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# Try It On! Contingency Effects of Virtual Fitting Rooms

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ABSTRACT: A revolutionary application of the virtual reality technology in online retailing, virtual fitting room (VFR), has attracted attention of researchers and practitioners recently. However, it remains unclear whether and how VFR influences sales and post-sales outcomes based on the limited literature, and retailers hesitate in adopting the technology due to concerns about its profit prospects. In this research, we conduct two large-scale field experiments to test the causal effects of different VFR designs, and a lab experiment to unveil the underlying theoretical mechanisms. We find that, although VFR can have a sizeable positive effect on sales, it can be counterproductive when used improperly. Specifically, personalized VFR may not increase sales if used in combination with conventional product visualizations because self-discrepancy becomes salient under this condition. Moreover, VFR significantly influences post-sales outcomes, i.e., it enhances customer satisfaction and reduces product return rate. The findings provide distinct theoretical contributions and managerial implications.

KEY WORDS AND PHRASES: virtual reality, virtual fitting room, online sales, customer satisfaction, product returns.

Color versions of one or more of the figures in the article can be found online at www.tandfonline.com/mmis.

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## Introduction

The fashion industry contributes to 2% of global GDP, and female customers constitute the largest target market [16, 48]. Across channels, online apparel retail exhibits a strong growth potential (by 14% from 2017 to 2021 to a total of 167.25 billion USD); across regions, the sector witnesses the fastest growth in China (projected to nearly double the size of the U.S. market in 2025) [10, 65].

Online retailers of apparel items traditionally rely on appealing product visualizations to stimulate purchases, including 2D promotional photos or 3D displays, both of which typically feature attractive models/body figures to showcase the ideal looks of the item [30, 45, 57]. Such strategies can increase sales, since consumers often purchase an item because they like the way it looks on the model.

Recently, with the fast development of the virtual reality technology, virtual fitting room (VFR) becomes another promotional option for retailers to consider. Some studies indicate that VFR may help enhance consumer perceptions and attitudes (e.g., enjoyment and fun) [36, 37], which could potentially help increase sales. However, there are also concerns among online retailers about a potential decline in sales if VFR is launched [56]. This is because VFR allows consumers to virtually try on an item before purchase and better realize how it would actually look on themselves (which typically does *not* look as good as on the models), thus potentially diminishing the impulse to purchase that could otherwise be stimulated by appealing promotional photos or other traditional product visualizations.

The limited previous studies on VFR have predominantly employed laboratory experiments and self-reported data to examine how the system influences user perception (e.g., attitude towards using the avatar or the website), instead of actual purchase behavior. Although they provide valuable insights regarding VFR users' psychological or cognitive processes, it remains unclear whether, how and when VFR influences product sales. The question is of utmost importance to managers because of the considerable cost of implementing and maintaining VFR systems. Besides product purchases, post-purchase performances of the products (e.g., customer satisfaction and product return) are also direct determinants of online retailers' profit and long-term success. However, extant research has rarely examined how the virtual reality technology influences post-purchase metrics. In this study, we empirically test the causal effects of different VFR designs on consumer purchases and post-purchase behaviors using large-scale field experiments and unveil the underlying theoretical mechanisms.

To the best of our knowledge, this study is the first to empirically demonstrate the effect of VFR on sales, post-sales satisfaction and product return rate. Our results show that the effect of VFR on sales varies significantly depending on the types of avatars (personalized versus non-personalized) and the retailer's promotional strategy (i.e., whether VFR is deployed in isolation of or in combination with conventional visual displays such as promotional photos). The launch of personalized VFR, which is considerably more costly than non-personalized VFR [48], may in fact have an adverse effect on product sales if users' self-discrepancy becomes

salient. The optimal strategy for an online retailer to enhance sales is to entirely replace conventional visual displays with personalized VFR, instead of combining them. Moreover, we find that VFR can significantly increase post-purchase customer satisfaction and reduce the rate of product returns. Our findings help researchers and practitioners better understand the profit prospects of VFR and provide novel insights regarding how to configure and deliver VFR to maximize business performances.

## Relevant Literature

VFR is one form of image interactivity technology (IIT), which refers to the technology that makes users' online experience similar to a "real" product experience by enabling the users to alter a product's viewing background, distance, angle or even design features [48]. Thanks to IIT, users can obtain enriched product information via visual cues. Prior research has studied consumer responses to three major types of IIT, namely, (1) 3D product visualization (PV) [45], (2) mix-and-match (MM) of product images [17, 18] and (3) virtual try-on interface (e.g., VFR) [48]. PV and MM are essentially more sophisticated traditional product visualizations. Specifically, PV advertises the product in 3D instead of 2D promotional photos, while MM is an interactive tool that allows users "to coordinate an apparel ensemble on the screen" [18, p. 673] by selecting the photos of complementary items (e.g., T-shirt, shorts and sandals; and the photos are often 2D instead of 3D) from the catalog and viewing the entire outfit. Prior research highlights the importance of media richness, vividness and interactivity in such IIT systems, as they enhance user learning and perceived diagnosticity of the website [31, 32, 70].

As a higher level of IIT, VFR enables a more realistic user experience where users can select and/or personalize a 3D virtual model that mirrors their actual looks and fit the clothes on the virtual self [48]. In comparison, neither PV nor MM uses a virtual model or allows the user to virtually try the clothes on their own body figure. Advanced VFR allows a thorough examination of the products when the users virtually try on a combination of texture mapped product images that are zoomable with 360-degree views. Earlier studies investigate non-personalized VFR [19, 41] with generic/standardized virtual models, and suggest that consumers find non-personalized VFR more enjoyable and useful than 2D zoomable product representation. More recent studies have started examining personalized VFR with customizable virtual models created based on the users' own faces and body figures. Specifically, Kim and Forsythe [35, 36, 37, 38] focus on the perceived usefulness, entertainment and ease of use of personalized VFR, while Merle and colleagues [48] argue that it can lead to more positive consumer perceptions than non-personalized VFR because of higher self-congruity of the virtual model.

The role of virtual models in VFR shares certain similarities with that of avatars in virtual worlds (e.g., Second Life). Hence, Table 1 also lists relevant studies on virtual worlds and avatars. For example, Nah et al. [51] show that compared to 2D

Table 1. Summary of Relevant Literature

| Topic | Authors | IV | DV | Moderator/Mediator | Data (Sample) | Major findings |
|---|---|---|---|---|---|---|
| Virtual world/avatar | Animesh et al. [3] | Environmental stimulus | Intention to purchase virtual products | NA/telepresence, flow, social presence | Survey (354) | Interactivity, sociability, stability, and density have asymmetric effects on telepresence, social presence and flow. Flow mediates the effects of technological and spatial environments on purchase intention of virtual products. |
| | Nah et al. [51] | 2d/3d | Behavioral intention | NA/telepresence, enjoyment, brand equity | Lab experiment (445) | Compared to 2d, 3d virtual world environment has both positive (due to telepresence and enjoyment) and negative (due to distraction) effects on brand equity. Brand equity, in turn, has a positive effect on behavioral intention. |
| | Suh et al. [71] | Avatar similarity | Intention to use avatar | NA/avatar identification, emotional attachment, perceived diagnosticity | Lab experiment (92) | A user's intention to use an avatar increases when the avatar is more similar to the user, because avatar similarity enhances the user's attitude to and perceived usefulness of the avatar. |
| | Lee and Chen [42] | Usability factors | Future visit/use intention | NA/cognitive appraisal, perceived control, affective appraisal, psychological ownership, self-investment | Lab experiment (239) | Users tend to spend more time, participate in more activities, and revisit a virtual world with high usability that enhances psychological ownership. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Wang et al. [76] | Avatar interfaces, explanation facilities | Perceived usefulness, perceived enjoyment | NA/cognition-based trust, affect-based trust | Lab experiment (215) | Explanation facilities enhance perceived usefulness and thus cognition-based trust. Avatar interfaces enhance perceived enjoyment and thus affect-based trust, but only for users who rate the avatar as highly professional. |
| Product visualization | Jiang and Benbasat [32] | Visual control, functional control | Perceived diagnosticity, flow | NA/NA | Lab experiment (80) | Visual and functional control increase consumers' perceived diagnosticity and flow. |
| Product visualization | Suh and Lee [70] | VR interface | Consumer learning | Cognitive fit, product types/ cognitive fit | Lab experiment (85) | VR increases consumer learning about products; and the effect is greater for virtually high experiential products than for virtually low experiential products. |
| | Jiang and Benbasat [31] | Online product presentations | Intention to purchase, intentions to return | NA/perceived diagnosticity, compatibility with in-store shopping, shopping enjoyment, attitudes toward products, attitudes toward shopping at a website | Survey (176) | Vividness and interactivity of product presentation enhance its efficacy. Perceived diagnosticity, compatibility, and enjoyment influence consumer attitudes to a website. Consumer attitudes to the products and the website influence purchase intentions. |
| | Li et al. [43] | | | NA/NA | Qualitative study (30) | 13 types of psychological activities were classified into 5 features of virtual experience when individuals interact with 3d computer simulations: active process, presence, involvement, enjoyment, and affordance. |

*(continues)*

Table 1. Continued

| Topic | Authors | IV | DV | Moderator/Mediator | Data (Sample) | Major findings |
|---|---|---|---|---|---|---|
| | Li et al. [45] | Virtual experience | Consumer learning, cognitive activities | Product type/NA | Lab experiment (n = 33; 73; 60; 28) | Virtual product affordance influences the effectiveness of 3d visualization. 3d visualization leads to better consumer learning, brand attitude and purchase intention than 2d graphics and TV ads for geometric and mechanical products. |
| | Schlosser [61] | Object interactivity (OI) | Attitudes, intention | Goal to search or browse/ cognitive elaboration, mental imagery | Lab experiment (n = 56; 17; 151; 169) | OI (or passive content) enhances cognitive elaboration of browsers (or searchers) and thus their attitudes. OI enhances mental imagery of both browsers and searchers and thus their purchase intentions. |
| Personalized VFR | Kim and Forsythe [37] | Perceived usefulness, perceived entertainment | Intention to purchase, reuse, and revisit | NA/attitude toward using product virtualization technologies | Survey (978) | Perceived entertainment (hedonic value) has a greater impact on user attitude toward using the product virtualization technology than perceived usefulness (utilitarian value). |
| | Kim and Forsythe [36] | Perceived usefulness, perceived entertainment, perceived ease of use of virtual try-on | Post-use evaluation of virtual try-on | Technology anxiety, innovativeness/attitude toward using virtual try-on, intended use of virtual try-on | Survey (491) | Perceived usefulness and entertainment value are strong determinants of consumer attitudes to using virtual try-on for online apparel shopping. |

| | | | | | | |
|---|---|---|---|---|---|---|
| | Kim and Forsythe [38] | Perceived usefulness, perceived entertainment, perceived ease of use of sensory enabling technology (SET) | Post-use evaluation of SET | Technology anxiety, innovativeness/attitude toward using SET, intended use of SET | Survey (354) | Perceived usefulness and entertainment value have strong effects on consumer attitudes to all sensory enabling technologies, whereas the effect of perceived ease of use and the roles of technology anxiety and innovativeness vary by technology. The 2d views play a strong functional role; 3d rotation views play both functional and hedonic roles; and virtual try-on plays a strong hedonic role. |
| Non-personalized VFR | Fiore et al. [19] | Image interactivity technology (IIT) | Attitude, willingness to purchase, willingness to patronize | NA/experiential value, instrumental value, telepresence | Lab experiment (206) | The level of IIT affects telepresence, experiential and instrumental values, which in turn influence consumer attitude, willingness to purchase and patronize. |
| | Lee et al. [41] | IIT, utilitarian shopping orientation, hedonic shopping orientation | Consumers' attitude toward an online retailer, behavioral intention | NA/perceived usefulness, perceived ease of use, perceived enjoyment | Lab experiment (206) | The level of website IIT influences perceived usefulness, ease of use, and enjoyment, which in turn affect the users' attitude to the retailer and behavioral intention. |
| Mix-and-match /image interactivity | Fiore and Jin [17] | Exposure to mix-and-match image interactivity function | Approach responses to the retailer | NA/NA | Lab experiment (103) | Mix-and-match image interactivity function enhances all the approach responses under study. |

*(continues)*

Table 1. Continued

| Topic | Authors | IV | DV | Moderator/Mediator | Data (Sample) | Major findings |
|---|---|---|---|---|---|---|
| | Fiore et al. [18] | Optimum stimulation level (OSL), recreational shopping | Attitude, willingness to purchase, willingness to patronize | NA/trying the image interactivity feature as a stimulating experience, emotional arousal, pleasure | Lab experiment (103) | OSL or recreational shopping has significant indirect effects on the three approach responses by motivating individuals to try the image interactivity feature as a stimulating experience. |
| Personalized & non-personalized VFR; mix-and-match | Merle et al. [48] | Virtual try-on self-congruity, body esteem, | Intention to consider the retailer for future shopping | NA/hedonic value, utilitarian value, confidence in apparel fit | Lab experiment (152) | Self-congruity with the virtual model influences confidence, utilitarian, and hedonic value, leading to greater favorability of the web site; body esteem influences self-congruity and confidence. |
| Personalized & non-personalized VFR | This present study | VFR, personalized VFR, and non-personalized VFR | Product sales, post-purchase customer satisfaction, product return rate | Conventional visual displays/ perceived risk, perceived enjoyment, expected apparel performance, self-discrepancy | Field experiments (933 products in Study 1; 894 products in Study 2), Lab experiment (160) | VFR significantly increases sales, but the effect can be contingent. Personalized VFR can lead to a greater increase in sales than non-personalized VFR, but only when CVD is unavailable. Perceived risk and enjoyment mediate the positive effect of personalized VFR on sales. In the presence of CVD, self-discrepancy mediates the effect of personalized VFR on sales. In addition, VFR (especially personalized VFR) significantly increases customer satisfaction and decreases the rate of product returns. |

virtual world environment, 3D environment can have both positive (due to telepresence and enjoyment) and negative (due to distraction) effects on brand equity. Suh et al. [71] find that users exhibit greater intentions to use avatars that closely resemble themselves, because they have more positive attitudes (e.g., affection, connection, and passion) to such avatars and feel better able to evaluate apparel products with such avatars.

Notably, the literature has exclusively focused on self-reported measures as outcomes such as website evaluation or favorability. The very few studies that examine purchase intentions focus on the effects of either 3D PV [43, 44, 45, 61] or MM [17], instead of VFR. Their findings may not directly apply to the VFR context because of the fundamental differences across these IIT systems as we discussed above. Among the studies on VFR, Fiore et al. [19] conduct a lab experiment with 206 undergraduates to examine how the use of non-personalized VFR influences users' perceived willingness to shop on the website. Based on lab experiment with 152 female students, Merle et al. [48] propose an indirect path between personalized VFR and the participants' reported tendency of considering the focal website for future apparel purchases, mediated by utilitarian and hedonic value in the shopping process. Note that, these studies focus on the favorability to the retailer (i.e., interest in shopping on the website or intention to consider it for future purchases), and do not directly examine the likelihood of purchasing the products displayed in VFR. Moreover, they do not test the contingency effect of VFR or its interrelationship with conventional visual displays of the product; and purchase intentions do not necessarily translate into actual purchases according to the literature [1, 50, 58]. Meanwhile, some other studies suggest that, although personalized VFR is perceived as more hedonic, it may *not* help enhance product evaluation and purchase [35, 36]. In sum, based on extant research, it remains inconclusive how VFR influences product sales. Furthermore, prior research has rarely studied the impact of any form of IIT (including VFR) on post-purchase customer attitudes or behaviors.

## Theory and Hypotheses

### Impact of VFR on Sales

Drawing on relevant theories in the MIS, psychology and marketing literatures, we propose that the influences of VFR on online purchases of apparel products can be intricate. On the positive side, it helps reduce perceived risk and enhance enjoyment of online shopping, thus potentially enhancing purchases. Meanwhile, instead of presenting an ideal image using fashion models, VFR with personalized avatars reveals realistic self-images of the customers wearing the product. This may lower customers' expectation about how the product would look and thus potentially reduce the impulse to purchase (echoing the practitioners' hesitation on adopting VFR as discussed earlier). Hence, we develop competing hypotheses below about

the effectiveness of personalized VFR compared to non-personalized VFR. Moreover, under a certain condition, personalized VFR may result in self-discrepancy that further decreases purchases; and we thus develop a contingency-effect hypothesis as well.

### Positive Influences via Reduced Risk and Enhanced Enjoyment

A main factor that impedes online purchases of apparel products is the lack of direct experiences without trying them on, which leads to increased perceived risk of purchase due to the difficulty in judging the products' fit [59] and decreased consumer enjoyment in the shopping process [11]. VFR helps alleviate such issues because it provides virtual experiences, which may (1) compensate for the lack of tactile/experiential information and thus mitigate perceived risk [48, 53] and (2) increase hedonic value (e.g., entertainment, excitement and fun) and thus enjoyment [19, 35, 36, 41]. Compared to non-personalized VFR with standardized avatars, personalized VFR allows customers to try the clothes on their own avatars created based on their own faces and body figures, and thus produces more lifelike and vivid virtual experiences that are similar to offline shopping experiences [38, 48]. Hence, personalized VFR can be more effective in reducing perceived risk and enhancing enjoyment than non-personalized VFR. For these reasons, VFR could help increase online sales of apparel retailers, and personalized VFR might increase sales even more.

*Hypothesis 1: An online apparel retailer's sales would be higher when VFR is available than when it is not.*

*Hypothesis 2a: Personalized VFR leads to a greater increase in sales than non-personalized VFR.*

### Negative Influence via Lowered Product Expectation

Besides perceived risk and shopping enjoyment, the customer's expected performance of the product (in our case, how the product might look on her-/himself) would also drive the online purchase decision [45, 60]. The higher the expected performance, the higher the likelihood of purchase [69]. Customer expectations are often set based on reference points provided by external stimuli (e.g., images in product advertisements) [57, 78].

When personalized avatars are available in VFR, customers can virtually try the clothes on their virtual selves before making the purchase decision. Hence, personalized VFR has a unique feature that is unavailable in traditional online retailing contexts, i.e., it presents a realistic self-image prior to purchase. This self-image presented by personalized VFR will then serve as the reference point for expectation formation. When the realistic self-image is not observable, customers form expectations based on imagined self-image (in traditional online retail settings,

imagined self-image is typically formed based on promotional photos, videos or 3D displays of the product) [30]. Since people tend to imagine their own appearance based on the desired look when shopping for appearance-enhancing products [60], the imagined self-image is often more appealing than the realistic self-image. For these reasons, because personalized VFR provides an observable self-image as a more realistic reference point, it may lead to lower customer expectation about the product and thus reduce the impulse to purchase. In comparison, non-personalized VFR is unlikely to have this negative impact because it employs a same standardized virtual model for all users and thus is unable to provide a highly realistic self-image as reference point for expectation formation. Therefore, we propose H2b below as a competing hypothesis to H2a:

> *Hypothesis 2b: Personalized VFR leads to a lower increase in sales than non-personalized VFR.*

### (Contingent) Negative Influence via Self-Discrepancy

As discussed above, customers in personalized VFR can observe their realistic self-image prior to purchase. If they are simultaneously exposed to the ideal image and thus can directly compare it with their realistic self-image, they may experience significant self-discrepancy. Under this circumstance, the impact of personalized VFR on sales may become significantly less positive or even turn negative.

The self-discrepancy theory [27] has been a key theory in explaining people's appearance-management behaviors. The theory posits that disparities may exist between the ideal self (the attributes that an individual would like to possess) and the real self (the attributes that the individual actually possesses). Such disparities can result in an unpleasant psychological state and a motivation to avoid or reduce the perceived self-discrepancy, especially for females [29]. In most cultures, females are interested in fashion and beauty, and engage in various appearance enhancement or management behaviors [21] with an attempt to approximate the ideal appearance based on cultural aesthetic standards and external stimuli such as media images [23]. When the perception of one's appearance matches the ideal, positive attitudes and feelings are likely to result; when one's appearance is discrepant from the ideal, she will develop negative attitudes and feelings [60].

When personalized VFR is made available in combination of conventional visual displays (CVD hereafter) of the products (e.g., appealing promotional photos featuring fashion models), self-discrepancy can become salient because customers can directly compare their self-image revealed in personalized VFR with the ideal image presented in CVD[1]. Typically, customers' realistic self-images in VFR fall short of the aesthetic ideals, which are often rigid/narrow and cannot realistically be achieved by the majority [33, 57]. Prior research has documented a "negative affective state" (e.g., depression, anger, shame, insecurity and guilt) of individuals under significant self-discrepancy [54, 67]. The most straightforward and commonly adopted coping strategy to alleviate self-discrepancy is to exit and stay away

from the current scenario [60], e.g., to leave the webpage of the product without purchasing it or abandon the retailer's website all-together. Hence, the negative attitudes or mood states under salient self-discrepancy can reduce customer purchases, and thus personalized VFR could negatively affect sales in the presence of CVD. Therefore, we hypothesize that

*Hypothesis 3: Personalized VFR is more likely to increase sales when CVD is absent than when CVD is present.*

## Impact of VFR on Customer Satisfaction and Product Return

To gain a more thorough understanding about the impact of VFR, we examine not only customer purchases but also post-purchase outcomes, i.e., customer satisfaction and product return. Post-purchase outcomes are vital for corporate profitability and long-term business success. Specifically, customer satisfaction determines repeat purchases (customer retention) and word-of-mouth (customer acquisition), while the high product return rate is a major concern for online retailers because it adds significant operations cost and diminishes profit.

After product purchase, customer satisfaction is determined by the difference between the perceived performance of the actual product and the expectation [12, 47]. When product performance exceeds or meets expectation, the customer is satisfied; otherwise, dissatisfaction will result. Extant research suggests that IIT vividness and interactivity enhance diagnosticity and thus customer learning about the product [31, 32]. VFR is more vivid and interactive than traditional IIT or product display and thus helps customers form an expectation that is closer to the actual product. Therefore, with VFR, consumers are likely to perceive a smaller post-purchase disparity between the expectation and the actual product performance, and thus experience higher satisfaction. When personalized avatars are available, VFR can adjust customer expectations to an even more realistic level as it mirrors the self-images of the customers wearing the product on their own bodies. In contrast, non-personalized VFR using standardized avatars does not effectively unveil how the product fits different customers and thus may set unrealistic expectations [30]. In other words, without personalized VFR, the realization of product fit/realistic self-image is postponed from pre-purchase to post-purchase, increasing the chance of post-purchase dissatisfaction. Hence, we hypothesize that,

*Hypothesis H4: Post-purchase customer satisfaction would be higher when VFR is available than when it is not.*

*Hypothesis H5: Personalized VFR leads to a greater increase in customer satisfaction than non-personalized VFR.*

One major source of cost for online retailers is the logistic cost for processing product returns [68], which is typically considered as the "Achilles heel" of e-commerce [13]. For example, the return rate for apparel items on Zappos.com averages about 35% [28]. In general, product return often results from customer

dissatisfaction with the product purchased [9]. Because VFR may increase customer satisfaction as discussed above, it is likely to help reduce the rate of product returns. In the particular context of online shopping, customers are likely to return a product when they perceive a significant gap between the real product (after it is examined physically) and the online product (before it is observed physically) [69]. As the most advanced form of IIT, VFR provides more visual cues than traditional technologies that allow customers to gain richer product information online [48]. When personalized virtual models are available in VFR, customers can have a simulated direct experience with the online product that resembles how they may physically try on the real product. Such vivid telepresence helps maximize customers' knowledge about how the product would actually work prior to purchase [39, 69], and thus minimize the perceived gap between the online and real products after purchase. Therefore, we hypothesize that,

*Hypothesis H6: The rate of product returns would be lower when VFR is available than when it is not.*

*Hypothesis H7: Personalized VFR leads to a greater decrease in return rate than non-personalized VFR.*

## Overview of Methodology

We conducted two large-scale field experiments (Study 1 and Study 2) with real-world behavioral data (e.g., actual purchases and product returns) to test our hypotheses, and a controlled lab experiment (Study 3) using self-reported measures of user perceptions to delineate the theoretical mechanisms behind the effects observed in the field experiments. Insights from field experiments can be readily applied to managerial decision making because they demonstrate the economic magnitude of the effect, while lab experiment is powerful to reveal the psychological process that would otherwise be difficult to measure in real-world settings.

We conducted Study 1 at an online retailer of young women's apparel and analyzed a total of 933 product items and 24,435 product purchases during the observation period. This study demonstrates the overall causal effects of VFR on sales, customer satisfaction and product return rate (i.e., hypotheses H1, H4, and H6). Study 2 not only confirms the results for H1, H4 and H6, but also takes a step further to compare the effects of personalized versus non-personalized VFR (i.e., H2a, H2b, H5, and H7), as well as the moderating role of CVD (i.e., H3). It was conducted at a mobile app store of apparel items, with 894 product items and 163,944 product purchases in the observation period. Study 3 was conducted with university students in a controlled laboratory setting. The lab experiment enables us to explicitly test the theoretical underpinnings that we proposed when developing the hypotheses (e.g., the mediating roles of perceived risk, enjoyment, expectation and self-discrepancy).

# Study 1

## Experimental Design

Study 1 tests the causal impact of VFR on sales, post-purchase satisfaction, and product returns. A field experiment was conducted at a large retailer of fast fashion items for young women in China, which sells its products via an official website/online store. On August 25th, 2016, the retailer started introducing VFR in its online store. The launch of VFR was the focal treatment in this field experiment. Our analysis focuses on the observation period between August 4th and September 14th, i.e., a three-week pre-treatment period and a three-week post-treatment period[2]. There were no other changes in the online store except for the focal treatment during this period; and we only keep the products that were available throughout the entire period in the sample. We obtained access to data on product sales, customer satisfaction (measured by average consumer rating of a product after purchase, from highly dissatisfied to highly satisfied)[3], and the rate of returns for products purchased during both the pre-treatment and the post-treatment periods[4].

In the VFR, users were able to try on the clothes using a virtual model. The users could opt to personalize the virtual model by uploading their own photos and inputting measurements of their own body figures, or to simply use a non-personalized standardized virtual model. Our data could not track whether a user had used a personalized or non-personalized virtual model in the VFR before making a purchase. Hence, in Study 1, we only focus on the overall impact of VFR, and do not compare the effects of personalized versus non-personalized VFR (which we will do in Study 2).

Because of the considerable cost and time required to fully implement VFR for all product items, the retailer only made VFR available for one third of its products randomly selected from the entire inventory. In other words, one third of the products were in the treatment group, while the rest of the products were in the control group. Table 2 indicates the randomization of treatment assignment across products[5]. As shown in Table 2A, within each product subcategory (tops, bottoms, or dresses), the actual percentage of products in the treatment group is within the 95% confidence interval (computed by $p \pm 1.96 \times [p\times(1\text{-}p)/n]^{1/2}$, where $p$ is the proportion of treatment products in the full sample and $n$ is a subcategory's sample size) of this subcategory, indicating that the allocation of the treatment is proportionately transmitted to all product subcategories. In addition, there are no significant differences in product price, pre-treatment sales volume, pre-treatment customer satisfaction and pre-treatment return rate between the treatment group and the control group (Table 2B).

## Model and Results

To estimate the treatment effect of VFR, we use a difference-in-difference approach following Angrist and Pischke [4]:

Table 2. Randomization Checks for Study 1. A. Randomization of Treatment Assignments across Product Subcategory

| Total no. of products | No. of treated products | Product subcategory | Percentage of treated products | 95% CI for percentage of treated products |
|---|---|---|---|---|
| 933 | Yes: 311 (33.33%) | Tops (534) | 182/534 (34.08%) | [29.34%, 37.33%] |
| | No: 622 (66.67%) | Bottoms (130) | 46/133 (35.39%) | [25.23%, 41.44%] |
| | | Dresses (269) | 83/270 (30.86%) | [27.70%, 38.97%] |

**B**. Differences in Prices, Pre-treatment Sales Volumes, Pre-treatment Customer Satisfaction, and Pre-treatment Return Rates of Treated and Control Products.

| Analysis | Product group | Mean | St. Dev. | $p$-value ($t$-value) |
|---|---|---|---|---|
| Price | Treated | 146.730 | 98.374 | 0.297 (1.043) |
| | Control | 161.217 | 234.874 | |
| Sales Volume | Treated | 15.720 | 46.730 | 0.999 (0.001) |
| | Control | 15.723 | 46.506 | |
| Customer Satisfaction | Treated | 4.712 | 0.594 | 0.475 (0.714) |
| | Control | 4.742 | 0.562 | |
| Return Rate | Treated | 0.101 | 0.201 | 0.240 (1.176) |
| | Control | 0.085 | 0.182 | |

$$Y_{it} = \beta_0 + \beta_1 Treat_i + \beta_2 Post_t + \beta_3 Treat_i \times Post_t + \alpha X_{it} + \varepsilon_{it} \quad (1.)$$

We estimate a separate model for each dependent variable $Y_{it}$ (i.e., sales volume, post-purchase customer satisfaction and rate of product return of product item $i$ purchased at period $t$). $Treat_i$ indicates whether product item $i$ belongs to the treatment group ($Treat_i$ =1 if item $i$ is in the treatment group, and $Treat_i$ = 0 if item $i$ is in the control group); $Post_t$ is a dummy variable indicating the pre-treatment period (0) or the post-treatment period (1); and $X_{it}$ is a vector of control variables including price, product subcategories, price promotion[6], historical rating and historical sales (measured by the average rating and average daily sales of each product since it was introduced). The coefficient of $Treat_i \times Post_t$, $\beta_3$, is the parameter of interest that captures the difference-in-difference treatment effect of VFR.

## Testing Hypotheses H1, H4, and H6

Table 3 presents the estimation results for Equation (1). We find a significant and positive treatment effect on sales ($\beta_3$ = 8.568, $p < 0.001$ in column (1), supporting

Table 3. Model Estimation Results of Study 1

| | (1) Product Sales | (2) Customer Satisfaction | (3) Return Rate |
|---|---|---|---|
| DV (Dependent Variable) → | Coefficient (std. error) | Coefficient (std. error) | Coefficient (std. error) |
| Treat | –0.272 (1.444) | –0.0001 (0.034) | 0.012 (0.013) |
| Post | –6.986*** (1.201) | 0.016 (0.030) | 0.011 (0.011) |
| **Treat*Post** | **8.568*** (2.040)** | **0.112* (0.050)** | **–0.049** (0.018)** |
| Price | –0.004[a] (0.002) | 3.5E-6 (6.2E-5) | –1.5E-5 (2.2E-5) |
| Tops | 0.027 (1.101) | –0.019 (0.027) | –0.005 (0.010) |
| Bottoms | 0.390 (1.572) | –0.0002 (0.038) | 0.006 (0.014) |
| Historical Sales | 14.819*** (0.221) | –0.002 (0.005) | 0.003 (0.002) |
| Historical Rating | 0.203 (0.876) | 0.542*** (0.022) | –0.069*** (0.008) |
| Promotion | 10.526*** (2.226) | –0.028 (0.050) | 0.020 (0.020) |
| Constant | 3.751 (4.259) | 2.230*** (0.107) | 0.407*** (0.038) |

*Note*: ***p < 0.001. **p < 0.01. *p < 0.05. [a] p < 0.1. The coefficient of *Treat*Post* captures the difference-in-difference treatment effect of VFR. VFR, virtual fitting room.

H1. The coefficient indicates that the launch of VFR increased the retailer's sales by 65.430% relative to the mean of 13.095. Moreover, column (2) shows that VFR significantly increases post-purchase customer satisfaction ($\beta_3 = 0.112$, $p < 0.05$). Hence, we find support for H4. Finally, consistent with our expectation in H6, column (3) shows that VFR significantly decreases the rate of product returns ($\beta_3 = -0.049$, $p < 0.01$). Considering the retailer's average return rate of 8.624%, the size of the coefficient indicates that the launch of VFR induced a reduction of 56.818% in product return rate.

## Robustness Checks

To ensure the robustness of the results, we perform a series of additional analyses in Appendix B. In brief, we first estimate a time-effect model to ensure a parallel common trend between the control and treated groups before treatment. Second, we find consistent results when re-estimating the model (Equation 1) using the subsets of data (i.e., after removing the products that received price promotion, after removing price outliers, or keeping repeat purchasers during the experiment period only). Third, we find consistent results after controlling for simultaneous purchases of treated and control products. Fourth, our results remain robust to alternative measures of variables. Finally, we conduct additional analyses in Appendix D to rule out the potential premier effect of VFR.

In summary, the results of Study 1 support **H1, H4** and **H6**. We observe not only statistical significance but also sizeable economic magnitude of the effect of VFR.

Next, in Study 2, we will compare the effects of different types of VFR (personalized versus non-personalized) and investigate an important contingency factor that moderates VFR effectiveness.

## Study 2

### Experimental Design

Study 2 was conducted at another retailer of women's apparel products, which sells through its mobile app in China. To test the effectiveness of VFR, the retailer randomly

Table 4. Randomization Checks for Study 2: A. Randomization of Treatment Assignments across Product Subcategory

| Total no. of products | No. of treated products | Product subcategory | (% of treated products) | 95% CI for percentage of treated products |
|---|---|---|---|---|
| 894 | Yes: 180 (20.13%) | Top (354) | 75/354 (21.19) | [15.96, 24.31] |
| | No: 714 (79.87%) | Bottom (225) | 44/225 (19.56) | [14.89, 25.37] |
| | | Dress (315) | 61/315 (19.37) | [15.71, 24.56] |

*Note* : The numbers preceding the percentages are counts of products. For example, 180 is the number of treated products, the percentage 20.13% in parentheses is the proportion of treated products relative to total number of all products; 75 is the number of treated tops, 354 is the total number of tops, the percentage 21.19% in parentheses is the proportion of treated tops relative to total number of tops.

**B**. Differences in Prices, Pre-treatment Sales Volumes, Pre-treatment Customer Satisfaction, and Pre-treatment Return Rates of Treated and Control Products.

| Analysis | Product group | Mean | St. Dev. | *p*-value (*t*-value) |
|---|---|---|---|---|
| Price | Treated | 253.889 | 142.424 | 0.230 (1.201) |
| | Control | 268.647 | 148.571 | |
| Sales Volume | Treated | 22.772 | 45.469 | 0.345 (0.947) |
| | Control | 19.360 | 32.736 | |
| Customer Satisfaction | Treated | 4.847 | 0.186 | 0.821 (0.226) |
| | Control | 4.851 | 0.064 | |
| Return Rate | Treated | 0.078 | 0.107 | 0.438 (0.777) |
| | Control | 0.072 | 0.080 | |

**C**. Randomization of Treated Products between Groups T1 and T2 across Product Subcategory.

| Total no. of treated products | No. of treated products with conventional promotional photos | Product subcategory | (% of treated products) | 95% CI for percentage of treated products |
|---|---|---|---|---|
| 180 | Yes (T1): 90 (50%) | Top (75) | 38/75 (50.67) | [38.68, 61.32] |
| | No (T2): 90 (50%) | Bottom (44) | 20/44 (45.46) | [35.23, 64.77] |
| | | Dress (61) | 32/61 (52.45) | [37.45, 62.55] |

*Note*: The numbers preceding the percentages are counts of products. For example, 90 is the number of T1 products, the percentage 50% in parentheses is the proportion of T1 products relative to total number of treated products; 38 is the number of T1 tops, 75 is the total number of treated tops, the percentage 50.67% in parentheses is the proportion of treated T1 tops relative to total number of treated tops.

**D**. Differences in Prices, Pre-treatment Sales Volumes, Pre-treatment Customer Satisfaction, and Pre-treatment Return Rates between Groups T1 and T2.

| Analysis | Product group | Mean | St. Dev. | *p*-value (*t*-value) |
|---|---|---|---|---|
| Price | T1 | 254.000 | 139.347 | 0.992 (0.010) |
| | T2 | 253.778 | 146.218 | |
| Sales Volume | T1 | 19.056 | 32.694 | 0.274 (1.097) |
| | T2 | 26.489 | 55.328 | |
| Customer Satisfaction | T1 | 4.858 | 0.109 | 0.446 (0.764) |
| | T2 | 4.834 | 0.247 | |
| Return Rate | T1 | 0.084 | 0.090 | 0.528 (0.632) |
| | T2 | 0.073 | 0.122 | |

selected 180 products (out of a total of 894 products) and made VFR available for them. Hence, there were 180 products in the treatment group, and 714 products in the control group. Table 4 confirms the randomization of treatment assignments across products. As shown in Table 4A, the 95% CI for the percentage of treated products in each product subcategory (tops, bottoms, or dresses) includes the observed percentage in this subcategory. Thus, the allocation of the treated and untreated products is proportionately transmitted to all product subcategories. Table 4B shows that there are no significant differences in product price, pre-treatment sales volume, customer satisfaction, and product return rate between the treatment group and the control group, further ensuring the randomization of the treatment.

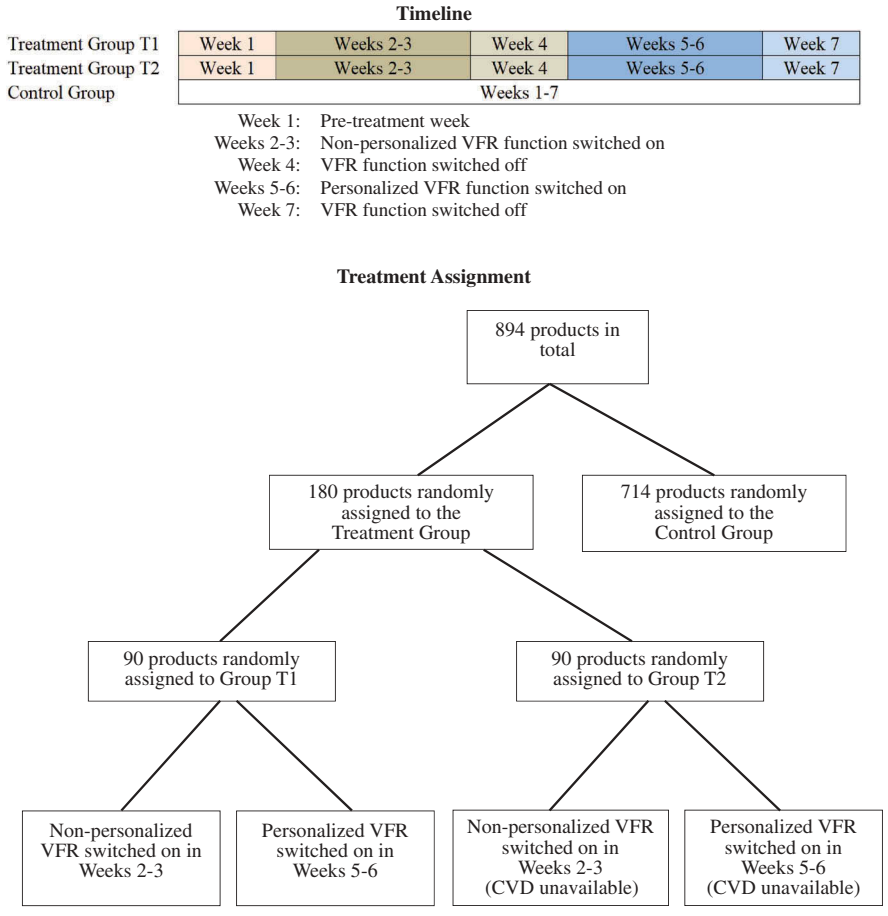


*Figure 1.* Experimental design of study 2. *Note*: CVD is available unless marked as "unavailable." VFR, virtual fitting room; CVD, conventional visual display.

Figure 1 illustrates the experimental design. The products in the treatment group were randomly divided into two subgroups T1 and T2, with 90 products in each subgroup. For each product in T1 and the control group, conventional promotional photos were always displayed on the app. In comparison, in T2, conventional promotional photos were absent when VFR was available. Tables 4C and 4D confirm that the randomization of product assignment across T1 and T2. Appendix A provides additional information on customer characteristics across time periods and treatment conditions.

The company launched VFR on July 17$^{th}$, 2017. In the first two weeks following the launch (i.e., Phase 1 from July 17$^{th}$ to 30$^{th}$), only non-personalized standardized virtual model was made available in the VFR. After Phase 1, the VFR function was switched off for a week (July 31$^{st}$ to August 6$^{th}$). In the two weeks from August 7$^{th}$ to 20$^{th}$ (Phase 2), VFR was switched back on; however, only personalized virtual model

was available in VFR during this period. Each user who entered VFR was asked to scan their full body to create a personalized avatar that matched her face and body. The VFR function was switched off again after Phase 2. The purpose of inserting "switch-off" periods after treatment periods is to show that the treatment effect would dissipate when the treatment is switched off [40, 55]. We have access to weekly sales data for all the products on the app (including both the products in the treatment group and those in the control group) for each week shown in Figure 1.

## Model and Results

To estimate the treatment effects of personalized versus non-personalized VFR on product performances under various conditions (with or without the presence of conventional promotional photos), we specify the model below following the literature on factorial designs [6, 40, 49]:

$$Y_{it} = \alpha_0 + \alpha_1 SVFR_{it} + \alpha_2 PVFR_{it} + \alpha_3 SVFR_{it} \times CVD_{it} + \alpha_4 PVFR_{it} \times CVD_{it} + \beta X_{it} + \varepsilon_{it} \quad (2.)$$

Again, we examine three dependent variables $Y_{it}$ (i.e., sales volume, post-purchase satisfaction[7] and return rate[8] or product $i$ purchased at time $t$, respectively). Error terms are clustered at the product level. *Standardized virtual fitting room* ($SVFR_{it}$) is an indicator variable equal to 1 if standardized/non-personalized VFR was available for product $i$ in week $t$ and 0 otherwise. *Personalized virtual fitting room* ($PVFR_{it}$) is an indicator variable equal to 1 if personalized VFR was available for product $i$ in week $t$ and 0 otherwise. $CVD_{it}$ is a dummy variable indicating the presence (1) or absence (0) of conventional promotional photos for product $i$ in week $t$. $X_{it}$ represents a vector of control variables including product price, subcategory, historical sales, historical sales, price promotion[9] and weekly fixed-effects.

### Testing Hypotheses H1, H2a, and H2b

Column (1) of Table 5 presents the estimation results when sales volume is the dependent variable. Consistent with our results in Study 1, we observe positive and significant main effects of both non-personalized ($\alpha_1$ = 9.758, $p < 0.001$) and personalized ($\alpha_2$ = 24.944, $p < 0.001$) VFR on sales, supporting **H1**. The coefficient of personalized VFR is much higher than that of non-personalized VFR, in support of **H2a** instead of **H2b** (subsequent Wald test of parameter constraints confirms that $\alpha_2$ is significantly higher than $\alpha_1$, $p < 0.01$). Hence, VFR significantly increases product sales, and using personalized avatars in VFR leads to a greater increase in sales than using non-personalized avatars[10].

Table 5. Model Estimation Results of Study 2.

| DV (Dependent Variable) → | (1) Product sales | (2) Customer satisfaction | (3) Return rate |
|---|---|---|---|
| Variables | Coefficient (std. error) | Coefficient (std. error) | Coefficient (std. error) |
| SVFR | 9.758*** (1.035) | 0.018* (0.009) | –0.019*** (0.004) |
| PVFR | 24.944*** (4.129) | 0.041*** (0.009) | –0.035*** (0.004) |
| SVFR*CVD | 17.883*** (3.329) | –0.026* (0.011) | 0.019** (0.006) |
| PVFR*CVD | –25.983*** (4.185) | –0.005 (0.011) | –0.011* (0.005) |
| Price | –0.004** (0.001) | 1.6E-5 (1.7E-5) | –7.0E-5*** (9.9E-6) |
| Top | –0.547 (0.460) | –0.015** (0.005) | –0.004 (0.003) |
| Bottom | –0.712 (0.481) | –0.015* (0.006) | –0.006[a] (0.003) |
| Historical Sales | 9.063*** (0.092) | –0.008*** (0.001) | 0.003*** (0.0003) |
| Historical Rating | –1.223 (0.838) | 0.058* (0.025) | –0.018 (0.012) |
| Promotion | 7.664*** (0.348) | 0.030*** (0.006) | –0.0004 (0.004) |
| Week Fixed Effects | Included | Included | Included |
| Constant | 1.021 (4.093) | 4.603*** (0.123) | 0.173** (0.056) |

*Note*: ***p < 0.001. **p < 0.01. *p < 0.05. [a]p < 0.1. SVFR represents the availability of standardized virtual model; PVFR represents the availability of personalized virtual model; and CVD represents conventional visual display.

### Testing Hypothesis H3

The coefficient of the interaction term *SVFR*CVD* in column (1) is positive and significant ($\alpha_3$ = 17.883, $p < 0.001$), implying that the positive effect of non-personalized VFR is even higher when conventional promotional photos are also available. In sharp contrast, the coefficient of *PVFR*CVD* is negative and significant ($\alpha_4$ = -25.983, $p < 0.001$), indicating that the effect of personalized VFR is significantly mitigated in the presence of conventional promotional photos. Hence, we find support for **H3**. The main effect and interaction effect coefficients indicate that, using non-personalized and personalized avatars in VFR increased sales by 37.247% and 95.210% relative to the mean, respectively; on top of these effects, simultaneous presence of CVD further increased sales by 68.261% when using non-personalized avatars, but decreased sales by 99.179% when using personalized avatars.

### Testing Hypotheses H4 and H5

With customer satisfaction as the dependent variable (column 2), we find positive coefficients of both non-personalized and personalized VFR ($\alpha_1 = 0.018$, $p < 0.05$; $\alpha_2 = 0.041$, $p < 0.001$). These results are consistent with those in Study 1 and support **H4**, i.e., VFR significantly increases customer satisfaction. Subsequent Wald test of parameter constraints of $\alpha_1$ and $\alpha_2$ shows that personalized VFR leads to a greater increase in

customer satisfaction than non-personalized VFR ($p < 0.05$), supporting **H5**. Unlike its moderating effect on sales, CVD does *not* significantly mitigate the effect of personalized VFR on customer satisfaction ($\alpha_4 = -0.005, p > 0.1$).

### Testing Hypotheses H6 and H7

As shown in column (3), both non-personalized VFR and personalized VFR significantly reduce the rate of product returns ($\alpha_1 = -0.019, p < 0.001$; $\alpha_2 = -0.035, p < 0.001$). These results are consistent with our finding in Study 1 and support **H6**. The sizes of the coefficients suggest that, relative to an average return rate of 6.464%, the introductions of non-personalized and personalized VFR reduced return rate by 29.394% and 54.146%, respectively. Subsequent Wald test of parameter constraints of $\alpha_1$ and $\alpha_2$ shows that, in support of **H7**, personalized VFR is more effective in reducing product return rate than non-personalized VFR ($p < 0.05$). Moreover, return rate can become even lower when both personalized VFR and CVD are available ($\alpha_4 = -0.011, p < 0.05$).

### Robustness Checks

Appendix C presents the robustness checks. First, we estimate an alternative model without interaction terms, and use an indicator for each unique treatment condition (i.e., non-personalized VFR alone, personalized VFR alone, non-personalized VFR with CVD, and personalized VFR with CVD). Second, we re-estimate the treatment effects using the subsets of data (i.e., after removing data from the switch-off periods, after removing data from the pre-treatment week, or keeping repeat purchasers across the pre-treatment and post-treatment periods only) and find consistent results. Third, the results remain robust after controlling for simultaneous purchases of treated and control products. Fourth, we find consistent results when using various alternative measures.

In sum, in Study 2, we observe consistent results as in Study 1 that support **H1, H4** and **H6** regarding the overall impact of VFR. Moreover, we demonstrate the moderating role of CVD and find support for **H3**; and show the differential effects of personalized versus non-personalized VFR, which support **H2a** (instead of **H2b**), **H5** and **H7**.

## Study 3

We conducted Study 3 in a laboratory setting using self-reported measures of user attitudes/perceptions. The purpose of this study is to explicitly test the theoretical mechanisms that we proposed when developing the hypotheses, which can help explain the observed effects from the field experiments. As we argued in the Theory and Hypotheses section, personalized VFR may influence customer purchases via perceived risk, enjoyment and expected product performance. Moreover, it may cause self-discrepancy in the presence of CVD. Hence, Study 3 focuses on

testing the mediating roles of perceived risk, enjoyment, product expectation and self-discrepancy.

## Subjects and Experimental Design

We randomly invited 160 subjects out of a large pool of all female students who took Introduction to Marketing (a required course for business majors) at a major university in Shanghai. The invitees were informed that the study was intended to assess their perceptions about online apparel shopping and that they would receive 30 Chinese Yuan (about US$4.3) for participation in the study. All invited students agreed to participate the experiment. Prior to the experiment, all participants completed a survey to submit information on their height, weight and body shape measures. Upon entering the lab, we took a clear front-facing full body photo of each participant. The subjects' average age was 21.1 years and average BMI (i.e., weight in kilograms divided by squared height in meters) was 20.495.

We used a 2 (personalized vs. non-personalized VFR) × 2 (presence vs. absence of CVD) between-subjects experimental design, and randomly (we present randomization checks subsequently) assigned the participants into one of the four treatment groups: Group 1 (*non-personalized VFR and absence of CVD*), Group 2 (*non-personalized VFR and presence of CVD*), Group 3 (*personalized VFR and absence of CVD*), and Group 4 (*personalized VFR and presence of CVD*). Each participant was handed a tablet device with a VFR app where the avatar had already been created at the backstage by the research assistants. In the condition of personalized VFR, participants used personalized avatars created based on their own face photos and body shapes. In the condition of non-personalized VFR, participants used a standardized virtual model, which was designed based on a focus group study prior to the experiment (height: 165cm; weight: 55kg; age: 21; bust: 95B; average belly, waist, hip and bottom sizes, oval face, light skin and black ponytail). In the presence of CVD, participants were shown a promotional photo of the apparel item featuring a typical fashion model. In the absence of CVD, the promotional photo was not displayed. Appendix E describes the detailed experiment procedure.

## Variables and Measures

After trying on the product in VFR, participants rated their likelihood to purchase using the scales from Taylor and Todd [73]. We also collected data on four major mediators based on the theory we proposed, i.e., perceived risk, enjoyment, expected product performance, and self-discrepancy. Perceived risk was measured based on Kim et al. [34] to capture the participants' perception about the potential uncertainties/negative values from the current online shopping experience. Perceived enjoyment captures the hedonic value of the shopping experience apart from any anticipated performance consequences, and we measured it by adapting six items from Childers et al. [11] and Lee et al. [41]. To measure the expected

performance of the apparel product, we used the scale in Eckman et al. [14] to capture the participants' expectation about how the product would look on them. We employed appearance self-discrepancy scales adapted from Trampe et al. [75] to measure participants' perceived discrepancies between their ideal appearance (how they would ideally like to be) and actual appearance [33, 75]. To control for the curiosity effect, we asked the participants whether the VFR made them feel curious to find out more information about the product [52]. Besides, based on Suh et al. [71], we measured perceived facial similarity and body similarity between the avatar's physical appearance and the user's own physical appearance, to conduct manipulation checks for the personalized avatar.

In addition, we collected data on additional control variables that could also affect apparel purchase decision based on the literature [5, 15, 64]. Before the participants were assigned to the treatment conditions, they completed a survey to rate their appearance self-esteem which captures the self-worth derived from their appearance and weight [25, 62, 71]; body dissatisfaction regarding how unsatisfied they are with their body [22, 63]; VFR experience [7]; VFR familiarity [7, 46]; attitude toward VFR [8]; and personal information including age, living expenses, and online shopping frequency. Because we used a real brand's VFR app in the experiment, we measured brand familiarity, brand attitude and interest in the focal product before they started using VFR [7, 8, 46, 77]. Appendix F summarizes the list of constructs and their measurements. All constructs exhibit satisfactory levels of reliability and validity (Appendix G).

We ensured the randomization of the participants, so that our treatment stimuli were the only factors that caused the disparities in the outcomes across treatment groups [26]. Specifically, one-way analysis of variance (ANOVA) results indicate no significant differences across treatment groups in appearance self-esteem ($F = 0.960$, $p > 0.1$), body dissatisfaction ($F = 0.185$, $p > 0.1$), VFR experience ($F = 0.739$, $p > 0.1$), VFR familiarity ($F = 0.439$, $p > 0.1$), attitude toward VFR ($F = 0.840$, $p > 0.1$), pre-treatment interest in the product ($F = 0.879$, $p > 0.1$), brand familiarity ($F = 0.425$, $p > 0.1$), brand attitude ($F = 0.411$, $p > 0.1$), age ($F = 0.709$, $p > 0.1$), BMI ($F = 1.637$, $p > 0.1$), monthly living expenses ($F = 0.792$, $p > 0.1$) and online shopping frequency ($F = 0.498$, $p > 0.1$).

## Data Analysis

### Manipulation Check

We conduct a manipulation check for the level of personalization by measuring facial and body similarities between the virtual model and the participant using the measures from Suh et al. [71]. The results show that both facial similarity ($t = 16.652$, $p < 0.001$) and body similarity ($t = 13.260$, $p < 0.001$) are significantly higher in personalized VFR than in non-personalized VFR. Thus, our manipulation check was successful.

Mediation Analysis Results

First, we analyze the data collected from the treatment conditions where VFR was provided without CVD. Specifically, we conduct Hayes' Mediation Process Analysis [24] with 5,000 bootstrap samples using the personalized VFR indicator (1 for personalized VFR and 0 for non-personalized VFR) as the independent variable, likelihood of purchase as the dependent variable, and perceived risk, enjoyment, expected apparel performance and appearance self-discrepancy as the mediators. We also include the set of control variables specified earlier in the model.

As shown in column (1) of Table 6A, personalized VFR significantly reduces perceived risk ($\beta$ = -0.850, $p < 0.05$), enhances enjoyment ($\beta$ = 0.961, $p < 0.05$) and reduces customer expectation about the product ($\beta$ = -1.898, $p < 0.01$) compared to non-personalized VFR. Perceived risk significantly reduces the

Table 6. Results of Study 3. A. Underlying Mechanisms of Personalized VFR's Impact on Likelihood of Purchase.

| | (1) In absence of CVD | (2) In presence of CVD | (3) Moderation effect of CVD |
|---|---|---|---|
| Path | Coefficient (std. error) | Coefficient (std. error) | Coefficient (std. error) |
| Personalized VFR → Perceived Enjoyment | 0.961* (0.449) | 0.911* (0.394) | –0.169 (0.299) |
| Personalized VFR → Perceived Risk | –0.850* (0.330) | –1.737*** (0.397) | 0.362 (0.283) |
| Personalized VFR → Expected Apparel Performance | –1.898** (0.557) | –1.439** (0.481) | –0.467 (0.391) |
| Personalized VFR → Self-discrepancy | 0.020 (0.531) | 2.086*** (0.388) | 1.821*** (0.355) |
| Perceived Enjoyment → Likelihood of Purchase | 0.419** (0.122) | 0.437*** (0.104) | –0.077 (0.141) |
| Perceived Risk → Likelihood of Purchase | –0.459* (0.176) | –0.292** (0.101) | 0.135 (0.173) |
| Expected Apparel Performance → Likelihood of Purchase | 0.192[a] (0.108) | 0.144[a] (0.085) | –0.080 (0.116) |
| Self-discrepancy → Likelihood of Purchase | 0.008 (0.098) | –0.411*** (0.109) | –0.396** (0.132) |
| Direct Effect of Personalized VFR on Likelihood of Purchase | 0.844 (0.525) | –2.350*** (0.424) | –2.509*** (0.445) |
| Total Effect of Personalized VFR on Likelihood of Purchase | 1.273* (0.513) | –2.190*** (0.494) | – |

*Note*: VFR, virtual fitting room; CVD, conventional visual display. ***p < 0.001. **p < 0.01. *p < 0.05. [a] p < 0.1.

B. Indirect Effect of Personalized VFR on Likelihood of Purchase through Each Mediator.

| | (1) In absence of CVD | (2) In presence of CVD |
|---|---|---|
| Path | 95% BootCI of Indirect Effect | 95% BootCI of Indirect Effect |
| Personalized VFR → Perceived Enjoyment → Likelihood of Purchase | [0.027, 1.081] | [0.110, 0.928] |
| Personalized VFR → Perceived Risk → Likelihood of Purchase | [0.070, 1.055] | [0.157, 1.080] |
| Personalized VFR → Expected Apparel Performance → Likelihood of Purchase | [-1.273, 0.039] | [-0.667, 0.027] |
| Personalized VFR → Self-discrepancy → Likelihood of Purchase | [-0.116, 0.142] | [-1.715, -0.392] |

*Note*: BootCI stands for bootstrap confidence interval. VFR, virtual fitting room; CVD, conventional visual display.

likelihood of purchase ($\beta$ = -0.459, $p < 0.05$), while enjoyment ($\beta$ = 0.419, $p < 0.01$) and product expectation ($\beta$ = 0.192, $p < 0.1$) increase it. Hence, perceived risk, enjoyment and product expectation mediate the effect of personalized VFR on purchase likelihood in the absence of CVD. However, the mediation paths of the positive mechanisms underlying H2a (via perceived risk and perceived enjoyment) are more significant than that of the negative mechanism underlying H2b (via expected apparel performance), as shown by column (1) of Table 6B. The results thus provide explanation for the net positive effect of personalized VFR compared to non-personalized VFR that we find in Study 2, which supports H2a instead of H2b.

Next, we consider the conditions when VFR is used in combination with CVD. Again, we conduct Hayes' Mediation Process Analysis [24] with 5,000 bootstrap samples using the same independent variable, dependent variable and control variables. The results are reported in column (2) of Tables 6A and 6B. The three mediation paths via perceived risk, enjoyment and product expectation remain largely consistent no matter whether CVD is present. However, the mediation path via self-discrepancy significantly differs when CVD is present versus when it is absent. Specifically, self-discrepancy significantly mediates the link between personalized VFR and purchase likelihood when CVD is present (95% bootstrap confidence interval is [-1.715, -0.392] as shown in column 2 of Table 6B), but does not when CVD is absent (95% bootstrap confidence interval is [-0.116, 0.142] as shown in column 1 of Table 6B). These results support the theoretical mechanism that we proposed, i.e., the adverse effect of personalized VFR when combined with CVD can

be attributed to the increased salience of self-discrepancy. Column (3) formally test the difference in each path between columns (1) and (2), and confirms that CVD significantly moderates the mediating paths via self-discrepancy, and thus significantly moderates the overall effect of personalized VFR on purchase likelihood.

## Discussion

The main purpose of this research is to advance the understanding of VFR's effectiveness, specifically, whether (Study 1), when (Study 2), and why (Study 3) VFR enhances online sales of apparel items. Moreover, we investigate the impact of VFR on customer satisfaction and product returns. Two major findings are derived from the field experiments. First, although the introduction of VFR can cause an increase in sales, its effectiveness varies significantly depending on the types of avatars employed and the simultaneous presence of other promotional venue. Specifically, VFR with personalized avatars can lead to a greater increase in sales than non-personalized avatars, but only when CVD is unavailable. Second, VFR helps increase post-purchase customer satisfaction and reduce the rate of product returns, and personalized VFR is more effective on these two outcome variables than non-personalized VFR. The lab experiment reveals the theoretical mechanisms behind the effects observed from the field experiments: the positive effect of personalized VFR on purchases can be attributed to reduced perceived risk and increased enjoyment; however, when CVD is present, personalized VFR increases users' self-discrepancy, which in turn reduces the likelihood of purchase.

## Contributions to the Literature

This study makes distinct theoretical contributions. First, previous studies on VFR have largely focused on its main effect or mediators (see Table 1), and existing theories suggest competing perspectives (i.e., VFR could potentially have both positive and negative influences on customer purchases). Hence, the sales impact of VFR is inconclusive based on the literature and can depend on the relative sizes/prominences of the competing effects. It is thus important to empirically examine the actual effect of VFR. Moreover, little is known about whether and how VFR might influence post-purchase outcomes. Our study fills in these research gaps by unveiling the causal effects of VFR on product purchases, post-purchase satisfaction and product returns.

Second, there is very limited research on the conditional effects of VFR, except for Kim and Forsythe [36, 38], which examined the moderating role of users' technology anxiety and innovativeness. In this study, we identify a novel moderator (i.e., availability of CVD) that is critical in the context of online shopping and controllable/manageable by the retailers. We show that, in the presence of CVD, the sales impact of personalized VFR could turn from positive to negative. This finding highlights the importance of examining VFR from a contingency perspective and contributes to a more complete understanding of VFR's impact.

Third, as summarized in Table 1, previous studies in the relevant literature have largely focused on user attitudes as outcomes using self-reported measures based on lab experiments. In comparison, we analyze real-world behavioral data from large-scale field experiments, which not only enhances realism but also enables us to unveil the economic magnitude of the effect of VFR, proffering novel managerial insights to guide business practices.

Moreover, our study enriches the literature on self-discrepancy and highlights its relevance to the online retailing context. The self-discrepancy theory [27] has been widely applied to various contexts in psychology research [23, 33]. However, previous studies on the effect of VFR have ignored it. We add new insights by unveiling its unique role in determining/mediating the effectiveness of VFR. Specifically, self-discrepancy can be made salient under a certain circumstance and can be the key factor that determines the positiveness or negativeness of personalized VFR's effect on sales.

## Implications for Practitioners

The primary concern among online retailers considering the adoption of VFR is its cash-flow prospects [56], because of the considerable costs for implementing and maintaining a VFR system, especially for personalized VFR [48]. We find that VFR can lead to a sizeable increase in sales instead of decline. In addition to sales, practitioners are also concerned about post-sales outcomes including product return and customer satisfaction, which are vital determinants of profitability and long-term success in the online retail industry. However, it is challenging for managers to identify a "perfect" strategy that benefits both sales and post-sales performances, since a strategy that boosts sales often negatively affects post-sales outcomes, or vice versa[11]. Our findings suggest that VFR can potentially serve as an effective vehicle to benefit not only sales but also post-sales outcomes. We show that VFR significantly decreases the rate of product returns. This is important especially considering that retailers' reverse logistics cost for product returns averages 8.1% of total sales [74]. Moreover, we demonstrate the positive impact of VFR on post-purchase satisfaction. Because satisfaction can lead to repeat purchase, loyalty, and thus higher future sales [72], VFR may be beneficial to retailers' long-term cash flows. Compared to non-personalized VFR, personalized VFR exhibits greater potentials in increasing product sales and customer satisfaction and decreasing product return rate. These positive profit prospects of VFR can help alleviate managers' hesitation about adopting the technology.

However, practitioners should be extra careful when implementing VFR, which may produce adverse outcomes otherwise. Although personalized VFR by itself works well in increasing sales, it does not when CVD is also present. In other words, it is ineffective and even counterproductive if a retailer simultaneously employs both personalized VFR and CVD. Hence, to maximize sales, retailers should completely replace CVD with personalized VFR, instead of combining them.

However, although personalized VFR and CVD do not complement each other in increasing sales, their combination is effective in further reducing product return rate. Therefore, managers should prioritize and weight their business goals when deciding whether to deploy VFR in isolation or along with other promotional component/technology on their website or mobile app. Notably, our study is among the first to provide explicit guidelines regarding how to effectively deliver VFR (i.e., avatar types; incompatibility or complementarity with alternative promotional tool) to improve product performances (i.e., sales, customer satisfaction and return rate).

## Limitations and Future Research

The study is not without limitations. However, they provide venues for future research. First, consistent with the relevant literature [14, 33, 48], we focus on female apparel products to test our hypotheses because female customers are the main target of the apparel retailers [48] (e.g., according to IBIS, the revenue of women's apparel retailers in the U.S. was $43 billion in 2017, while that of men's was only $9 billion). Future research may empirically study male users of VFR as well. Second, our field experiments were conducted in the mid-range market, which is of significant economic importance and contributes the largest share in the fashion industry (e.g., the global sales of mid-range retailers such as Zara, Uniqlo and Gap totaled over $80 billion in 2017 according to Fast Retailing reports). While we speculate that our conclusion can also be applied to the low-end and high-end markets[12], future research may gather direct empirical evidence from these markets. Third, future research can explore additional moderators or boundary conditions for the effect of VFR, such as the point of Internet access (e.g., mobile versus desktop) and shoppers' goals (e.g., searcher versus browser). Fourth, we focus on the nature of the virtual model in VFR (i.e., personalized or non-personalized). With the rapid development of technology, new features such as recommendation of matching clothes (e.g., recommending a skirt to match the focal shirt under consideration) are becoming available for VFR systems. Such features were not available in the VFR systems we studied. Future research could investigate the effect of such new features, as well as how they potentially interact with the level of VFR personalization to influence product sales and returns. Finally, beyond the apparel industry, the risk-reducing and enjoyment-enhancing aspects of VFR may help increase online sales of other product categories as well (especially where customers demand more realistic shopping experiences to evaluate the product [43]), which can be meaningful for future studies to explore.

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## NOTES

1. In this study, we focus on the performances of online stores instead of offline stores. In traditional online stores without VFR, self-discrepancy cannot occur because, unlike in offline stores, customers cannot try the clothes on their own body [20]. Moreover, self-discrepancy cannot occur without simultaneous presence of CVD. Traditionally, CVD is prevalent in online stores (instead of offline stores) because it serves as an important vehicle for customers to visually evaluate each product without being able to examine it in person [30]. For these reasons, self-discrepancy is an important issue to online stores (rather than offline stores) when they provide VFR.

2. When expanding the observation window to a longer period, e.g., two months after treatment, we still observe consistent results regarding the effects of VFR.

3. The retailer employs a customer rating platform that was introduced by Alibaba and is prevalently adopted in China, where the seller gets an automatic "highly satisfied" rating if the customer does not provide a rating within 15 days of purchase. Hence, with the automatic ratings, the response rate for customer satisfaction is 100%. If we only count non-automatic customer-initiated ratings, the response rate is 43.94%. We observe consistent findings when estimating the treatment effect based on non-automatic ratings only.

4. The average period of product return (from the date of purchase to the date on which the retailer receives the returned product) was 9.3 days.

5. Although our analysis is on the product level, we also confirm that there are no systematic differences across customers in the pre-treatment versus post-treatment periods in Appendix A.

6. During the observation period (August 4$^{th}$ - September 14$^{th}$, 2016), a one-time price promotion was offered on August 7$^{th}$-9$^{th}$ for the Chinese Valentines' Day, which was during the first-week of the pre-treatment period. For this price promotion, the retailer selected 100 products (10.93% of the treated group and 10.61% of the control group; $t = 0.15$, $p = 0.93$) and offered 40 off on orders of 229, 100 off on orders of 499, or 200 off on orders of 799 (in Chinese Yuan). Hence, we use a dummy variable (1 if product $i$ was offered promotions in period $t$, 0 otherwise) to control for the effect of price promotion.

7. The retailer in Study 2 adopts a similar rating platform as that in Study 1, which automatically assigns a "highly satisfied" rating if the customer does not rate it within 15 days of purchase. Hence, the response rate with automatic ratings is 100%. When excluding non-automatic ratings from the sample, the response rate becomes 54.51% and the estimated treatment effect leads to consistent conclusions.

8. The average period of product return (from the date of purchase to the date on which the retailer receives the returned product) was 8.25 days.

9. The retailer offered a one-time store-wide summer promotion (i.e., 10% off on two items, 20% off on three items, or 30% off on four or more items) on August 26$^{th}$ and 27$^{th}$ 2017, which were during the last week (week 7) of the experiment period. Since this promotion applied equally to all products in week 7, we use a dummy indicator for week 7 to control for it in the model (labeled as "*Promotion*" in Table 5). We also control for the fixed effects of the other weeks in the model.

10. While the retailer in Study 1 mainly targets on younger women, the retailer in Study 2 serves a wider range of age groups. When re-estimating the model with the subsample of older customers (≥ 45yo) only, we find consistent results: the effect of standardized VFR is 0.597 ($p < 0.001$) and that of personalized VFR is 1.091 ($p < 0.001$).

11. For instance, traditional IIT or advertisements featuring highly attractive model images might lure more customers to buy the product but could reduce post-purchase satisfaction and increase product returns when customers realize that the product actually does not look so good on them after purchase.

12. In the high-end market, the inherent risk of purchase is greater because of the higher prices of the products. Hence, VFR might play a more important role as it helps reduce risk perception, and thus the sales-enhancing effect of VFR could be even more significant. In the low-end market, although the inherent risk of purchase may be lower, VFR can still significantly improve sales because it helps add excitement and fun to the shopping process

of otherwise less-exciting products. Hence, in both high-end and low-end markets, the positive effect of VFR can still hold.

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