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Systematic Review

Virtual Try-On Systems in Fashion Consumption: A Systematic Review

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Abstract: The application of virtual try-on (VTO) technologies in the fashion industry is garnering increasing attention and is regarded as a significant innovation in enhancing the consumer experience for fashion shoppers. This study conducts a systematic review to evaluate the impact of VTO systems on consumer behavior and experiences within the fashion industry. By analyzing 69 research articles, we identified key factors influencing consumers' purchasing decisions and VTO adoption intentions. These factors include attitudes, media, symbolic gratification, technological gratification, emotional values, utilitarian values, and user attributes. Based on these findings, we construct conceptual frameworks that clearly delineate how direct factors and their influencing elements impact consumers' purchase and technology adoption behaviors. This review synthesizes the psychological and technological dimensions shaping consumer behavior, addressing critical gaps in the literature specific to fashion consumption. Moreover, future research directions were discussed. By addressing key challenges such as boundary factors, user segmentation, and technological advancements, this study offers actionable insights to guide researchers and practitioners in creating more personalized, immersive, and effective VTO systems in the fashion industry.

Keywords: virtual try-on; virtual reality; fashion; augmented reality

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1. Introduction

1.1. The Role of Digital Technology in Fashion Retailing

Digital technology has dramatically changed the apparel industry, with projections that one third of sales will happen online by 2027 [1]. In retail, digital technologies aim to enhance interactivity and assist consumers in making informed purchasing decisions [2]. These technologies encompass a range of applications, such as virtual try-on (VTO), AI-driven fashion recommendation systems, and intelligent clothing matching technologies. VTO systems are designed for scenarios where consumers have already expressed interest in trying on specific garments. Their primary objective is to provide a near-realistic try-on experience, enabling users to better evaluate products [3]. In contrast, other technologies rely on consumer preference data to recommend products of potential interest, which do not fulfill the specific need for a try-on experience [4].

VTO systems, while innovative, still fall short of fully replicating the experience of trying on physical garments, which remains a barrier to widespread consumer adoption of online apparel shopping and contributes to high return rates [5]. Innovations in image interactivity technology (IIT) are addressing this challenge by simulating real-world interactions with products [6]. These technologies allow users to modify item features and viewing angles, providing an engaging virtual shopping experience that closely mimics physical retail environments [7]. Among the most promising developments are VTO systems leveraging web interfaces, virtual reality (VR), augmented reality (AR) and digital avatars to offer immersive simulated apparel fittings [3]. VTO gained new relevance during

the COVID-19 pandemic by providing an entertaining and authentic method of apparel shopping safely from home [8].

Adoption of VTO is growing in various sectors such as watches, cosmetics, footwear, apparel, eyewear, and accessories, with technological refinement continuing across these areas [9–15]. However, some retailers are skeptical about VTO's potential to significantly enhance conversions and reduce returns, highlighting the need for ongoing innovation and research on both the technical and experiential fronts.

1.2. Technology and Applications of Virtual Try-On Systems

The application of IIT in the fashion industry is primarily manifested through VTO systems which use websites, VR, AR, and avatars to allow consumers to try on clothes virtually [4]. VR immerses users in digital simulations of the real-world settings, creating detailed computer-generated environments [16–18]. Through VR, retailers can vividly demonstrate intricate product details using sophisticated visual and auditory storytelling, giving customers an experience that closely mimics reality [19]. AR is defined as the technology that combines virtual objects with the real environment, aligns them interactively in real-time [20]. It enhances, extends, edits, or modifies the experience of the real world using digital information [21]. A defining attribute of AR is its interactive, synchronous, real-time, and computer-generated essence [20,22–25]. In VTO systems, avatars or virtual models represent users in virtual environments, granting shoppers the chance to assess the fit of selected virtual garments in a realistic scenario. Considerable progress in digital fashion technologies has led many retailers to develop their own VTO systems.

As shown in Figure 1, current VTO implementations can be categorized into three types based on imaging techniques and avatar types used: website-based VTO, VR-based VTO, and AR-based VTO. Website-based VTO can be further divided into single fitting and mix-and-match systems according to the amount of items allowed for fitting. Single fitting systems, such as Amazon Outfit-VITON, My Virtual Model, and Fits.me, allow users to try on one item at a time [26]. Mix-and-match sites like Guess.com, Taobao AI Fitting Room, and Uniqlo 4D Fitting Room, enable users to try on multiple items at once [27].

	Web site VTO		**VR VTO** (required VR headset)	**AR VTO** (required scanner or camera)
	Single fitting	Mix and Match		
2D Avatar	• Amazon Outfit-VITON	• Guess.com • Taobao AI fitting room		
3D Avatar	• My Virtual Model • Fits.me	• Uniqlo 4D fitting room	• Meta Avatars Store • NIKELAND	• Zeekit(APP) • POIZON(APP)

Figure 1. Categories of VTO and commercial applications.

VTO systems that employ VR or AR are considered advanced forms of IIT [7]. In these systems, users often appear as 3D avatars, including real-time projections of themselves. VR-based VTO, such as Meta Avatars store and NIKELAND, creates computer-generated virtual shopping environments that require VR headsets. Conversely, AR-based VTO employs scanners or cameras to project users in real-time, showing the clothes or products they are virtually wearing, as seen in popular AR VTO applications like Zeekit and POIZON [6].

1.3. Research Gaps

The existing literature reviews, as summarized in Table 1, have explored the diverse applications and impacts of virtual immersion technologies such as VR, AR, MR across a wide

range of industries including food [28], tourism [29], and general retail contexts [30–32]. However, no analysis has specifically focused on fashion despite its widespread use of VTO systems. Given the transformative effects of VTO on consumer behavior, return rates, and sustainability within the fashion sector, a targeted examination of this niche is clearly warranted [33]. This study addresses this gap by focusing specifically on the fashion industry, where VTO technologies tackle unique challenges and demands [3,15,34]. Unlike previous reviews that broadly examine VR/AR applications in general retail contexts, this study highlights how the unique attributes of fashion interact with VTO technologies to shape consumer behavior. By emphasizing the distinct consumer demands in fashion retail, this review demonstrates how VTO systems influence perceptions and decisions. This study provides practical insights and a strategic framework for designing effective VTO systems. It maps the determinants influencing consumer behavior through VTO technologies and provides foundational guidelines for system refinement. In doing so, this analysis contributes both theoretical perspectives and practical applications to the fashion retail sector.

Table 1. Comparison of this review with other literature reviews.

Study	IIT	Application Context	Key Insights
[31]	VR, AR	Non-specific	Comparative analysis of AR and VR in retail. Synthesizes debates on motives, applications, and consumer acceptance, proposing a future research agenda.
[35]	VR	Non-specific	Explores VR shopping behavior, identifying gaps in human–computer interaction. Advocates for research on social dimensions and eye-tracking in VR shop design.
[29]	VR, AR	Tourism	Highlights gaps in technology awareness, usability, and time commitment in tourism applications. Proposes theory-based research for VR/AR adoption.
[28]	VR	Food	VR creates complex, realistic environments for food sensory evaluation and substitutes real-life settings for purchasing behavior studies. Validates VR as a tool for investigating consumer behavior towards food.
[36]	VR	Non-specific	Validates VR's ability to replicate real-life behavior and influence consumer decisions. Recommends expanding VR applications and developing interactive environments.
[30]	VR, AR	Non-specific	Maps design artifacts to influential purchase factors. Highlights gaps in virtual commerce and introduces meta-commerce as a future trend.
[37]	AR	Non-specific	Proposes an S-O-R-based conceptual framework for AR adoption, emphasizing user experience design and multidisciplinary perspectives.
[32]	AR	Non-specific	Demonstrates AR's impact on utilitarian and hedonic values, perceived risk, and behavioral intentions. Suggests exploring the social and behavioral aspects of AR.
[38]	AR, VR, MR, 3D	Non-specific	Conducts a holistic analysis of AR, VR, MR, and 3D using the TCM-ADO framework. Provides implications for future research and practice.
[39]	AR	Non-specific	Shows AR's ability to enhance utilitarian and hedonic shopping experiences, leading to higher purchase intentions, app reuse, and recommendations.
This study	VTO, VR, AR, avatar	Fashion	Synthesizes factors influencing consumer behavior and technology adoption in VTO systems, offering practical frameworks for the fashion industry.

This work aims to provide a structured evaluation of the evolution and implementation of VTO in fashion retail, focusing on its impact on consumer behavior, including purchase and adoption intentions. Through a systematic review of existing literature, we identify and analyze the main factors shaping consumer decisions and the operational mechanisms of VTO. By clarifying the relationship between VTO system components and consumer influencing factors, we offer recommendations for future research on VTO application in the fashion industry.

This research contributes to scholarly discussions by detailing the internal workings of VTO and uncovering hidden factors affecting customer engagement. Practically, our findings provide tested frameworks that help retailers design and optimize VTO systems. By integrating insights from this review with actionable strategies, retailers can better leverage VTO to meet changing consumer demands, enhance user experiences, and improve operational efficiency in the digital era.

The paper is structured as follows: Section 2 describes the methodology used for assessing studies within the literature review. Section 3 discusses the key findings from reviewed works and outlines future research opportunities. Section 4 concludes the study's findings and limitations.

2. Literature Review Process

This study follows the guidelines established by Petticrew and Roberts (2008), organizing the literature review procedure into three stages: preparation, execution, and reporting [40]. The review process includes the following steps:

(1) Commissioning an examination.
(2) Identifying and selecting documents.
(3) Selecting primary studies.
(4) Conducting backward and forward searches.
(5) Extracting data and tracking progress.

Formulating clear research questions is essential to ensure a thorough and systematic evaluation. In the initial stage, a pilot search was conducted to delineate the study's scope, formulate research questions, and establish inclusion and exclusion criteria. The main research questions identified were as follows:

RQ1: What are the key determinants of VTO technologies that influence fashion consumers' purchasing adoption judgments?

RQ2: How do these determinants influence consumers' purchasing behavior and adoption of VTO technologies?

RQ3: How do consumer attributes influence their adoption and purchase intention of virtual try-on (VTO) systems?

2.1. Search Strategy

The PRISMA protocol was employed in this systematic review, as it provides a structured and widely recognized framework for systematically identifying, evaluating, and synthesizing research in the field [41,42]. The first stage involves literature identification, for which the Scopus and Web of Science databases were chosen. These two databases, renowned for their extensive coverage in computer science and marketing, were selected to ensure comprehensive literature retrieval. The initial search string used was as follows:

(Virtual reality OR VR OR Augmented Reality OR AR OR Avatar) AND (Virtual fitting OR Virtual try-on OR Fashion OR Cloth* OR Apparel OR VTO OR VFR) AND (shop* OR retail* OR market* OR consum*)

The search was restricted to the subject areas in Web of Science and to titles, abstracts, and keywords in Scopus, covering the time range from 1993 to the present. Ultimately, this search yielded 930 papers: 615 from Web of Science and 315 from Scopus. To validate the search scope's suitability, we manually checked for several highly recognized publications in the field and verified their presence in the search results.

2.2. Study Selection

To ensure academic quality, we followed the methodology outlined by Shen et al. (2021) [30] and clearly defined the inclusion and exclusion criteria for this review. The inclusion criteria were as follows: (1) peer-reviewed publications, including journal articles, conference papers, and book chapters; (2) studies published in English; and (3) studies related to VTO in fashion consumption. The exclusion criteria were as follows: (1) publications unavailable as full texts; (2) duplicate papers; (3) studies unrelated to the review topic based on titles, abstracts, or full texts; (4) studies lacking significant empirical or theoretical contributions to consumer behavior in fashion consumption; and (5) studies that did not address at least one of the three research questions.

Initially, we screened the retrieved literature based on titles, abstracts, introductions, and conclusions, according to the inclusion and exclusion criteria. After removing duplicates (102) and non-English papers (194), 634 articles were retained for full-text analysis. Subsequently, we screened these articles based on their titles and abstracts, resulting in the exclusion of 309 articles unrelated to the review's topic and 12 articles that were not available as full text. Next, we conducted a full-text review of the remaining articles, excluding 162 studies with no empirical or theoretical contributions to the field of consumer behavior in fashion industry and 96 articles that did not address at least one research question, leaving 55 articles. During this process, references were manually checked against the eligibility criteria, followed by forward and backward searches. This resulted in the inclusion of an additional 14 studies. Through these steps, we ensured the literature search was comprehensiveness and precision, providing a solid foundation for the systematic review. Ultimately, 69 articles advanced to data extraction and examination. The selection process is illustrated in Figure 2.

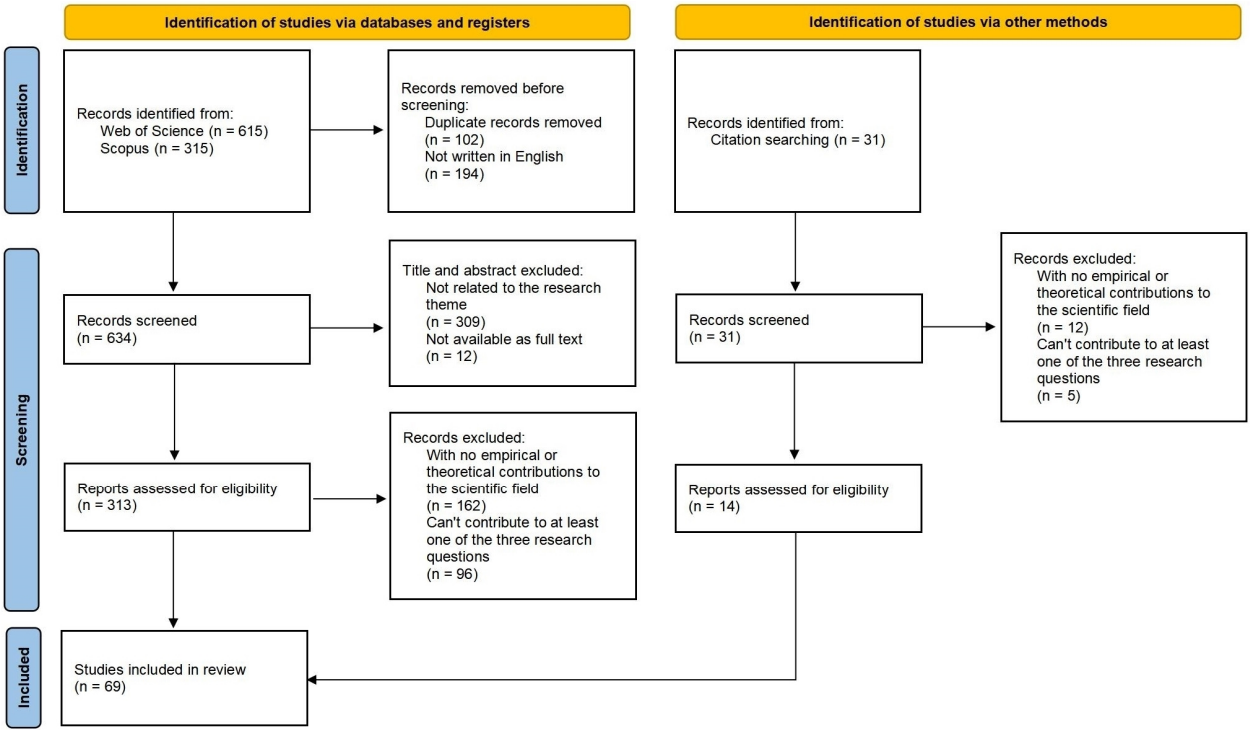

Figure 2. PRISMA 2020 flow diagram for selection of sources.

2.3. Data Extraction

During the data extraction phase, three researchers independently compiled relevant findings in an Excel spreadsheet. Specifically, we recorded details including study titles, abstracts, authors, research aims, methodologies, hypotheses, and conclusions. Each

researcher subsequently cross-checked the others' work to ensure accuracy, resolving any disputes through discussion.

3. Results and Discussion

3.1. Time Distribution

First, a quantitative analysis of the 69 included studies showed a marked increase in papers related to VTO after 2016, with a particularly pronounced growth between 2019 and 2023. This upswing can largely be credited to revolutionary advancements in VR and related IIT which have enabled the development of practical VTO solutions. The annual distribution of articles from 2005 to 2024 is depicted in Figure 3.

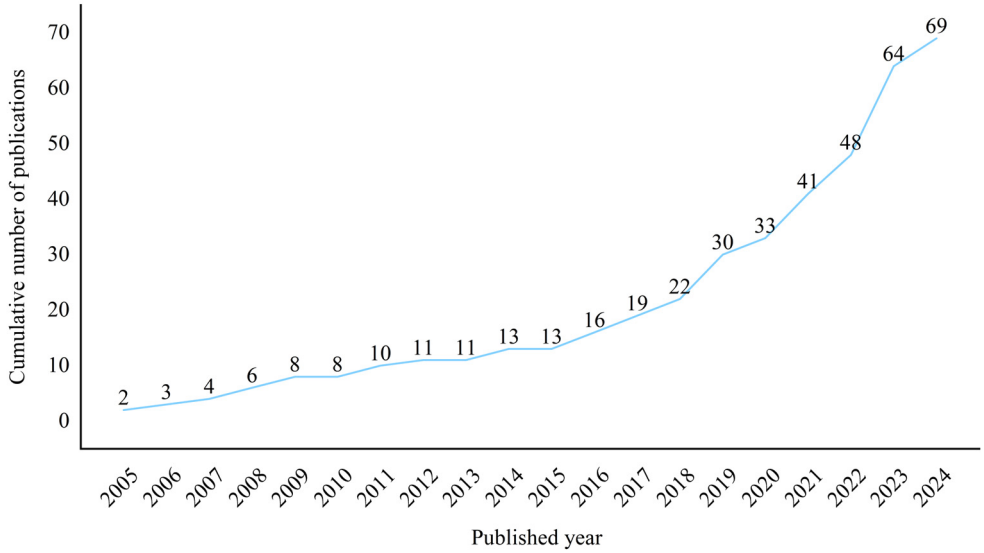

Figure 3. Yearly distribution of publications.

3.2. Research Methods

The research methods used in studying VTO systems in fashion consumption are summarized in Table 2.

Table 2. Summary of the research methods (69 papers, 86 studies).

Methods	Sources	N	%
Experiment	[7–9,23,27,34,43–73]	49	56.98
Survey	[3,5,10,12,15,73–90]	23	26.74
Interview	[5,12,15,73,78,79,85,91,92]	9	10.47
Field Study	[8,14,67,81,91]	5	5.81
Total		86	100

Experiments were the most popular approach, representing 56.98% of the whole with 49 studies utilizing this method. Surveys followed as the second most commonly used method with 23 studies, accounting for 26.74%, implying these two methods as the primary approaches for examining VTO's impact on consumer behavior. Additionally, several studies used interviews (N = 9, 10.47%) and field studies such as observation (N = 5, 5.81%).

3.3. VTO Application Environment

Table 3 summarizes our analysis of VTO application environments. Over 40% of the studies concentrated on web-based VTO systems, including popular platforms such as My Virtual Model, Sephora Virtual Artist, Max Factor My Virtual Makeup Artist, and Modiface AR. Meanwhile, slightly less than a quarter of the studies involved dedicated equipment for enhanced or mixed realities.

Table 3. Overview of examined shopping environments.

Category	Studies	N	%
Web-based	[5,7,27,43–45,47–50,54,56,60,61,64,67,73,77–81,84,87,89,91–94]	29	41.43
APP	[3,9,10,15,34,51,53,55,57,63–66,75,81,84,85,87,89,95]	20	28.57
Device-specific	[12,23,46,52,58,62,68,70–72,74,76,82,96–98]	16	22.86
Multi-environment	[8,14,59]	3	4.29
Unspecified Environment	[6,99]	2	2.86
Total		70	100

Increasing mobile usage and rapid digitalization have significantly expanded opportunities for exploration in recent years. Nearly a third of current studies utilize virtual fashion apps that permit home try-ons, such as Taobao, which allows users to wear selections digitally and view selections from all angles [85]. Similarly, Wanna Kicks allows sneaker enthusiasts to preview emerging styles in AR before purchase [75]. As barriers to virtual try-on research continue to decrease, the prevalence of such mobile-centered platforms will underpin more authentic experiential captures from any location.

3.4. Antecedents and Consequences

In this section, we address research questions RQ1 and RQ2, summarizing the key factors that influence consumer behavior when using VTO systems. Specifically, we examine factors affecting technology adoption and fashion purchase intentions among virtual shoppers. By constructing conceptual frameworks, the analysis explores how these factors influence consumers' behaviors and experiences. Additionally, we categorize consumer attributes to understand how these differences affect their adoption and purchase intentions regarding VTO systems.

Since purchase and adoption outcomes directly relate to decision-making and engagement with virtual technologies, they are the primary interest for analysis and framework development. The conceptual frameworks are derived from the models presented in the literature through these steps:

(1) Identify constructs explicitly connected to purchase decisions and usage intentions from the literature, denoting these as direct factors.
(2) Identify all constructs leading to the direct factors, denoting these as secondary factors.
(3) Define tertiary factors as those preceding the secondary factors. Document these factors and their interrelations.
(4) Represent significant direct impacts with a solid arrow to the result, noting positive or negative effects with symbols. Indicate insignificant direct impacts with a dashed arrow. Distinguish verified mediators using rectangles. Designate moderators through dotted lines and symbols to moderate connections. Controversial links are highlighted with a red solid arrow flagged by an exclamation point.
(5) Consolidate identified models, merge comparable notions, and organize the amalgamated framework.

3.4.1. Influential Factors Essential to Purchase Intention and Adoption Intention

Six pivotal concepts are identified as directly influencing purchase intention and adoption intention: media, attitude, symbolic gratification, technology gratification, emotional values, and utilitarian values.

As shown in Table 4, medium includes media design features, the presence or absence of IIT, and various modalities of IIT. Attitudes encompass consumer perspectives towards brands, retailers, and virtual platforms. Symbolic gratification refers to the satisfaction individuals derive from associating with certain symbols, emblems, or recognizable elements in the virtual fitting room, fulfilling needs related to self-identity, social status, or group affiliation [100]. This includes ten sub-variables: autonomy, competence, identification,

self-referencing, relatedness need fulfillment, social interactivity, self-brand connection, self-expression, self-image threat, and telepresence.

Table 4. Direct factors of purchase intention (PI) and adoption intention (AI).

Categories	Direct Factors	Description
Medium (ME)	Design	The design features of virtual fitting rooms include the color, interface, esthetics and sense of balance.
	Presence or not	The presence or absence of IIT.
	IIT modalities	Various modalities of IIT (e.g., VR, AR, avatars, etc.).
Attitude (AT)	Brand	Attitude towards the brand.
	Retailer	Attitude towards the retailer.
	Technology	Attitude towards the IIT technologies.
Symbolic Gratification (SG)	Autonomy	Autonomy represents the need to experience behavior as voluntary.
	Competence	Competence refers to the human need to feel that one's behavior is enacted effectively.
	Identification	Identification is defined as the process whereby an individual may seek to emulate or embody another person as a strategy for constructing and sustaining their own identity.
	Self-referencing	It is a user's psychological state when they associate themselves with the garments they wear or their appearance in a virtual environment.
	Relatedness need fulfillment	It refers to the need to interact, be connected to, and experience caring from others.
	Social interactivity	It refers to the extent and quality of interactions that occur between users within a digital or online environment.
	Self-brand connection	The extent to which a consumer has incorporated a brand into his or her self-concept.
	Self-expression	A social behavior in which an individual with behavioral motivation tries to convey personal information and image to others in a planned way.
	Self-image threat	An experience that calls into question one's favorable views about oneself.
	Telepresence	The psychological state of 'being there' in a computer-mediated environment, augmented by focused attention.
Technology Gratification (TG)	Perceived diagnosticity (or perceived informativeness)	It is defined as the ability of an application to convey relevant product information for evaluating quality and performance.
	Fit confidence	The degree of confidence with when using apparel fit system.
	Curiosity	An eager wish to know or learn about something.
	Novelty	Novelty refers to the quality or state of being new, original, or unusual.
	Trendiness	It refers to the quality or state of being fashionable, current, and up-to-date with the latest styles, trends, or technologies.
	Interactivity	An experiential phenomenon that occurs when a user interacts with a website or other computer-mediated communication entities.
Emotional Values (EV)	Decision comfort	Decision comfort reflects a person's sensation of being "fine or ok" while engaging in a specific decision.
	Immersive experience (or flow experience)	The holistic sensation that people feel when they act with total involvement.
	Satisfaction	The state of pleasure or disappointment that a customer feels by comparing the perceived effect of a product or service with its expected value.

Table 4. *Cont.*

Categories	Direct Factors	Description
Emotional Values (EV)	Inspiration	A temporary motivational state induced by a marketing-related stimulus toward the intrinsic pursuit of a consumption-related goal.
	Perceived intrusiveness	When consumers do not feel in control over the information they are sharing, it can lead to an uncomfortable feeling and raise feelings of intrusiveness.
	Perceived enjoyment (or perceived pleasure)	The extent to which an individual finds an activity to be pleasurable and satisfying.
	Perceived fantasy	Fantasy involves executing activities that are unattainable in reality, such as adopting fresh identities and lifestyles.
	Perceived playfulness	Perceived playfulness refers to the extent to which an individual perceives an activity as enjoyable, engaging, and fun.
Utilitarian Values (UV)	Perceived ease of use (perceived convenience or effort expectancy)	The extent to which prospects perceive a reduction in the effort required for using and buying.
	Perceived usefulness (or Performance expectancy)	The extent to which a person believes that using a technology will enhance his or her productivity.
	Product benefit	Product benefit refers to the product utility and its uses.
	Vividness (or perceived esthetic quality or aesthetic experience)	It includes the graphical effects in terms of vividness, realism of 3D images, visual appeal of the graphical look, etc.
	Risk	Perceived risk describes consumers' feelings of uncertainty regarding purchase decision outcomes.
Consumer Characteristics (CC)	Age	The age of the consumer
	BMI	Body mass index (BMI)
	Gender	Male or female
	Innovativeness	The latent underlying preference for new and different experiences. Consumers with high levels of innovativeness are more likely to seek information and new experiences that stimulate their senses.
	Individualism	The extent to which customer emphasizes personal aspects.
	Familiarity	The degree to which consumers are familiar with VTO systems.
	Fashion consciousness	Fashion consciousness assesses individuals' ideas and attitudes toward fashion and influences individual decision-making.
	Optimism	A positive view of technology and a belief that it offers people increased control, flexibility, and efficiency in their lives.
	Privacy priming	When privacy concerns are particularly salient, customers will prime privacy.
	Technology anxiety	The fear and apprehension people feel when thinking about or actually using technology-related tools.
	Sensation seeking tendency	SST reflects an individual's desire to search for novel, varied, and intense stimuli.
	Self-monitoring	Self-monitoring is a characteristic of an individual's personality that impacts their ability to manage their public image, navigate social interactions, and adjust their behavior to align with diverse social contexts.
	Self-discrepancy	The ability of consumers to perceive the degree of discrepancy between self-concept and the image of a brand/product.
	Body esteem (or body satisfaction)	Body esteem refers to an individual's self-evaluation of their body or appearance.

Technology gratification focuses on the immediate enjoyment and satisfaction users gain from specific technologies, typically derived from the intuitive attributes, versatile

capabilities, and engaging user experience [67]. It includes six variables: perceived diagnosticity (or informativeness), fit confidence, curiosity, novelty, trendiness, and interactivity.

Emotional values encompass the feelings and psychological states evoked by using the technology. They cover the general emotional and psychological experiences associated with a product or service, such as the sentiments stirred by meaningful interpersonal communication, personal success, or alignment with individual beliefs [67]. Emotional values include eight variables: decision comfort, flow experience (or immersive experience), satisfaction, inspiration, perceived intrusiveness, perceived enjoyment (or perceived pleasure), perceived fantasy, and perceived playfulness. Perceived enjoyment, perceived fantasy, and perceived playfulness are closely related variables jointly known as hedonic value, which involves the beneficial emotional and experiential contentment consumers derive from using products or services, particularly regarding VTO systems [101,102].

Utilitarian values play a pivotal role in consumer decision-making, emphasizing practicality, helpfulness, and financial advantages [103]. We recognized five key variables: perceived ease of use (or convenience or effort expectancy), perceived usefulness (or performance expectancy), product benefit, perceived esthetic quality (or vividness), and risk.

In addition, previous studies examined how user characteristics influence technology adoption and fashion purchase intention, revealing twelve variables: age, gender, innovativeness, individualism, familiarity, fashion consciousness, privacy priming, technology anxiety, sensation-seeking tendency, self-monitoring, self-discrepancy, and body esteem (or body satisfaction).

3.4.2. Comparative Studies of Media

Of the reviewed papers, 22 research articles focused on media and its related variables. The design of VTO systems significantly impacted the adoption intention [91]. Additionally, VTO on a website can increase offline purchase intentions [49]. Personalized VTO boosted online sales in experiments [14]. However, vividness alone did not impact technology adoption [91].

Nineteen works compared different types of media, finding that each has unique advantages, though none was clearly superior. While VR and AR provided richer experiences than standard interfaces, the latter remained more convenient and enjoyable than AR-based VTO [23,34]. Additionally, incorporating 3D models into traditional displays enhanced the sense of presence, usefulness, and ease of use, while reducing perceived risk [44,45,78,80].

While many studies argued that VR and AR enhanced the shopping experience over traditional websites, their effectiveness varied significantly depending on the product category [10,23,34]. For example, VTO for shoes struggles to replicate real-world interactions, raising questions about whether they can fully replace physical trials [65]. Consequently, virtual options currently serve as supplements rather than substitutes.

Personalized simulations using AR proved more effective than static images alone [10,23]. Allowing customers to see personalized avatars significantly increased purchase intentions compared to general models [62]. However, AR's advantages were not universal, and were less impactful for those satisfied with their appearance when stacked up against conventional 2D displays [76].

In contrast to the overlay capabilities of AR, VR immersed users in fully customizable virtual worlds with extensive interactive avatars. VR trials demonstrated tangible effects on subsequent in-store purchases [48,49]. Research indicated that highly engaging VR outperformed less immersive implementations, promoting usage, entertainment, utilitarian value experiences, and time spent [68,72]. While AR applications only require a camera-equipped phone, VR demands complex equipment like headsets and controls for deep immersion, complicating widespread adoption. As a result, retailers implementing VR must carefully weigh technological investments against the benefits of maximum immersion.

3.4.3. Conceptual Framework of Attitudes

As shown in Figure 4, 19 studies examined the impact of attitudes and their influencing factors on purchase and adoption intentions. The framework integrates multiple layers of influence, from initial user perceptions to attitudes and final behavioral intentions, while accounting for moderating effects that may alter these relationships.

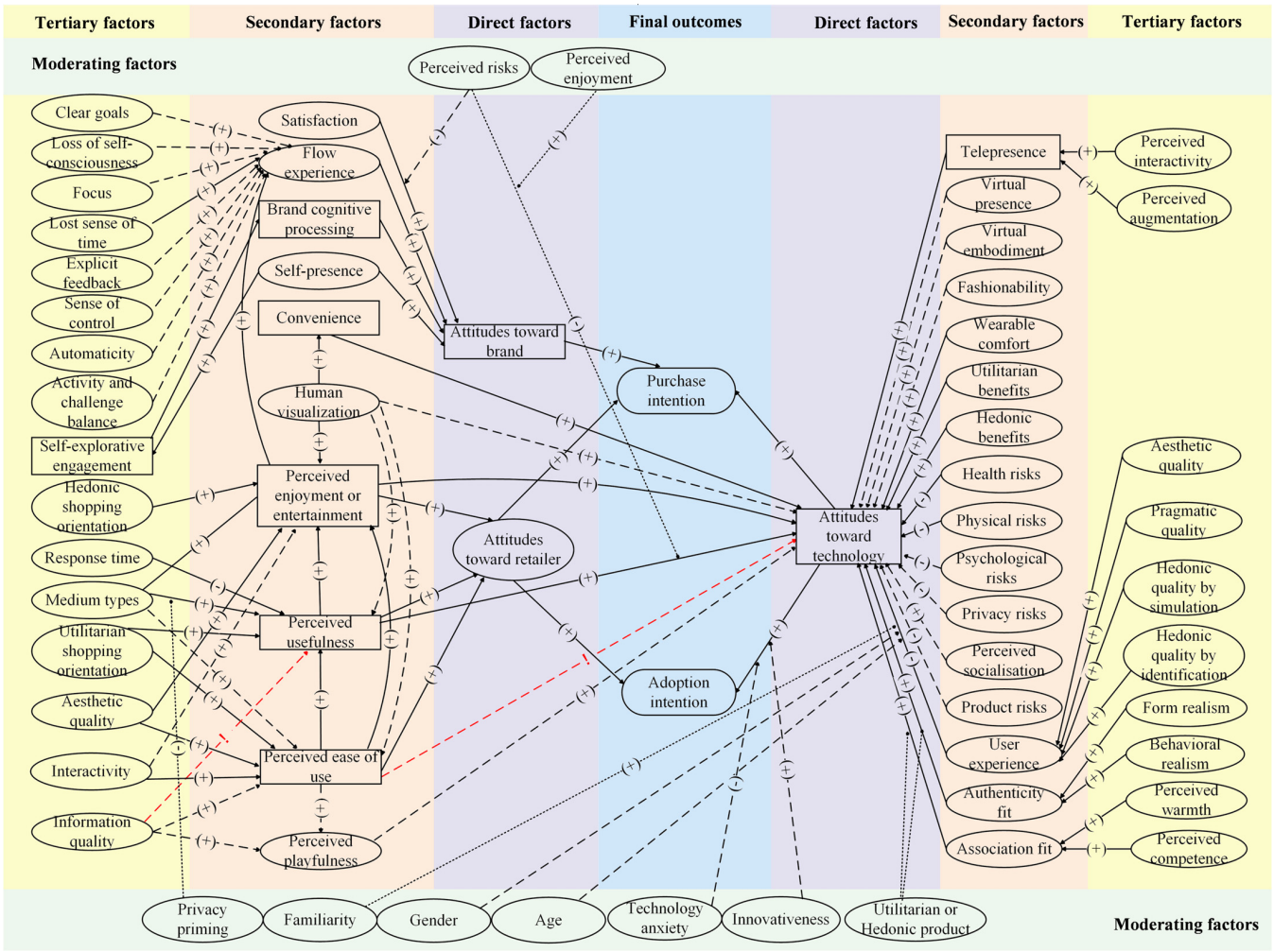

Figure 4. Conceptual framework of attitudes.

Studies consistently showed that improving consumer attitudes directly benefited purchase and usage intentions. Specifically, favorable perspectives on brands, sellers, and technologies were positively associated with intent to buy [3,63,94]. Additionally, positive attitudes towards retailers and technology were straightly correlated with adoption intentions [51,86,95].

To enhance consumer attitudes towards brands, strategies include increasing VTO experience satisfaction [12] and enhancing self-presence, which positively affected brand cognitive processing through self-explorative engagement [95]. Improving flow experiences, such as reducing the notion of time passing, also strengthened brand attitudes [94]. For retailers, enhancing attitudes could be achieved by improving perceived enjoyment, perceived usefulness, and perceived ease of use [44].

Previous studies increasingly focused on consumer perspectives on immersive interactive technologies. Herz et al. found that both utilitarian and hedonic benefits improved attitudes towards technology [83]. Detailed analyses indicated that perceived enjoyment, telepresence, user experience, perceived usefulness and convenience shaped consumer attitudes toward technology [5,34,61,63,66,84,86]. Other studies found that authenticity

fit, association fit, and wearable comfort positively affected attitudes toward technology [54,83].

Further analysis explored factors directly elevating attitudes. For the aforementioned variables that directly positively influenced attitudes, scholars found that perceived usefulness can be enhanced by reducing response time and adopting advanced IIT forms, while interface esthetic quality and advanced forms of IIT improved perceived enjoyment [44,61]. For AR VTO, interactivity and augmentation improved telepresence [86].

Regarding risks, research showed that health and psychological risks negatively impacted attitudes toward technology [83], while other risks (e.g., privacy, product risks) had no effect [83,84]. User experience was enriched by improving the esthetic and pragmatic quality, hedonic quality of simulation, and hedonic quality of identification [63]. Additionally, enhancing form realism and behavioral realism improved VTO authenticity fit. Perceived warmth and perceived competence increased association fit during the try-on experience [54].

It is worth noting that the impact of perceived ease of use on attitudes toward technology may vary depending on the VTO types. In AR VTO and VTO with 3D rotation views, perceived ease of use significantly improved consumers' attitudes toward technology [61,66,80]. However, for VTO with only 2D views, perceived ease of use did not significantly affect attitudes toward technology [80]. Furthermore, research has found that information quality in AR VTO apps enhanced utilitarian value and contributed to perceived usefulness [61,64]. However, another study revealed that information quality did not significantly affect perceived usefulness in shoes AR VTO apps [66]. Therefore, the utilitarian values of information quality require further investigation.

Regarding moderating factors, it was found that the positive impact of perceived usefulness on technology attitude was negatively moderated by perceived risks; however, this negative effect was alleviated by perceived enjoyment [3]. Additionally, the significant positive influence of authenticity fit and association fit on consumer attitudes varied depending on product type, whether utilitarian or hedonic [54]. These findings highlighted the importance of context and product type in shaping the effectiveness of VTO systems.

3.4.4. Conceptual Framework of Symbolic Gratification and Technological Gratification

Twelve articles explored the concepts of symbolic gratification and technological gratification and their related variables. The research framework derived from these studies is illustrated in Figure 5.

Factors within symbolic gratification, such as self-referencing, telepresence, autonomy, self-image threat, identification, and social interactivity, significantly influenced users' purchase intention [8,27,67,71,77,85]. Furthermore, enhancing the sense of ownership control, rehearsability, and self-efficacy was shown to improve self-referencing [71]. Selecting media with higher levels of IIT also enhanced telepresence [27].

In the context of technology gratification, perceived diagnosticity and curiosity significantly and positively affected users' purchase intention [10,46,67]. The impact of novelty on purchase intention remains debatable. Moes et al. suggested that novelty mediated the relationship between medium types and purchase intention [48], while Khelladi et al. found that novelty did not significantly affect purchase intention [67].

Factors such as competence, autonomy, self-brand connection, identification, and fit confidence had notable positive effects on technology adoption intention [53,55,77,85]. VTO systems enhanced competence by incorporating challenges and achievements. Avatar customization and identification fulfilled users' autonomy needs by allowing greater personal control and self-expression [85]. Furthermore, self-brand connection was promoted through the malleability of the self, imagery, and VTO presence. Notably, VTO presence enhanced the malleability of the self via the mediation of imagery, creating a more personalized and engaging experience [53]. For identification, avatar-user resemblance and fashion item realism played crucial roles, making users feel more connected to their virtual representations [77]. Additionally, perceived augmentation had a significant positive effect

on fit confidence. Users who were satisfied with self-uploaded photos experienced higher levels of perceived augmentation, although body esteem did not have significantly impact on this [55]. Using media with higher levels of IIT also enhanced perceived diagnosticity, making the technology more appealing and effective [10,46].

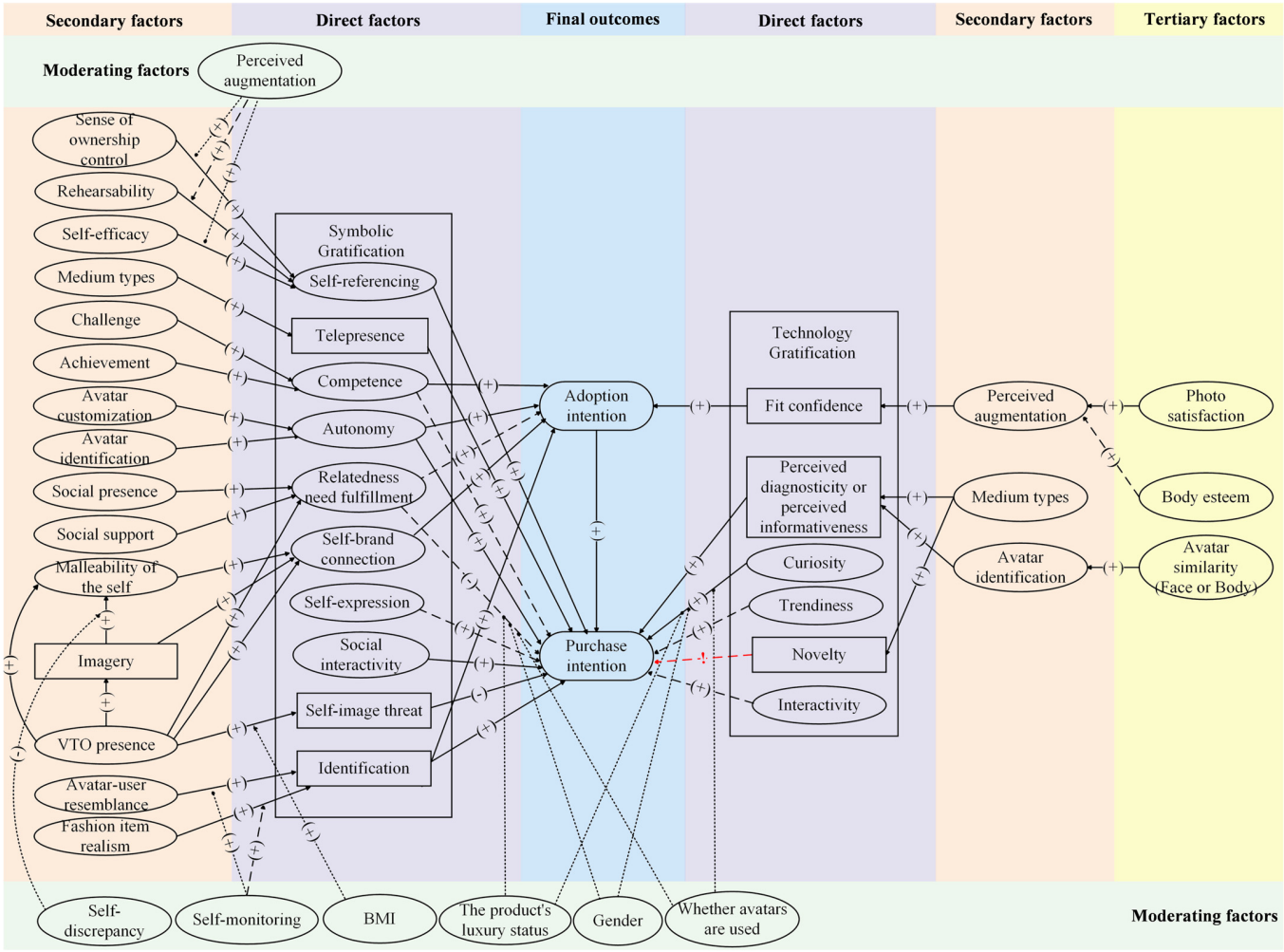

Figure 5. Conceptual framework of symbolic and technological gratification.

Moderating factors that influence technology adoption and purchase intention included BMI, self-monitoring, self-discrepancy, the luxury status of products, gender, the use of avatars, and perceived augmentation [8,53,67,70,77]. Perceived augmentation played a key role in moderating various relationships. It positively affected the influence of ownership and self-efficacy on self-referencing, although it did not have the same moderating effect on the relationship between rehearsability and self-referencing [70]. The luxury status of products, gender, and the avatar use positively moderated the influence of social interactivity and curiosity on purchase intention. These factors illustrated how personal and contextual elements shape consumer responses to VTO systems [67].

3.4.5. Conceptual Framework of Emotional Values

Twenty-two studies investigated emotional values and related concepts, summarized in the framework shown in Figure 6.

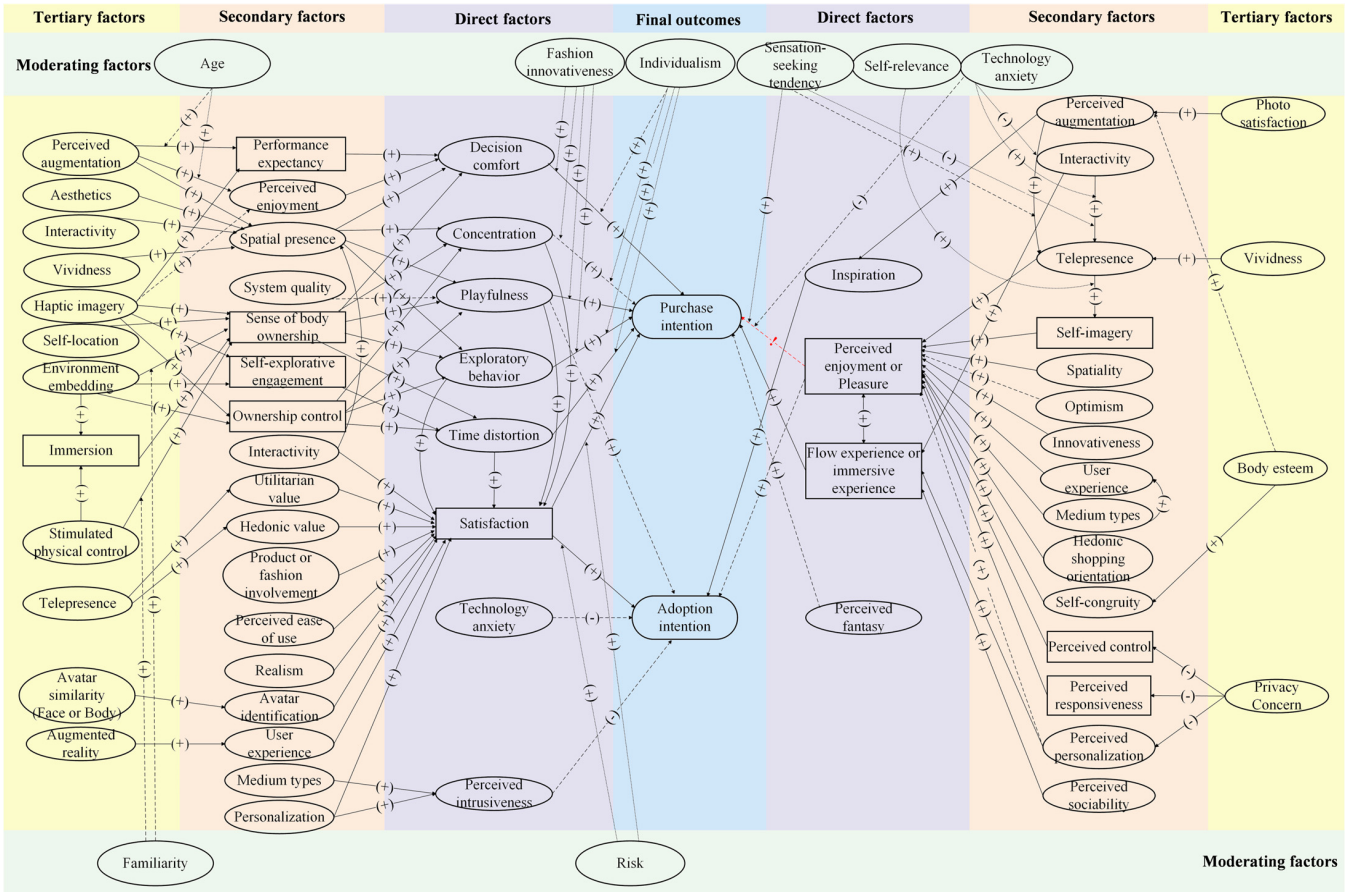

Figure 6. Conceptual framework of emotional values.

Several variables were identified as having a direct positive effect on purchase intention, including decision comfort, playfulness, exploratory behavior, time distortion, satisfaction, and immersive experience [12,60,69,81,88]. Conversely, concentration and perceived fantasy did not significantly affect purchase intention [67,88]. The impact of perceived enjoyment on purchase intention was debated; some studies found a positive effect [27,89], while others indicated its impact varied by product types, being beneficial for NFTs-virtual clothes [67] but not for real clothing products online [44].

For technology adoption intention, satisfaction and inspiration were positively associated with adoption intention [55,81]. However, factors such as technology anxiety, perceived intrusiveness, playfulness, and perceived enjoyment showed no significant effect on adoption intention [10,44,66,79].

Further analysis revealed secondary factors that influenced these primary factors, contributing to a more comprehensive understanding of consumer behavior in the context of VTO systems. Performance expectancy, perceived enjoyment, and spatial presence enhanced decision comfort [75,88]. Spatial presence, the sense of body ownership, and ownership control positively affected concentration and playfulness [60,88], while system quality did not significantly impact playfulness [66]. Additionally, body ownership and ownership control positively affected exploratory behavior and time distortion [60].

Various factors positively affected satisfaction, including concentration, playfulness, exploratory behavior, time distortion, utilitarian value, hedonic value, product involvement, interactivity, perceived ease of use, realism, avatar identification, user experience, and personalization [12,14,46,52,60,63,64,81]. Factors that significantly impacted perceived enjoyment included telepresence, self-imagery, spatiality, innovativeness, user experience, medium types, hedonic shopping orientation, self-congruity, perceived control, perceived responsiveness, and immersive experience [7,15,27,43,44,48,59,63,70,87,90]. Furthermore,

interactivity, perceived sociability, perceived personalization, and perceived enjoyment positively affected flow experience [69].

Moderating factors introduced additional complexity within the VTO framework. Significant moderators included age, fashion innovativeness, individualism, risk, self-relevance, technology anxiety, and sensation-seeking tendency [13,62,69]. For instance, risk acted as a moderator between satisfaction and both purchase and adoption intention [62]. These moderating factors underscore the nuanced ways personal and contextual elements can influence the effectiveness of VTO systems.

3.4.6. Conceptual Framework of Utilitarian Values

Nineteen studies explored the concept of utilitarian values and their related factors, summarized in the research framework depicted in Figure 7.

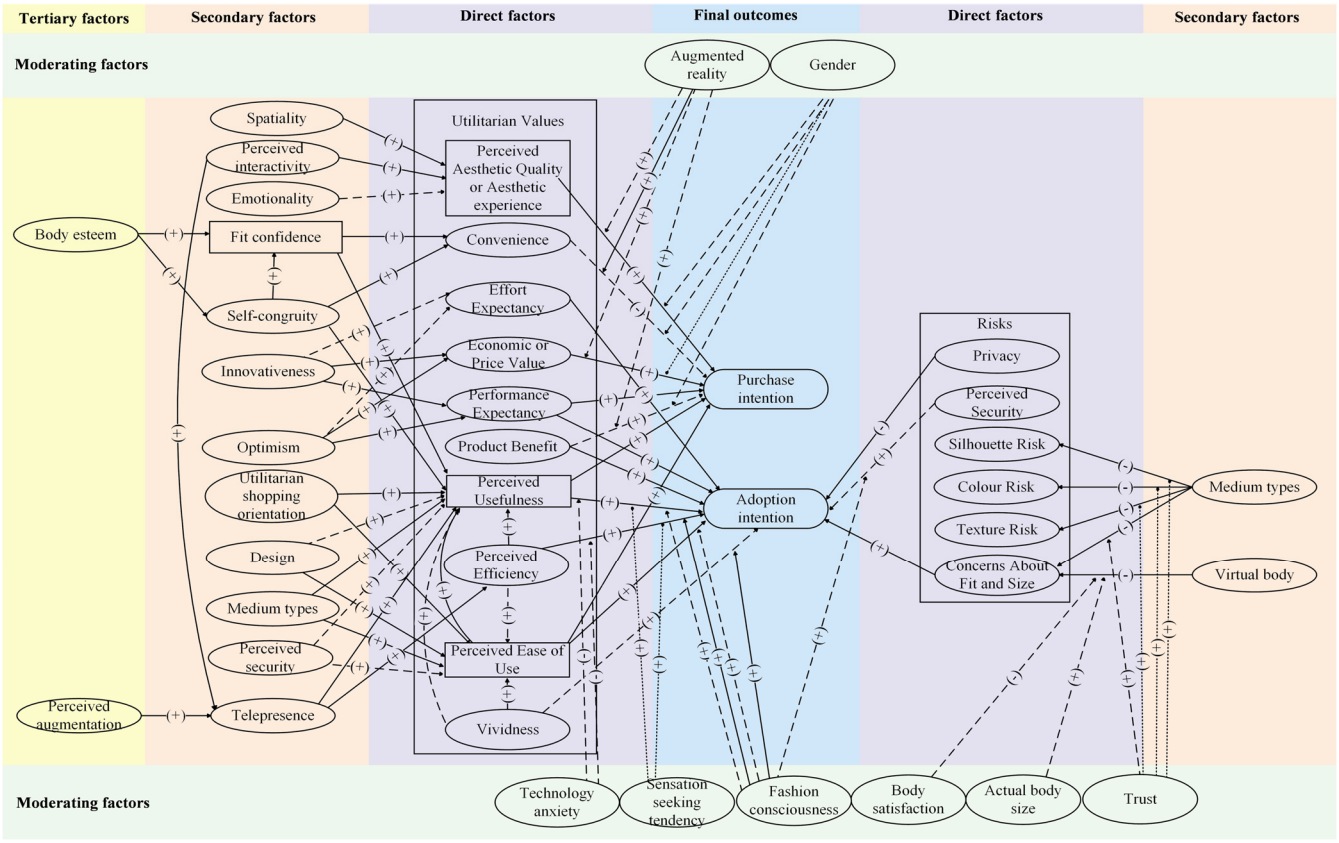

Figure 7. Conceptual framework of utilitarian values.

Research consistently showed that utilitarian values positively affected purchase intention [7,27,64,86]. Key components of utilitarian values, such as perceived esthetic quality, economic value, performance expectancy, perceived usefulness, and perceived ease of use, directly enhanced purchase intention [3,44,74,87]. However, convenience and product benefit did not significantly impact purchase intention [74].

Effort expectancy, performance expectancy, product benefit, perceived usefulness, perceived efficiency, and perceived ease of use were proven effective in increasing adoption intention [74,87]. In contrast, vividness did not significantly affect adoption intention [91]. Reducing privacy risk and addressing concerns about fit and size further promoted adoption intention [6,56,90].

Several secondary factors influenced the direct factors within the framework. Perceived interactivity and spatiality positively impacted perceived esthetic quality, while emotionality did not [70]. Fit confidence and self-congruity were found to improve con-

venience [7]. Meanwhile, innovativeness and optimism had a marked effect on economic value and performance expectancy but did not significantly affect effort expectancy [87].

Moreover, factors that significantly affected perceived usefulness included fit confidence, self-congruity, utilitarian shopping orientation, medium types, telepresence, perceived ease of use, and perceived efficiency [7,44,51,91]. In contrast, VTO system design, vividness, and perceived security did not significantly influence perceived usefulness [91]. Furthermore, telepresence had a substantial impact on perceived efficiency [91]. Perceived ease of use was significantly influenced by medium types, utilitarian shopping orientation, design, vividness, and information quality [44,52,91], whereas perceived security and perceived efficiency had minimal effect [91]. Additionally, the use of 3D-VTO helped reducing risks related to clothing attributes such as silhouette, color, texture, fit, and size [45]. Similarly, employing a virtual body contributed to mitigating fit and size risks [56].

Lastly, several moderating factors were identified, including gender, augmented reality, technology anxiety, sensation-seeking tendency, fashion consciousness, body satisfaction, actual body size, and trust [15,45,51,56,74,91]. For instance, augmented reality influenced the connection between convenience and purchase intention, but it did not moderate the links between perceived esthetic quality or experience, economic or price value, product benefit, and purchase intention [74]. Furthermore, trust in internet shopping moderated the relationship between VTO medium types and risks associated with silhouette, color, and texture, but it did not impact the relationship between medium types and risks related to fit and size [45].

3.4.7. Conceptual Framework of User Characteristics

Twenty research papers explored the role of user characteristics in influencing purchase and adoption intentions. Based on their roles in the research models, these factors were categorized as moderating variables or general variables.

Among the moderating factors, age was found to influence the relationship between augmentation and perceived enjoyment [75]. BMI significantly moderated the effect of VTO presence on self-image threat, particularly affecting higher BMI consumers who experience greater self-image threat [8]. Gender differences also emerged, with social interactivity and curiosity impacting purchase intention differently for men and women [67]. Men placed less importance on price value and perceived esthetic quality when considering purchase choices [74].

Innovativeness enhanced the positive effects of decision comfort, playfulness, and exploratory behavior on purchase intention, indicating that more innovative users derived greater benefits from these factors [88]. Individualism similarly boosted the likelihood of deriving purchase intention from playfulness and exploratory behavior [88]. Familiarity with VTO systems positively moderated the effect of user experience on attitude toward technology, suggesting that more familiar users had a better experience and a more favorable attitude [63]. Fashion consciousness positively moderated the relationship between perceived efficiency and adoption intention, highlighting the role of fashion awareness in technology adoption [91].

Privacy priming had a significant moderating effect, weakening the positive impact of augmented reality on perceived usefulness when privacy concerns are high [51]. Technology anxiety strengthened the relationships between interactivity, augmentation, and telepresence, indicating that anxious users may need more engaging experiences to feel comfortable [15]. Sensation-seeking tendency enhanced the effects of perceived usefulness and perceived efficiency on adoption intention and strengthened the impact of interactivity on telepresence, reflecting the adventurous nature of sensation seekers [15]. Self-monitoring moderated the relationship between avatar-user resemblance and identification, with higher self-monitors more sensitive to the match between their avatars and themselves [77]. Lastly, self-discrepancy moderated the relationship between imagery and malleability of the self [53].

In addition to these moderating factors, several general variables also played a crucial role. Innovativeness was positively correlated with adoption intention, indicating that innovative users were more likely to adopt VTO systems [5,79,80]. Optimism enhanced economic value and performance expectancy, highlighting the positive outlook of optimistic users [87]. Finally, body esteem positively influenced self-congruity and fit confidence, indicating that users who feel good about their bodies are more likely to trust the virtual fitting experience [7]. By integrating these findings, we gain a comprehensive understanding of the multifaceted role of user characteristics in shaping the purchase intention and adoption of VTO systems. This perspective not only identifies key factors but also underscores the importance of considering user diversity in VTO research and application.

3.5. Future Agenda

This section outlines future research recommendations by theme, providing a clear and structured overview of directions and specific suggestions.

3.5.1. Exploring the Boundary Factors

With respect to the theme of exploring the boundary factors, future research should further investigate the boundary conditions of VTO shopping, focusing on ways to substantially enhance the shopping experience. The design of VTO systems is crucial for promoting consumer adoption intention [91]. Future studies should explore aspects such as user interface, store ambiance and layout in immersive VR VTO systems.

3.5.2. Comparative Study Design

Regarding the theme of comparative study design, future research should evaluate the difference in effectiveness of different types of VTO on various product categories. As the metaverse continues to evolve, understanding whether VTO can effectively replace or complement real try-ons becomes essential. Additionally, since fashion products vary widely, consumers' perceptual needs before purchase differ by category [66]. For retailers, understanding which VTO systems are suitable for their product categories can not only reduce time and cost but also enhance consumer usage and purchase intentions. The applicability of VTO across different fashion product categories also requires further investigation. While personalized scanned avatars have been shown to enhance body ownership, presence, and dominance [62], they also posed privacy risks. Research is needed to address these privacy concerns effectively.

3.5.3. User Segmentation

Concerning the user segmentation theme, future research should explore the role of shoppers and their individual characteristics in influencing VTO shopping experiences. Differences in VTO adoption and purchase intentions among consumers have been extensively identified, including factors like technology anxiety, familiarity with VTO, culture, and gender differences [67,74]. Furthermore, an interdisciplinary approach combining technological innovation with consumer psychology is essential to foster more engaging, personalized, and immersive shopping experiences. By doing so, VTO has the potential to become not merely an innovative tool but a critical element in the evolution of fashion retail, offering consumers unparalleled levels of personalization and satisfaction in their shopping journeys.

3.5.4. Technological Challenges and Future Directions

Despite significant advancements in VTO systems, their further development still faces several critical technological challenges that require in-depth research and innovation. Future studies should address these challenges to ensure the effective implementation and broader adoption of VTO systems. First, robust privacy protection mechanisms are needed to address consumer concerns regarding the use of personal data, such as body measurements and photos, in VTO platforms [104]. Second, improving the realism of virtual

garments remains a pivotal task. Key areas for advancement include fabric simulation, size adaptation, and occlusion management, all of which are fundamental to delivering an authentic and immersive consumer experience [26,97]. Lastly, the issues associated with immersive environments, such as cyber-sickness in VR/AR applications [105], demand significant improvements in hardware and software technologies to reduce latency and ensure high-resolution, seamless interactions.

4. Conclusions

This comprehensive review synthesizes findings from 69 research papers to explore the influence of VTO systems on consumer behavior within the fashion industry. The analysis results show that research in this field advanced primarily after 2019 and is currently increasing. In terms of research methods, experiments were the most commonly used, accounting for 56.98% of the studies. Regarding VTO application environments, over 40% of studies focused on web-based VTO systems. Content analysis of the 69 articles identified key factors that directly influence consumers' purchasing decisions and adoption intentions, including attitudes, media exposure, symbolic gratification, technological gratification, emotional values, utilitarian values, and user attributes. Based on these insights, we developed conceptual frameworks that outline how these factors and their underlying elements shape consumers' purchasing behaviors and technology adoption processes. Finally, this research identified key gaps and proposed future directions, inspiring further interdisciplinary studies between information science and retail management to enrich our understanding and application of this transformative technology in the fashion industry.

Despite the comprehensive nature of this literature review, several limitations must be acknowledged. Firstly, the review primarily focuses on English-language publications, which may overlook significant research conducted and published in other languages. Future research should extend the search to include non-English publications to capture a more diverse and comprehensive range of studies. Secondly, the included studies exhibit considerable variability in research design, sample characteristics, and methodologies. This diversity poses challenges in drawing definitive conclusions and making direct comparisons. While efforts were made to include only peer-reviewed publications, the quality and robustness of the studies' designs, data collection methods, and analyses vary, potentially influencing the reliability and generalizability of the synthesized findings. Future studies should aim to standardize research methodologies and enhance the quality and rigor of experimental designs to facilitate more consistent and reliable comparisons. Thirdly, the rapidly evolving nature of VTO systems means that some findings may quickly become outdated. Technological advancements, such as large language models (LLMs), have the potential to enhance personalization and user interaction in VTO systems. Future research should consider how such technologies might influence consumer behavior and adoption, ensuring that ongoing developments are reflected in studies of VTO technology. Lastly, future studies should consider longitudinal and experimental designs to provide deeper insights into the long-term effects and causal relationships in VTO technology adoption and consumer behavior.

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