital library offers a strong focus on computing-related publications, and Scopus has broad coverage across multiple disciplines; this gives our review a good balance in depth and breadth. For Scopus, we used the search query to filter to conference papers, articles, book chapters, and reviews (`DOCTYPE`s `cp`, `ar`, and `ch`, respectively). For ACM, we employed interface options to filter to documents classified as "Research Article," "Extended Abstract" and "Short Paper."

The first author conducted this search twice over the course of a year (once in May 2020 and once in May 2021). As shown in the PRISMA flowchart in Figure 3, our final searches[4] resulted in N=1428 records in 2020, and N=1558 records in 2021. This two-search approach resulted from the project being paused by external factors. However, it had the added benefit of giving the research team ample time to become well acquainted with the screening criteria, for the first author to set up and facilitate the screening infrastructure, and resulted in thorough but up-to-date data. It also mitigates potential issues with database irregularities mentioned by previous work in regards to the ACM digital library [99, 140].

[2]https://www.scopus.com/home.uri, last accessed 9 September 2021
[3]https://libraries.acm.org/digital-library/acm-guide-to-computing-literature, last accessed 9 September 2021
[4]We use capitalized N to refer to the size of the initial search results, and will use non-capitalized n to refer to subsets of the search results as we report filtering and screening steps.

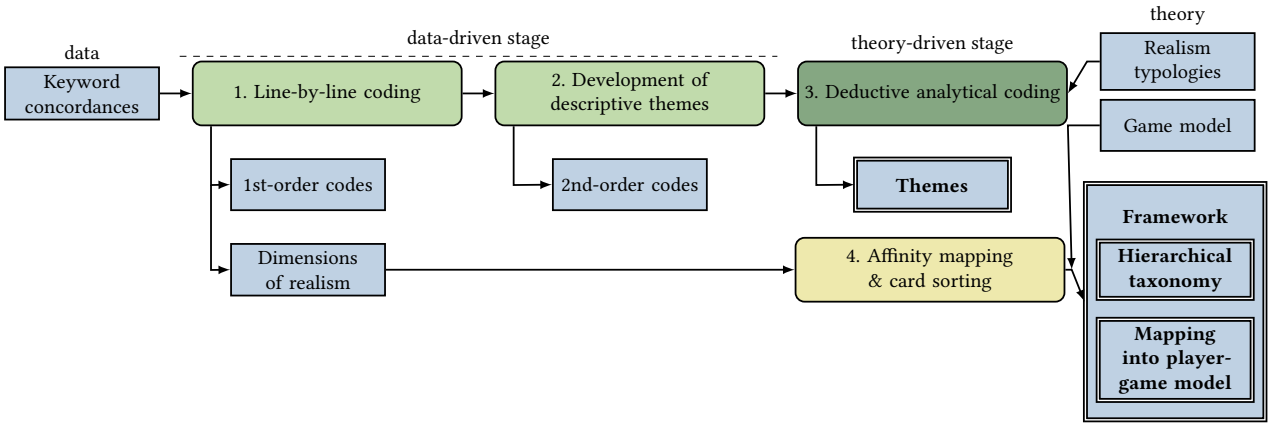

Figure 2: The method consisted of thematic synthesis (light and dark green, rounded corners) conducted using keyword concordances as data (left input) and existing realism taxonomies as theory (right input). From this we derived dimensions of realism, with which we conducted card sorting activities and affinity mapping with our research team (yellow, rounded corners). The overall process resulted two main contributions (bold font, double border): 1) themes based on the thematic synthesis, and 2) a framework consisting of a comprehensive hierarchical taxonomy resulting from the affinity mapping with the dimensions of realism produced by the thematic synthesis, and an overview of how each type of realism maps in Adams [2]'s game model.

Database	Query
The ACM Guide to Computing Literature	`[Abstract: game*] AND [Abstract: play*] AND [[Abstract: realism] OR [Abstract: realistic] OR [Abstract: fidelity] OR [Abstract: and]] AND NOT [Keywords: "game theory"] AND NOT [[Abstract: "boardgame*"] OR [Abstract: "boardgame*"] OR [Abstract: "game theoretic"] OR [Abstract: "game theory"]]`
Scopus	`(ABS (game*) AND ABS (play*) AND ABS (realism OR realistic OR fidelity) AND NOT ABS ("board game*" OR "boardgame*" OR "game theory" OR "game theoretic")) AND (EXCLUDE (EXACTKEYWORD , "Game Theory")) AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar") OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "re")) AND (LIMIT-TO (LANGUAGE , "English"))`

Table 2: This table lists the final search queries in the syntax of each database. The corresponding filters we applied to the ACM search results to mirror the filters in the Scopus search (`DOCTYPE`s) were applied through the ACM digital library interface (filtering for research articles, extended abstracts, and short papers). The final search was conducted on 01-MAY-2021.

A separate breakdown of how the 2020 and 2021 search papers underwent screening is provided in the supplementary materials.

Duplicate Removal. We removed duplicates from the merged list of records in a two-step process: first, automatically identifying and removing matches based on the combination of identical title (regardless of capitalization) and year through a custom Python script (removing n=78, i.e., resulting in n=1480). Second, our script also identified n=35 papers as potential duplicates based on identical title (again regardless of capitalization) but dissimilar years of publication; these were checked manually and removed if identical in content (n=25). After removal of duplicates, we arrived at n=1455 unique records identified as of interest for the next phase.

Screening Phase. In a screening phase with four coders, we checked all identified papers based on title and abstract against our inclusion and exclusion criteria. Papers were included if the following two **inclusion criteria** applied:

(1) *The paper discusses a digital game that is designed for human players.* The game can be for any digital device, i.e., "traditional" ones like PC or console, but also tablets/phones, or mixed-reality technology (augmented reality, virtual reality/head-mounted displays.)
(2) *The paper addresses realism in the context of that digital game or digital games in general.* The reference to realism can consist of a definition of realism, dimensions thereof (e.g., "visual realism"), examples of realism (something that is realistic or unrealistic), or effects of realism. It can also be referred to as fidelity.

Our **exclusion criteria** were formulated as follows:

- The paper is not about games at all (for example, it instead refers to mathematical game theory, e.g., via keywords such as "*Nash equilibrium*" or "*differential game*").
- The paper is not about digital games with human players.
- The paper does not mention or discuss realism or fidelity within games, or refers to a different kind of fidelity (e.g., imitation fidelity in psychology, or the degree of sophistication/completion of a game prototype).

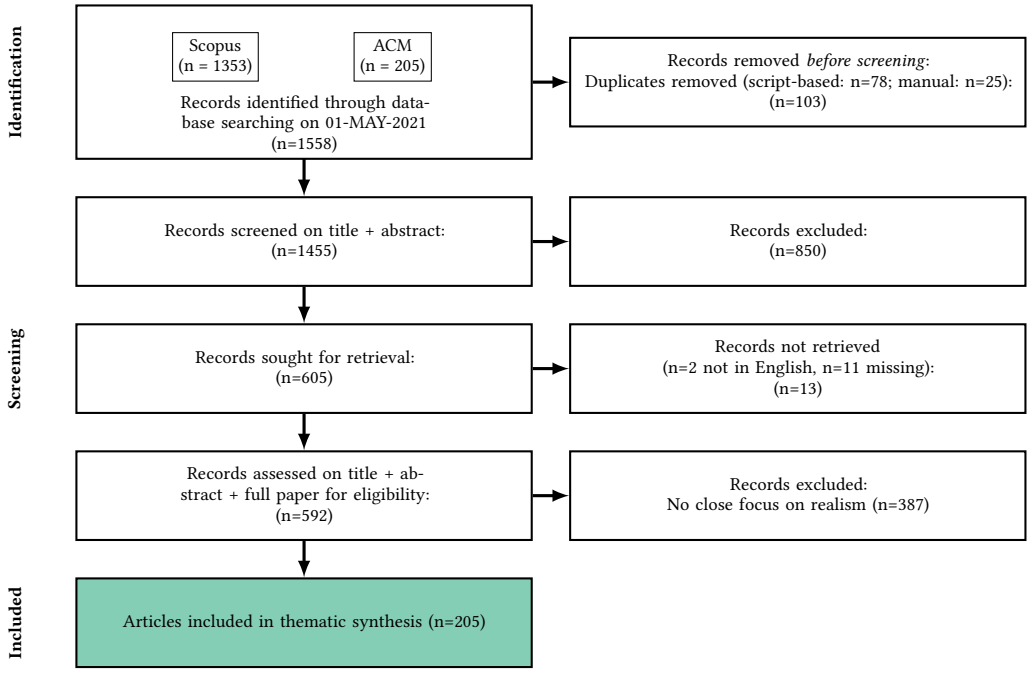

Figure 3: This PRISMA flowchart [122] demonstrates the systematic review process from identification to the final sample of included papers.

- The paper is written in a language other than English.

We applied this screening by separating the records evenly into four batches: each batch (~326 papers) was coded by two coders, and each coder was assigned two batches. In case of disagreement, a third coder acted as a tie-breaker (~6% of papers). A total of 605 papers were identified as matching our inclusion criteria.

Critical Appraisal. Generally, the next step should be an assessment of quality [154]. However, in this review, our primary interest was how researchers conceptualize realism in digital games (as opposed to exploring empirical effects of specific types of realism, which we aim to explore in future work). The methodological quality of studies included in the review's corpus—while the usual focus of this stage in systematic reviews—is irrelevant to our specific scope. For the purposes of this review, the quality of a paper is determined by whether it describes realism in digital games to a sufficient degree of detail. As will become clear in the next phase of the review, a quality assessment measure is inherent in our data extraction and synthesis methods, because low-quality papers based on this criteria are automatically represented less. Additionally, a non-trivial number of identified and screened papers were not empirical. To our knowledge—while there are many criteria for quality assessment of papers with quantitative, qualitative, or mixed-methods studies—there are no such guidelines for theoretical papers in literature reviews. For these reasons, we decided to leave out a formal quality assessment step, and instead proceeded with the eligibility scoping phase as the final screening step.

Eligibility Scoping. In the eligibility scoping phase, we screened the previously identified records again for a close focus on realism to decide whether they should be eligible for synthesis. A close focus on realism was here defined as either a) an empirical study in which realism of any kind is an independent variable, or perceived realism of any kind is a dependent variable, or b) a theoretical paper (i.e., involving no user testing) in which the presented theory, model, or framework features any kind of realism as a key component. Records were thus coded either as *empirical include*, *theoretical include*, or *exclude: realism is tangential*. Additionally, all papers were tagged as either empirical or theoretical. The records were screened based on title and abstract and full paper. (To save time, the full paper was not checked if it was already clear from the title and abstract whether our criteria were met, and whether a paper was empirical/theoretical.)

We conducted this phase with three coders: all three coders coded the same first 25 papers individually, then met to discuss points of disagreements or uncertainty. They then coded another same 50 papers separately, followed by another discussion meeting. Based on the shared understanding of the scoping criteria developed in these meetings, the remaining papers were then coded separately without meetings. However, the coders informed each other of new codes that were generated in a dedicated Slack discussion thread. In this process, 387 papers were excluded because realism was not the paper's main focus, two because the paper was not in English, and 11 because their full-text version could not be located. This resulted in 205 papers that met our criteria for a close focus on realism in digital games (n=164 papers involved empirical user testing of some sort, i.e., user studies or surveys of some kind; n=41 did not, i.e., were theoretical). These were included in our thematic synthesis.

Additional inductive coding was applied during this stage (on all n=605 papers undergoing the scoping phase) to identify different types of realism mentioned in the titles and abstracts, identify instances in which realism is mentioned but not defined, or in which realism is described in positive or negative terms. A first set of inductive codes was developed by the first author based on the first batch of 25 shared-coding papers, and then reviewed by two other coders. Consensus coding was used to refine these codes throughout the rest of the scoping phase and the discussion meetings. An overview of how many papers were coded with each of these codes is shown in the appendix.

Data Extraction. To conduct our thematic synthesis, we first extracted the relevant data from the 205 papers in our corpus. Using a custom Python script to apply the `pdf2htmlEX` command line tool [171], we extracted the text of all eligible papers. We then used the Natural Language Toolkit (`nltk`) python package for text analysis [17, 132] to perform a keyword occurrence analysis. This resulted in a list of snippets consisting of all occasions in which "realism," "unrealism," "realistic," "unrealistic," "realistically," "unrealistically," or "fidelity" were mentioned in the texts, along with the 600 characters preceding and 600 characters succeeding the keyword occurrence: we call such snippets *keyword concordances*. An example of a keyword concordance is shown in Figure 4; the appendix lists how many papers contributed concordances for each applied keyword.

Synthesis. As mentioned, thematic synthesis consists of a data-driven stage (inductive line-by-line coding on the extracted data and development of descriptive themes) and a theory-driven stage (deductive analytical coding). The line-by-line coding consisted of inductive open coding, which was performed by the first author using reflexive thematic analysis [22–24]. We chose this particular method because it allows for a flexible, iterative approach that places the researcher into "*the active role [...] in the knowledge production process*" [24]. As the first author has several years of experience in reading and thinking about realism in games, we see this active role as a strength that reflexive thematic analysis can draw on (see also reflexivity statement below).

Following prior researchers [77, 102], we distinguish between first-order codes (descriptive and close to the data) and second-order codes (refined and more interpretive) resulting from this stage. Figure 4 shows examples of first-and-second-order codes for an example concordance. The first-order themes also consisted of dimensions of realism, which were informed but not constrained by the initial realism types developed in the screening stage (see appendix). We list the dimensions of realism developed as first-order themes in the synthesis stage and provide an overview of how many concordances were coded as relating to them in Figure 5. In the subsequent second theory-driven stage, the first author constructed themes based their understanding of realism typologies in related work. Using axial coding and multiple iterations, the first author developed the final themes reported in the next section.

Reflexivity. In line with recommendations for qualitative research [104, 147, 160], we critically reflect on our own assumptions and biases in coding the data and constructing themes. As mentioned, this was conducted by the first author, who has prior experience with games research on realism from their doctoral work. Initially this involved helping in and supervising the design and development of games that explored themes of realism and unrealism implicitly. Viewed from a more nuanced perspective at a later time after much reading of the literature, they then explicitly researched (un-)realism in games in several studies [139, 141, 178]. As such, they may have a greater interest than others in the ways that realism can be constrained to benefit PX.

The research team as a whole covers perspectives at different academic stages (undergraduate to associate professor), grounded in games research as well as computer science, cognitive systems, interaction design, user experience research, and health sciences. Despite encouragements to all team members to voice and defend opinions, one of the more junior researchers reflected on a reliance on the more senior researchers' opinions for a few realism types they were less familiar with. We acknowledge this bias as a potential limitation for the framework. The authors' personal preferences and experience with games cover role-playing games, shooters, couch co-op games, and turn-based strategy games. This ranges from games with "low-fi" graphics like *Overcooked 2* [163], *Minecraft* [114], *Into the Breach* [56], or *Hollow Knight* [162], to comparatively more photorealistic graphics like in *Guild Wars* [5], *Fallout 4* [159] or *Red Dead Redemption 2* [138]. Their own conceptualizations of game realism prior to the project were rooted in graphics (all researchers; this includes aesthetics beyond realism), physics (four researchers), and narrative (mentioned by three; also informed by fantasy movies and games like *Skyrim* [158]), as well as audio and physical player input (two researchers).

4 RESULTS OF SYSTEMATIC REVIEW WITH THEMATIC SYNTHESIS

We first report the themes, and then the initial realism types. The latter were refined later to develop our hierarchical taxonomy, as we discuss in the next section.

4.1 Themes

The reflexive thematic analysis resulted in four main themes, which we report here in detail. The first two relate to the conceptualization of realism as a whole. The second two are contradictory, showcasing the opposing perspectives of realism vs. unrealism as design goals. Finally, we report a secondary (sub)theme, relating to the conceptualization of realism in VR in particular.

4.1.1 Main Theme 1: Realism is an Elusive Multidimensional Construct. The papers only rarely defined realism as a whole. Instead, they mostly focused on specific types of realism, and often shied away from defining those as well, instead preferring to give examples. We suspect that this is because the construct was often considered an ambiguous one, as for example stated by Denham et al. [44]: "*defining what realism is in virtual space and how it operates to inform and create a sense of the 'real' is unclear*".

Realism was often equated to fidelity (e.g., "*the fidelity, or realism in applied games*" [98] or "*realism/fidelity*" [81]), or one was defined in terms of the other (e.g., "*fidelity refers to the realism of a game*" [33] or "*perceptual fidelity is sensory realism*" [150]). For other researchers who made a distinction between the two, fidelity was generally seen as an objective, technically-constructed concept:

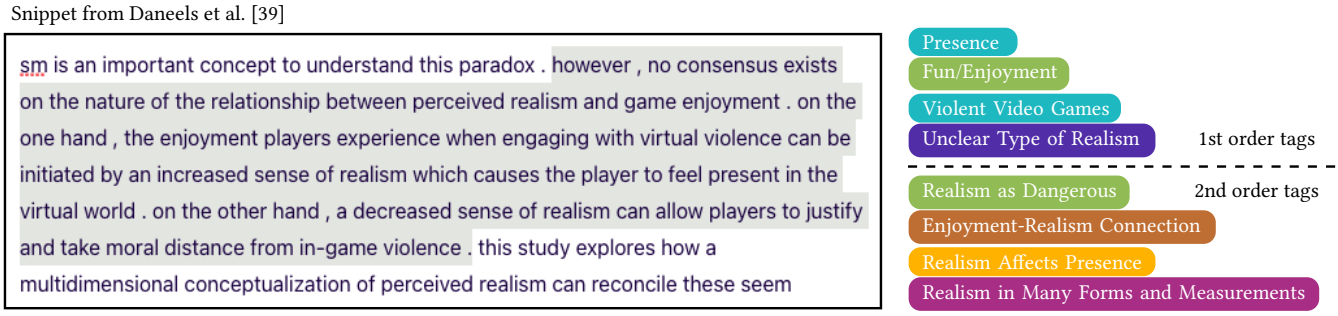

Figure 4: Example of a keyword concordance (600 characters before and after the keyword) for "*realism*" on the left, and the respective thematic synthesis coding (1st and 2nd order tags) on the right.

"*visual (graphical) fidelity ranges from high to low quality, defined with respect to polygon count, and resolution (both texture resolution and overall resolution)*" [81]. In contrast, realism was then a more subjective, psychological or experiential concept: "*there is a thin line separating realism and audiovisual fidelity [...] it was decided to examine them as two distinct factors because realism [...] is not limited only to technical features but has functional and psychological dimensions as well [...] it also encompasses game-player interactions*" [53].

Further, as also pointed out by Lin and Peng [92], papers on realism in games often use realism as a general term when they actually—based on context—mean a specific type of realism.

There was a strong pattern of agreement that realism is a multidimensional construct, but the papers indicated different opinions about what kinds of realism exist and how it can be or should be measured. While the concordances also contain mention of how realism was measured in empirical work (as a whole, or specific types), we did not explore this avenue further because it goes beyond the scope of our research question, and our search methodology is not suited to reliably describe this aspect in more detail. However, we note that several papers expressed a belief that mixed effects found for (aspects of) realism may stem from different conceptualizations and operationalizations of realism dimensions: "*a multidimensional conceptualization of perceived realism can reconcile these seemingly contradictory perspectives*" [39]. Another pattern positioned realism as a phenomenological lens, which could also explain mixed effects (e.g., "*defined as the participant's perception*" [92] and "*perceived realism [is] reflected in subjective experiences of game play[. It is] not directly observable*" [121]). In particular, with this conceptualization of realism, players' expectations—based on their real-world experiences and prior history of interaction with games—become a substantial factor: "*ultimately, perceived video game realism is a user's assessment of how well the game has simulated some event or action based on his or her expectations or mental models*" [105]. Throughout the corpus, a lack of clarity is noteworthy about whether realism should be considered through a subjective or objective lens, which may complicate conclusions about realism's empirical effects.

Realism is predominantly framed as a continuum rather than a binary construct. However what constitutes the non-realistic end of this continuum varies across the literature: For example, low quality [81] or substantial difference to the targeted realistic referent [95] occurs as such, but most commonly it is stylization/abstraction/lack of detail [64, 71, 148, 180, 182].

4.1.2 Main Theme 2: It's Complicated: Realism is Closely Related to Many Other Concepts. Realism is a conceptual shapeshifter: it has proximate and sometimes synonymous relationships with many closely related constructs: immersion, enjoyment, presence, naturalness, flow, and interactivity.

Immersion. One of the most prevalent patterns emergent in the data (i.e., one of the most frequent inductive codes) is realism's close connection to immersion. Occasionally, the two constructs were framed as synonymous (e.g., [49]). More commonly, they were mentioned and also measured together. For example, "*Realism evaluation questions adapted from the Immersion questionnaire by Jennet[t] et al. [[78]]*" [42] or the item "*I was so immersed in the virtual reality, it seemed real*" used by Heinrich et al. [70]. Some researchers address this connection directly. For example, "*The strong correlation between perceived realism and immersion demonstrates that the more a player thinks a VR game is realistic, the more he or she is immersed in the game. Perceived realism may be a cause or result of immersion*" [72]. This ambivalent or dual perspective is echoed by many and in both directions: immersion causes perceived realism, and perceived realism causes immersion. The latter is more common (phrased as hypotheses and findings) in our corpus: "*Therefore, we also predict that perceived realism will positively influence immersion (H4) [...] this hypothesis was supported*" [106]. However the inverse is also asserted by a few [72, 116, 183]. For example, Ho [72] reports empirical evidence for this: "*the results reveal that players' perceived degree of realism varies as their level of immersion changes.*" Moreover, a few researchers explicitly see realism and immersion at odds with each other: "*in gaming, it becomes necessary to reduce the realism of the game [...] to improve the player's pleasure and engagement*" [33].

Enjoyment. This was another frequent connection, exemplified by Fokides et al. [53] who report "*both subjective realism and audiovisual fidelity*" influenced enjoyment. McGloin et al. [106] relate this to a model-matching theory: "*It is unsurprising, perhaps, that an enjoyable game is one that is realistic and immersive [...] It is likely that perceived game realism increases the ease of model matching between the game and the user's existing real world models, which allows the user the ability to focus more on the game's challenges.*

This more intense focus on the game challenges often results in enjoyment [...] Hypothesis 10 posited that perceived realism would predict enjoyment and was supported".

Presence. This was similarly prevalent. It materialized as virtual embodiment being mediated by avatar realism (e.g., behavioural and photographic [95]), spatial presence being impacted by general realism [149, 150], and general presence being facilitated by environmental realism [181], subjective realism [53], realistic animations, behavioural realism and realistic interaction [63], interaction and display fidelity [87], graphic realism [92], and general realism [14, 39, 72]. Lukosch et al. [98] on the other hand consider presence to be itself a multidimensional construct consisting of immersion (synonymous with "*psychological fidelity*"), naturalness ("*physical fidelity*"), and spatial awareness/engagement.

Naturalness, Interactivity, Flow, and Motivation. Again, naturalness and realism were sometimes equated (e.g., "*naturalness (defined as the perceived realism of the character's movements)*" [120] or "*naturalness, defined as how realistic is a virtual character's performance*" [119]). Others frame it as something that *contributes* to realism (e.g., "*a grabbing task is more natural, therefore resulting in a higher realism*" [170]). This was particularly common among research on input controllers and their intuitive mapping of input to game mechanics (e.g., [105, 150, 172]). In these cases, realism was also often in turn mediated by interactivity ("*how interactive they felt the system was*" [150]) [149, 150]. Realism and naturalness often merge with additional concepts like life-likeness and believability (e.g., in animation [84], but also for example in research on haptics in VR [62]). As mentioned, Lukosch et al. [98] equate naturalness with physical fidelity, specifically. Finally, realism was also often described in the context of facilitating flow [37, 174] (e.g., [86, 89, 121, 183]) and motivation in educational games (e.g., [26, 116, 145]).

4.1.3 *Main Theme 3: We Always Need More Realism.*

This theme is one side of the coin of realism as a design goal. Partially realism is a design goal because it is seen as equivalent to, a driving force behind, or a mediating factor of the concepts mentioned in the previous theme (e.g., immersion, enjoyment, presence [92]). Realism is considered to have "*a notable influence*" [145], and in its various forms is "*deeply rooted in all forms of entertainment [...,] involved in the active participating nature of video games [... and] an essential element of players' arousal and affect*" [92]. It is reported to be a preference (e.g., [10, 26, 49, 112, 125, 148, 175, 182]) and a positive factor for PX [33, 53, 70, 112, 172, 180–182]; it is used in marketing [15, 34], and is considered a goal of game design [41, 120].

Additionally, realism (or a lack of unrealism) has many other (potentially) positive functions in games. It is an *intensifier*: avatar fidelity is described as producing "*heightened or decreased emotional responses*" [8], and general realism is said to "*enhance[...] the experience of subsequent emotions*" [92]. Conversely, a lack of realism is a marker of *untrustworthiness* ("*realism [...] improves the confidence in the game [... Players] have to feel they can trust the scenarios the game presents*" [145]; vs. skepticism when players "*identif[ied] game features that appeared unrealistic, and [took] these as indicative of the developers' approach to [other realism types]*" [82]). Unrealism in virtual characters is also described as promoting *frustration* [40]. Further, unrealism in tasks or interaction is described as increasing *cognitive load* by hindering players from "*more quickly match[ing their] mental model to the game play situation*" [106].

Finally, realism is considered integral to *learning* in educational games: "*positive relationships are likely to exist between fidelity and training effectiveness*" in decision-making and psychomotor learning [33]. A serious game and simulation "*needs to be realistic*" [125] or "*realistic enough*" [54] to "*support long-term learning*" [1] and "*transfer what they had learned to real practice*" [26]. Sometimes this is rationalized through realism's connection to flow, which is in turn considered a "*prerequisite*" [89] for learning.

4.1.4 *Main Theme 4: We* Don't *Always Need Realism and Sometimes Should Avoid It.*

This theme contrasts with the previous one to frame *un*realism as a design goal. Sometimes, high realism is simply considered unnecessary to the goals of the game. For example, there may be limits in how realistically participants' avatars' hands need to be portrayed in VR [70]. Others note that literature reports games of "*insufficient fidelity*" [85] unexpectedly being effective learning tools. As such, "*non-empirical evidence from a broad variety of sources suggests that [...] a simple picture of 'more fidelity being more effective' may not be entirely correct*" [180]. Some view realism as actively detrimental to learning: it "*can even hinder learning with cognitive overloads*" [52]. Similarly, Fokides et al. [53] report studies in which "*realism distracted students from their learning tasks*" [53]; and Veinott et al. [167] found better training effects "*for the low visual fidelity and low cognitive fidelity condition*" [167].

In constructing this theme, we note that realism is also often positioned in a trade-off relationship with other factors: narrative ("*the competition between historical narratives and a fictional cinematic space*" [34]), feelings of safety (in alarming VR experiences [89], haptics of unpleasant sensations [62], and avoiding real-world repercussions [26]), resources [8, 84, 181] or other costs like increasing likelihood of lag [81], as well as aesthetics ("*cat depictions with the lowest realism ratings receive[d] significantly higher aesthetic ratings*" [148]). Fun and user experience are also framed in trade-off with realism: "*in gaming, it becomes necessary to reduce the realism of the game [...] to improve the player's pleasure and engagement*" [33]. In contrast, "*a more realistic system [...] would limit the players' freedom and disincentivise risky, violent play*" [44]. Other examples include detailed full-body movements [113, 139].

Further, we point out that some games research frames unrealism as a priority goal: "*Considering intentional non-realism [...] exaggerated simulated physics has been a staple of digital games since early platformers like Mario Bros [...] can manipulating realism result in positive affect (empowerment, thrill)? Can manipulating realism optimize challenge?*" [67]. This goal mirrors and positively frames many of the aspects mentioned as a negative for realism: unrealism can improve player performance (e.g., by adjusting difficulty set by enemy agents [40, 43]), learning effects (through abstraction), and feelings of safety. It can also reduce costs, and create a more playable game: "*being able to revive already fatally wounded avatars is necessary to make a violent game playable*" [44].

4.1.5 *Secondary Theme: The Virtual Reality–Realism Coalescence: VR as Realism and Realism as the Goal of VR.*

The concept of realism was paramount in papers exploring VR games. This prompted a secondary theme development that materializes how realism is

sometimes equated to VR and of particular prominence in VR games research. Many papers portrayed perceived realism as a key purpose or goal of VR as a medium: e.g., "*the main purpose of virtual reality (VR) is to enhance realism and the player experience*" [87] and "*virtual reality is intended to help players immerse themselves totally in a game, and, thus to increase realism*" [183]. In other research, realism is a key feature provided inherently by VR: "*the most prominent feature of VR is high-quality virtual realism or immersion, coupled with body tracking, where the person feels fully present or located in the virtual world*" [49], and "*[VR] has been gaining popularity in recent years because of the realistic experience it provides*" [64]. Lukosch et al. [98] extend this concept to augmented reality as well: "*with the advance of AR and VR technologies, the possibilities to improve the realism in applied games has increased*" [98].

4.2 Dimensions of Realism Types

Through the thematic synthesis, the first author developed a list of dimensions of realism that occurred in the keyword concordances. (The dimensions found during this process can be seen as an iteration of the pre-synthesis initial realism types based on the papers' titles and abstracts, see supplementary materials.) An overview of this list is presented in Figure 5. It shows that for the majority of keyword concordances, the type of realism was either entirely or partially unclear. Visual/graphic realism was the most commonly specified type, followed by character/avatar realism, and then overall realism of a game. The major archetypes of realism dimensions already prevalent in our informal primer in the Background section are also high up in the list: interaction/device realism (but also embodied/movement/enactive realism), narrative realism, representational/sensory/perceptual realism, and psychological aspects (like player response realism, emotional realism, experience or experiential realism). However, we were able to identify far more distinctions in types of realism than was initially evident in the papers' titles and abstracts. This also includes speculatively mentioned realism dimensions like gustatory realism [50, 58] and ethical realism [98].

Further, the list also includes aspects which we do *not* actually consider aspects of game realism, such as prototype realism (sophistication or completeness of a game prototype, although this was generally conflated with graphic realism [19]), or study realism (realism of an experimental evaluation or scenario, e.g., [168]).

5 A FRAMEWORK OF REALISM DIMENSIONS IN DIGITAL GAMES

Our literature review and thematic synthesis helped us define a list of dimensions of realism in digital games. Building on this, we further refined the list of identified realism dimensions through affinity mapping sessions with the full research team. With all five coders, we thus developed a framework consisting of an underlying vocabulary of realism dimensions in digital games. The framework consists of and can be viewed through two lenses: how the different types of realism inter-relate to one other (which we capture in a hierarchical taxonomy, see Figure 6), and how they fit into a prototypical model of player-game interaction, for which we draw on Adams's model [2] (see our mapping of realism dimensions in Table 3). Adams's player-game model [2] conceptualizes the interaction between a player and a game as a *player* who provides *input* to the game, which are then processed via *core mechanics*, to respond with an *output*. We chose this model as we needed a simple illustration of player-game interaction, to help us structure and map realism types within this interaction context. In the interest of building a design vocabulary of realism types, this kind of scaffolding can also help future designers and researchers be aware of which realism types may be relevant when designing a new input method, output method, or in-game mechanic. Other similar models exist, but are usually more complex, e.g., Caroux et al. [31] who model video game aspects of player-game interaction as input and output, game contents, and multiplayer aspects (for the purposes of classifying in-game realism, we believe that the latter can be subsumed under the first two aspects). Adams [2]'s model also echoes Norman [118]'s interaction cycle with respect to the system: users articulate input to the system (*execution*), the system processes changes to the internal state in response, and then the output is presented to the user (for *evaluation*).

5.1 Card Sorting and Affinity Mapping

We conducted card sorting to map dimensions in Adams's game model [2]. The model sees *players* providing *input* to the game, which has *core mechanics* by which the input is processed, to then provide an *output* to the player in response. We used the web platform *OptimalSort* [97] to create a virtual card sorting application. For the card sorting, the first author prepared cards consisting of the realism dimensions in Figure 5, and set the categories to consist of the elements of Adams [2]. Exact descriptions used for each of these elements is presented in the supplementary materials.

All five authors then individually performed the card sorting task. In several virtual discussion sessions using virtual collaborative whiteboard application *Miro* [111], the research team then met to discuss results and resolve disagreements. When a realism dimension was unclear, the researchers went back to the tagged concordances in Dovetail to gain an impression of how the literature uses the concept in discourse. Through this iterative procedure, we refined the dimensions of realism one more time, and decided how each dimension fits into Adams [2]'s model.

Further, early on in these discussions, we noticed that the dimensions were often differing or overlapping in their abstraction level. We thus took copious notes and created multiple visualizations of how the different realism dimensions relate to each other. Based on these, the first author then created a first draft of a hierarchical taxonomy of realism types, and presented it for discussion among the research team.

Mapping of Realism Dimensions into Player-Game Interaction. We present our final list of the dimensions of realism in Table 3. This table also indicates how each item fits into Adams's player-game model [2]. We present a list of descriptions for each of the realism dimensions as supplementary material.

Hierarchical Taxonomy. Finally, we present the hierarchical taxonomy of the realism dimensions in Figure 6. With this part of the framework, we describe how the different dimensions of realism relate to one other. More detailed context for this figure is provided as part of our overview of realism dimensions in the supplementary

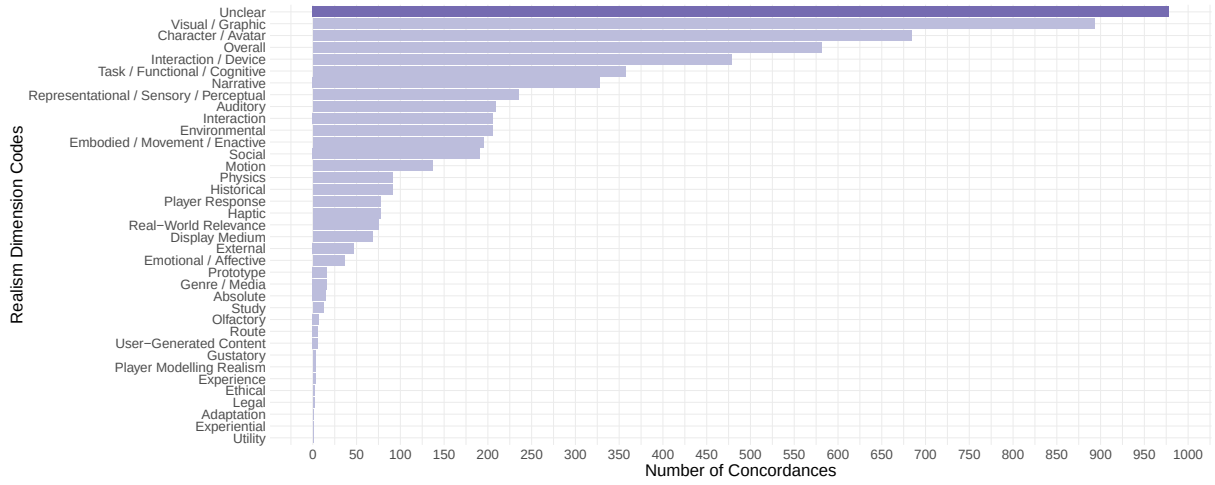

Figure 5: Inductive codes for first-order tags of realism dimensions based on the keyword concordances of the 205 papers in the thematic synthesis. Again, most commonly, the type of realism was not clearly specified. Papers and concordances could be tagged with multiple codes.

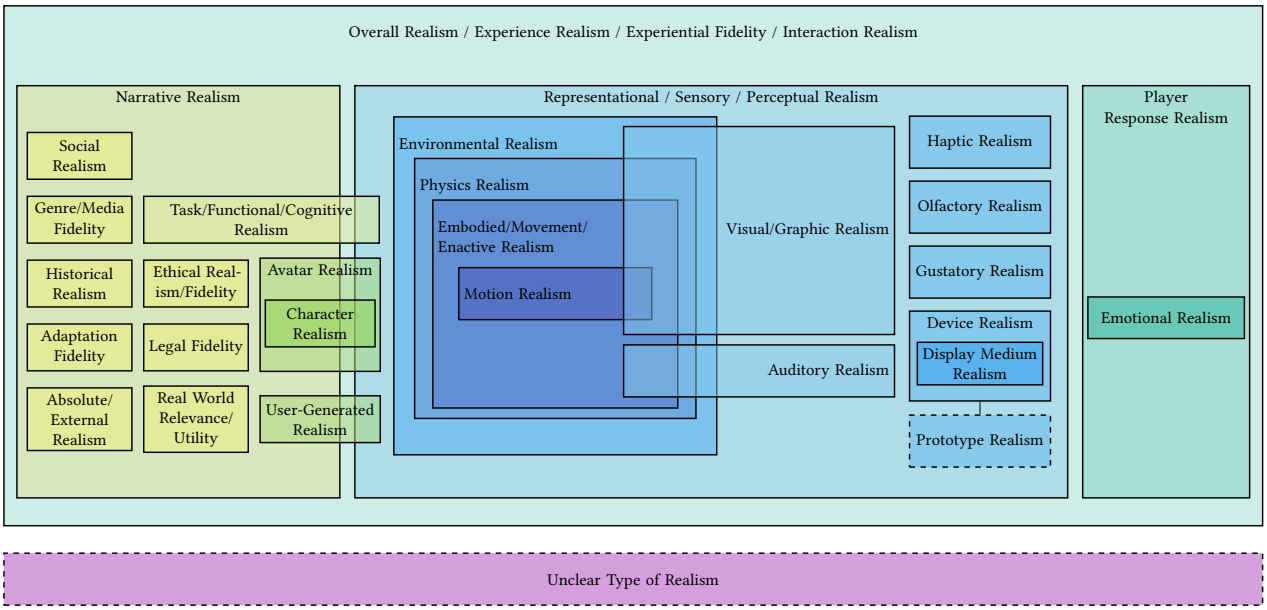

Figure 6: This hierarchical taxonomy of the realism dimensions shows how they relate to one another and vary in abstraction.

materials. However, we note that in this overview, the three high-level domains are *narrative realism*, *representational/sensory/perceptual realism*, and *player response realism*. In contrast to the domains in our informal review/primer, the realism dimensions relating to interaction are thus subsumed within the *representational/sensory/perceptual* realism. Narrative realism dimensions also overlap with the *representational/sensory/perceptual* realism; especially, for example, the *task/functional/cognitive* dimension, which was therefore drawn as expanding into the *representational/sensory/perceptual* one. However, the interaction with the game system was generally described through how players perceived it (in terms of input, and the represented core mechanics that it affects and presents in terms of output). Interactive dimensions (e.g., *embodied/movement/enactive*) therefore become part of the larger, more abstract *representational/sensory/perceptual* dimension.

6 DISCUSSION AND TAKEAWAYS

Based on our research, we discuss what our findings mean in the context of existing research.

Type of Realism / Fidelity	Game Level: Input	Core Mechanics	Output	Player Level
Overall Realism / Experience Realism / Experiential Fidelity / Interaction Realism	●	●	●	●
Representational / Sensory / Perceptual	●	●	●	
Visual / Graphic			●	
Haptic			●	
Auditory	●		●	
Olfactory			●	
Gustatory			●	
Device	●		●	
Display Medium			●	
Prototype				
Environmental		●	●	
Physics		●	●	
Embodied / Movement / Enactive	●			
Motion	●		●	
Avatar	●	●	●	
Character		●	●	
User-Generated Content	●	●	●	
Narrative		●		
Social		●		
Historical		●		
Real World Relevance / Utility	●	●	●	
Adaptation		●		
Genre / Media		●		
Absolute / External Realism		●		
Ethical		●		
Legal		●		
Task / Functional / Cognitive		●		
Player Response				●
Emotional				●

Table 3: This table displays our mapping of realism dimensions: how they map into a prototypical model of player-game interaction—based on Adams's game model. We use ● to indicate the corpus talking about a realism dimension primarily at the game level (input, output, or core mechanics); we use ● to indicate the corpus writing about it primarily on the player level. We also used ● to indicate applications that we as a research team considered even when this was not present in the discourse (e.g., an abstract dimension containing others and thereby inheriting their attributes). Finally, dimensions in italics were either strongly debated about whether they fit into the player-game model at all (prototype and user-generated content), or speculative (gustatory and ethical).

Need for Conceptual and Terminological Clarity. Based on our main themes 1 and 2, many imprecise mentions of realism exist. Realism is often implicitly equated with other constructs like immersion; authors' conceptualization of realism as a whole—and the particular dimensions they are exploring—remains ambiguous.

We thus formulate the following suggestion for best practices to improve clarity in our field: When writing about realism, we should give **a clear definition of realism as a whole**, including whether we consider realism **through a subjective or objective lens**. If we subscribe to a subjective lens, we should also consider effects of real-world experiences, expectations, and mental models. Further, in our papers, we should clearly specify which dimensions of realism we are referring to. Our framework can provide a foundation to begin this discursive practice. Finally, we

suggest that authors clarify their understanding of the **continuum of realism** with examples of what they consider to be the opposite of high realism (e.g., abstraction, stylization, lack of detail, exaggeration).

Function and Generalizability of the Framework. We consider our framework to have several functions as a form of intermediate-level knowledge [74]. To clarify, we position our framework's function with regards to Bederson and Shneiderman [13]'s and Rogers [142]'s perspectives on how forms of theory can serve the HCI field. We consider our framework to have both *descriptive* and *explanatory* power [13], in that it can "*clarify terminology about objects and actions, identify key concepts or variables, and thereby guide further inquiry and education.*" Additionally, we hope that it also has potential *conceptual* power: to help with "*informing and articulating the design and evaluation of prototypes, user interactions and user studies*" [142] in realistic or purposefully unrealistic designs.

Our framework is based on a systematic review of game-related research papers. As such—for now—we can only hope for generalizability to future research on interactive media in general. However, as we noted in our primer to realism typologies in different research strands, games research is particularly comprehensive when it comes to realism: covering narrative, perceptual, interactive, and psychological factors. We thus do see potential for our framework to be applied in other research areas as well. For example, VR applications may be promising, especially given the increasing overlap between games research and VR research. Further, our findings about realism as a construct and its dimensions seemed amplified in the context of VR games research. There is substantial history in VR of "*improving realism [as] a driving force behind much of VR research*" [12]. However, here too, we suspect, Shneiderman's statement of priorities will hold true: we should "*encourage[s] approaches that facilitate user tasks [and—in the context of games—user enjoyment] rather than mimic reality*" [153]. As such, we hope that this paper can also spark discussion and deepen connections between these two fields of research.

Application and Implications of Review. Our review and the resulting framework can be applied by designers and researchers alike. It can sensitize the fields of games research and HCI in general to the multifaceted nature of realism and encourage greater conceptual and terminological clarity. This more granular approach to realism research in interactive media—specific realism types rather than realism as a whole—can inform a more systematic approach towards assessing which types hold most importance for PX. In turn, this can help with design and implementation decisions given limitations of technology and hardware. It may also serve as a reference in empirical research to assess potential confounding factors: when isolating effects of a specific type of realism, this list of realism types present in the literature can prompt researchers to consider which other realism types should be kept the same to avoid interaction effects. The mapping of realism dimensions onto Adams [2]'s model, i.e., a basic model of player-game interaction, provides designers and researchers with an overview of which types of realism may be relevant when specifically designing or researching an input method, in-game mechanic, or output method. Finally, the hierarchical taxonomy helps provide depth to the mapping, by showcasing which realism types might be considered a subtype of others. This can help designers and researchers to keep track of which other additional realism types they may be manipulating or should consider at a specific level of abstraction.

In practical terms, our review also showcases which types of game realism are most prevalent in the literature (see Figure 5). This shows that—aside from the even more common lack of clarity about specific realism types—realism is most commonly conceptualized in terms of visual/graphic realism, character/avatar realism, and overall realism. A predominance of visual aspects and virtual agents in realism is perhaps unsurprising given humans' dominant visual sense [128] and the importance of social interaction [6]. Other types of realism are less explored: our overview in Figure 5 details how often codes were found in our review of the literature. This emphasizes a large number of less explored realism types that may be of interest for future research, although we note that there may be many additional papers that address realism types without explicitly including realism as a variable of immediate interest (and therefore would not have been included in our review). For example, realism is considered a key aspect of haptic experiences [83], yet is not always explicitly studied when designing and evaluating haptic interfaces. Our systematic review also connects back to our informal primer: the four domains of perceptual, interactive, narrative, and psychological realism are still largely visible and applicable within the more detailed systematic review. Similarly, the lack of clear definitions of realism and realism types shown in the primer was even more evident in the systematic review. However, our review methodology does not assess which effects were found or remain unexplored for each realism type; these specifics should be conducted via reviews of individual realism types in the future, e.g., via meta-analysis [35, 93].

7 LIMITATIONS

Our research is dense and, of course, also limited in the research choices that we made. As a systematic review, we must address limitations of both evidence and methodology [123]. For evidence, as noted, traditional forms of quality appraisal do not apply because the papers' study data are irrelevant to our work. The papers included in our systematic review—like any snapshot of the literature—are, thus, likely of varying quality. However, our methodology through its focus on keyword usage inherently focuses less on papers that do not discuss realism explicitly or in detail.

In terms of methodology, we acknowledge some limitations. Primarily, we note that we employed thematic synthesis with reflexive thematic analysis and a single coder. The findings are thus shaped and constructed by the first author's perspective and experience. While we consider this a strength, it can also be considered a limitation in the form of potential bias. We attempted to mitigate this by integrating the full research team after this process for the refinement of the realism dimensions and the development of the framework. The use of automatic text extraction tools also carries a risk of limitations because some PDF encodings can be troublesome and—with a corpus of 205 papers—errors may be overlooked. Further, our choice to extract keyword concordances must also be considered in light of a trade-off between gaining a systematic, selective overview of how the keywords are used, and the potential to lose sight of the framing of realism in each paper as a whole. We

hope that our choice of keyword concordance size (600 characters before and after the keyword occurrence) reflects a good balance.

Finally, our framework development is based on a simple model of player-game interaction; in the future, it may be worthwhile to explore mappings of realism types onto more complex models of player-game interaction. Further, the framework originated within our research team. We considered expanding this to include more perspectives; for example, through an online survey, or interviews with experts. However, the framework is expansive and requires much theory before it can be reliably followed. Most people do not have this background readily available. In the future, we will seek out further validation, but consider it out of scope for this paper. Thus we note that our framework should be considered a first working model of realism in games, and may need to be updated in the future as empirical research on game realism progresses.

8 CONCLUSION

Realism is a foundational concept built into games as interactive, multisensorial, narrativized, and affecting media. Hence, it is important to understand how realism affects PX. With the themes presented in this paper, we showcase realism as a complex, multidimensional construct that requires more attention in future research on its effects. Our framework provides a vocabulary for realism. Using it, these effects can be explored systematically in the future. Overall, our work highlights that realism needs greater specificity also when referenced tangentially in other work—especially in VR games as a medium, which are in some ways often interpreted as synonymous with realism. Realism overlaps conceptually with other constructs of PX which we delineated in this paper; this provides authors with a starting point and a reminder to *avoid using the term synonymously with other constructs*—unless they conceptualize them as such. Further, our themes span the continuum of design goals from realism to purposeful unrealism. This can help future game designers and developers by inspiring more nuanced and targeted designs of realistic and unrealistic elements in digital games in the future.

As a whole, we contributed multiple overviews of existing dimensions of realism in digital games: First, our informal primer categorizes prior work roughly by domain and originating field of study. Second, our iterated, granular framework offers a nuanced perspective of the realism dimensions in games present in the literature. With this, we provide a comprehensive design vocabulary for in-game realism, and a foundation for more systematic explorations of effects of specific realism dimensions on PX in the future.

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