Owning the (Virtual) World: A Systematic Review of Psychological Ownership of Interactive Virtual Objects and Environments

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Abstract

In this systematic review, we analyze the literature on psychological ownership of virtual objects and environments according to the PRISMA statement. Psychological ownership describes the feelings of possession towards an object which are independent of legal possession. The construct stems from organizational management literature, but is gaining in importance in Human-Computer-Interaction as users invest billions to own virtual objects. The analysis of 21 research papers reveals how and why ownership emerges and presents the dimensions and consequences of such feelings. In addition, we relate these variables to the classic psychological ownership motives of self-efficacy, self-identity, and belonging, as well as the routes of control, identity transfer, and intimate knowledge. We outline why designers should pay attention to the phenomenon and how it can be utilized in different contexts. Finally, the paper concludes by outlining why and what research will be needed in the future.

CCS Concepts

• **Human-centered computing → HCI theory, concepts and models**.

Keywords

Psychological Ownership, Virtual Reality, Augmented Reality, Interactive, Object Attachment

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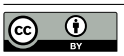
1 Introduction

Would you pay for a new toy for your virtual pet? What about virtual real estate? Although for some readers, the answer is a clear 'no', there are still millions of people who, in turn, pay billions of dollars to game companies for a chance to gain some virtual cosmetic item [60]. What motivates them to invest so heavily into a seemingly 'fake' reality? What drives their desire to possess objects in these virtual worlds?

The topic of psychological ownership has been a focal point of many managerial or marketing research papers. How organizational structures allow workers to feel or not feel ownership of their work and work outcomes has far-reaching consequences on business and worker happiness [3, 75]. The same phenomenon in virtual environments has only recently been discovered for research, however. Although there is a substantial amount of thought going into how we see ourselves and our bodies in virtuality in the form of embodiment research, with certain standards already established (presence, sense of embodiment, etc.), virtual objects and how we relate to them is still a niche topic [25]. With the rapid advancement of Virtual Reality (VR) and Augmented Reality (AR) technology, it is imperative to think about the way in which we can, do, and should interact with our ever-extending virtual environments. In this systematic review, therefore, we collect the literature that tries to unravel the phenomenon of psychological ownership in virtual worlds and of virtual objects. While first giving a brief overview of the original concept of psychological ownership, coined by Pierce et al. [55], we go on to present the way in which researchers have been adapting the concept to the extended or virtual reality context. We give an overview of the operationalizations of psychological ownership in these contexts, and present what leads to feelings of ownership in virtuality. After establishing how and why ownership emerges, we present the consequences of such feelings, why designers of virtual worlds should pay attention to the phenomenon, and how it can be utilized in different contexts. To consolidate these findings, we identify the dimensions that make up psychological ownership in virtuality. We present them in a preliminary model to offer some clarity of the complex phenomenon. Lastly, we will discuss the current state of the literature and establish aspects that need more attention in future research. The ultimate goal of this review is to answer the following research questions: What is psychological ownership? How does it present itself in VR, AR and other interactive environments? What facilitates its emergence? What effects and consequences can or does it have? How is it measured? Why should we study psychological ownership in and of



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interactive virtual worlds, and what are its potential applications? What should future research focus on?

2 Background: Classic Psychological Ownership

The underlying concept of psychological ownership, sometimes also called perceived ownership, may be far older than the structured science that coined the term. It is the feeling of owning an object or an abstract idea, that it somehow belongs to and is connected to you. Behavioral psychologists and even philosophers have noted the tendency of humans to claim certain things as their own, from pieces of land to simple toys, in the case of children [61]. In 2001, Pierce et al. [55] formally introduced the concept of psychological ownership and built the theoretical and foundational construct for further research. They identified three roots that make up the basis of psychological ownership and three routes that lead to its emergence. (1) **Self-efficacy** describes the ability of a person to have an effect on the world around them, to see that their actions have meaningful consequences, (2) **self-identity** describes inserting personal traits or characteristics into the target, and (3) **having a place or belongingness** describes the innate desire to and feeling of finding a home or a place where you belong in the target.

The emergence benefits from three routes [55]. (1) **Controlling the target**, (2) **coming to intimately know the target** and (3) **investing oneself into the target**. Not all of these routes need to be activated to facilitate psychological ownership, but their effect is additive. The emergence is also highly context-dependent [56].

Psychological ownership is distinct from legal ownership, as one can experience a sense of ownership for a target they do not legally own and vice versa [56]. Furthermore, the target of psychological ownership does not need to be an object [56]. Ownership can be felt for ideas, companies, work outcomes, even for pets [32]. The consequences in classic research fields of psychological ownership range from improving employees' work attitude, job satisfaction, willingness to stay at a company, and much more [56, 75]. It can conversely also have negative consequences such as resistance to change or over-possessiveness [56]. In marketing research, meanwhile, consumers' psychological ownership of products can make them more willing to buy products and increase their happiness [7, 13]. Over the last 20 years, scholars have continued to add more dimensions to psychological ownership, especially in the field of organizational management. Avey et al. [3] distinguished two types of psychological ownership, the promotion-oriented and prevention-oriented kind. The former is focused on positive (work) outcomes. It incorporates the same motives as the original concept, but also adds the motive of accountability, which represents the positive and negative responsibility one has for the target of ownership. The second type, prevention-oriented ownership, encompasses the negative side of psychological ownership and can be summarized in the concept of territoriality. Acting prevention-oriented leads employees to resist change and be defensive about their work (outcomes). To empirically evaluate the impact of their dimensions, Avey et al. proposed the Psychological Ownership Questionnaire (POQ). They found that psychological ownership impacts on job-satisfaction, intentions to stay with one's organization and affective commitment. When Olckers [48] found the POQ unfit for research on South African organizations, they developed the South African Psychological Ownership Questionnaire (SAPOS). They added the dimensions of autonomy and responsibility. While there is a strong theoretical basis, there is an ongoing debate around which dimensions belong to psychological ownership and how it can be measured [12, 49]. As the literature on psychological ownership in a virtual context is still very young, this systematic review should guide research. It will demonstrate the current state of the literature in virtual contexts. Thus, it should help systematically organize the somewhat unclear nature of the classic psychological ownership construct for virtual applications and thereby provide a guideline. We will also connect our findings with contemporary psychological ownership HCI-frameworks and discuss them. In any case, the review should help future scholars to see how their predecessors have adapted the classic construct to the virtual world, what they found and what knowledge is still lacking. Lastly we aim to give designers and developers a basic guide for utilizing psychological ownership in their projects. We especially want to encourage its adaption into new meaningful contexts like AR and VR based therapeutic and educational applications.

3 Selection Process

3.1 Defining Interactive Virtual Environments and Virtual Objects

When setting out to conduct this systematic review of virtual environments, we quickly learned that it was difficult to define the scope that we wanted to encompass. Researchers seem to use the terms *digital* and *virtual* interchangeably and never quite define them. As a review of all research that deals with psychological ownership and any form of digital content would be out of scope, we followed the definition of interactive virtual environments and objects below. In consumer research, researchers have found a difference in how people experience psychological ownership towards digital and physical objects. They claim that there is a fundamental difference in how digital and physical objects can evoke feelings of ownership, causing people to value digital goods differently, possibly even less than physical goods [2, 73]. Even money and its connected purchasing power seem to be more valued in a physical state [81]. However, digital goods are no monolith – the previously mentioned literature focuses primarily on goods that act as a medium for information, like books, music, photographs in either physical or digital form. Being a medium for information is the purpose of their existence. However, the further you look into more interactive goods like video games and VR and AR environments, the less their purpose is to purely store information. Koles and Nagy [33] in their 2021 work have proposed a continuum of digital object attachment and postulated that the more complex and interactive a digital object is, the more object attachment it can create. For the purposes of this review, what they call higher-level (levels 3 and 4) digital objects are actually *virtual* objects. These (virtual) objects postulate the computed representation of an actual object. Their form, visuals, and the external representation thereof are the main purpose of their existence. On the other hand, digital or disembodied objects can be regarded as an amalgamation of data that serves a more utilitarian purpose – e.g. spreadsheets, music libraries, social media profiles. In short, the present review adheres to the following:

digital objects contain only information and present information, whereas virtual objects present real objects in their (full) visual and interactive capabilities. The present review focuses exclusively on virtual objects.

3.2 Databases

Four databases form the basis for this review's selection process: the ACM Digital Library, IEEEXplore, ScienceDirect and Web of Science. While this review focuses primarily on interactive virtual worlds and objects, be it VR or AR or interactive media like video games, we still thought it prudent to include an HCI-focused database (ACM) due to the close relationship between this field and XR-research.

3.3 Keywords

Relating to our previous definition of interactive virtual environments and objects, we included technologies that facilitate such environments in our search. Hence, we used "augmented reality" and "virtual reality". As explained above, there seems to be no clear definition of what the terms digital and virtual encompass in the literature. To ensure that we cover most of these definitional diversions, we included both "digital" and "virtual" as keywords. To further encompass possible interactive virtual experiences that do not include VR or AR technology, we included the term "immersive". Lastly, we included "object attachment" to check if there was related literature that combined the two concepts. The keywords and pairings consequently are as follows:

- "Psychological Ownership" AND "Virtual Reality"
- "Psychological Ownership" AND "Augmented Reality"
- "Psychological Ownership" AND "Human-Computer Interaction"
- "Psychological Ownership" AND "virtual"
- "Psychological Ownership" AND "digital"
- "Psychological Ownership" AND "immersive"
- "Psychological Ownership" AND "Object Attachment"

To ensure that no other concepts regarding ownership like legal ownership or body ownership were mixed into the results, we always specified "Psychological Ownership" as one term.

3.4 Inclusion criteria

To be included in this review, research papers must focus on psychological ownership as one of their main or their main topic(s) and propose insights into the concept. They need to analyze psychological ownership of interactive virtual objects or environments according to the definition we proposed. They must have empirical evidence for their findings, quantitative or qualitative. Their publication date must lie before or within 2024 to ensure the future replicability of this literature review.

3.5 Exclusion criteria

We would exclude research that does not present enough insight into the concept of psychological ownership to meaningfully advance the field – i.e. if they just briefly mentioned the concept. Furthermore, we would exclude all research that analyzed feelings of ownership in a way that does not fit the definition we proposed.

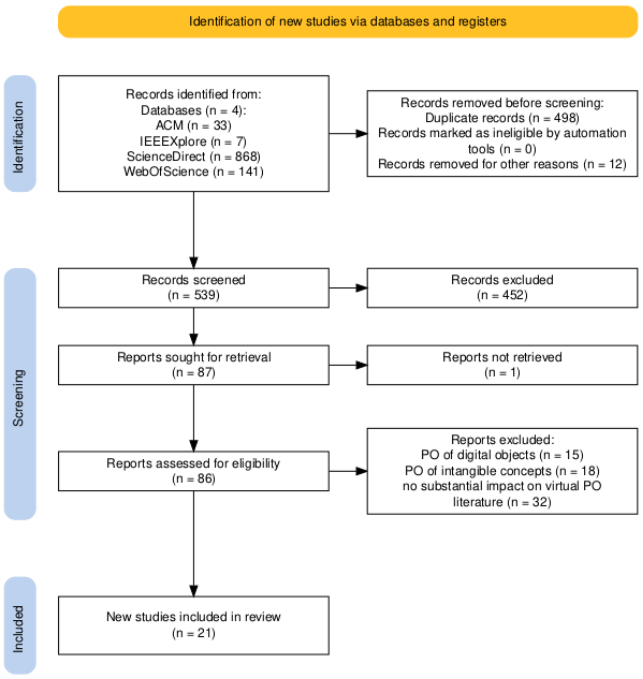

Figure 1: PRISMA flow diagram [23]

This means research focusing on intangible concepts like the ownership of online communities or knowledge sharing and hiding. Lastly, we did not analyze research that looked at other established forms of ownership, such as body ownership or legal possession, as a form of psychological ownership.

3.6 Review method and material

The first author of this paper conducted most of the literature selection process. Both authors discussed the inclusion and exclusion criteria in advance, which the main author used to sort the literature. If fringe cases came up that made a clear classification difficult, both authors would discuss them. An example of this is the work of Kühn et al. [37]. The paper made it to the second-to-last review stage. We discussed its inclusion and, through that, the general inclusion of works where only touchscreen-based interaction with pictures served as a possible antecedent to psychological ownership, which would have added quite a few papers to our final review literature. The first author argued for the inclusion, as we already had included the work of Luangrath et al. [43], a work that also analyzed the modality of touch. However, the second author pointed out that the latter also analyzed the phenomenon of embodiment, which was strongly connected with contemporary research of VR and XR. Kühn et al. [37] and similar works, on the contrary, only analyzed touch interaction with images. That would not adhere to our definition of virtual objects, as images count as digital. The first author conceded, and we agreed that such literature would be excluded from the review.

To search literature, we first searched the keyword combinations in the databases' search engines. We saved the resulting entries with the Zotero Browser plugin [10] into Zotero [11], marking the

entries' origins and the keywords with tags. We double checked the entries after each search. After the entire search was completed, we exported a list of the entries in a csv format. After the abstract screening phase, we used this list to note each paper's topic and its exclusion and inclusion criteria.

3.7 Results

The systematic review process revealed 1049 entries found across all five databases, 33 in ACM, seven in IEEEXplore, 868 in ScienceDirect, and 141 in Web of Science. Of these, 498 were duplicate records. 12 were removed because they were seemingly unrelated to the search and showed either none of the keywords or missing keywords. We screened the abstracts and titles of the remaining 539 papers by hand, of which we excluded 452 for various reasons, mostly because they either did not mention psychological ownership at all or only in terms of organizational and managerial research, i.e. classic psychological ownership. It was impossible to receive only one of the 87 remaining papers, leaving us with 86 to assess eligibility. In accordance with the previously explained inclusion and exclusion criteria, we excluded 18 papers that focused on psychological ownership of disembodied ideas, e.g., social media, online communities, brand-attachment and others. There were 15 papers that focused on what we define as digital objects or digital goods, which we also excluded. Lastly, we removed 32 papers that did not significantly contribute new information to the field of psychological ownership of virtual objects. This means papers where researchers only briefly touched on the idea of psychological ownership as a future possibility of research or only mentioned it briefly in one or two sentences. This left us with our core literature consisting of 21 papers. The systematic process is depicted in figure 1. 20 of the 21 review papers we found were published openly, while one paper was provided by the authors – it had been published in a peer-reviewed journal, but not as open source. Chronologically, the first of the papers was only published in 2011, while the bulk of the research was published in 2018 or later. This shows how new and current this topic of research is. The 21 articles present qualitative or quantitative empirical research. Half of the literature stems from the fields of marketing, (e-)retail or business. The other half comes from various fields that can be best encompassed by information system research, e.g. Human-Computer-Interaction, UX-Research, among others. We utilized the papers' keywords and in unclear cases their journals to classify the works into either HCI or marketing literature. Marketing is a broad term that we chose for the purposes of easier presentation. It encapsulates everything from retail and product presentation to commerce-related literature. Twelve papers focused on AR as a facilitator for psychological ownership, three on computer gaming, two on virtual avatars (either scanned or created on a phone). Four papers focused on the influence of interaction modality on psychological ownership, especially haptics. The last paper did not limit itself to a specific technology, but discussed virtual worlds in general. We present the 21 papers in table 1.

4 Psychological Ownership of Interactive Virtual Objects and Environments

The research on psychological ownership of interactive virtual objects and environments appears to be mainly concentrated in the fields of marketing and human-computer interaction (HCI). In parallel to the classic psychological ownership literature, there has not yet been a consensus for the definitive structure of the construct. While in the classic literature there are ongoing discussions about which dimensions psychological ownership encompasses, this is also true for the review literature. The core parts of the construct are seemingly widely accepted, i.e. the roots and routes established by Pierce et al. [55]. However, in the literature, we found that there is much less focus on establishing clear dimensions of ownership. Instead, especially marketing research seems to be focused on specific variables that are inherent to certain contexts like product presentation, while the HCI literature is still finding its footing in how psychological ownership works in interactive virtual environments like collaborative AR. We will present the contributions of the reviewed literature and connect them to the motives and routes of psychological ownership.

4.1 Antecedents of Psychological Ownership

4.1.1 Control. While there is some variance in what constructs researchers use to evoke psychological ownership, one that is mentioned consistently and operationalized most often is control. As in the original definition, control is one of the routes to psychological ownership – the more control a person has over their target, the more ownership they should feel [56]. Seven of the reviewed papers have operationalized control in some form and found it to have a statistically significant influence on the emergence of psychological ownership [9, 24, 41, 47, 64, 69]. The specific definitions of control in these papers often rely on the context. Lee and Chen [41] for example attribute perceived control of users of virtual worlds to their ability to navigate and communicate effectively while also experiencing the world to be secure. Song et al. [69] represent control with the concept of simulated physical control established by Hilken et al. [27], which sees the simulated physical interaction with objects in AR as a type of embodiment. In interviews with persons who had a photorealistic avatar of themselves created, Cork et al. [9] found that the control that their participants felt or wanted to feel over their avatar extended further than their direct physical control (also known as agency) over it – towards security, utilization and customization. They wanted to know that their avatar and thus their likeness could not be misused. Furthermore, they wanted to be able to have a say in how the avatar looked and if it should be modified. In general, participants felt very little control of their avatar, as some factors were not within their power to verify like where and how the avatar is stored, who could access it, among others. This fear of external control suggests that there exists a negative dimension of control – a form of subtractive control that may negatively impact feelings of ownership. This is explicitly not only a lack of control but an additional layer of an unknown, external influence exerting control over one's ownership target (in this case photorealistic avatars).

In [64], the researchers define perceived control as a desire-driven way to handle given situations, which means taking a more

Table 1: Overview over core literature in publishing order

Ref	Field	Technology	Antecedents of PO	Effects of PO	Instrument(s)
[41]	HCI, UX-design	virtual worlds	cognitive appraisals, affective appraisals, perceived control, self-investment	positive future use intention	[54]
[59]	HCI	AR	personal space, control over environment, emotional object attachment	feelings of violation	semi-structured interviews
[58]	HCI	AR	anchoring of objects, responsibility	enjoyment, possession	[3, 48, 51]
[57]	HCI	AR	contextual role of participant, AR scenario	interpersonal tensions	[48], self-created
[24]	HCI	AR	object reality, user control of object	increased possession, lower separation from object	self-created
[64]	HCI	gaming	perceived control, emotions in gaming, personality traits, game performance	higher consumer happiness	[1]
[9]	HCI	avatars	control of avatar, customization options, connection between avatar and user's identity, involvement in avatar creation process	sensitivity to how avatar is used and to potential abuse	interviews and thematic analysis
[78]	HCI	avatars	avatar customization	higher avatar attachment	[36, 75]
[47]	marketing, gaming	MMORPGs (PC)	perceived control over character	increased e-loyalty	[75]
[13]	marketing, retail	touch-input	interface-touch, object interactivity	endowment effect, stronger willingness to pay	[6, 54]
[7]	e-retail	AR, touch-input	interface modality (touch)	better product attitudes, higher purchase intention	[54]
[8]	marketing	AR	customization, interactivity, social cognition	none measured	[54]
[69]	marketing, retail	AR	environmental embedding, simulated physical control, immersion	higher decision comfort	[54]
[31]	marketing	AR	product information (utilitarian vs. hedonic, presence	enhanced product evaluation	[54]
[76]	marketing	Gaming	gaming motivations (escapism, achievement)	non-linear relationship with online gaming addiction	[41, 75]
[79]	marketing	AR	flow experience	more favorable product attitudes, stronger desire to buy	[54]
[43]	marketing	touch-input	vicarious touch, type of touch (diagnostic vs. typical), embodiment	higher product valuation, willingness to pay, purchase intention	[54]
[74]	marketing	gaming	intimate knowledge	perceived game enjoyment	[54]
[52]	marketing	AR	immersion	higher decision comfort, enhanced purchase intention, awe-experience	[54]
[4]	marketing	AR	immersion	stickiness to retailer (p>.05)	[80]
[71]	marketing	touch-input	product type (material vs. geometric)	–	[6]

active role. They contrast this primary perceived control with secondary perceived control, meaning a more passive approach and adapting to situations (e.g. withdrawing or submitting in a situation that exceeds one's capabilities) [62]. In their research, they identify perceived control as its primary, active form. Similarly, Moon et. al [47] use the same underlying definition of primary and secondary control [62], but take secondary control to represent a search for meaning in events that happen to users/players. In this study, control is also primarily focused on the perceived control of their specific video game characters, as they examined psychological ownership of Massively Mutliplayer Online Role-Playing Games (MMORPGs). These five papers see control as something the user or participant perceives as an inherently subjective construct. Conversely, the study of Han et al. [24] is the only one that uses control as an objective factor of their given experimental situation. In their study about shared AR, either the user or their (real or virtual) partner can control the object. Here, control is a constraint inherent to the system. The measurement for control did, therefore, not ask for their subjective perceived degree of control but to what extent they felt the right to control the object [24]. They observed a higher perceived right to control when they were also in control objectively, which implies that there could be ways to infer a sense of control without relying on subjective cognitive measures.

Unique to virtual objects is their degree of interactivity. While not a measure for control per se, a higher degree of interactivity may cause more perceived control or at least the possibility of control. Researchers in [13] and in [8] showed that higher interactivity also increased psychological ownership.
Another related construct could be customization, which three of the reviewed papers found to be a predictor of psychological ownership [8, 9, 78]. Carrozzi et al. [8] essentially see customization as a form of control [28]. Furthermore, in relation to their findings on control, Cork et al. [9] see customization and the ability to deny or allow it also as an aspect of the control that their participants felt over their photorealistic avatars. Relating to avatars as well, Young Chung et al. [78] also found customization to positively impact feelings of ownership, relating it to a sense of control. However, it would be an incomplete reasoning to attribute customization only to perceived control. The core of customization is to adapt a target, either object or environment, to your specific liking. This aspect should make it clear that customization is also related to self-identity and the route of investing yourself into your target.

4.1.2 Self-identity. While control is an operationalized variable in some of these studies, self-identity is not consistently mentioned. The root or motive of self-identity is most likely driven by the route of investing yourself into your target. Customization, as previously mentioned, allows for exactly that: Invest something of your own personality or identity into your target by designing it to your liking. Five papers in the review literature give insights into these concepts [8, 9, 41, 74, 78]. Lee and Chen [41] analyzed self-investment, i.e. the amount of effort one puts into (using) the target and found it to be a partial predictor of feelings of ownership. In [9], Cork et al. found that not only the control over customization is important to participants with a photorealistic avatar, as mentioned previously. They also see themselves or part of their self in the avatars, literally as well as figuratively. One participant expressed fear that any negative action their avatar would take – or rather, would be made to do – would reflect negatively on them. The researchers highlight how often participants would use "I" and "me" when referring to their avatar. Both of these findings imply that some form of identity transference or investment of self has taken place. This clearly hints at two types of ownership emerging – psychological ownership of the avatar as an object when the participants are currently not embodying it and body ownership when they are. Self-identity is one of the aspects of body ownership and we will discuss the connection between this and psychological ownership further in the discussion section.

Also related to avatars, Young Chung et al. [78] found that customization of 3D-avatars (Apple Meemoji) increased participants' psychological ownership of them, especially when avatars represented their ideal selves. This again implies an act of investment of self into the avatar. Lastly, in their 2022 paper, Tan and Yang [74] determined that intimate knowledge of MMORPG players of their in-game (proprietary) items fostered higher ownership of them, regardless of the way they came to possess these items. While this does not feature customization, intimate knowledge of an object can only be achieved through self-investment and investment of time and/or effort to come to know the target.

While far less prominent than control as an antecedent in the current literature, the effects of customization, self-identity and self-investment still seem to have a direct impact on the psychological ownership of a virtual target. As we established before, customization is also strongly related to control. Therefore, these concepts should gain more attention and scrutiny in future research.

4.1.3 Object attributes. The basic three roots, three routes concept of psychological ownership describes the point of view of the person who feels a sense of ownership toward a target. What is ignored in this design is the role that the (object) attributes of the target and their affordances play in facilitating the assumption of ownership. Pierce et al. [56] themselves explained that feelings of ownership come not only from a person and their traits, but also from the object/target of ownership itself. They assert that targets of ownership can either facilitate or hinder the development of ownership along the three routes through their attributes like attractiveness, accessibility, openness, and the degree to which they can be manipulated. Due to context sensitivity and the plethora of possible targets of psychological ownership, it is unfeasible to try and create a comprehensive list of such attributes. However, exactly this context sensitivity could mean that *when* such an attribute is found, the contribution to that specific context could be immense.

DeVries et al. [13] as well as Ştir and Zaiţ [71] found that the product type itself has an impact on perceived ownership. Ştir and Zaiţ, for example, found that material products (where the nature of the product is important) caused participants to feel more ownership towards them than geometric objects (decorative products). It could be interesting to analyze which object qualities influence feelings of ownership themselves or their antecedent. For example, control is an established antecedent of ownership – control itself can be influenced easily by something inherent to virtual environments and technology like VR and AR, i.e. interactivity. Since more control leads to more feelings of ownership, it follows that more interactivity leads to more control. The interactive attributes and

affordances of virtual objects and environments could, therefore, be its own topic of psychological ownership research. Future research should give more attention to not just the person experiencing ownership but to the target of that ownership itself. Pierce et al. themselves brought the target's attributes into the discussion but never added them to their model of psychological ownership. With the manifold design possibilities of virtual environments and objects, it would be prudent to pay closer attention to the dimension of the ownership target's attributes and their impact on the classic routes and roots of psychological ownership.

4.1.4 Immersion and Presence. The concepts of immersion and presence are part of the foundation of AR, VR and Extended Reality (XR) research. Three papers [4, 52, 69] saw a feeling of immersion as an antecedent for psychological ownership. However, they each use a slightly different definition of the term, while all in essence meant the feeling of being mentally drawn into the virtual environment. Although there is a debate about the definition of immersion, when we employ the construct, we mean the inherent qualities of a system that enable it to facilitate absorbing experiences [67]. Presence (after Slater's definition) meanwhile describes the feeling of being in a place, in this case the virtual environment. This is spatial presence, but there is also the sub-construct of involvement that describes how cognitively engaged a user is with the virtual environment (or stimuli) [67, 68].

In the review literature, only one paper focused on presence after this definition as an antecedent of psychological ownership [31]. Since we employ Slater's definitions for immersion and presence, for us, what the former three papers describe as immersion belongs to the involvement aspect of presence. This is of course a very reduced point of view and should not be misconstrued as a debate about the nature of immersion and presence – both topics for which the definitions have long been debated. It seems that a feeling of presence (or in the researchers' terms, immersion) can enhance feelings of ownership. Therefore, we want to highlight these findings to show that there is great potential to examine psychological ownership in conjunction with the immersive and presence-inducing qualities of AR and VR technology.

4.1.5 Context. As described in section 2, psychological ownership is a context-dependent phenomenon. We will therefore briefly outline the contexts we found in this collection of literature so future scholars can adapt their own research.

The marketing literature mostly focused on (e-)retail situations with a focus on the influence psychological ownership has on purchase intention and behavior, and related constructs. The context-dependent antecedents of feelings of ownership were mostly seen in characteristics of either the technology that facilitates the interaction, such as AR or touchscreens, or in the presentation of the products in question. For example, Song et al. [69] cited the phenomena of environmental embedding and simulated physical control as an influence on psychological ownership, two constructs that are inherent to AR. In general, the marketing literature looked at mostly retail situations where a consumer product was the focus and therefore the target of ownership. Similarly, the literature centered primarily on shared AR experiences and the effect this social setting has on interaction and feelings of ownership. Poretski et al. conducted multiple experiments [57–59] analyzing social norms and shared ownership in the unique and novel situation of interacting with the same virtual objects. They found that the framing of the situation alone has an impact on who feels how much ownership over virtual objects. It is evident from their research that shared or collaborative AR is based on existing social norms surrounding (psychological) ownership and may need to develop their own norms over time. Specifically analyzing existing social norms surrounding shared (psychological) ownership during real and virtual collaboration could clarify what aspects govern these interactions.

4.1.6 Interface and Interaction Modality. A small part of the papers analyzed the influence of the interaction or interface modality [7, 13, 43, 71]. DeVries et al. [13] and Brengman et al. [7] found that product presentation via indirect methods (computer and mouse) vs. direct interaction via touch-input (tablet) has an impact on psychological ownership, with touch-input having a positive effect. Ştir and Zaiţ [71] could not replicate these findings. Luangrath et al. [43] found the effect of vicarious touch which describes the interesting phenomenon that merely perceiving a hand touching a product induces psychological ownership. They saw this as a type of embodiment, with onlookers briefly preceiving the disembodied hand as part of themselves. While this is not a form of interaction per se, the researchers themselves urged future research into this effect in immersive technologies. We argue that these findings offer enough evidence to encourage future research to focus on the modality of interaction, haptics and touch in particular.

4.2 Effects of Psychological Ownership

As we just demonstrated, there is ample research on the antecedents and requirements for feelings of ownership to develop. It is, however, vital to understand what consequences these feelings can and do have. Understanding can help avoid negative consequences or facilitate positive ones. Most important is to demonstrate why research into this topic is necessary and beneficial. In marketing research, there are very clear influences that feelings of ownership have, while in the field of HCI the effects are barely known.

4.2.1 Positive effects. As the concept of psychological ownership itself is a cognitive-affective construct [56], it stands to reason that feelings of ownership would have consequences for a person's affect and cognition. Multiple of the review papers have found positive outcomes, ranging from better attitudes towards products to consumer happiness or enjoyment. In [7, 31, 43, 76] the researchers found that psychological ownership either directly causes positive product evaluation or attitudes or mediates the influence of other variables on them. Lee and Chen [41] demonstrated that a high psychological ownership of a virtual world would boost the future use intentions of users. This last finding especially shows how psychological ownership can have a beneficial influence on the user's attitude towards a product and even impact their usage habits.

Affective effects that do not directly relate to the object or target are higher consumer happiness, higher decision comfort, awe-experiences and (game) enjoyment. Tan and Yang [74] found that having a higher ownership of the items you possess in an MMORPG directly enhances your enjoyment of the game. Shahzad et al. [64] similarly demonstrated that higher psychological ownership of

video games enhances the consumer happiness of players. Unrelated to gaming, Pathak and Prakash described that feelings of psychological ownership toward retail products in AR enhance the consumers' decision comfort in acts of buying, which in turn enhances feelings of awe- or wow-experiences.

4.2.2 Economic effects. One goal of the marketing literature is, of course, to provide consumers with a better experience and influence their purchasing behavior. Five articles have clearly demonstrated that psychological ownership can influence customers' intent to purchase, as well as how much they would be willing to spend on the target of their feelings of ownership [7, 13, 43, 52, 79]. This is likely due to the endowment effect that describes the tendency of people to ascribe a higher (monetary) value to the goods they own [44]. Although not as directly impactful as the intention to purchase a product, there are other economic effects evoked by feelings of ownership. Lee and Chen [41] find that psychological ownership towards a virtual world elevates the future use intention of users, while in [47], Moon et al. find it boosts e-loyalty in gamers, which similarly describes how attached gamers are to their virtual worlds and how likely they are to return to it [22]. These findings show that psychological ownership is a strong tool in marketing to influence consumer behavior.

4.2.3 Negative effects. It would be remiss not to present the negative consequences that feelings of ownership can have. While Avey et al. [3] already established territoriality as a more negative aspect of ownership in organizations, two of the papers we analyzed also show how (too much) ownership can have unintended effects. Wang et al. [76] researched the effect that feelings of ownership have on online gaming addiction and found that they have a nonlinear relationship. It seems that when users have low feelings of ownership, they are unlikely to develop an addiction, while the same seems to be true for very high feelings of ownership. Medium high psychological ownership contributes most to addiction. The researchers assume that highest psychological ownership also comes with game completion and thus less novelty and engagement, which lower the chances of developing an addiction. This would mean that the 'right' amount of ownership is felt when users are familiar enough with a game to have fun but still have enough novel experiences left to explore. This is a very thought-provoking finding for future researchers to keep in mind as people spend more and more time in virtual worlds.

The second negative consequence found in the literature could also be called an ethical implication. We already discussed the concept of control of photorealistic avatars in Cork et al.'s [9] work. As participants expressed worry over who might have access to their avatar, how it might be misused and how that misuse would reflect on their real persona, these negative feelings need to be understood and mitigated. While the ethics of photorealistic avatar creation deserves its own dedicated research, what we can extract from these findings is that psychological ownership seemingly comes with feelings of responsibility, something that the organizational literature has already explored [49]. It seems that the more external, uncontrollable influences act on the target of ownership, the more negative emotions can develop. As researchers and designers of virtual worlds, we have a responsibility to analyze these negative affects and adapt the experiences we create to account for them.

4.3 Measuring and Instruments

A large portion of the reviewed papers rely on an instrument established by Peck and Shu [54] in 2009. It is comprised of three items: I feel like this is my [target], I feel a very high degree of personal ownership of the [target], I feel like I own this [target]. Their analysis of internal consistency revealed a Cronbach's alpha value of over .95. They in turn had based these items on the first established measurement of psychological ownership (of organizations) from Van Dyne and Pierce [75], but adapted the sentiment to reflect ownership of objects instead of organizations. It is noteworthy that Peck and Shu's measurement is aimed very clearly at psychological ownership in and of itself with no subscales capturing its dimensions. In the classic ownership literature, there have been multiple instruments proposed by researchers that measure the subscales of psychological ownership. Avey et al. [3] propose 16 items over 5 dimensions (self-efficacy, self-identity, accountability, belongingness and territoriality) while Olckers [48] proposed 3 dimensions (identity, responsibility and autonomy) with 21 items, just to give some examples. Especially in the marketing literature of this review the researchers almost always calculated complex structural equation models with multiple mediating and moderating variables. In this context, it makes sense to keep each measurement less complex.

In the more HCI-oriented literature, however, only Lee and Chen [41] in their 2011 paper used Peck and Shu's scale to measure ownership, while Young Chung et al. [78] used the original Van Dyne and Pierce scale [75]. The other papers either employed self-created scales [24], interviews [9, 58] or other qualitative measures. Han et al. [24] measured the subscales possession, control, identity and user-object separation with one item each. Poretski et al. [57] in their 2021 paper used a self-created scale that they adapted from Olckers' [48] 2013 scale. They measured items for the five dimensions control, identity, possession, responsibility and territoriality.

It seems that while there is a certain common base for measuring ownership in the marketing literature with the instrument from Peck and Shu [54], in more HCI-focused literature there is still a wide range of instruments and methods. While it seems that researchers in HCI more often focus on subdimensions like control and identity, there is a general lack of much quantitative evidence. Researchers here frequently employ qualitative methods like interviews. Given that psychological ownership research in this context is still very young, this is easily explained. Nonetheless, measuring psychological ownership in virtuality should stay in the focus of researchers. It could very well be the case that there are differences in capturing psychological ownership between the real world and virtual worlds. To the best of our knowledge, there exists no literature comparing the two. Analyzing whether the two types of psychological ownership require different measurements would be of great benefit to the topic as a whole.

5 Discussion

As virtual worlds and objects are beginning to augment parts of our lives like shopping [31, 69], therapy [14, 16] and education [29], designers and researchers need to understand how users perceive virtual objects and how they integrate them into their life through psychological ownership.

Table 2: Measurements of psychological ownership employed by HCI-literature

Used by	Subscale	Items	Based on
[41]		This is my virtual world.	[76]
		I feel a very high degree of personal ownership for this virtual world.	
		I sense that I own this virtual world.	
		It is hard for me to think about this virtual world as mine. (reverse-coded)	
[57]	Posession	I have a feeling that the ____ in this scenario belongs to me.	[57]
		I feel that I own the ____ in this scenario.	
		These are [this is] MY ____.	
		It is easy to think of the ____ in this scenario as MINE.	
	Control	I should have the right to delete the ____.	
		I have the freedom of choice regarding how to move the ____ in this scenario.	
		I have the right to change the ____ whenever I choose to do so.	
	Identity	I feel a personal connection to the ____ in this scenario.	
		I feel a bond with the ____ in this scenario.	
		I feel emotionally invested in the ____ in this scenario.	
	Responsibility	It is my fault if the ____ in this scenario does not show properly (or unintentionally disappears).	
		I am accountable for anything that may happen to the ____ in this scenario.	
		If the ____ in this scenario offend/s someone, it is on me to fix it/them.	
		It is my responsibility if someone feels uncomfortable with the ____ in this scenario.	
	Territoriality	Others should not change or delete____ in this scenario.	
		I will protect the ____ in this scenario from being changed or deleted by others.	
		I feel the need to protect the ____ from others near me.	
[24]	Possession	To what extent do you feel a sense of belongingness to the object in this session?	none
	Control	To what extent do you feel the right to control the object in this session?	
	Identity	To what extent do you feel a bond to the object in this session?	
	Separation	To what extent do you feel separate/distinct from the object in this session?	
	Ownership	Who do you think own [sic!] the object?	
[64]		I sense game is mine. [sic!]	[1]
		I feel personal ownership of this game.	
		I feel personally connected with this game.	
		It is hard for me to think about this game as mine.	
		It does not make me feel that it is mine.	

At the start of this review, we set out to show how psychological ownership operates in interactive virtual environments, what causes people to feel it, what effects it has and why it is an important research topic. What we discovered is that the research is rather disjointed and seemingly unique to each field that undertakes it. We found that around half of the literature discussing psychological ownership in virtual contexts is marketing-related while the other half is from the field of HCI. We will discuss the contributions of these two types of research to the overlying concept and what their findings implicate for the field of HCI research.

In general, there seems to be a lot of focus on the precursors to the development of psychological ownership. However, it is very rarely the case that the routes are directly operationalized and measured. Rather, the routes are seen as overarching contributors to feelings of ownership and researchers use them to select the antecedents that they want to study.

Control turned out to be the most prevalent subdimension of psychological ownership. While it is arguably also the one that could be most easily directly operationalized, researchers related a lot of constructs back to control to explain their influence on psychological ownership. The researchers described different types of control with different aspects they focus on, from perceived, experiential control to the explicit physicality of control. We would describe these types as a form of *direct control*, i.e. the ability to impact the virtual object or world with one's actions and to immediately get the feedback of the impact of those actions. This in turn directly relates to the dimension of self-efficacy. The second form of control is a more *experiential control*. Customization for example also gives a user the ability to directly effect a change in the target object, but may also give them the ability to alter the experience and subjective feel of the virtual environment. This type of control can also relate to the dimensions of self-identity and investing yourself into the target, as you regulate the overall experience with your own preferences. In a lesser way, it may also relate to having intimate knowledge of the target and feeling a sense of belonging. We can see the effect customization can have in related literature, specifically in [38], where Lacroix et al. found that letting people customize a robot enhanced their psychological ownership towards

Table 3: Measurements of psychological ownership employed by marketing literature

Used by	Subscale	Items	Based on
[8, 74] [7, 69] [43, 79]		I feel like this is my [target]. I feel a very high degree of personal ownership of the [target]. I feel like I own [the target].	[54]
[13]		I feel like the product is already mine. I feel a very high degree of personal ownership of the product. I feel like I own the product. I feel attached to my chosen product.	[6, 53, 54, 65]
[31]		While I was using the AR application... ...I felt like I owned these sneakers. ...I felt like these sneakers were my belongings. ...I felt as if these sneakers were mine. ...I could feel how it would be like to actually own these sneakers.	[54]
[52]		While shopping in AR,I felt as if this was my product While shopping in AR, I felt a very high degree of personal ownership of the product While shopping in AR, I felt as if I owned this product	[54]
[4]		When using this mobile AR shopping app, I felt the digital objects are mine. When using this mobile AR shopping app, I felt a very high degree of personal ownership of the digital objects When using this mobile AR shopping app, I felt like owning the digital objects	[8, 34, 80]
[71]		I feel like the product is already mine. I feel a very high degree of personal ownership of the product. I feel like I own the product. I feel attached to my chosen product.	[55, 70, 75]

it as well as enhanced the agency they attributed the robot. Similarly in the realm of human-agent-interaction, When working with an AI-text-generator, users felt the most psychological ownership when they had most control over the text itself [15]. Even in now usual aspects of life like reading e-books, consumers bemoan that they do not fully own these books, as in cloud-based services, the provider can still control their access [26]. Whether in the digital or virtual realm therefore, control is an integral aspect of psychological ownership. It is here where interactive virtual technology can shine – the heretofore unparalleled ability to change and control almost all aspects of one's environment.

The dimension of self-identity may also be of a specific interest for the field of HCI. With the emergence of photorealistic avatars, identity transference may be easier than ever [18]. AR and VR technology enables users to feel a realistic and absorbing experience, while the system capabilities offer almost endless possibilities for customization and personalization. Utilizing these attributes of immersive technology for facilitating and researching psychological ownership in particular has thus far been neglected in HCI research. However, research into virtual body ownership is a prominent subset of the literature on immersive technologies. In general, virtual body ownership and the sense of embodiment specifically scrutinize the different aspects of what makes a virtual body 'belong' to a person. (Virtual) body ownership seemingly relies on the similarity of the virtual body and the real body [30]. Identity transference in embodiment in particular could offer insights into the same phenomenon in psychological ownership research. Fiedler et al. [18] began to analyze what impacts the sense of self-identification with one's avatar and found that the self-similarity and the self-attribution of and towards it are the main factors in the identity transference. While for virtual objects the dimension of self-similarity is practically non-existent, self-attribution could well be an influencing factor for the root of self-identity and the route of investment of self. Explicitly analyzing the differences and connections between the constructs of embodiment/virtual body ownership and psychological ownership of virtual objects will certainly benefit both research fields.

But not only the bodily representation of users can enhance the dimension of self-identity in virtual worlds. Contemporary literature shows that even small acts like naming an object can enhance feelings of ownership [72]. Baxter et al. [5] show that people can use certain parts of objects as emblems which represent aspects of their personality or identity (like the mileage of a car). They present very object-focused design methods for object attachment which could easily be adapted to the virtual context. The social aspect of virtual worlds should also not be forgotten. Related literature clearly shows that there is an act of self-identity transference connected with the use of social media and online communities [40]. Social VR is a prominent part of contemporary HCI research, which shows that here, too, a transfer of identity takes place [19, 20]. While most of this research is particularly focused on avatar representation, researchers should still consider the aspects of (social) VR that facilitate identity transference that do not rely on a virtual body.

We found no paper explicitly analyzing the sense of belonging although immersive technology offers the possibilities of creating an individual space (for example Meta Horizon Worlds [45]). We urge researchers to consider these prominent features of immersive technology and utilize them for future research into psychological ownership in virtuality. In related literature about online or digital communities, Lee and Suh [40] show how to operationalize belongingness and that increased engagement in online communities enhances feelings of belongingness. Another study, utilizing an older social game called "Second Life", showed that fostering engagement and social and location awareness could enhance users' willingness to return to a virtual world [21], which could also represent a feeling of belonging there. While this work did not analyze psychological ownership, it could give hints as to how virtual worlds can influence it.

The third factor that we could determine in this review is context and what you could call framing on a larger scale. As psychological ownership is a context dependent construct, it stands to reason that each unique context in which researchers want to analyze it will have its own unique mechanisms and variables. In marketing literature, researchers especially focused on retail [13, 69, 79] and e-retail contexts [7, 31, 43, 52], in which either product presentation, the type of product and the modality of interaction played important roles in facilitating feelings of ownership and consequently bringing consumers to want to buy products. In HCI literature, researchers mostly focused on collaborative AR and how designers of virtual worlds can manage feelings of ownership among multiple actors [8, 24, 57, 59]. An interesting finding is that no paper exclusively focused on ownership in VR but instead only on AR. It is arguably easier to assess the impact a virtual object has on a person when it is the only thing that is virtual in an otherwise familiar real environment. However, as long as there is no research done into psychological ownership in VR specifically, we can only speculate. It stands to reason that there may be differences between feelings of ownership in AR and VR. It could be that the higher congruency of interacting with virtual objects in a virtual environment could have an impact on the contextual level and facilitate the emergence of psychological ownership better – or at least differently – than in AR (see for example [39]). The influence of the virtual nature of an object itself in AR, embedded into an otherwise real environment, and the plausibility of such an arrangement itself could have an impact on the emergence of psychological ownership compared to the complete virtuality of VR (see for example [77]).

This leads us to another point about the technology researchers utilize in virtual ownership research. While eleven of the papers looked into AR as a facilitator of ownership feelings, only three of them used dedicated AR headsets. Most examined mobile AR, i.e. smartphones and tablets. While this is apt for retail research where mobile AR devices seem to be the (future) status-quo, with the emergence of sophisticated AR-devices or spatial computing such as the Meta Quest 3 and Apple Vision Pro, HCI researchers should focus their attention on these devices and the specific context and possibilities they present.

Interestingly, only one of the papers we found focused on the virtual worlds or environments themselves and not on a specific object [41]. More research into environments could give better insights into what impact framing and context can have on users' feelings of ownership in virtual worlds. Together with the aforementioned lack of focus on imbuing self-identity into the virtual worlds and the possibilities the technology itself brings, future research should pay more attention to the inherent features of immersive technology and virtual environments for facilitating psychological ownership.

The second substantial part of psychological ownership research is understanding its effects. Especially in HCI research it seems that at the moment, there is more focus on the antecedents than on the effects – a reasonable direction, considering the recency of research into feelings of ownership in this field. Nonetheless, the field of HCI should begin to explicitly research the consequences of psychological ownership. This will help to better understand the use cases in which feelings of ownership can be meaningful, but can also protect users from potential negative effects. Most importantly, it will expand the as of yet limited picture we have of psychological ownership in virtual contexts and enable future researchers and designers to discern which aspects of ownership may be important for their applications.

As we discovered in section four, especially the retail literature found (positive) effects of psychological ownership. While some of them are important from an economic perspective, like a higher willingness to pay for products that the consumer has high feelings of ownership towards, other effects could also be interesting to the field of HCI. Positive affective changes in users' attitudes towards products, enhanced product valuation as well as higher perceived enjoyment and consumer happiness offer substantial implications for the design of virtual experiences. With applications targeting positive behavior change like exercise and therapy, it is paramount to examine the potential use psychological ownership could have in this regard.

The literature generally focused more on positive consequences of psychological ownership and consequently found more evidence for these than for negative effects. However, some findings indicate that feelings of ownership may have substantial negative consequences, which future research needs to address. While only Wang et al. [76] explicitly examined the effect of psychological ownership of MMORPGs on gaming addiction, other researchers inadvertently found other negative effects. Different views and norms surrounding ownership in a collaborative context seem to foster interpersonal tension [57]. Similarly, related literature shows that even sharing digital goods like accounts can lead to conflict unique to this co-ownership or co-use [17]. Territoriality behavior may also occur in the context of social media, influencing the behavior towards (brand) accounts [46]. Another negative aspect of psychological ownership are uncertain external factors exerting control over one's target of ownership – in this case photorealistic avatars of oneself – which may give rise to negative feelings [9]. The previously discussed phenomenon of devaluing digital goods in contrast to physical goods can lead to problematic interactions with these goods, as shown by [42]. They show that even children see the theft of digital goods as less problematic than of physical goods. It is therefore of utmost importance to explicitly focus on the negative effects of psychological ownership and how we can mitigate them to ensure future use of this phenomenon is safe and beneficial to the user instead of harmful.

To sum up this discussion, we can see that the construct of psychological ownership is generally the same, regardless of whether

the context is the real world, digital objects, communities or virtual objects. However, the consequences of this context are paramount. We see that digital goods are valued very differently and often times less than physical goods. The unclear ownership parameters of digital objects and services can lead to conflict. However, we can also see where virtual worlds, objects and technology can mitigate or eliminate these problems. Virtual immersive technology can offer a high degree of control and personalization as well as high immersive qualities and social interactions, all of which have been shown to positively influence psychological ownership in this review.

6 Psychological Ownership in HCI

Regarding the general concept of psychological ownership in the field of HCI, Kuzminykh and Cauchard [35] established a framework consolidating and reframing the most prevalent motives of psychological ownership and how they act in one's relationship with physical and digital goods. The instrumental motive represents self-efficacy, the symbolic motive represents self-identity, and the perceptive motive describes the tendency of humans to sort their surroundings into categories. The last motive seems especially important in connection with this review's literature and the concept of physical, digital, and virtual objects. The authors describe the differences between how people feel about "real" physical objects and digital ones. While physical media and its organizing and keeping seem as important as self-expression, digital media lacks many aspects that make it suitable for this. Their short literature review finds that digital goods seem less costly, as less effort is involved in procuring them. This can make objects seem less valuable to their owners. This is coupled with a certain "ephemerality" as they put it, making digital goods less substantial. Interestingly, they too state control as a leading motive in feeling ownership for digital possessions, as it seems to make a difference whether people possess digital copies of objects like e-books or music on their own harddrive or can only access these products by using cloud services. This echoes the findings of Cork et al. [9], who found that their participants worry about what can be done with their 3D-avatars when they are currently not embodying them. Koles and Nagy [33] express something similar when describing their digital object continuum. They juxtapose temporary with enduring objects, relating to the previously mentioned aspect of ephemerality. Further, they postulate that the more complex and interactive an object is, the more digital object attachment can occur. Our findings support that control is an essential driving factor of psychological ownership of virtual objects. Kuzminykh and Cauchard [35] make an intriguing point in stating that the basic psychological ownership literature does not separate between digital and physical objects; it does not mention the object type. However, combining their findings with the framework of Koles and Nagy [33] and our literature review, we can clearly see that new aspects of ownership emerge when dealing with digital and virtual objects. While Kuzminykh and Cauchard [35] state a perceptive motive as people dividing the world into things they own and things they do not, it may make sense to extend this motive's meaning with how "real" people perceive objects to be. In regards to our findings and the two frameworks of Kuzminykh and Cauchard [35] and Koles and Nagy [33], it stands to reason that a highly interactive, virtual object in a highly immersive virtual environment is perceived as much more ownable, so to speak, than an ebook obtained in a subscription-based service. Our model offers a representation of this additional virtual component that is neglected in classic psychological ownership literature. We encourage future scholars to keep these aspects of objects and psychological ownership in mind when dealing with digital and virtual worlds.

7 Limitations

While this review could identify and present the current literature on psychological ownership of virtual objects, there are certain limitations that we have to account for.

The study of psychological ownership emerged from business and organizational research. As such, directly adapting this concept that originally examined the ownership employees felt toward the organization they worked in comes with certain caveats that we did not focus on in this paper. We examined the existing literature that had already adapted the concept without more closely discussing how and if this transfer works. As far as we know, no such discussion exists as of yet – this could, however, make for a very interesting future paper.

In the same vein, we only focused on a very specific subset of research that explicitly analyzes virtual objects and peoples' psychological ownership towards them. However, psychological ownership research in marketing and retail (among other fields) has first examined the concept in the digital domain. For example, there have been studies about consumers' psychological ownership towards their digital music libraries [50, 66], their data and how that ownership impacts their IT-security behavior [63]. These and other topics could give insight into how designers and researchers can adapt the concept to other contexts. We decided against including them, however, as such an analysis would be out of scope. It would now be a meaningful contribution to analyze these papers psychological ownership of digital goods and objects – that one could consider as a kind of precursor to virtual psychological ownership research – and compare the results to our findings.

Lastly, the omission of the concept of virtual body ownership excludes the most prominent form of ownership in immersive technology research. Identifying which points of connection exist between the two forms of ownership could give valuable insights into viable future research directions.

8 Contribution

The field of psychological ownership research is vast and the emerging literature in virtual contexts is still finding its footing and thus seemingly unstructured. We thought it prudent therefore, to offer an overview of the concept of psychological ownership and what factors belong to it and influence it. We propose a conceptual model that offers this overview and also serves as a design guide for future research and designers that want to incorporate psychological ownership and its aspects into their applications. Figure 2 shows this model. We depict the basic structure of the roots and routes of psychological ownership and how they influence each other. This encompasses the cognitive-affective aspect of the construct that focuses on the experience of the person who feels psychological ownership. In this review, however, we identified multiple external

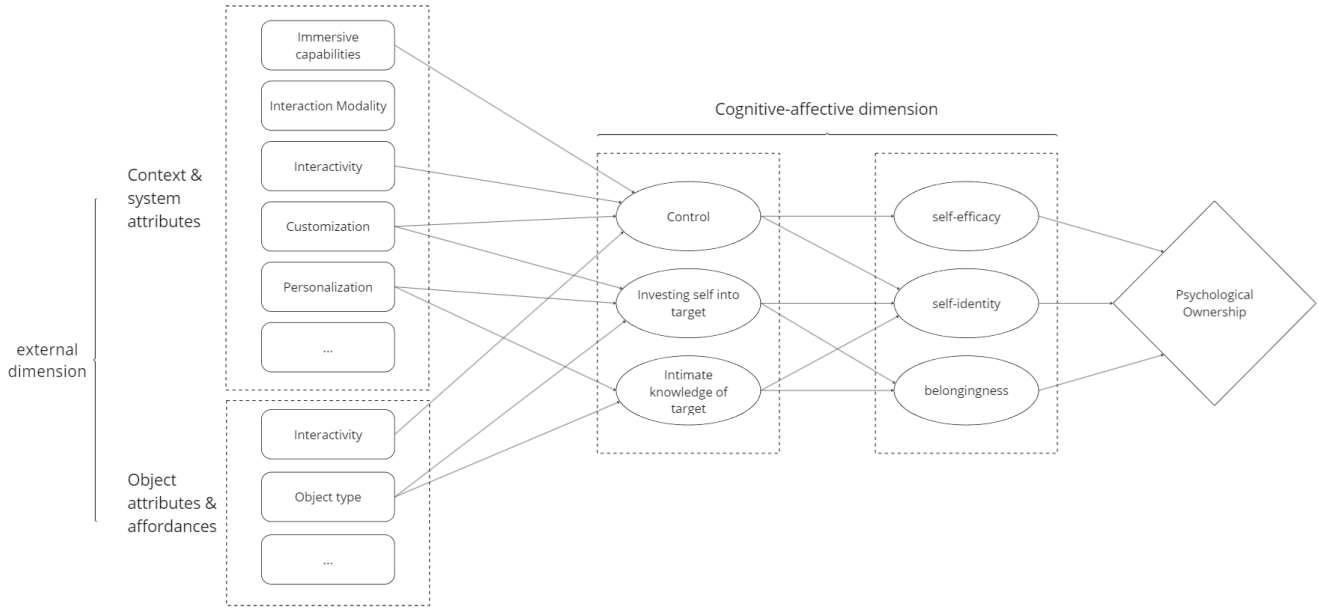

Figure 2: Proposed design model of psychological ownership dimensions and influencing factors with the classic roots and routes of psychological ownership on the right and the aspects we identified in this review on the left

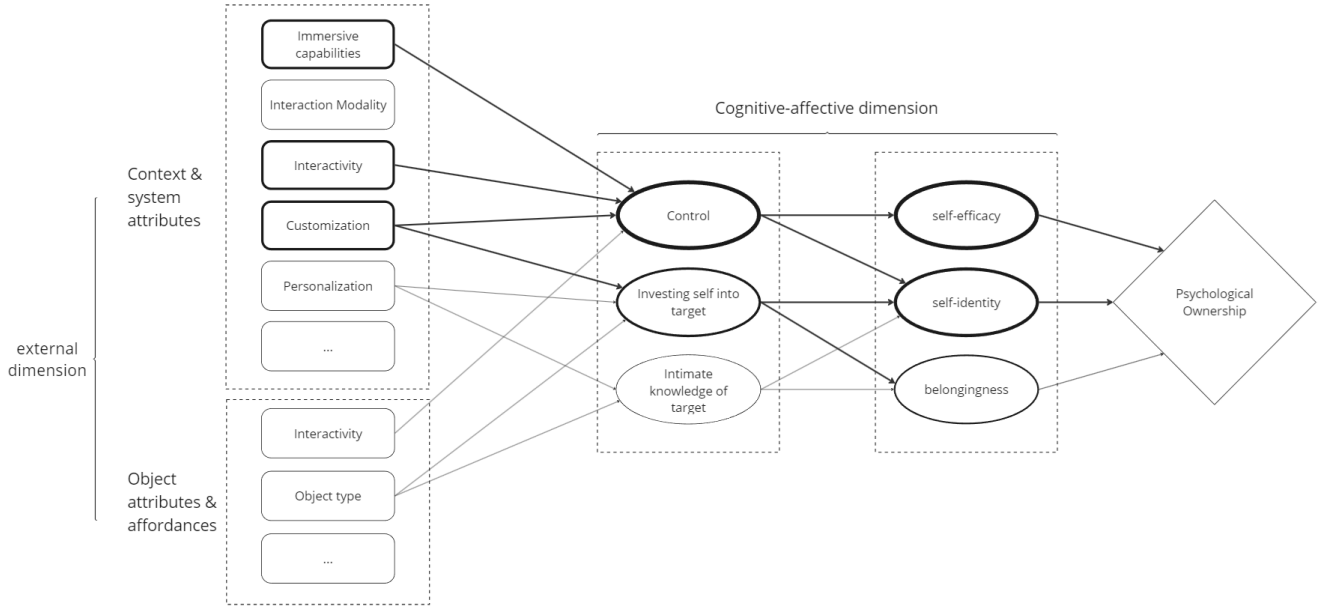

Figure 3: Example on how to use the proposed design model for planning and analyzing how to influence psychological ownership in applications. The thickness of the paths and outlines indicates the strength of the factor's influence.

influences on the routes of psychological ownership. In the model, we framed them as such by concentrating them on the left side, suggesting their influence on the core dimensions of psychological ownership. As we stated before, the routes are additive, and so should their influencing factors be. Thus, we decided to create the model in such a way that designers and researchers can see the (additive) impact the factors that they choose to implement in their applications will likely have on the dimensions of ownership. The core part of the model (cognitive-affective dimension) is based on the classic construct of psychological ownership. Connections between the roots and routes are symbolic representations of their relationships as presented in the literature. For example, according to Pierce et al. [55], self-efficacy is a direct result of feelings of control. Other connections are based on deductive reasoning, e.g. as customization can be seen as a form of control, the latter should have an influence on the motive of self-identity. These relationships should not be construed as a scrutinized model but as a representation of the network of literature we examined. Therefore all connections between the external dimension on the left and the core model are informed by the findings of this review. To give an example, the apparent influence of interactivity on control stems from the findings of Ştir and Zaiţ [71], which showed that interacting with an object caused higher levels of psychological ownership than merely looking at it. Attributing this to the route of control was deductive reasoning. In sum, the model can be used to work out impact paths and impact factors for empirical studies. In the second image (figure 3) we exemplify the model's usage. If we wanted to create an application focusing specifically on interactivity, immersive capabilities, and customization for example, we would see that these factors primarily influence the dimension of control, while having a smaller influence on self-investment. In this example, these activations mean that mostly the motives of self-efficacy and self-identity are influencing the emergence of psychological ownership. We present stronger influences with stronger lines. This, too, is not based on any statistical analysis but serves merely as a guide for designers and researchers to quickly see which effects they can expect or should control. Think of an exemplary high-fidelity AR-Application in which users can customize their safety-critical workplace, like a flight or crane simulator or control application. If a team of researchers wanted to analyze, say, how the pilots' identification with their workplace influences their reactions in critical situations, the model would show them that they should also enable personalization to enhance the motive of self-identity. While this is a purely fictional example, it demonstrates the model's capabilities and its necessity, as the complex nature of psychological ownership and its interconnected mesh of roots and routes can be difficult to navigate. If during this process, researchers identify novel effects and relationships between constructs, the model can easily be expanded, for example by adding new arrow-paths. In the example, the researchers could hypothetically discover that hand-tracking enables greater identification with the target than controller interaction and could therefore add a new path from "Interaction Modality" to "Investing self into target" or "Control". The model should consequently serve as a neatly arranged summary of our findings as well as a basic guide for future research.

9 Conclusion and future research

In this review, our objective was to consolidate the existing literature that examined the construct of psychological ownership and its antecedents and consequences in virtual environments and virtual objects. We found that especially the marketing and retail literature employs psychological ownership in AR to foster positive buying behavior and consumer attitudes. HCI research, however, is still in very early stages, examining collaborative contexts especially and trying to discern emerging (social) norms surrounding ownership in shared virtual environments. We found that control was the route most widely utilized to facilitate feelings of ownership, while investing yourself into the target and intimately knowing your target were secondary (but still operationalized). The motives of psychological ownership, self-efficacy, self-identity and belonging were not the focus of the review literature and almost never directly operationalized or measured. Especially the sense of belonging or having a home did not attract much attention. Antecedents that did not directly go back to Pierce and colleagues' classic construct of the three roots and three routes of ownership, but had a distinct impact on facilitating it, were object attributes, feelings of presence and the situation's context and framing.

Positive effects of feelings of ownership especially emerged in marketing research and retail situations, where consumers experienced more positive object attitudes, increased happiness and higher purchase intentions facilitated by psychological ownership of products. The HCI literature has not yet focused on the finding of effects of ownership, but showed its unique characteristics in collaborative AR. We established the need for further research in the field of HCI on antecedents and consequences of psychological ownership. Although there have been interesting domains established, such as collaborative AR, a more systematic approach to ownership research in virtual environments would be highly beneficial. We need to explore how we can operationalize the antecedents presented in this review, especially the ones that can best utilize the inherent capabilities of interactive virtual media like control, customizability and self-identity and belonging. Furthermore, we need to establish what positive and negative consequences psychological ownership in virtuality can have and how we can adapt the marketing literature's findings to our field. As psychological ownership is still a context-dependent phenomenon, it is necessary at the same time to quickly adapt these basic findings to specific contexts such as collaborative AR or therapeutic contexts to establish a foundation for this type of application. Overall, psychological ownership is a phenomenon with many underlying effects and facilitation variables, making systematic research an arduous process. Researchers should use this review to find a common basis for their endeavors. As we have seen, psychological ownership of virtual objects and environments certainly is possible – but how the aspects unique to virtual technology actually play into that will hopefully be the topic of numerous future contributions.

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