Female consumers' acceptance and functional demand for 3D virtual shoe fitting room in the context of online shopping

Luying Cao[1]*, Pouline Chai Lin Koh[2,a], Sook Khuan Wong[3,b]

*907472547@qq.com; [a]Pouline.Koh@taylors.edu.my; [b]jenny@saito.edu.my

[1]Glorious Sun Guangdong School of Fashion, Huizhou University, 516007 Huizhou, China
[2]The Design School, Taylor's University, 47500 Subang Jaya, Selangor, Malaysia
[3]Saito University College, 46200 Petaling Jaya, Selangor, Malaysia

Abstract. This research aims to identify the needs among Chinese female customers when purchasing shoes online from the perspective of comfort, functionality, aesthetic, practicability, authenticity, individualization, and interactivity. The data was collected from 384 Chinese female consumers in the Pearl River Delta in Guangdong province and analyzed in SPSS. The results confirmed the difficulties when consumers purchase shoes online. The factors that can affect consumers' willingness of using 3D shoe fitting and their functional requirements of 3D virtual shoe fitting room were also confirmed. This study proposes that contribute to develop virtual fitting technology and e-commerce retailing, it brings huge potential commercial prices value and help to achieve maximum economic benefits.

Keywords: 3D virtual fitting; shoe virtual try-on; online shopping; shoe purchasing; functional demand

1. Introduction

With an increasing number of internet users, online shopping is becoming more and more popular with a significant growth of e-commerce in recent years [1,2,3]. The number of online shopping users reached 845 million, accounting for 79.2% of the total internet users. The online retail sales of China in 2022 reached 13.79 trillion RMB, up 4.0% year-on-year [4].

According to Statista [5], the global footwear market is predicted to witness a revenue of 398.40 billion U.S. dollars in 2023, with an annual growth rate of 3.47% (CAGR 2023-2028). From the year 2020, COVID-19 has caused significant changes in consumer behavior and the benefits of online shopping are arguably more prominent than ever [6,7,8,9]. Consumers who buy footwear move most of their purchases online. Online footwear sales increased by 10% in 2020, and the online sales penetration rate of fashion footwear increased by 12% [10].

However, the high return rate of products purchased online, has been claimed as a common effect of online e-commence for many years. 66% of Chinese internet users have returned a product purchased online from April 2021 to April 2022, global ranked second [11]. The main reason consumers around the world return fashion products they bought online is that the item doesn't fit, with 38% of consumers citing this reason [12]. Among those fashion product categories with high return rate, the footwear has a high proportion. The inconsistency in size and fit means that footwear has traditionally had a higher return rate than clothing and other

ECIT 2024, March 15-17, Changsha, People's Republic of China

DOI 10.4108/eai.15-3-2024.2346173

categories [13]. The top two reasons for returns are “size too small” and “size too large”, accounting 30% and 22% respectively [14]. The return rate of footwear can be as high as 35%, which is three times that of general e-commerce. This has exacerbated the already high shipping costs of shoes and the resulting rate difference between cartons and clothing mailing envelopes [10]. Due to the uncertainty of fit, it is difficult to obtain the correct shoe size, resulting in a higher return rate of online orders, resulting in negative customer experience and increasing company cost [15]. As a result, it is very important to promote fit consistency to reduce returns, in other words, reducing the possibility of returns should be the top priority. It is also demonstrated by Ader et al. (2021) [16], 70% of returns are due to improper fit or style, indicating that shopping tools are a key lever to prevent returns and improve the consumer experience.

According to Bizen et al. (2021) [17], the new online shopping model also brings about a series of problems including consumers cannot accurately judge whether the shoe fits comfortably on their own foot, and there is a certain degree of blindness and uncertainty in the purchase. It also argued by Revkov and Kanin (2020) [18], it is difficult to find the correct shoe size from the online store due to the inability to try on the selected shoe. This has resulted in a large number of returns and additional shipping costs for the seller. With the virtual shoe testing system, the comfort of the shoes can be accurately judged, and consumers can avoid buying unfit shoes. Also it can reduce return goods, reduce social logistics costs, and reduce unnecessary economic losses for businesses [19]. Therefore, virtual shoe testing is undoubtedly a subject with practical research value and practical application background [20,21,22]. 3D fitting technology combines virtual technology and real fitting organically aims to enrich the fashion product selection and consumption experience of online shoppers, saving time and energy, and enabling people to better enjoy online shopping [23]. Beck and Crié, (2018) [24] believed that virtual fitting room, as a new sales auxiliary means of environmental protection, may affect the willingness of online shopping.

The research focuses on the functional requirement of 3D virtual shoe fitting for Chinese female customers. 3D virtual shoe fitting room not only reduces labor costs for merchants, but also provides customers with more convenient and accurate services. This study holds important implications for theoretical contribution on technical framework of virtual fitting system application prospect of virtual reality technology in the construction of online shopping platform.

2. Literature review

2.1 The increasing female shoe market

The increase in the number of professional women worldwide has increased the demand for fashionable and fashionable shoes, which can be used in formal and casual occasions. In 2022, the global footwear market was 409.5 billion U.S. dollars, and it is expected to reach 725.1 billion U.S. dollars by 2032. The CAGR for 2023-2032 is 6.1% [25]. In addition, the global women’s footwear market in 2022 is estimated to be 178.4 billion U.S. dollars, and by 2027, women’s footwear sales will reach 219.5 billion U.S. dollars, with a CAGR of 4.2% [26]. The Asia-Pacific region is the largest regional market in 2021, holding the share 39.3% and will further expand to the highest CAGR from 2022 to 2027 [27]. Hence, shoes market is getting more and more attention among fashion industry. This is mainly due to the high demand for fashionable and comfortable shoes.

2.2 The functional requirement for 3D virtual fitting

In the research of Wang et al. (2017) [28], they use questionnaire survey methods to investigate consumers' online shopping habits, ability to accept new things, perceptions of 3D virtual fittings, usage attitudes and actual functional needs. And they found that more than 95% of consumers have a strong desire to try 3D virtual fittings, 80% of consumers support the establishment of virtual fitting rooms in physical stores, and more than 60% of respondents expressed their willingness to upload their own photos or human bodies. Chinese consumers generally have a positive view and willingness to use the virtual fitting room [29]. According to Gulfraz et al. (2022) [30], the functional requirement dimension contains practicability, authenticity, individualization and interactivity.

2.2.1 Practicability

Practicality refers to the ability to effectively display the wearing effect of fashion product on models, and to provide purchase guidance for consumer on buying fashion product. Wang et al. (2017) [28] stated that all respondents hope the virtual fitting room has a certain practicability. It is argued by Huang and Huang (2022) [31] that the disadvantage of the 3D fitting system is out of touch with the online shopping store. To be specific, the system focuses more on the establishment of models, and is more like a 3D dress-up entertainment software. So the clothes that online shoppers choose in the online store still cannot be tried on at will, thus the actual practicality of the system needs to be further studied.

2.2.2 Authenticity

Most of consumers who buy fashion product online hope they can be like in the physical store and the same touch feel can experience the comfort of it, and they pay attention to the 3D reality of virtual fitting room [31,32]. In the e-commerce, the consumer hopes to preview the fitting effect online to make purchase decision [29]. The actual goal of 3D virtual fitting is to strive for users to be in a state of "realistic engagement" in the three-dimensional virtual environment created by computers, and to have an immersive feeling, which is the so-called "immersion" [33].

2.2.3 Individualization

It is advised by Xu and Zhou (2020) [34] that virtual fitting technology can not only provide users with fitting services, but also add service items, such as clothing style recommendation and personalized collocation, so as to achieve true service users and benefit users. Lee et al. (2022) [35] also agree that virtual fitting room should meet the diverse shopping needs of consumers. According to Degutis et al. (2023) [36] e-commerce retailers can provide consumers with personalized options and options related to purchasing, while allowing them to choose their favorite data disclosure level.

2.2.4 Interactivity

Interactivity has a positive impact on product attitude [37]. With the development of the online retail industry, the lack of direct experience in the product has been determined as a major problem, and virtual tools have been developed to create a more direct and interactive product experience [38,39]. The 3D virtual fitting room provides consumers with a real-time interactive platform, and interaction has become one of the most prominent features of the 3D virtual fitting

room [40,41].

2.3 The improvement of 3D virtual shoes fitting

Much of the current literature on 3D fitting technology pays particular attention to garment, research related to 3D shoe fitting is extremely new, and the present virtual try on theory seldom involves in this topic [42,43]. It is argued by Revkov and Kanin (2020) [18] that one possible solution to the shoe fitting problem is to create a virtual fitting method and the method should be cheaper, publicly available, efficient and improved and can provide consumers with a pleasant online buying experience.

According to Jalali et al. (2020) [20], choosing a suitable shoe size is not as easy as expected. The mismatch in the size of this shoe may be due to the incorrect measurement of the foot size when buying the shoe. There are two main factors that instruct consumers to make a purchase decision: the appearance of the footwear and the fit of the footwear. Fitting is one of the most important functions of footwear comfort [22]. The main challenge of buying shoes online is the inability to actually try them on [17]. Therefore, potential customers have to rely on the information provided online. It can be seen that the birth of the virtual shoe testing system will be the development trend of the shoe retail industry. Virtual shoe testing is undoubtedly a subject with practical research value and practical application background [44].

3. Methodology

A quantitative questionnaire survey aims to find the needs among Chinese female customers when purchasing shoes online, and to obtain the functional requirements for 3D virtual shoe fitting room. This questionnaire survey will be conducted online.

The questionnaire survey will be distributed across the Pearl River Delta (PRD) Economic Zone the Guangdong Province. Because Guangdong Province has the highest amount of online shopping consumption, especially the PRD e-commerce market, ranking first in the country. The PRD Economic Zone covers 9 cities – Guangzhou, Shenzhen, Zhuhai, Foshan, Jiangmen, Dongguan, Zhongshan, Huizhou city and Zhaoqing, accounting for 55.5% of Guangdong's population and 4.5% of China's total population accounting for 80.9% of Guangdong's GDP or 9.0% of China's GDP. The PRD accounts for 95.1% of Guangdong's exports and 24.8% of China's total exports, and accounting for 71.3% of the total retail sales of consumer goods in Guangdong or 7.4% of the total retail sales of consumer goods in China [45].

The target audience of this research is 18-40 year old female consumers who have certain economic ability and spend a lot of time on online shopping. The population of Guangdong Province in 2022 was about 126.57 million, ranking first in all provinces in China, and Guangdong's population density is also higher than many countries in the world [46]. Due to the criteria for choosing the respondents is the survey only for women who have the habit of buying shoes online, before the questionnaire survey, there will be a brief explanation, stating that this survey is aimed at female consumers who have online shopping habits, especially female consumers who buy shoes online. On the basis of calculation formula on Survey System, the sample size of population is 384. Participants are given 5 minutes to fill in the questionnaire. After the questionnaire is collected, draw statistical software SPSS to analyze data.

4. Results and discussion

4.1 Demographic profile

Table 1. Demographic information of respondents

Demographic Variables		Frequency	Percentage (%)
Age	18-29 years old	214	55.7
	30-40 years old	170	44.3
Occupation	Students	40	10.4
	Employed	243	63.3
	Self-employed	69	18.0
	Others	32	8.3
Monthly income	Below 3000rmb	51	13.3
	3000-5000rmb	81	21.1
	5001-10000rmb	186	48.4
	Above 10000rmb	66	17.2
The money spend on fashion product each month	Below 500rmb	90	23.4
	501-1000rmb	148	38.5
	1001-2000rmb	94	24.5
	Above 2000rmb	52	13.5

With the online questionnaires designed and distributed, a total of 411 surveys were collected. Except for questionnaires under 18 years and over 41 years of age that do not meet the 18-40 age group, the valid questionnaires is 384, meeting the expectation. From Table 1, On the overall, 55.7% (n=214) respondents were 18-29 years, 44.3% (n=170) were 30-40 years, and the younger age group accounted for 12% more than the older age group. The results show that 63.3% respondents are employed. Get rid of the students, the working women including the employed and self-employed contribute 81.3%. This also proves why the demand for fashionable and comfortable women's shoes are increasing. It is closely related to more and more women going to work and they need to purchase shoes, and if there is no enough time to go shopping in the physical store, they will prefer to buy shoes online.

48.4% respondents' monthly income is 5000-10000 RMB, almost the proportion of half contributed, 3000-5000 RMB and above 10000 RMB are respectively 21.2% and 17.2%, ranking ranking second and third place. 38.5% respondents spend 501-1000 RMB on fashion product, and 1001-2000 RMB (24.5%) and below 500 RMB (23.4%) ranking second and third place.

4.2 Online shopping behavior analysis

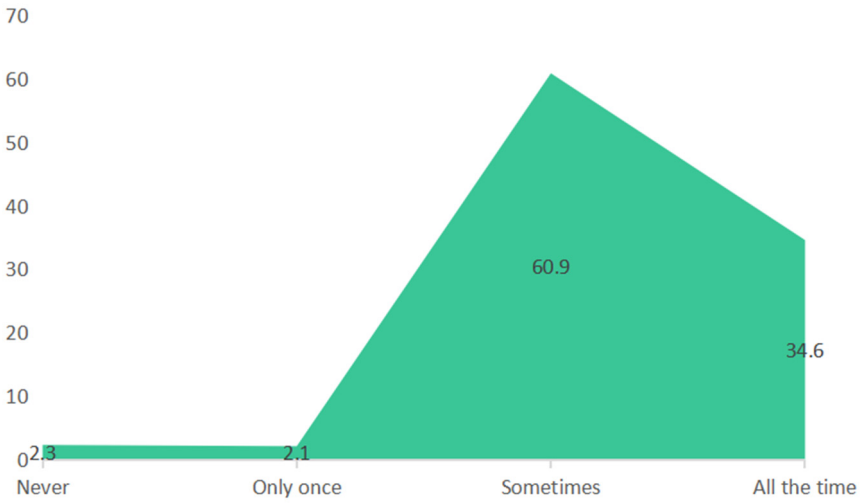

Figure 1. The frequency of buying shoes online

Results in Figure 1 discover that 97.7% (n=375) of respondents have the online shopping experience of shoes. It means almost every woman has purchased shoes in the online store, and "sometimes" and "all the time" contribute 95.5%.

4.3 Consumer cognition analysis

4.3.1 Descriptive analysis

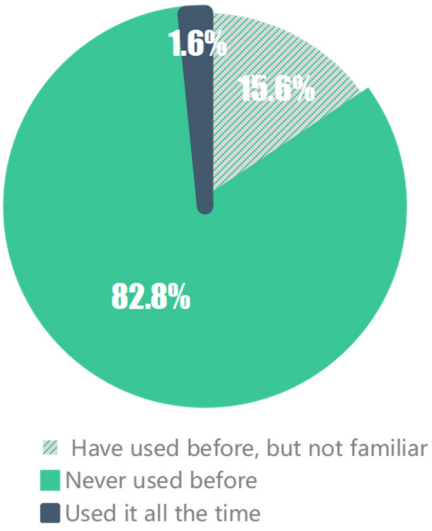

Figure 2. Knowledge of 3D shoe fitting

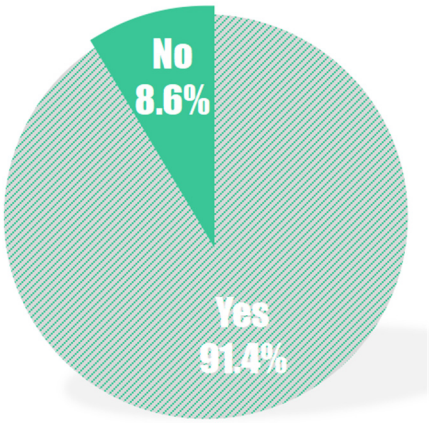

Figure 3. Willingness of using 3D shoe fitting

It can be proved in Figure 2 that only 17.2% (n=66) respondents have used 3D virtual shoe fitting when purchase shoes online, and 98.4% (n=378) of the users are not familiar with 3D virtual shoe fitting. It can be seen that the promotion of the 3D virtual shoe fitting room needs to be increased, and it is not generally accepted by customers. When is comes to the willingness of using 3D shoe fitting, 91.4% (n=351) agree to have a try for using 3D shoe fitting when purchasing online (Figure 3). It shows that most female consumers have the desire to accept new things, which is conducive to the promotion of the 3D virtual shoe fitting system.

4.3.2 Analysis on the influence factors of 3D shoe fitting using attitude

Table 2. Chi-square test of the influence factors of age on willingness of using 3D shoe fitting

		Willingness of using 3D shoe fitting (%)		c^2	P
		Yes	No		
Age	18-29 years (N=214)	93.9	6.1	3.905	0.048
	30-40 years(N=170)	88.2	11.8		
Occupation	Students	90.0	10.0	8.536	0.036
	Employed	93.4	6.6		
	Self-employed	91.3	8.7		
	Others	78.1	21.9		
Monthly income	Below 3000rmb	88.2	11.8	2.785	0.426
	3000-5000rmb	91.4	8.6		
	5001-10000rmb	93.5	6.5		
	Above 10000rmb	87.9	12.1		
Money spend on fashion product each month	Below 3000rmb	90.0	10.0	7.028	0.071
	3000-5000rmb	93.9	6.1		
	5001-10000rmb	93.6	6.4		
	Above 10000rmb	82.7	17.3		
Frequency of buy shoes	Never	100.0	0.0	2.748	0.432
	Only once	87.5	12.5		

online	Sometimes	92.7	7.3		
	All the time	88.7	11.3		
Knowledge of 3D shoe fitting	Never used before	92.1	7.9	5.043	0.08
	Have used before, but not familiar	90.0	10.0		
	Used it all the time	66.7	33.3		

First of all, the influence of age on willingness of using 3D shoe fitting will be discussed. It can be seen from Table 2 that P=0.048<0.05, female consumers aged 18-29 and aged 30-40 are statistically significant whether they are willing to use 3D virtual test shoes when buying shoes online. Compared with the 30-40 year age group, the younger 18-29 year age group is more willing to try 3D virtual shoe fitting. It can be seen that the promotion of 3D virtual shoe fitting room needs to be increased more for the relatively older age group.

When it comes to occupation, P=0.036<0.05, the results of Table 2 can show female consumers with different occupation are statistically significant whether they are willing to use 3D virtual test shoes when buying shoes online. Compared with "Others", "Students" "Employed" "Self-employed" are more willing to try 3D virtual shoe fitting, especially "Employed" are strong willing to using 3D virtual shoe fitting room when purchasing shoes online. It can be seen that the promotion of 3D virtual shoe fitting room needs to be increased more for the relatively older age group.

When the consumer's monthly income is tested in a chi-square test with their willingness of using 3D shoe fitting, P=0.426>0.05, there is no significant difference in the attitudes of female consumers with different monthly incomes towards 3D shoe virtual fitting rooms. And the study found that more than 88.2% of female customers are willing to try 3D shoe virtual fitting rooms, regardless of their monthly income. Therefore, 3D shoe virtual fitting rooms can be applied to consumers with different monthly incomes.

Next is money spend on fashion product each month on willingness of using 3D shoe fitting, P=0.071>0.05, there is no significant difference in the attitudes of female consumers with different money spend on fashion product each month towards 3D shoe virtual fitting rooms. And it can be found that more than 82.2% of female customers are willing to try 3D shoe virtual fitting rooms, regardless of their money spend on fashion product each month. As a result, regardless of how much they can dominate fashion products every month, they are more than willing to try 3D shoe virtual fitting rooms.

The chi-square test results of consumers' frequency of buy shoes online and willingness of using 3D shoe fitting can be seen in the Table 2 above, P=0.432>0.05, consumers with frequency of buy shoes online have no significant difference in willingness of using 3D shoe fitting. This shows that the customer who shop shoes online often or rarely or not are very willing to try 3D shoes, when observing it carefully, consumers who have never bought shoes online are 100% willing to try the 3D virtual shoe fitting room, indicating that consumers who never buy shoes online have a strong desire for the 3D virtual shoe fitting room. This can undoubtedly promote the development of e-commerce through 3D virtual shoe fitting technology.

Through the chi-square test and correlation analysis of "Knowledge of 3D shoe fitting" and "Willingness of using 3D shoe fitting" in Table 2, P=0.08>0.05, consumers with different understanding degree of 3D virtual fitting have no significant difference in willingness of using 3D shoe fitting. They are willing to try 3D shoes fitting room whether they know it or not. But

when taking a closer look at the percentages, the respondents who are very willing to try on shoes in 3D are the people who have never used it before, on the contrary, 33.3% of regular users were not willing to use 3D shoe fitting room. This proves that there are still many problems in the existing 3D virtual shoe fitting room. Before the next design and promotion of 3D virtual shoe fitting room, it is necessary to improve the functions according to the needs of customers, including elaborating its functions and using instructions to consumers carefully, and conducting a wide range of publicity for 3D virtual shoe fitting, so as to enhance the desire of consumer to try.

To sum up, firstly, "age" and "occupation" can significantly affect consumers' willingness of using 3D shoe fitting, in the future design and promotion of 3D shoe fitting room, attention should be paid to attracting more older customer, and more customer from other occupations other than students, employed and self-employed should be recruited to accept new things. Secondly, "monthly income" "money spend on fashion product each month" "frequency of buy shoes online" and "knowledge of 3D shoe fitting" can not significantly affect consumers' willingness of using 3D shoe fitting, this will be of great help to the expansion of consumers who buy shoes online by using 3D virtual shoe fitting room.

4.4 Consumer need for online shoes shopping analysis

4.4.1 Analysis on the difficulties when buying shoes online

Figure 4. Difficulty of buying shoes online for different shoe type

In this study, respondents were asked to choose one type of shoes they find is most difficult to purchase online (Figure 4). The results of the study reveal that, a total of 140 (36.5%) respondents pointed out the most difficult type of shoes is the shadow mouth shoe with heels. Findings also showed that the percentages of sandal shoes, boots, flat leather shoes and sneakers are almost 28.9% to 6.8%.

Table 3. Multiple response frequency analysis table on difficulties when purchase shoes online

Multiple choice item	N	Response rate (%)	Popularity rate (%)	c^2	P
Wrong sizes	130	20.60	33.90	193.05	0.000
The shoes are not comfortable	253	40.10	65.90		
Poor material	123	19.50	32.00		
Actual colors are different from the visuals shown online	54	8.60	14.10		
Hard to match clothes	71	11.30	18.50		
Total	631	100.00	164.30		

Table 3 shows the analysis items: “Wrong sizes” “The shoes are not comfortable” “Poor material” “Actual colors are different from the visuals shown online” “Hard to match clothes” Chi-square goodness-of-fit test significance P=0.000<0.05, which means that the selection ratio of each show significant differences. “The shoes are not comfortable” accounts for the highest proportion, reaching 40.0%. This shows that many shoes that are purchased online are not comfortable to wear. Then followed by “Wrong sizes” and “Poor material” account for 20.6% and 19.5% respectively, which are roughly equal. Therefore, except for the comfort issue, buying shoes that are not the right size and quality that do not meet the expected are also problems that often appears on online shopping shoes.

4.4.2 Analysis on the points when buying shoes online

Table 4. Multiple response frequency analysis on points when purchase shoes online

Multiple choice item	N	Response rate (%)	Popularity rate (%)	c^2	P
The accuracy of size	113	16.50	29.40	58.62	0.000
Whether the shoe type fits my foot type	151	22.10	39.30		
Whether the actual product look the same with the online pictures	169	24.70	44.00		
Whether the shoes are comfortable	250	36.60	65.10		
Total	683	100.00	177.87		

Table 4 shows the analysis items: “The accuracy of size” “Whether the shoe type fits my foot type” “Whether the actual product look the same with the online pictures” “Whether the shoes are comfortable” Chi-square goodness-of-fit test significance P=0.000<0.05, which means that the selection ratio of each show significant differences. “Whether the shoes are comfortable” accounts for the highest proportion, reaching 36.6%. This shows that consumers have high requirements for the comfort of shoes. Then followed by “Whether the actual product look the same with the online pictures” and “Whether the shoe type fits my foot type” account for 24.7% and 22.1% respectively, which are roughly equal. Therefore, except for the comfort demand, the consistency of the real shoes and the online display is what consumers care about, so as the consistency of the shoe type and their own foot type.

4.5 Consumer functional requirement for 3D shoe fitting room analysis

4.5.1 Different dimensions of consumer functional requirement

Table 5. Multiple response frequency analysis table on functional requirement

	Multiple choice item	N	Response rate (%)	Popularity rate (%)	c^2	P
Comfort	Breathability	185	27.90	48.20	46.48	0.000
	Shock absorption and cushionability	98	14.80	25.50		
	Softness	218	32.90	56.80		
	Stability and support	162	24.40	42.20		
Functionality	Anti-slip	295	45.60	76.80	280.31	0.000
	Abrasion-resistant	234	36.20	60.90		
	Waterproof	84	13.00	21.90		
	Anti-static	34	5.30	8.90		
Aesthetic	The color matching of the page is comfortable	223	32.80	58.10	29.62	0.000
	The interface layout is reasonable	160	23.60	41.70		
	Clear navigation bar	172	25.30	44.80		
	The theme of each page is clear	124	18.30	32.30		
Practicability	It has plenty of shoe styles for selection	196	27.60	51.00	75.23	0.000
	It can recommend right shoe types	240	33.90	62.50		
	It can recommend accurate shoe sizes	190	26.80	49.50		
	It has smooth and fast purchasing process	83	11.70	21.60		
Authenticity	I can feel the hardness of the shoes	168	24.90	43.80	102.89	0.000
	I can feel the thickness of the shoes	76	11.20	19.80		
	I can feel the weight of the shoes	84	12.40	21.90		
	I can feel whether the shoes heel the foot	217	32.10	56.50		
Individualization	It can provide a real person trial assessment	131	19.40	34.10	59.38	0.000
	It can provide customized size (such as too small or too large size and half size)	177	16.30	46.10		
	It can provide customized version (such as too narrow or too wide)	194	17.90	50.50		
	It can solve the left and right foot inconsistency	83	7.60	21.60		
	It can provide various material for shell, lining, and sole	186	17.10	48.40		
	It can provide various color for shell, lining, and sole	134	12.40	34.90		
	It can provide various heels	173	15.90	45.10		
Interactivity	It can provide matching garment	138	12.70	35.90	67.76	0.000
	It can provide sharing function on social platforms	123	21.70	32.00		
	I can invite my friends join in my shopping process	166	29.30	43.20		
	The individual privacy data can be protected	278	49.00	72.40		
Interactivity of fitting effect display	Show the whole body effect with the appropriate clothing	215	32.70	56.00	47.57	0.000
	Show the whole partial effect	96	14.60	25.00		
	It can rotate 360 degrees	188	28.60	49.00		

Interactivity of fitting evaluation report	It can provide historical wearing records and effect comparisons	159	24.20	41.40	57.69	0.000
	It is concise and easy to understand	225	34.10	58.60		
	It is detailed and specific	95	14.40	24.70		
	The text and pictures are integral	192	29.10	50.00		
	The evaluation criteria are objective	148	22.40	38.50		
Expectation for 3D shoe fitting room	It can provide the accurate shoes for me	250	37.60	65.10	92.90	0.000
	It can bring me a satisfactory online shopping experience	158	23.80	41.10		
	It can save me a lot of time on buying shoes in physical store	181	27.20	47.10		
	It can bring me a lot of fun	76	11.40	19.80		

It can be seen from Table 5, from the point of view of comfort, “Softness” and “Breathability” are the first two that female consumers pay attention to. When it comes to functionality, most of participants choose “Anti-slip” and “Abrasion-resistant”. For aesthetics, “Comfortable color matching of the page” and “Clear navigation bar” are the ones that consumer value. From a functional point of view, the importance of “right shoe types recommendation”, “plenty of shoe styles for selection” and “accurate shoe sizes recommendation” is basically the same. If look at it from the perspective of authenticity, “I can feel whether the shoes heel the foot”, “I can feel the hardness of the shoes” and “It can provide a real person trial assessment” are the top three factors to be considered. In the future 3D virtual shoe fitting room design, “It can provide customized version (such as too narrow or too wide)”, “It can provide various material for shell, lining, and sole”, “It can provide customized size (such as too small or too large size and half size)” and “It can provide various heels” are the first three aspects to be considered from the perspective of individualization. The last functional requirement is about interactivity and it contains three aspects. “The individual privacy data can be protected” is the most popular choice, therefore, the protection of customers” private data is of paramount importance. When the participants were asked about the requirements of fitting effect display, “Show the whole body effect with the appropriate clothing” and “It can rotate 360 degrees” are what they wont most. For the fitting evaluation report, “It is concise and easy to understand” and “The text and pictures are integral” are what they care about most. Overall, consumers’ expectation for 3D shoe fitting room is “It can provide the accurate shoes for me”, “It can save me a lot of time on buying shoes in physical store” and “It can bring me a satisfactory online shopping experience”.

4.5.2 Function requirements sorting of 3D virtual shoe fitting room

Table 6. Ranking of consumers' functional requirement for 3D virtual fitting

Items	mean value	mode	Ranking
The individual privacy data can be protected	4.26	5	1
The page design is easy to access with simple icons	4.23	5	2
It has plenty of shoe styles for selection	4.21	5	3
It can recommend right shoe types	4.21	5	4
It can provide matching garment	4.21	5	5
It can recommend accurate shoe sizes	4.20	5	6
It can provide historical wearing records and feet comparisons	4.20	5	7
It has smooth and fast purchasing process	4.16	5	8
It has high simulation effect	4.09	5	9
It can provide sharing function on social platforms	3.98	4	10

A Five Point Likert Scale (5=strongly agree, 4=agree, 3=neither agree nor disagree, 2=disagree,1=strongly disagree) was used to investigate the functions that consumers expect the 3D virtual shoe fitting room to have. The functional requirement ranking of consumers for 3D virtual shoe fitting is shown in Table 6. By means of mean analysis, the results show that the mode of nine of the functions is 5 points, and only one is 4 below 5, and the mean value is above 3.98 points, indicating that consumers have a strong demand for the functions of the 3D fitting room and think each function is very necessary. It can be seen from the ranking that consumers have high requirements on the individual privacy data protection. Second, consumers pay attention to page design with simple icon of 3D virtual shoe fitting room so they can access it easily. In other words, they may be disappointed if the page design is complex and difficult to operate. In addition, consumers also attach great importance to "plenty shoe style selection", "right shoe types recommendation" and "matching garment providing", which requires enterprises to ensure a sufficient number of shoes for consumers to try on when developing a 3D virtual shoe fitting room. Furthermore, it would be better if it can provide historical wearing records and feet comparisons and help consumers to recommend accurate shoe sizes.

5. Conclusion

5.1 Implications

The study provide a realistic theoretical contribution on technical framework of virtual fitting system application prospect of virtual reality technology in the construction of online shopping platform, and enriched prior literature on 3D virtual fitting technology and consumer satisfaction with online shopping. Another aspect of contribution is to provide a realistic theoretical basis for the development and application of new markets and new systems, since consumers' lifestyles and consumption concepts are gradually changing with the development of the Internet, and it is required to continuously explore and analyze the root causes of their changes.

5.2 Limitations and future research directions

The research will identify the needs among Chinese female customers when purchasing shoes online. In addition, it will examine the functional requirements of 3D virtual shoe fitting for Chinese female customers. For instance, investigate customers' attitude and expectation to the 3D virtual shoe fitting technology. The research sample was limited to the 18-40 years old female group who has a certain purchasing power in China. And it lacked demographic and geographic diversity [47]. It is worth to note that this study focuses on Chinese female shoe market, therefore, if the research is extended to male and children, it will have certain limitations.

Acknowledgments: 2020-2021 Huizhou University Independent innovation ability improvement plan project and Grant no: HZU202059.

References

[1] Asiedu, R. and Dube, F.N. 2020. "Antecedents of Chinese consumer' online shopping behaviour", *Asian Journal of Business Research*, 10(2). doi:10.14707/ajbr.200085.

[2] Amoah, F. and Marriott, A. 2021. “Dimensions of online shopping experience and satisfaction : An application of pine and Gilmore’s 4es”, *African Journal of Business and Economic Research*, 16(2), pp. 117–137. doi:10.31920/1750-4562/2021/v16n2a6.
[3] Yang, L., Xu, M. and Xing, L. 2022. “Exploring the core factors of online purchase decisions by building an E-Commerce Network Evolution model”, *Journal of Retailing and Consumer Services*, 64, p. 102784. doi:10.1016/j.jretconser.2021.102784.
[4] Ma, Y. 2023. “China: Online shoppers 2022.” *Statista.* September 14, 2023. https://www.statista.com/statistics/277391/number-of-online-buyers-in-china/
[5] *Statista*. 2023. “Footwear - worldwide: Statista market forecast.” August, 2023 https://www.statista.com/outlook/cmo/footwear/worldwide
[6] Guthrie, C., Fosso-Wamba, S. and Arnaud, J.B. 2021. “Online consumer resilience during a pandemic: An exploratory study of e-commerce behavior before, during and after a COVID-19 lockdown”, *Journal of Retailing and Consumer Services*, 61, p. 102570. doi:10.1016/j.jretconser.2021.102570.
[7] Schnack, A., Wright, M.J. and Elms, J. 2021. “Investigating the impact of shopper personality on behaviour in immersive virtual reality store environments”, *Journal of Retailing and Consumer Services*, 61, p. 102581. doi:10.1016/j.jretconser.2021.102581.
[8] Yun, J., Lee, D., Cottingham, M., & Hyun, H. 2023. “New Generation Commerce: The rise of live commerce (L-commerce)”, *Journal of Retailing and Consumer Services*, 74, p. 103394. doi:10.1016/j.jretconser.2023.103394.
[9] Zhang, T., Li, G., and Tayi, G. K. 2023. “A strategic analysis of virtual showrooms deployment in online retail platforms.”, *Omega*, 117, 102824. https://doi.org/10.1016/j.omega.2022.102824
[10] Poole, R. 2021. “How should the footwear industry respond to online shopping?” *AlixPartners,* March 16, 2021. https://www.alixpartners.com/insights-impact/insights/as-consumers-buy-more-shoes-online-how-should-the-footwear-industry-respond/
[11] Armstrong, M. and Richter, F. 2022. “Infographic: How common are online returns?” *Statista*, June 8, 2022. https://www.statista.com/chart/27584/how-common-are-online-returns-gcs/
[12] *Statista*. 2023. “Main reasons for online shoppers worldwide to return clothes purchased online as of 2021.” March 13, 2023 https://www.statista.com/statistics/1300981/main-reasons-return-clothes-bought-online/
[13] Gustafsson, E., Jonsson, P., & Holmström, J. 2021. Reducing retail supply chain costs of product returns using digital product fitting. International Journal of Physical Distribution & Logistics Management, 51(8), 877-896.
[14] Smith, R. 2023. “E-commerce returns management: A definitive guide in 2023.” *Helplama Helpdesk,* November，2023. https://helpdesk.helplama.com/definitive-guide-for-ecommerce-returns/
[15] Allan, J. J., Munteanu, S. E., Bonanno, D. R., Buldt, A. K., Choppin, S., Bullas, A., Pearce, N. and Menz, H. B. 2023. “Methodological and statistical approaches for the assessment of foot shape using three-dimensional foot scanning: A scoping review”, *Journal of Foot and Ankle Research*, 16(1). doi:10.1186/s13047-023-00617-z.
[16] Ader, J. , Adhi, P, Chai, J., Singer, M., Touse, S., and Yankelevich, H. 2021. “Returning to order: Improving returns management for apparel companies.” *McKinsey and Company*, May 25, 2021. https://www.mckinsey.com/industries/retail/our-insights/returning-to-order-improving-returns-management-for-apparel-companies#/
[17] Bizen, H., Yoshida, M., Jimbu, M., and Kawai, Y. 2021. “Virtual Shoe fitting system that uses augmented reality to measure feet and try on shoes.” *2021 IEEE 3rd Global Conference on Life Sciences and Technologies (LifeTech)*. https://doi.org/10.1109/lifetech52111.2021.9391966

[18] Revkov, A. and Kanin, D. 2020. “Fitting - Online 3D Shoe Try-on”, *Proceedings of 3DBODY.TECH 2020 - 11th International Conference and Exhibition on 3D Body Scanning and Processing Technologies, Online/Virtual, 17-18 November 2020* [Preprint]. doi:10.15221/20.58.
[19] Uhm, J. P., Kim, S., Do, C., & Lee, H. W. 2022. “How augmented reality (AR) experience affects purchase intention in sport e-commerce: Roles of perceived diagnosticity, psychological distance, and perceived risks”, *Journal of Retailing and Consumer Services*, 67, p. 103027. doi:10.1016/j.jretconser.2022.103027.
[20] Jalali, A., Azadinia, F., Jalali, M., Saeedi, H., Shahabi, S., & Rajabi Moghadam, A. 2020. “Evaluating shoe fit in older adults using a 3D scanner: A cross-sectional observational study”, *Footwear Science*, 12(3), pp. 161–171. doi:10.1080/19424280.2020.1790671.
[21] Kim, N. and Do, W. 2019. “Developing elderly men’s footwear sizing system based on their foot shapes”, *Fashion and Textiles*, 6(1). doi:10.1186/s40691-019-0184-2.
[22] Mishra, M. K., Abtew, M. A., and Bruniaux, P. 2022. “Customization of shoe last based on 3D design process with adjustable 3D ease allowance for Better Comfort and Design.”, *The International Journal of Advanced Manufacturing Technology*, *123*(9–10), 3131–3146. https://doi.org/10.1007/s00170-022-10427-5
[23] Subhiksha, R., Gifta, C.C, and Nachiyar, T.S. 2022. “A Proposed Hedonic model for Virtual Fitting room.” *International Journal of Research Publication and Reviews*, 04(01), 1806–1812. https://doi.org/10.55248/gengpi.2023.4149
[24] Beck, M. and Crié, D. 2018. “I virtually try it … I want it ! virtual fitting room: A tool to increase on-line and off-line exploratory behavior, patronage and purchase intentions”, *Journal of Retailing and Consumer Services*, 40, pp. 279–286. doi:10.1016/j.jretconser.2016.08.006.
[25] Shikha, V. and Roshan, D. 2023. “Footwear Market Research, 2032” *Allied Market Research,* May，2023. https://www.alliedmarketresearch.com/footwear-market
[26] Verghese, S. 2022. “Women’s Footwear Market Overveiw.” *Future Market Insights,* July, 2023. https://www.futuremarketinsights.com/reports/womens-footwear-market
[27] *Market Analysis Report*. 2022. “Footwear market size, Share and Growth Analysis Report, 2030.” https://www.grandviewresearch.com/industry-analysis/footwear-market
[28] Wang, M., Yu, C., & Fang, F. 2017. “Consumer cognition and functional requirements of three-dimensional virtual fitting”, *Journal of Wool Textile*, 45, pp.11.
[29] Li, A., and Xu, Y. 2020. “A study of Chinese consumers’ adoption behaviour toward virtual fitting rooms.” *International Journal of Fashion Design, Technology and Education*, *13*(2), 140–149. https://doi.org/10.1080/17543266.2020.1758798
[30] Gulfraz, M. B., Sufyan, M., Mustak, M., Salminen, J., & Srivastava, D. K. 2022. “Understanding the impact of online customers’ shopping experience on online impulsive buying: A study on two leading e-commerce platforms”, *Journal of Retailing and Consumer Services*, 68, p. 103000. doi:10.1016/j.jretconser.2022.103000.
[31] Huang, S., and Huang, L. 2022. ”CLO3D-based 3D virtual fitting technology of Down Jacket and simulation research on dynamic effect of cloth.”，*Wireless Communications and Mobile Computing*, *2022*, 1–11. https://doi.org/10.1155/2022/5835026
[32] Wei, Z. 2022. “Optimizing 3D virtual fitting mirror using augmented reality technology under internet plus”. 2022 IEEE International Conference on Electrical Engineering, Big Data and Algorithms (EEBDA).
[33] Chou, T., Chu, C.-H. and Liu, S. 2023. “Virtual Footwear try-on in augmented reality using Deep Learning Models”, *Journal of Computing and Information Science in Engineering*, pp. 1–24. doi:10.1115/1.4062596.

[34] Xu, A., and Zhou, J. 2020." Research on key technology of virtual fitting system.", *Journal of Advances in Textile Science and Technology*, 03, p.28-32.
[35] Lee, H., Xu, Y. and Porterfield, A. 2022. "Virtual fitting rooms for online apparel shopping: An exploration of consumer perceptions", *Family and Consumer Sciences Research Journal,* 50(3), pp. 189–204. doi:10.1111/fcsr.12428.
[36] Degutis, M., Urbonavičius, S., Hollebeek, L. D., & Anselmsson, J. 2023. "Consumers' willingness to disclose their personal data in e-commerce: A reciprocity-based social exchange perspective", *Journal of Retailing and Consumer Services*, 74, p. 103385. doi:10.1016/j.jretconser.2023.103385.
[37] Wu, L. 2019. "Website interactivity may compensate for consumers' reduced control in e-commerce", *Journal of Retailing and Consumer Services*, 49, pp. 253–266. doi:10.1016/j.jretconser.2019.04.003.
[38] Chekembayeva, G., Garaus, M. and Schmidt, O. 2023. "The role of time convenience and (anticipated) emotions in AR Mobile Retailing application adoption", *Journal of Retailing and Consumer Services*, 72, p. 103260. doi:10.1016/j.jretconser.2023.103260.
[39] Plotkina, D. and Saurel, H. 2019. "Me or just like me? the role of virtual try-on and physical appearance in apparel M-retailing", *Journal of Retailing and Consumer Services*, 51, pp. 362–377. doi:10.1016/j.jretconser.2019.07.002.
[40] Karkour, M., Liang, D., AlAghbar, A., Melaab, R., & Doush, I. A. 2022. Mobile Application for Augmented Shopping: Virtual Shoe Try-on and Virtual Equipment Placement. In *2022 8th International HCI and UX Conference in Indonesia (CHIuXiD)* (Vol. 1, pp. 59-64). IEEE.
[41] Yang, S. and Xiong, G. 2019. "Try it on! contingency effects of virtual fitting rooms", *Journal of Management Information Systems*, 36(3), pp. 789–822. doi:10.1080/07421222.2019.1628894.
[42] Chu, C., Chen, Y.,Huang, Y. and Lee, Y. 2022. "A comparative study of virtual footwear try-on applications in virtual and augmented reality", *Journal of Computing and Information Science in Engineering*, 22(4). doi:10.1115/1.4053328.
[43] Hu, P., Nourbakhsh, N., Tian, J., Sturges, S., Dadarlat, V., and Munteanu, A. 2020. "A generic method of wearable items virtual try-on." *Textile Research Journal*, *90*(19–20), 2161–2174. https://doi.org/10.1177/0040517520909995
[44] An, S., Che, G., Guo, J., Zhu, H., Ye, J., Zhou, F., Zhu, Z., Wei, D., Liu, A., and Zhang, W. 2021. "Arshoe." *Proceedings of the 29th ACM International Conference on Multimedia*. https://doi.org/10.1145/3474085.3481537
[45] *HKTDC Research.* 2022. "Guangdong: Market Profile." June 21, 2023. https://research.hktdc.com/en/data-and-profiles/mcpc/provinces/guangdong
[46] Textor , C. 2023. "China: Population of Guangdong 2022." *Statista*. March 31, 2023 https://www.statista.com/statistics/1033846/china-population-of-guangdong/
[47] Petcharat, T., Jattamart, A. and Leelasantitham, A. 2023. "A conceptual model to imply a negative innovation assessment framework on consumer behaviors through the electronic business platforms", *Journal of Retailing and Consumer Services*, 74, p. 103450. doi:10.1016/j.jretconser.2023.103450.