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RESEARCH ARTICLE

The Effects of Information Layout, Display Mode, and Gender Difference on the User Interface Design of Mobile Shopping Applications

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ABSTRACT Online shopping has revolutionized our daily lives in the modern era. We can purchase needed goods on mobile shopping applications (apps) anytime and anywhere without leaving home. Especially during the COVID-19 pandemic, we have become increasingly dependent on various mobile shopping activities. However, the visual design of the shopping app interface often affects the user's interactive experience and the efficiency of browsing product information. In addition, gender differences are also worth being considered in the shopping interface design process. To achieve the goal, the research conducted a user study (N=40) of a 2 × 2 x 2 mixed factorial design (i.e., information layout x display mode x gender difference). Each participant performed four tasks during the experiment. The authors measured the task completion time, collected the subjective responses from the SUS and the 7-point Likert scale questionnaire, and interviewed participants. The results revealed that: (1) females perform faster in lighter mode when searching for information location, while males perform faster in darker mode. (2) The information layout affects the user's visual search performance and subjective evaluation; females prefer the list style, but men prefer the matrix style. (3) Participants (both males and females) perceived matrix style as more popular than list style in dark mode; however, the result was reversed in light mode. The findings generated from the research can serve as a good reference for the development of user experience in the user interface design of mobile shopping apps.

INDEX TERMS Display mode, gender difference, information layout, interaction design, shopping apps, user experience.

I. INTRODUCTION

In recent years, the dramatic increase in the use of mobile devices and wireless communication technologies has significantly impacted the rapid growth of mobile shopping users [1]. Mobile shopping is defined as consumers searching, browsing, comparing, and purchasing goods and services online via wireless handheld or mobile devices, such as smartphones and tablets [2]. As of January 2022, mobile commerce accounts for nearly two-thirds (65.7%) of global e-commerce retail sales [3]. In addition, mobile device users are an important target group for China's booming e-commerce sector. By 2021, approximately 69% of all e-commerce transactions in China will be conducted via mobile devices, and this percentage is expected to grow to 75% by 2025. For many Chinese consumers, smartphones have become their first choice for online shopping [4]. With the emergence of various mobile shopping applications (apps), the number of mobile shoppers has increased rapidly [5]. In recent years, the number of users shopping online via mobile devices has begun to exceed that of users shopping via websites [6]. This is mainly attributed to the mobility and portability of mobile devices [7], in addition to the benefits of mobile shopping, which include saving shopping time, comparing product prices, accessing promotional information or receiving customized offers [8].

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Effective access to information is a fundamental driver of utility value [9]. Recently, a study found that, on average, consumers include at least six browsing visits to mobile shopping apps before they complete a single purchase transaction [10]. Past research has confirmed that consumers can be well served by the shopping experience when they effortlessly find relevant information while browsing through a large amount of product information [11]. However, the limited screen size of mobile devices often limits consumers from quickly navigating through product information [12].

As we all know, in mobile shopping platforms, there is no physical contact between the user, the seller, and the product. The shopping interface designs, such as product catalogs, search engines, price comparisons, and shopping carts, form the basis of user interaction with the shopping interface [13], and the limited app platform interface has a certain impact on the user's shopping willingness [14]. In addition, the visual presentation of a shopping interface is a key factor influencing consumers' purchase decisions and behaviors [15]. Product information is one of the essential functional modules of the mobile shopping app, and almost all users are used to browsing and comparing product information before making shopping decisions [16]. In order to understand the characteristics and advantages of a characteristic product, users need a certain amount of time to navigate through a specific shopping interface [17]. Yang et al. emphasized that consumers' ability to perceive product information facilitates them to in making rational shopping decisions [18]. In other words, the user's ability to access product information in a mobile shopping interface affects the user's shopping experience [19]. Recently Yang et al. [16] proposed an algorithm to record information in the user's behavioral system to collect and thus provide personalized services to the user, which includes the user's browsing of products.

Complex visual designs often require more processing power and more cognitive effort for consumers to process the visual information of products [20], so improving the efficiency of consumers' visual searching is the key to the development of shopping platforms [21]. Typically, users go through several processes before making a mobile shopping decision, including opening a shopping app, entering a specific product, browsing and comparing product information, and adding to a shopping cart. Therefore, this study focuses on the impact of visual design on users' browsing of product information in the mobile shopping interface. Figure 1 illustrates the user's shopping process in the mobile shopping apps [16].

With the increasing sophistication of mobile shopping platforms, fast logistics, and more transactional services, mobile shopping platforms and brand operators have also become more focused on the user's mobile shopping experience in recent years [22]. The user experience of mobile shopping encompasses all aspects of the interaction between the user and the interface. It is reflected in the outcome of the user's intrinsic perceptual state, including preferences,

FIGURE 1. The user's shopping process in the mobile shopping apps (Adapt from Yang et al. [16]).

expectations, needs, emotions, attractiveness, and so on, representing the user's emotional recognition [23]. It has been found that a user's intention to make purchases on a shopping platform is usually enhanced by 30 seconds after interacting with the interface [6]. In a sense, the user's impression of the shopping interface design directly influences the user's purchase decision [24]. In addition, early research investigated the differences in gender preferences for website usability in the field of human-computer interaction [25]. Gender differences act as a critical variable in the research of user experience [26]. In studies on the travel industry, gender has been found to be a determinant of user performance for segmenting markets [27]. As the number of online shopping consumers proliferates and user preferences for online shopping interfaces are increasingly valued, gender differences may also be a very important consideration in the interface design of mobile shopping applications. Besides, the visual design of a competitive shopping app interface should help users to get the needed product information quickly and continuously improve their online shopping operation experience. In conclusion, user experience is a multidimensional and holistic concept. For example, a study by Anchahua et al. [28] concluded that user experience involves all aspects of the user interaction experience process. In addition, Zhu et al. categorized the evaluation metrics of user experience for mobile shopping applications into three dimensions: ease of use, visual aesthetics, and satisfaction [29]. Chen et al. [30] emphasized that online user experience has become a top priority for e-retailers to retain consumers. Therefore, it is imperative to strengthen the intuitive interaction of mobile shopping apps, which is an indispensable factor in the competitiveness of e-commerce.

II. RELATED WORKS

A. VISUAL DESIGN OF THE USER INTERFACE

For humans, the visual system is one of the most critical channels for accessing external information and has a significant impact on the user's processing of information and making decisions [31], directly affecting the user's subjective perceptions [32]. Visual design is essential to the interface quality [33]. It constantly affects the user's interaction with the interface [34]. Patel et al. [35] state that the

interface quality of mobile shopping applications is divided into dimensions such as general information quality and visual quality. Among them, visual design has been proven to be an essential component of interface quality [36]. Visual design is crucial to consumers' information searching and shopping decisions during the mobile shopping process [37]. In mobile shopping platforms, consumers require more cognitive resources to help process the visual elements of the interface [20]. These visual elements include text, images, colors, layouts, animations, supporting visual elements, and so on [38]. The complexity, quantity, style, and layout of these visual designs can profoundly impact the consumer's visual perceptions [39]. The human-machine interface is the medium through which information is transmitted between humans and machines. The interface layout is often a rational arrangement of interface elements according to certain objective constraints to ensure smooth communication between humans and machines [40]. In an interface, the design of the information layout affects the user's visual search strategy, and the user often has to switch between different layout styles to obtain sound cognitive processing [41]. The interface layout affects users' attention, emotion, and cognitive processing as they process information [42]. The nature of the information layout of the interface is a question of optimizing the combination of information, and the designer needs to assemble a comprehensive solution that meets the user's operational and visual aesthetic needs [43]. As consumers need to choose from many alternatives to meet their interaction needs, the layout of information in the interface determines, to a certain extent, whether consumers can order the products they want [44]. Common information layouts in shopping interfaces are the horizontal F-shapes (e.g., Flipkart) and the vertical grid layouts (e.g., Amazon). The different information layouts have a significant impact on user search behavior and attention [45]. Users who perform visual search actions among different interface information layouts require fast visual processing and control the eye's movement from the central position to the target position [46]. Studies on the effects of information layout on users are generally investigated through qualitative self-reporting, eye-tracking devices [47], and statistical analysis of behavioral data such as user learning time, task completion time, and error rates [48]. In addition, mobile devices are often equipped with smaller screens that may stimulate user-specific information processing mechanisms [49]. However, due to the limited ability of the human visual system to process information, an inappropriate interface information layout may increase the user's cognitive load, reduce search performance, and affect the user experience [50]. Therefore, it is necessary to deeply explore the impact of the layout approach of mobile shopping applications on users' online shopping.

A recent study found that the background color of the interface affects the user visual experience and search performance [51]. The terminology used to describe the contrast between text and background is usually called "polarity" [52]. In everyday life, the more common display backgrounds for mobile phone user interfaces are black on white or white on black, also known as light mode and dark mode [53]. In the past, researchers suggested that the text and background on a display should be color-coordinated in high contrast [54]. This type of visual presentation can effectively improve the readability of the user interface [44]. Research on the difference between light and dark mode has found that dark mode can be more battery efficient and can reduce user visual fatigue [55]. However, a large body of research has adhered to the "light mode" hypothesis, with Santos et al. [56] finding that the light mode background patterns tend to cause the user's pupils to contract naturally and that users are more likely to focus and perceive black text on a white background quickly, with light mode also performing better in terms of legibility [57], [58]. There are also significant differences in visual characteristics, with studies on screen size and text background color suggesting that text looks finer when it is white, and the background is black [53]. However, in terms of user performance, some studies have found that dark mode may reduce user response time by almost 8% compared to light mode [59], [60]. Research on the user's emotional experience with dark mode over light mode has found a higher preference for light mode. In addition, preference for polarity has also been influenced by factors such as gender, age, and culture [10]. Apraiz Iriarte et al. [52] also support users' preference for polarity. This is influenced by gender differences, with males generally having a greater preference for dark mode while females prefer light mode. It can be seen that display mode, as the main visual element of the mobile shopping interface, may have a great impact on the user shopping experience. Past studies have demonstrated the impact of text-to-background contrast on users' reading time, reading speed, preferences, error rates, and fatigue [61]. However, more research needs to be conducted on the effect of background display mode on the user experience of mobile shopping applications. Therefore, in this study, the background display mode of the mobile shopping application was used as a research variable.

B. THE GENDER DIFFERENCE

Early research on gender differences in information processing found inherent differences between males and females [62], but the similarities between the genders were much greater than the differences [63]. In spatial reasoning, males performed better, while females performed better in verbal activities [64]. In addition, previous studies have found that there are also gender differences in the processing of advertising messages [65], and studies have found that female users are distracted when the shopping interface is flooded with advertisements and information [38]. Males, in general, are more concerned with the content of the user interface and less with the visual appearance [66]. In addition, a study found that males devote more attention to information

usability [67]. This finding is consistent with Suh, Wilson, and On's [68] study, which suggests that females are more likely than males to be influenced by the semantic nature of top-down features. They also found no differences between the two genders for bottom-up features of stimuli. Differences between the genders, particularly in visual strategies, may be due to differences in brain structure, with the left hemisphere of the male brain being responsible for language functions and the right hemisphere for spatial processing. This difference in the asymmetrical structure of the left and right hemispheres between the genders results in males performing better in spatial activities and females performing better in verbal skills. In addition, asymmetries in the hemispheres also affect the allocation of visual attention between males and females [69]. It is well known that among standard shopping interfaces, it was found that only a few user interfaces for females' products were designed with user preferences in mind, such as colors or images. However, most shopping interfaces had only one fixed pattern. A study conducted by Kurniawan and Zaphiris [70] found that 94% of the websites were designed to cater to males' preferences, as 74% of the user interfaces were designed by male designers. It can be seen that gender differences in the design of mobile shopping interfaces should be studied and paid more attention to. In particular, elements that are rationally designed to address the gender differences in users' visual search deserve in-depth study.

In conclusion, the user experience of mobile shopping applications affects the whole process of users' online shopping. Some studies confirm that visual search efficiency is one of the factors that strongly affect user experience [71]. In exploring the interface design process of mobile shopping applications, researchers need to measure not only the performance of users' visual search operations, but also to fully understand how users feel about the interface [72]. In short, a positive user experience can promote users' online purchasing behavior [73]. In recent years, optimizing the user experience of online platforms has become critical in the online retail and marketing space [74]. Accordingly, the proposed experiment design adopted information layout, display modes, and gender differences as the research variables. It aimed to extract a more reasonable visual design of the user interface by comparing the above-mentioned variables and investigating the usability of mobile shopping apps for a better user experience.

III. RESEARCH OBJECTIVES AND QUESTIONS

This study investigated whether information layouts, display modes, and gender differences may affect the user's task performance as well as their personal subjective evaluations when operating a shopping app interface. In this study, several questions were addressed pertinent to whether users in the mobile shopping app interface performed faster when searching for information on the matrix-style than on the list-style operation interface. Detailed questions are listed as follows:

Q1: Does the information layout improve the user interactive experience of the shopping app interface?

Q2: Do males perform better than females in shopping apps?

Q3: Do the different types of display modes affect users' task performance in the mobile shopping app interface?

Q4: Is there an interaction effect among all three independent variables, i.e., information layout, display mode, and gender?

IV. METHODS AND MATERIALS

In this study, a $2 \times 2 \times 2$ mixed factorial design was employed in the experiment, in which the three independent variables were information layout, display mode and gender difference. The within-subject variable was the information layout (i.e., list-style and matrix-style). At the same time, the display mode (i.e., dark mode and light mode) and gender difference (i.e., male and female) were the between-subject variables. This experiment is a mixed factorial design, i.e., each participant needs to complete two types of layouts. Therefore, the counterbalance of order and sequence effects is planned in our experiment. The control of the sequence of the experiment aimed to offset the errors caused by the sequence and continuity effect. The experimental design in this study utilized Illustrator software for graphic design and subsequently used Proto.io to help create the app prototype. As we all know,apple is a major manufacturer of smartphones worldwide, with the company shipping more than 225 million iPhones worldwide in 2022 [75]. Therefore, it is of great practical importance to use Apple phones as the vehicle for our experiments. The prototype simulates a mobile shopping app interface by adopting the iPhone 7 plus with the iOS 10.3.3 version installed on a mobile phone. It is equipped with a 5.5-inch screen. The quality of product information and interface layout are essential dimensions of the interface quality of mobile shopping applications. One study found that time-saving is an essential factor influencing Chinese consumers' online shopping [76], and effortlessly finding the target information during browsing product information promotes interface ease of use [10], [77]. In addition, the Technology Acceptance Model (TAM) proposed by Davis [78] is widely used in e-commerce to study user acceptance and intention to use. Also, Tong [79] emphasized that the perceived usefulness of the user interface is essential for Chinese consumers' intention to purchase online.

Therefore, the experimental design of this study aimed to explore in depth by recording the task completion time (i.e., objective data) of participants completing the different tasks and their overall psychological evaluations (i.e., subjective data) regarding the experimental manipulation. More specifically, the dependent variables of the experiment were participants' task completion time, the system usability scale (SUS) questionnaire, and subjective evaluations (including the degree of effortlessness, the degree of helpfulness, and the degree of willingness to use). Figure 2 shows the research model of this study.

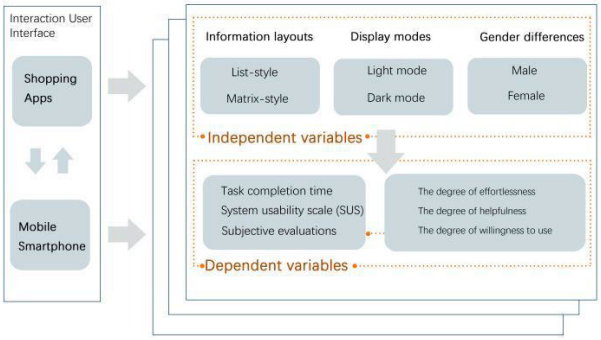

FIGURE 2. The research model of this study.

A. PARTICIPANTS

The participants in our experiment were all young consumers. This age group is known as the millennial generation [80]. Past studies have pointed out that millennial consumers are the most significant online shoppers and have greater purchasing power [81]. Accounting for 85% of total online transactions [82]. Therefore, young people are a representative group as the target of online shopping consumer research. In this study, a purposive sampling method was used to recruit 40 participants (i.e., 20 males and 20 females), aged 18-39, who had experience of using the shopping app on smartphones, including 26 undergraduate students (65%), eight Master's students (20%), and six Ph.D. students (15%). Among them, 34 (85%) were 18-28 years old, and six (15%) were 29-39 years old. The participants in this age range are representative of the majority of mobile shoppers. In addition, 28 (70%) had used a shopping app for less than one hour per day, eight (20%) for 1 to 2 hours per day, and only four (10%) for more than 2 hours but less than 3 hours per day. Figure 3 shows the basic statistics of the participants' background information.

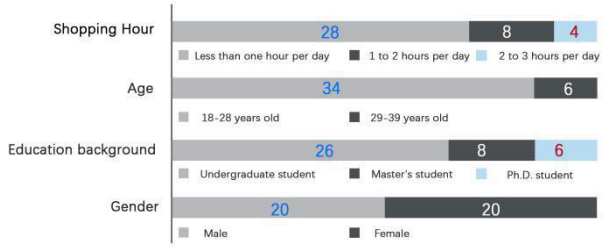

FIGURE 3. The basic statistics of the participants' background information.

All participants had standard or corrected-to-normal vision and were all right-handed. There was no barrier to using an app, and each participant could complete the experiment independently. The participants agreed and signed the informed consent. They all fully understood the experimental tasks and questionnaires. The duration of the experiment was approximately 30 minutes, and the participants were paid approximately 50 RMB for taking part in the experiment.

B. EXPERIMENT DESIGN AND PROCEDURE

It is well known that in almost mobile shopping apps, users can enter different product attributes in the search bar to obtain information about the products in that category, so that users can make shopping decisions based on the information provided. Typically, the product information in the shopping interface includes product price, name, features, usage, and precautions [83]. In addition, the number of products and promotions, as one of the key marketing variables, have a very strong influence on consumers' shopping decisions [84]. In addition, these factors also profoundly affect user satisfaction and willingness to continue using mobile shopping applications [85].

The experimental design focuses on electronic products. In this experiment, four different prototypes were created for the experiment (see Figure 4). The information presented on the prototype displays is mainly product images and product information including the product price, brand, promotions, user reviews, and the number of purchases. The content about product information is commonly presented in almost all types of user interfaces of shopping applications. The experimental design was also created based on users' shopping habits.

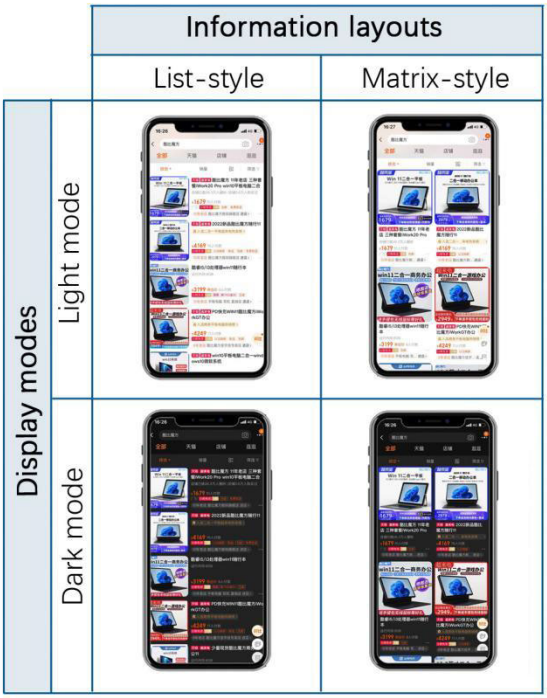

FIGURE 4. Four prototypes used in this experiment.

Before the experiment, the participants were told that the purpose of the experiment was to perform four tasks related to mobile shopping. More specifically, the participant was asked to sit at a table. On the table, an informed consent

TABLE 1. Experimental task designs of this study.

Task number	Descriptions	Purpose
Task 1	Find the location of the item priced at 3199 RMB.	Visual search for information location
Task 2	Find the location of an item with 12 interest-free installment.	Visual search for information location
Task 3	Find the location of the lowest priced item.	Visual search for information location and information comparison
Task 4	Find the location of the item with the highest number of payers.	Visual search for information location and information comparison

together with the questionnaire of background information and task descriptions were provided to the participant. The participants were asked to complete the consent form and the questionnaire regarding their background information. After that, the participant would start the experiment by performing the assigned tasks on the interface prototype. After completing the assigned task, the participant's task completion time was recorded by the screen recording software for further analysis. When an experiment was completed, participants were then asked to fill in the SUS questionnaire, with each item measured with a 5-point Likert scale (from 1 for "*strongly disagree*" to 5 "*strongly agree*"). The system usability scale (SUS) is a 10-item instrument measuring user perceptions of a product's usability [86]. The scale consists of ten questions and uses a Likert five-point scale. The singular questions are forward questions, and the plural questions are reverse. The scores of individual questions do not represent meaning. The data needs to be multiplied to obtain the final score. Then the participants were also asked to fill in the questionnaire regarding their subjective evaluations of the overall task operation via five questions on a 7-point Likert scale with the lowest score for each item as 1 (*very dissatisfied*), the highest score as 7 (*very satisfied*), and the medium score as 4. In the end, a semi-structured interview was conducted to help collect participants' personal feelings pertinent to task difficulty and other personal opinions or suggestions.

In this study, four tasks of this experiment were determined related to visual searching for information location and comparison (see Table 1) present the product information, including price, interest-free installment and the number of payers, in different positions and font sizes, which fits well with the actual application. The experiment simulated a shopping app used most frequently in China to enable the participant to conduct the assigned tasks. The participants of this study were all students from Hunan University in China as they may represent the majority of mobile shoppers. In addition, the controlled variables were the unchanged environmental settings with stable Wi-Fi speed.

TABLE 2. The results of the mixed two-way ANOVA for performance of task 1.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	63.99	1	63.99	3.90	0.056	0.10	
Display mode	19.28	1	19.28	1.51	0.227	0.04	
Gender	16.44	1	16.44	1.29	0.264	0.04	
Information layout×Display mode	0.29	1	0.29	0.02	0.895	0.00	
Information layout×Gender	37.69	1	37.69	2.30	0.138	0.06	
Display mode×Gender	68.80	1	68.80	5.40	0.026*	0.13	
Information layout×Display mode×Gender	53.65	1	53.65	3.27	0.079	0.08	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

V. EXPERIMENTAL RESULTS

A mixed factorial design was conducted for further statistical analysis. The collected data regarding the main effects of information layout, display mode, gender, and their interaction effects on participants' task completion time (i.e., in seconds), as well as subjective evaluations were analyzed using the SPSS software. Significant effects were further analyzed with the LSD post hoc comparison to help address the differences among the factor levels.

A. ANALYSIS OF TASK COMPLETION TIME

1) TASK 1

The results generated from the mixed factorial design of the Task 1 completion time are shown in Table 2, revealing no significant difference in the main effect of information layout, display mode and gender. There was a significant interaction effect between display mode and gender ($F_{(1,36)} = 5.40$, $p = 0.026 < 0.05$; $\eta^2 = 0.13$). Figure 5 illustrates that in light mode, the task operation of females ($M = 14.81$, $SD = 3.02$) was significantly shorter than that of males ($M = 15.76$, $SD = 3.28$). In contrast, in dark mode, the task operation of males ($M = 14.89$, $SD = 2.81$) was significantly shorter than that of females ($M = 17.65$, $SD = 5.98$).

2) TASK 2

The results generated from the mixed two-way ANOVA of the Task 2 completion time are shown in Table 3, revealing a significant difference in the main effect of information layout ($F_{(1,36)} = 5.74$, $p = 0.022 < 0.05$; $\eta^2 = 0.14$). This means that the task completion time of the matrix-style ($M = 5.57$,

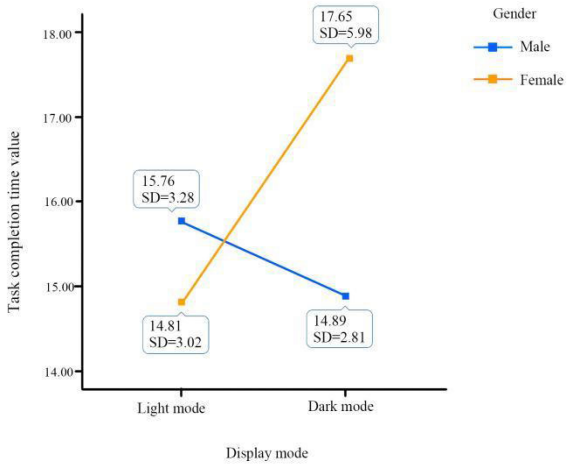

FIGURE 5. The interaction diagram of display mode and gender for performance of Task 1.

TABLE 3. The results of the mixed two-way ANOVA for performance of task 2.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	11.13	1	11.13	5.74	0.022*	0.14	list-style > matrix-style
Display mode	1.24	1	1.24	0.23	0.637	0.01	
Gender	10.83	1	10.83	1.98	0.168	0.05	
Information layout×Display mode	1.33	1	1.33	0.69	0.413	0.02	
Information layout×Gender	2.86	1	2.86	1.47	0.233	0.04	
Display mode×Gender	7.79	1	7.79	1.42	0.241	0.04	
Information layout×Display mode×Gender	6.68	1	6.68	3.45	0.072	0.09	

SD = 2.02) was significantly shorter than that of the list-style (M = 6.32, SD = 1.89). Nonetheless, there was no significant difference in the main effect of display mode and gender. Besides, there also existed no significant interaction effect among all factors.

3) TASK 3

The results generated from the mixed two-way ANOVA of the Task 3 completion time are shown in Table 4, revealing no significant difference in the main effect of information layout and display mode. Nonetheless, there existed a significant

TABLE 4. The results of the mixed two-way ANOVA for performance of task 3.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	1.24	1	1.24	0.08	0.781	0.00	
Display mode	35.95	1	35.95	1.53	0.224	0.04	
Gender	174.91	1	174.91	7.44	0.010*	0.17	female > male
Information layout×Display mode	0.11	1	0.11	0.01	0.935	0.00	
Information layout×Gender	1.04	1	1.04	0.07	0.799	0.00	
Display mode×Gender	18.44	1	18.44	0.78	0.382	0.02	
Information layout×Display mode×Gender	0.69	1	0.69	0.04	0.836	0.00	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

difference in the main effect of gender ($F_{(1,36)} = 7.44$, p = 0.010 < 0.05; $\eta^2 = 0.17$). This means that the task completion time of males (M = 5.71, SD = 3.39) was significantly shorter than that of females (M = 8.67, SD = 5.13). Besides, there also existed no significant interaction effect among all factors.

4) TASK 4

The results generated from the mixed two-way ANOVA of the Task 4 completion time are shown in Table 5, revealing a significant difference in the main effect of information layout ($F_{(1,36)} = 11.66$, p = 0.002 < 0.05; $\eta^2 = 0.25$). This means that the task completion time of the matrix-style (M = 5.31, SD = 1.90) was significantly shorter than that of the list-style (M = 6.06, SD = 1.91). However, there was no significant difference in the main effect of both display mode and gender. Nonetheless, there existed a significant interaction effect between display mode and gender ($F_{(1,36)} = 4.25$, p = 0.046 < 0.05; $\eta^2 = 0.11$). Figure 6 illustrates that in light mode, the task completion time of females (M = 7.75, SD = 2.17) was significantly shorter than that of males (M = 9.92, SD = 4.35). However, in dark mode, the task completion time of males (M = 7.44, SD = 2.69) was significantly shorter than that of females (M = 8.77, SD = 2.81).

B. ANALYSIS OF SUBJECTIVE EVALUATIONS

1) ANALYSIS OF THE SYSTEM USABILITY SCALE (SUS)

After the SUS questionnaire was analyzed, the overall mean score (M = 74.47, SD = 11.89) for all groups was above 70, indicating that the two main categories of information layout,

TABLE 5. The results of the mixed two-way ANOVA for performance of task 4.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	49.57	1	49.57	11.66	0.002 *	0.25	list-style > matrix-style
Display mode	10.62	1	10.62	0.74	0.395	0.02	
Gender	3.45	1	3.45	0.24	0.627	0.01	
Information layout×Display mode	4.50	1	4.50	1.06	0.310	0.03	
Information layout×Gender	8.67	1	8.67	2.04	0.162	0.05	
Display mode×Gender	60.95	1	60.95	4.25	0.046 *	0.11	
Information layout×Display mode×Gender	5.40	1	5.40	1.27	0.267	0.03	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

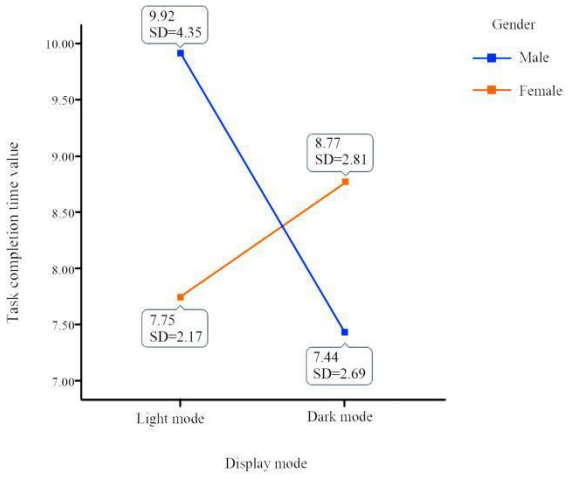

FIGURE 6. The interaction diagram of display mode and gender for performance of task 4.

the two main categories of display mode and the two main categories of gender all revealed high system usability (i.e., more than the required score of 68) by the participants (as shown in Figure 7).

The results generated from the mixed factorial design of the SUS are shown in Table 6, revealing no significant difference in the main effect of information layout, display mode, and gender. However, there was a significant interaction effect between display mode and gender ($F_{(1,36)} = 5.40$, $p = 0.026 < 0.05$; $\eta^2 = 0.13$). Figure 8 illustrates that in light

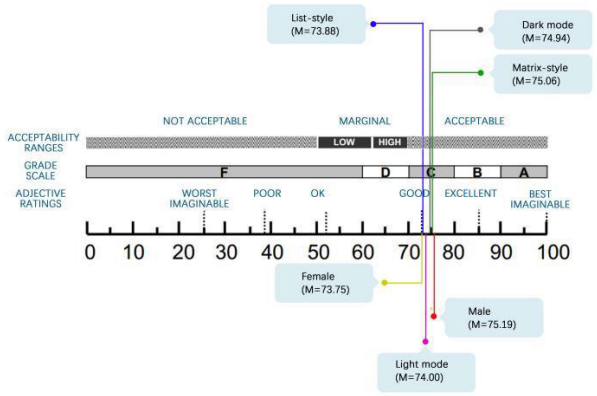

FIGURE 7. Distribution of the System Usability Scale (SUS) profiles for each group of experiments (adapted from Brooke, 1996).

TABLE 6. The results of the mixed two-way ANOVA for performance of the system usability scale (SUS).

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	28.20	1	28.20	0.26	0.613	0.01	
Display mode	17.58	1	17.58	0.10	0.754	0.00	
Gender	41.33	1	41.33	0.24	0.631	0.01	
Information layout×Display mode	13.20	1	13.20	0.12	0.729	0.00	
Information layout×Gender	34.45	1	34.45	0.32	0.576	0.01	
Display mode×Gender	765.70	1	765.70	4.25	0.044*	0.11	
Information layout×Display mode×Gender	22.58	1	22.58	0.21	0.650	0.01	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

mode, the average SUS score of females (M = 76.38, SD = 9.68) was significantly higher than that of males (M = 71.62, SD = 11.36). Nonetheless, in dark mode, the average SUS score for males (M = 78.75, SD = 14.45) was significantly better than that for females (M = 71.13, SD = 10.56).

2) ANALYSIS OF THE DEGREE OF EFFORTLESSNESS

The results generated from the mixed two-way ANOVA in terms of the degree of effortlessness are shown in Table 7, revealing no significant difference in the main effect of information layout, display mode, and gender. However, there existed a significant interaction effect between information layout and gender ($F_{(1,36)} = 5.51$, $p = 0.005 < 0.05$; $\eta^2 = 0.20$). Figure 9 illustrates that for list-style, females (M = 5.85, SD = 0.93) felt it was more effortless than did males

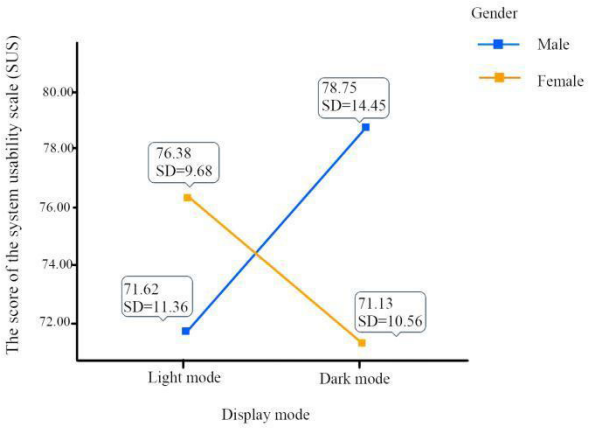

FIGURE 8. The interaction diagram of display mode and gender for performance of the System Usability Scale (SUS).

TABLE 7. The results of the mixed two-way ANOVA for degree of effortlessness.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	1.01	1	1.01	1.63	0.210	0.04	
Display mode	0.11	1	0.11	0.07	0.798	0.00	
Gender	0.01	1	0.01	0.01	0.932	0.00	
Information layout×Display mode	0.11	1	0.11	0.18	0.673	0.01	
Information layout×Gender	5.51	1	5.51	8.88	0.005*	0.20	
Display mode×Gender	0.31	1	0.31	0.19	0.798	0.00	
Information layout×Display mode×Gender	1.51	1	1.51	2.44	0.127	0.06	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

(M = 5.30, SD = 1.17). Nonetheless, for matrix-style, males (M = 5.60, SD = 1.10) felt it was more effortless than did females (M = 5.10, SD = 1.02). There was no significant interaction effect between display mode and gender ($F_{(1,36)}$ = 0.31, p = 0.798 > 0.05; η^2 = 0.00).

3) ANALYSIS OF THE DEGREE OF HELPFULNESS

Results generated from the mixed two-way ANOVA regarding the degree of helpfulness are shown in Table 8, revealing no significant difference in the main effect of information layout, display mode and gender. However, there existed a significant interaction effect between information layout and gender ($F_{(1,36)}$ = 9.79, p = 0.003 < 0.05; η^2 = 0.21). Figure 10 illustrates that for list-style, females (M = 5.95, SD = 0.69) felt more helpfulness than males (M = 5.55,

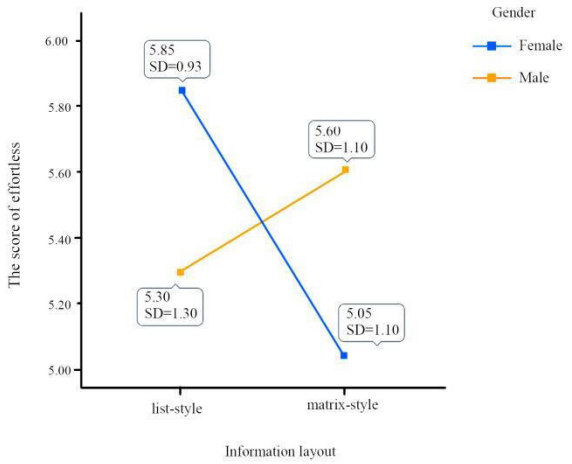

FIGURE 9. The interaction diagram of information layout and gender for degree of effortlessness.

TABLE 8. The results of the mixed two-way ANOVA for degree of helpfulness.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	0.45	1	0.45	1.09	0.304	0.03	
Display mode	0.80	1	0.80	0.61	0.414	0.02	
Gender	0.05	1	0.05	0.04	0.847	0.00	
Information layout×Display mode	0.80	1	0.80	1.93	0.173	0.05	
Information layout×Gender	4.05	1	4.05	9.79	0.003*	0.21	
Display mode×Gender	0.20	1	0.20	0.15	0.699	0.00	
Information layout×Display mode×Gender	0.80	1	0.80	1.93	0.173	0.05	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

SD = 1.10). Nonetheless, for matrix-style, males (M = 5.85, SD = 1.04) felt more helpfulness than females (M = 5.35, SD = 0.81).

4) ANALYSIS OF THE DEGREE OF WILLINGNESS TO USE

The results generated from the mixed two-way ANOVA of the degree of willingness to use are shown in Table 9, revealing no significant difference in the main effect of information layout, display mode, and gender. Nonetheless, there existed a significant interaction effect between information layout and display mode ($F_{(1,36)}$ = 4.65, p = 0.038 < 0.05; η^2 = 0.11). Figure 11 illustrates that in light mode,

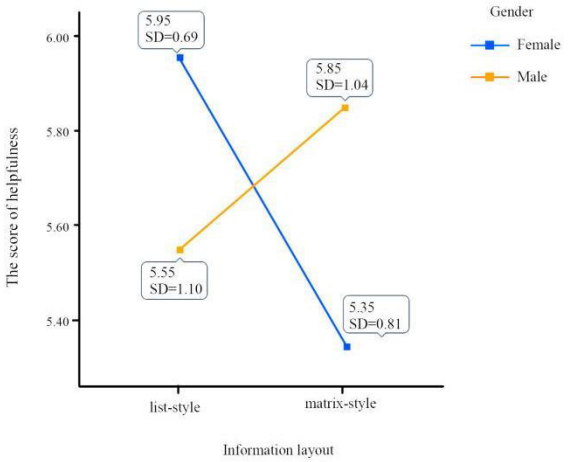

FIGURE 10. The interaction diagram of information layout and gender for degree of helpfulness.

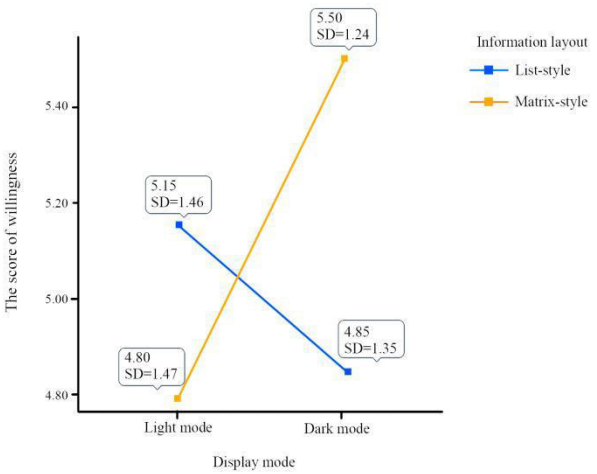

FIGURE 11. The interaction diagram of display mode and information layout for degree of willingness to use.

TABLE 9. The results of the mixed two-way ANOVA for degree of willingness to use.

Sourcer	*SS*	*df*	*MS*	*F*	*P*	η^2	Post Hoc
Information layout	0.45	1	0.45	0.42	0.522	0.01	
Display mode	0.80	1	0.80	0.38	0.543	0.01	
Gender	2.45	1	2.45	1.15	0.290	0.03	
Information layout×Display mode	5.00	1	5.00	4.65	0.038*	0.11	
Information layout×Gender	6.05	1	6.05	5.63	0.023*	0.14	
Display mode×Gender	0.80	1	0.80	0.38	0.543	0.01	
Information layout×Display mode×Gender	0.80	1	0.80	0.74	0.394	0.02	

* Significantly different at the α = 0.05 level (*p < 0.05);
** Significantly different at the α = 0.01 level (*p < 0.01)

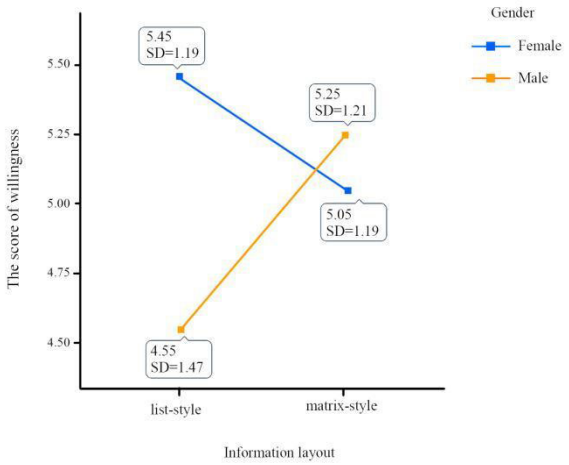

FIGURE 12. The interaction diagram of information layout and gender for degree of willingness to use.

participants were more willing to use the list-style (M = 5.15, SD = 1.46) than the matrix-style (M = 4.80, SD = 1.06). On the contrary, in dark mode, participants were more willing to use the matrix-style (M = 5.50, SD = 1.24) than the list-style (M = 4.85, SD = 1.35). In addition, there existed a significant interaction effect between information layout and gender ($F_{(1,36)} = 5.63$, $p = 0.0023 < 0.05$; $\eta^2 = 0.14$). Figure 12 illustrates that for list-style, females (M = 5.45, SD = 1.19) were more willing to use it than males (M = 4.55, SD = 1.47). On the contrary, for matrix-style, males (M = 5.25, SD = 1.21) were more willing to use it than females (M = 5.05, SD = 1.19).

VI. DISCUSSIONS

A. DISCUSSIONS OF TASK PERFORMANCE

In the experiment, Task 1 was designed to allow the participants to inquire about a product with a price of 3,199 RMB. Specifically, this task was to first find the app "Taobao" on the screen of a mobile phone, and then go to the app's main page, enter the product name and obtain information about the product. It was found that females outperformed males in the light mode; however, males outperformed females in the dark mode. The reason could be that the visual designs of the user interface might affect the user's aesthetic perceptions within a brief time (i.e., about 17 ms) [87]. In a sense, both males and females are often accustomed to light-colored backgrounds. However, when the screen switches to a dark mode, the overall visual difference in the user interface could be objectively more significant (i.e., the black text on a white background is replaced by white text on a black background). Females

may be more susceptible to dark-mode stimuli that affect their performance, as previous studies have found that females are more susceptible to visual stimuli than males [88], which has been well documented in experimental observations. In summary, the results of Task 1 performance can help answer Q3, i.e., different types of display modes affect users' task performance in the mobile shopping application interface.

Task 2 required the participants to find the location of an item with 12 interest-free installments, and Task 4 required them to find the product with the highest number of payments among the searched product information. Both tasks required participants to conduct visual searches of all the products presented on the user interface (10 in total) and compare them. It was found that the matrix-style was faster for the participants to conduct visual search activities than the list-style. Due to screen size limitations, in this experiment, the list-style had a horizontal layout of photos and text information, that is, photos on the left and product information on the right. In contrast, the matrix-style had a top-bottom layout and was presented in two rows. Thus, in the list-style, the product information was arranged densely on one side, while the matrix-style user interface was arranged with the photos and text spaced apart. The difference in information layout may have caused a difference in the allocation of attention resources during the participants' visual search processes, resulting in a difference in their task performance. Furthermore, previous studies have found that users' visual attention is sparser in the matrix-style user interface than in the list-style [89]. In other words, the matrix-style user interface is more likely to allow users to achieve rapid eye movements when visually scanning and comparing screen information, thereby allocating attention resources appropriately (i.e., the factor of completing the task causes users to be driven by top-down intrinsic attention). In the list-style user interface, on the other hand, although the information is arranged in a way that makes it easy to search, the dense information also causes a particular cognitive load on the user's visual distribution. In addition, the user's visual span is smaller when comparing product information due to the arrangement of visual information in a list-style user interface. In contrast, the visual span is more significant in a matrix-style user interface, which was well documented in an earlier study conducted by Legge and Mansfield [90], where the user's speed of reading text was reduced when the visual span was small. It was also observed that the layout of the matrix-style user interface was more frequently scrolled up and down. Moreover, the matrix-style also conforms to the user's F-shaped visual scanning motion pattern [91]. In summary, these could be the reasons why participants who adopted the matrix-style performed better when conducting the visual search for information location and information comparison. In summary, Tasks 2 and 4 show results that can help answer Q1, i.e., the information layout improves the user interaction experience of the shopping app interface. Specifically, the matrix style is faster than the list style for participants to perform visual search activities.

Task 3 required the participants to find the location of the lowest priced item. It was found that the female participants took more time to complete the assigned task compared to the male participants. Earlier research found that in terms of the gender difference in visual search activities, males generally make faster decisions than females because females are more likely to use all possible information when making a decision [92]. In contrast, males are more likely to use only partial information before making decisions [93]. In Tonbuloğlu's [94] study, females used multiple sources when searching for travel information. In contrast, males were more likely to process information based on a single source. These factors may have contributed to the superior performance of male participants in completing the task compared to females. The main finding is consistent with Kimbrough, Guadagno, Muscanell, and Dill's [95] study, which found that males generally outperformed females in speed and steps taken to complete the task. This is a possible reason why the female participants took more time to complete the assigned tasks compared to the male participants. In summary, the results of Task 3 performance can help answer Q2, i.e., males perform better than females in the shopping application.

B. DISCUSSIONS OF SUBJECTIVE EVALUATIONS

The overall analysis of searching for task 1 and the system usability scale (SUS) consistently showed that females were rated higher than males for light mode. In contrast, males were rated higher for dark mode. This is probably because in the light mode, there is almost no color contrast between the product images and the background mode, and the images are more attractive to females at this time; however, in the dark mode, the product images contrast very strongly with the background mode, which greatly affects the females' operating experience.

The subjective evaluation results showed that the average scores of all the levels of research variables were higher than the medium of 4 based on a 7-point Likert scale. In the subjective ratings on the degrees of effortlessness, helpfulness, and willingness to use, it was found that a significant interaction existed between information layout and gender, that is, females rated the list-style user interface higher than males. However, males rated the layout of the matrix-style user interface higher than females. An earlier study conducted by Hwang and Lee [89] also found significant differences in visual attention allocation between males and females on the shopping interface, with females paying more visual attention to shopping information than males. The user's visual search behavior in the shopping interface is a goal-oriented search behavior, which involves a number of visual adjustments and readjustments for both males and females [96]. Males and females differ significantly in their visual processing strategies [62], with females being better than males at visual recognition and decoding of non-verbal cues [97]. According to the selectivity model [98], females are better at processing comprehensive information, whereas

males are better at processing selective information [65]. In the case of the list-style user interface, where the product information on the right is arranged vertically, females may have an advantage over males in visual processing and therefore receive a higher level of fluency during the interactive experience; however, the matrix-style user interface, where images and text information are arranged above and below and presented alternately, increases females' cognitive load to some extent during their visual search for task completion and is influenced by the fact that females are more sensitive and critical in their evaluations of the user interface [99]. Therefore, females' subjective evaluations of the matrix-style user interface were generally lower. However, males were more adept at selective visual processing in the user interface, and the overall interaction experience could be more fluid in matrix-style. Males tend to rate the matrix-style user interface more positively in terms of the degree of effortlessness, helpfulness, and willingness to use.

A significant interaction was also found between the information layout of the user interface and gender in terms of the ratings of willingness to use. That is, females rated the list-style user interface as more desirable than males; however, males rated the matrix-style user interface as more desirable than females. A possible reason for this result is that females themselves pay more attention to the photo information on the user interface than males, with the same amount of photo and text information on both user interfaces, except that in the list-style user interface, females are driven by endogenous attention and pay more visual attention to the product information on the right-hand side, which can conform to females' visual decision-making characteristics throughout the visual search process. Therefore, females find this layout (the list-style user interface) more logical. However, when the layout is matrix-style, females do not have the same advantage over males in selective visual processing. Males are better at ignoring irrelevant visual cues and have more executive control than females [100]. At the same time, the spaced arrangement of text and photos is more visually appealing to females [67], which to some extent causes females to be distracted; therefore, they express lower purchase intentions when conducting the task. This visual search process can indeed be time-consuming and was well validated in the semi-structured interviews from the females following the experiment.

It was also found that a significant interaction existed between the information layout and display mode regarding the degree of willingness to use. More specifically, in the light mode, users (both males and females) found the list-style user interface more desirable. In contrast, users (both males and females) found the matrix-style user interface more desirable in the dark mode. Therefore, in the matrix-style user interface, the user's (both males and females) targeted visual search process is influenced by the background of the images, resulting in a higher cognitive load in terms of quickly identifying and comparing product information, which is consistent with earlier research findings that the low contrast situation results in increased reading time and recognition by the user [90]. In the case of dark mode (i.e., white text on a black background), the contrast between the image and the background is very high, allowing the user to quickly distinguish the position of the image from the product information, thus increasing the overall user-friendliness and user perception of ease of use, and therefore increasing the level of willingness to use. In addition, in the context of light mode (i.e., black text on a white background), the product information in the list-style user interface appears slimmer [53], which increases the cognitive load on the user's recognition to a certain extent. In summary. The results generated from our experiment revealing some significant interaction effects between display mode and gender in terms of task performance and SUS. In addition, there existed some significant interaction effects between information layout and gender pertinent to the degree of effortlessness, the degree of helpfulness, and the degree of willingness to use. We also found a significant interaction effect between information layout and gender. However, there existed no significant interaction effect among information layout, display mode, and gender. Therefore, the above-mentioned interaction results answer Q4.

C. LIMITATIONS AND FUTURE WORK

Although this study provides practical implications for research and practice, it has some limitations. First, the majority of participants in this study were college students. Although college students make up many mobile shopping app users, this group may only represent certain types of consumers. Future studies should include participants with more diverse backgrounds to obtain generalizability. Second, it is well known that consumers' shopping experience in mobile apps is also influenced by many factors, such as age, culture, price, occupation, and featured brand preferences.

Past research has confirmed that cultural differences are also a significant factor affecting the user experience of online shopping mobile apps [101]. With the increasing aging of the population in recent years, many seniors are also increasingly relying on mobile apps to solve their daily problems [29]. How to enhance the online shopping experience of seniors through design means is also a topic worthy of in-depth exploration. The latest research on consumers also found that 360-degree virtual technology [102] and augmented reality (AR) technology [103] are gaining widespread acceptance in the e-tailing industry. All these factors also deserve further discussions in the future. Third, the visual search for product information can help consumers quickly find product information and make shopping decisions, yet consumers' habits of browsing product information in mobile shopping are highly variable. These factors also deserve further exploration in the future.

VII. CONCLUSION

This study examined the combined effects of information layout, display mode, and gender on participants' task performance and subjective evaluations. It shows that the

information layout, display mode and gender of the mobile shopping application interface significantly impact the user experience, with practical and theoretical implications. Based on the experimental results, more concrete evidence is provided for the visual design of mobile shopping app interfaces and the differential characteristics of visual searches by gender. Several specific design recommendations for the user interface contributed by this study are listed as follows:

1) The matrix-style is superior when participants are searching for information location and information comparison.
2) When searching for information location, there is an interaction effect between the display mode and gender in visual search performance, with females performing faster in light mode and males performing faster in dark mode.
3) Regarding the subjective evaluations of the degrees of effortlessness, helpfulness, and willingness to use, participants all gave positive ratings for all the aspects of subjective evaluations. It was found that a significant interaction existed between information layout and gender, that is, females were rated higher than males for the list-style user interface; however, males were rated higher than females for the matrix-style user interface.
4) There is an interaction between information layout and display mode in terms of increasing users' willingness to use. That is, in light mode, users (both males and females) find the list-style more desirable. In contrast, in dark mode, users (both males and females) find the matrix-style more desirable.
5) In terms of gender differences in the task performance of shopping apps, female participants took more time to complete the assigned task compared to male participants.

This study confirms that layout and background display mode are important visual factors affecting user experience in mobile shopping applications, which provides reference points for mobile shopping application interface design developers:

1) For the presentation of product information, a matrix layout is recommended to enhance the visual search performance of users.
2) Using negatively polarized background display mode in the matrix layout is recommended to improve the user's willingness to use it.

In addition, this study also found that gender difference is a significant factor affecting the user experience of mobile shopping applications. With the increasing variety of online products, more and more product categories exist for different genders. Therefore, the interface design should be reasonably humanized according to the gender difference of users. For male consumers, adopting a positive polarity background pattern and a matrix layout is recommended. On the contrary, for female consumers, it is recommended to use the negative polarity background mode. At the same time, the layout uses a list layout. In practical application, it is suggested that operators can reasonably match the registered users according to their gender, which will be a practical guide to improving user experience.

The increase in the amount of time that consumers spend browsing the product pages of shopping apps may lead to an increase in their purchase rate, but recent studies have found that this effect is non-linear [21]. A good visual design of the interface should help improve the efficiency of the user's visual search, that is, users can find the products they intend to purchase quickly and easily. This study's findings can contribute to the research on the user interface design of mobile shopping apps. It is also recommended that designers may consider adding more visual design variables to help expand the mobile shopping app interface research, such as images, colors, animations, supporting visual elements, and so on. These visual design features of the user interface are worth further investigation.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

CONSENT TO PARTICIPATE

Informed consent was obtained from all participants.

REFERENCES

[1] L. Huang, X. Lu, and S. Ba, "An empirical study of the cross-channel effects between web and mobile shopping channels," *Inf. Manag.*, vol. 53, no. 2, pp. 265–278, Mar. 2016, doi: 10.1016/j.im.2015.10.006.
[2] H. R. Marriott, M. D. Williams, and Y. K. Dwivedi, "What do we know about consumer m-shopping behaviour?" *Int. J. Retail Distrib. Manag.*, vol. 45, no. 6, pp. 568–586, Jun. 2017, doi: 10.1108/IJRDM-09-2016-0164.
[3] S. Chevalier. (Dec. 21, 2022). *M-Commerce Share of Total Retail Online Sales Worldwide 2022, by Region*. [Online]. Available: https://www.statista.com/statistics/806323/mobilE-commerce-share-total-worldwide-region/
[4] Y. H. Ma. (Nov. 18, 2022). *E-commerce Market GMV in China 2011–2021*. [Online]. Available: https://www.statista.com/statistics/1129543/china-E-commerce-market-gross-merchandise-volume/
[5] X. Li, X. Zhao, W. Xu, and W. Pu, "Measuring ease of use of mobile applications in E-commerce retailing from the perspective of consumer online shopping behaviour patterns," *J. Retailing Consum. Services*, vol. 55, Jul. 2020, Art. no. 102093, doi: 10.1016/j.jretconser.2020.102093.
[6] G. M. Guan, M. Cha, Y. Wang, Y. Li, and J. Sun, "From anticipation to action: Data reveal mobile shopping patterns during a yearly mega sale event in China," *IEEE Trans. Knowl. Data Eng.*, vol. 34, no. 4, pp. 1775–1787, Apr. 2020, doi: 10.1109/TKDE.2020.3001558.
[7] P. Rodríguez-Torrico, R. S. J. Cabezudo, and S. San-Martín, "Tell me what they are like and I will tell you where they buy. An analysis of omnichannel consumer behavior," *Comput. Hum. Behav.*, vol. 68, pp. 465–471, Mar. 2017, doi: 10.1016/j.chb.2016.11.064.
[8] K. Yang, "Determinants of U.S. Consumer mobile shopping services adoption: Implications for designing mobile shopping services," *J. Consum. Marketing*, vol. 27, no. 3, pp. 262–270, May 2010, doi: 10.1108/07363761011038338.
[9] P. Francis, "Mobile app development process," Dec. 2017. [Online]. Available: http://thebhwgroup.com/blog/mobile-app-development-process
[10] J. S. Kumar, "The psychology of colour influences consumers' buying behaviour—A diagnostic study," *Ushus-J. Bus. Manag.*, vol. 16, no. 4, pp. 1–13, Oct. 2017, doi: 10.12725/ujbm.41.1.

[11] C.-M. Chiu, E. T. G. Wang, Y.-H. Fang, and H.-Y. Huang, "Understanding customers' repeat purchase intentions in B2C E-commerce: The roles of utilitarian value, hedonic value and perceived risk," *Inf. Syst. J.*, vol. 24, no. 1, pp. 85–114, Jan. 2014, doi: 10.1111/j.1365-2575.2012.00407.x.

[12] P. K. Chopdar, J. Paul, N. Korfiatis, and M. D. Lytras, "Examining the role of consumer impulsiveness in multiple app usage behavior among mobile shoppers," *J. Bus. Res.*, vol. 140, pp. 657–669, Feb. 2022, doi: 10.1016/j.jbusres.2021.11.031.

[13] B. Ganguly, S. B. Dash, D. Cyr, and M. Head, "The effects of website design on purchase intention in online shopping: The mediating role of trust and the moderating role of culture," *Int. J. Electron. Bus.*, vol. 8, nos. 4–5, Sep. 2010, pp. 302–330, doi: 10.1504/IJEB.2010.035289.

[14] P. Turumugon, A. Baharum, R. Hanapi, N. Kamarudin, E. A. Rahim, and M. Omar, "Users' mental model pattern for user interface design of mobile shopping apps," *Adv. Sci. Lett.*, vol. 24, no. 2, pp. 1158–1162, Feb. 2018, doi: 10.1166/asl.2018.10707.

[15] L. Wang, Z. Wang, X. Wang, and Y. Zhao, "Explaining consumer implementation intentions in mobile shopping with SEM and fsQCA: Roles of visual and technical perceptions," *Electron. Commerce Res. Appl.*, vol. 49, Sep. 2021, Art. no. 101080, doi: 10.1016/j.elerap.2021.101080.

[16] Y. Yang, J. Gao, and J. Qiu, "Design of wechat applet shopping system based on personalized recommendation," in *Proc. 3rd Asia–Pacific Conf. Image Process., Electron. Comput.*, Apr. 2022, pp. 343–348, doi: 10.1145/3544109.3544172.

[17] X. Lin, M. Featherman, S. L. Brooks, and N. Hajli, "Exploring gender differences in online consumer purchase decision making: An online product presentation perspective," *Inf. Syst. Frontiers*, vol. 21, no. 5, pp. 1187–1201, Oct. 2019, doi: 10.1007/s10796-018-9831-1.

[18] H. Yang and H. Lee, "Exploring user acceptance of streaming media devices: An extended perspective of flow theory," *Inf. Syst. e-Bus. Manag.*, vol. 16, no. 1, pp. 1–27, Feb. 2018, doi: 10.1007/s10257-017-0339-x.

[19] Y. Jung, B. Perez-Mira, and S. Wiley-Patton, "Consumer adoption of mobile TV: Examining psychological flow and media content," *Comput. Hum. Behav.*, vol. 25, no. 1, pp. 123–129, Jan. 2009, doi: 10.1016/j.chb.2008.07.011.

[20] R. Reber, P. Winkielman, and N. Schwarz, "Effects of perceptual fluency on affective judgments," *Psychol. Sci.*, vol. 9, no. 1, pp. 45–48, Jan. 1998, doi: 10.1111/1467-9280.00008.

[21] X. Zhang, R. Cui, and O. Yao, "The version effect of apps and operating systems in mobile commerce," *Prod. Oper. Manag.*, vol. 32, no. 2, pp. 637–654, Feb. 2023, doi: 10.1111/poms.13891.

[22] J. Guo, H. Hao, M. Wang, and Z. Liu, "An empirical study on consumers' willingness to buy agricultural products online and its influencing factors," *J. Cleaner Prod.*, vol. 336, Feb. 2022, Art. no. 130403, doi: 10.1016/j.jclepro.2022.130403.

[23] B. Edvardsson, "Service quality: Beyond cognitive assessment," *Manag. Service Qual., Int. J.*, vol. 15, no. 2, pp. 127–131, Apr. 2005, doi: 10.1108/09604520510585316.

[24] N. Crilly, J. Moultrie, and P. J. Clarkson, "Seeing things: Consumer response to the visual domain in product design," *Des. Stud.*, vol. 25, no. 6, pp. 547–577, Nov. 2004, doi: 10.1016/j.destud.2004.03.001.

[25] C. C. Hsu, "Comparison of gender differences in young people's blog interface preferences and designs," *Displays*, vol. 33, no. 3, pp. 119–128, Jul. 2012, doi: 10.1016/j.displa.2012.04.001.

[26] Y. Liu, Y. Li, H. Zhang, and W. Huang, "Gender differences in information quality of virtual communities: A study from an expectation-perception perspective," *Personality Individual Differences*, vol. 104, pp. 224–229, Jan. 2017, doi: 10.1016/j.paid.2016.08.011.

[27] C. Wang, H. Qu, and M. K. Hsu, "Toward an integrated model of tourist expectation formation and gender difference," *Tourism Manag.*, vol. 54, pp. 58–71, Jun. 2016, doi: 10.1016/j.tourman.2015.10.009.

[28] M. C. Anchahua, L. V. Garnique, and J. A. Tarazona, "User experience maturity model for ecommerce websites," in *Proc. Congreso Internacional de Innovación y Tendencias en Ingeniería (CONIITI)*, 2018, pp. 1–6, doi: 10.1109/CONIITI.2018.8587080.

[29] S. Zhu, X. Wang, W. Li, and Y. Dong, "Impact of the density of the elements belonging to the quick access area of a smartphone app on the visual search efficiency and user experience of elderly people," *Displays*, vol. 76, Jan. 2023, Art. no. 102363, doi: 10.1016/j.displa.2022.102363.

[30] J. V. Chen, D. C. Yen, W. Pornpriphet, and A. E. Widjaja, "E-commerce web site loyalty: A cross cultural comparison," *Inf. Syst. Frontiers*, vol. 17, no. 6, pp. 1283–1299, Dec. 2015, doi: 10.1007/s10796-014-9499-0.

[31] M. Bar, M. Neta, and H. Linz, "Very first impressions," *Emotion*, vol. 6, no. 2, pp. 269–278, 2006, doi: 10.1037/1528-3542.6.2.269.

[32] M. A. Recarte and L. M. Nunes, "Mental workload while driving: Effects on visual search, discrimination, and decision making.," *J. Exp. Psychol., Appl.*, vol. 9, no. 2, pp. 119–137, 2003, doi: 10.1037/1076-898X.9.2.119.

[33] A. Vance, C. Elie-Dit-Cosaque, and D. W. Straub, "Examining trust in information technology artifacts: The effects of system quality and culture," *J. Manag. Inf. Syst.*, vol. 24, no. 4, pp. 73–100, Apr. 2008, doi: 10.2753/MIS0742-1222240403.

[34] D. J. Wells, S. J. Valacich, and J. T. Hess, "What signal are you sending? How website quality influences perceptions of product quality and purchase intentions," *MIS Quart., Manag. Inf. Syst.*, vol. 35, no. 2, pp. 373–396, 2011, doi: 10.2307/23044048.

[35] V. Patel, K. Das, R. Chatterjee, and Y. Shukla, "Does the interface quality of mobile shopping apps affect purchase intention? An empirical study," *Australas. Marketing J.*, vol. 17, no. 6, pp. 1283–1299, 2015, doi: 10.1016/j.ausmj.2020.08.004.

[36] A. Vance, C. Elie-Dit-Cosaque, and D. W. Straub, "Examining trust in information technology artifacts: The effects of system quality and culture," *J. Manag. Inf. Syst.*, vol. 24, no. 4, pp. 73–100, Apr. 2008, doi: 10.2753/MIS0742-1222240403.

[37] J. S. Jia, B. Shiv, and S. Rao, "The product-agnosia effect: How more visual impressions affect product distinctiveness in comparative choice," *J. Consum. Res.*, vol. 41, no. 2, pp. 342–360, Aug. 2014, doi: 10.1086/676600.

[38] H. C. Hsieh, and N. C. Cheng, "A study on shopping websites payeasy for female consumers in Taiwan," in *Proc. 4th Int. Conf. Design, User Exper., Usability, Users Interact.*, vol. 9187, Jul. 2015, pp. 206–213, doi: 10.1007/978-3-319-20898-5_20.

[39] R. Pieters, M. Wedel, and R. Batra, "The stopping power of advertising: Measures and effects of visual complexity," *J. Marketing*, vol. 74, no. 5, pp. 48–60, 2010, doi: 10.1509/jmkg.74.5.048.

[40] L. Deng and G. Wang, "Quantitative evaluation of visual aesthetics of human-machine interaction interface layout," *Comput. Intell. Neurosci.*, vol. 2020, Mar. 2020, Art. no. 9815937, doi: 10.1155/2020/9815937.

[41] J. H. Lim, T. Ryu, and Y. Kim, "Effects of visual stimulus on response behavior of control-on-display interface," *Int. J. Hum.-Comput. Interact.*, vol. 30, no. 4, pp. 291–302, Apr. 2014, doi: 10.1080/10447318.2013.858459.

[42] T. Saari, N. Ravaja, J. Laarni, M. Turpeinen, and K. Kallinen, "Psychologically targeted persuasive advertising and product information in E-commerce," in *Proc. 6th Int. Conf. Electron. Commerce (ICEC)*, 2004, pp. 245–254, doi: 10.1145/1052220.1052252.

[43] L. Deng, G. Wang, and S. Yu, "Layout design of human-machine interaction interface of cabin based on cognitive ergonomics and GA-ACA," *Comput. Intell. Neurosci.*, vol. 2016, Jan. 2016, Art. no. 1032139, doi: 10.1155/2016/1032139.

[44] M. Yi, D. Bao, and Y. Mo, "Exploring the role of visual design in digital public health safety education," *Int. J. Environ. Res. Public Health*, vol. 18, no. 15, p. 7965, Jul. 2021, doi: 10.3390/ijerph18157965.

[45] J. Wu and S. Song, "Older Adults' online shopping continuance intentions: Applying the technology acceptance model and the theory of planned behavior," *Int. J. Hum.-Comput. Interact.*, vol. 37, no. 10, pp. 938–948, Jun. 2021, doi: 10.1080/10447318.2020.1861419.

[46] F. Tinelli, A. Guzzetta, C. Bertini, D. Ricci, E. Mercuri, E. Ladavas, and G. Cioni, "Greater sparing of visual search abilities in children after congenital rather than acquired focal brain damage," *Neurorehabilitation Neural Repair*, vol. 25, no. 8, pp. 721–728, Oct. 2011, doi: 10.1177/1545968311407780.

[47] A. Nissen, "Exploring the neural correlates of visual aesthetics on websites," in *Information Systems and Neuroscience*, vol. 32. Vienna, Austria: Springer, 2020, pp. 211–220, doi: 10.1007/978-3-030-28144-1_23.

[48] S. D. Starke and C. Baber, "The effect of four user interface concepts on visual scan pattern similarity and information foraging in a complex decision making task," *Appl. Ergonom.*, vol. 70, pp. 6–17, Jul. 2018, doi: 10.1016/j.apergo.2018.01.010.

[49] B. E. Kahn, "Using visual design to improve customer perceptions of online assortments," *J. Retailing*, vol. 93, no. 1, pp. 29–42, Mar. 2017, doi: 10.1016/j.jretai.2016.11.004.

[50] J. Grobelny, W. Karwowski, and C. Drury, "Usability of graphical icons in the design of human-computer interfaces," *Int. J. Hum.-Comput. Interact.*, vol. 18, no. 2, pp. 167–182, 2005, doi: 10.1207/s15327590ijhc1802_3.
[51] L. Deng, Z. Zhang, F. Zhou, and R. Liu, "Effects of app icon border form and interface background color saturation on user visual experience and search performance," *Adv. Multimedia*, vol. 2022, pp. 1–12, Jul. 2022, doi: 10.1155/2022/1166656.
[52] A. A. Iriarte, G. L. Erle, and M. M. Etxabe, "User preferences and associations with light or dark interfaces," in *Proc. 25th Int. Congr. Project Manag. Eng.*, Alcoi, Spain, Jul. 2021, pp. 1893–1906.
[53] H.-Y. Lin and C.-H. Chen, "The effects of display size and text-background color type on the Chinese digital reading performance of Taiwan college students," *J. Sci. Des.*, vol. 5, no. 2, pp. 2-101–2-110, Sep. 2021, doi: 10.11247/jsd.5.2_2_101.
[54] J. Nielsen. (2001). *113 Design Guidelines for Homepage Usability*. [Online]. Available: http://www.useit.com/homepageusability/guidelines.html.
[55] E. Lunn. (2020). *What is Dark Mode- and Should You Be Using it*. [Online]. Available: https://www.forbes.com/uk/advisor/mobile-phones/what-is-dark-mode-and-should-yoube-using-it/
[56] F. S. Santos, L. H. D. Santos, P. C. Saldan, F. C. S. Santos, A. M. Leite, and D. F. D. Mello, "Breastfeeding and acute diarrhea among children enrolled in the family health strategy," *Texto Contexto-Enfermagem*, vol. 25, no. 1, pp. 1–8, 2016, doi: 10.1590/0104-070720160000220015.
[57] J. Dobres, N. Chahine, B. Reimer, D. Gould, B. Mehler, and J. F. Coughlin, "Utilising psychophysical techniques to investigate the effects of age, typeface design, size and display polarity on glance legibility," *Ergonomics*, vol. 59, no. 10, pp. 1377–1391, Mar. 2016, doi: 10.1080/00140139.2015.1137637.
[58] C. Piepenbrock, S. Mayr, and A. Buchner, "Smaller pupil size and better proofreading performance with positive than with negative polarity displays," *Ergonomics*, vol. 57, no. 11, pp. 1670–1677, Aug. 2014, doi: 10.1080/00140139.2014.948496.
[59] S. M. Luria, D. F. Neri, and C. Schlichting, "Performance and preference with various VDT phosphors," *Appl. Ergonom.*, vol. 20, no. 1, pp. 33–38, Mar. 1989, doi: 10.1016/0003-6870(89)90006-9.
[60] H. L. Snyder, J. J. Decker, C. J. Lloyd, and C. Dye, "Effect of image polarity on VDT task performance," in *Proc. Hum. Factors Soc. Annu. Meeting*, 1990, vol. 34, no. 19, pp. 1447–1451, doi: 10.1177/154193129003401901.
[61] A.-H. Wang, C.-C. Tseng, and S.-C. Jeng, "Effects of bending curvature and text/background color-combinations of e-paper on subjects' visual performance and subjective preferences under various ambient illuminance conditions," *Displays*, vol. 28, nos. 4–5, pp. 161–166, Dec. 2007, doi: 10.1016/j.displa.2007.06.003.
[62] S. J. Simon, "The impact of culture and gender on web sites," *ACM SIGMIS Database, Database Adv. Inf. Syst.*, vol. 32, no. 1, pp. 18–37, Dec. 2000, doi: 10.1145/506740.506744.
[63] F. N. Dempster, "The spacing effect: A case study in the failure to apply the results of psychological research," *Amer. Psychol.*, vol. 43, no. 8, pp. 627–634, Aug. 1988, doi: 10.1037/0003-066X.43.8.627.
[64] B. Burstein, L. Bank, and L. F. Jarvik, "Sex differences in cognitive functioning: Evidence, determinants, implications," *Hum. Develop.*, vol. 23, no. 5, pp. 289–313, 1980, doi: 10.1159/000272593.
[65] J. Meyers-Levy and D. Maheswaran, "Exploring differences in males' and females' processing strategies," *J. Consum. Res.*, vol. 18, no. 1, pp. 63–70, 1991, doi: 10.1086/209241.
[66] M.-O. Richard, J.-C. Chebat, Z. Yang, and S. Putrevu, "A proposed model of online consumer behavior: Assessing the role of gender," *J. Bus. Res.*, vol. 63, nos. 9–10, pp. 926–934, Sep. 2010, doi: 10.1016/j.jbusres.2009.02.027.
[67] K. Oyibo, Y. S. Ali, and J. Vassileva, "Gender difference in the credibility perception of mobile websites: A mixed method approach," in *Proc. Conf. User Modeling Adaptation Personalization*, Jul. 2016, pp. 75–84, doi: 10.1145/2930238.2930245.
[68] T. Suh, R. T. Wilson, and S. On, "Gender difference in visual attention to digital content of place-based advertising: A data-driven scientific approach," *Electron. Commerce Res.*, vol. 23, no. 2, pp. 877–897, Jun. 2023, doi: 10.1007/s10660-021-09494-9.
[69] J. Levy, "Lateral differences in the human brain in cognition and behavioral control," in *Cerebral Correlates of Conscious Experience*, P. Buser and A. Rougeul-Buser, Eds., New York, NY, USA: North Holland Publishing, 1978, pp. 320–342.
[70] S. Kurniawan and P. Zaphiris, Eds., *Advances in Universal Web Design and Evaluation: Research, Trends and Opportunities: Research, Trends and Opportunities*. Hershey, PA, USA: IGI Global, 2006.
[71] H.-S. Doong, H.-C. Wang, and G. R. Foxall, "An investigation of consumers' webstore shopping: A view of click-and-mortar company," *Int. J. Inf. Manag.*, vol. 31, no. 3, pp. 210–216, Jun. 2011, doi: 10.1016/j.ijinfomgt.2010.06.006.
[72] N. Bevan, "What is the difference between the purpose of usability and user experience evaluation methods," in *Proc. Workshop UXEM*, 2009, vol. 9, no. 1, pp. 1–4.
[73] L. Cai, X. He, Y. Dai, and K. Zhu, "Research on B2B2C E-commerce website design based on user experience," *J. Phys., Conf. Ser.*, vol. 1087, Sep. 2018, Art. no. 062043, doi: 10.1088/1742-6596/1087/6/062043.
[74] J. Bluhm and R. Berchtenbreiter, "User experience improvement for online travel agencies through eye-tracking: The onlineweg.de case study," in *Eye Tracking in Tourism* (Tourism on the Verge). Cham, Switzerland: Springer, 2020, pp. 113–135, doi: 10.1007/978-3-030-49709-5_9.
[75] F. Laricchia. (Feb. 21, 2023). *Quarterly Smartphone Market Share Worldwide by Vendor 2009–2022*. [Online]. Available: https://www.statista.com/statistics/271496/global-market-share-held-by-smartphone-vendors-since-4th-quarter-2009/
[76] T. Broekhuizen and E. K. R. E. Huizingh, "Online purchase determinants: Is their effect moderated by direct experience?" *Manag. Res. News*, vol. 32, no. 5, pp. 440–457, Mar. 2009, doi: 10.1108/01409170910952949.
[77] B. Kesari and S. Atulkar, "Satisfaction of mall shoppers: A study on perceived utilitarian and hedonic shopping values," *J. Retailing Consum. Services*, vol. 31, pp. 22–31, Jul. 2016, doi: 10.1016/j.jretconser.2016.03.005.
[78] F. D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," *MIS Quart.*, vol. 13, no. 3, pp. 319–340, 1989, doi: 10.2307/249008.
[79] X. Tong, "A cross-national investigation of an extended technology acceptance model in the online shopping context," *Int. J. Retail Distrib. Manag.*, vol. 38, no. 10, pp. 742–759, Sep. 2010, doi: 10.1108/09590551011076524.
[80] G. A. García, D. R. Gonzales-Miranda, O. Gallo, and J. P. Roman-Calderon, "Employee involvement and job satisfaction: A tale of the millennial generation," *Employee Relations, Int. J.*, vol. 41, no. 3, pp. 374–388, Apr. 2019, doi: 10.1108/ER-04-2018-0100.
[81] S. Ram, "Meeting millennials where they shop: Shaping the future of shopping malls," Nov. 2017, p. 15. [Online]. Available: http://www.mckinsey.com/industries/capital-projects-andinfrastructure/our-insights/meeting-millennials-where-they-shop-shaping-the-future-of-shopping-malls
[82] A. E. Sampoerno and N. A. Haryono, "Pengaruh financial literacy, income, hedonism lifestyle, self-control, dan risk tolerance terhadap financial management behavior pada generasi milenial Kota surabaya," *Jurnal Ilmu Manajemen*, vol. 9, no. 3, pp. 1002–1014, Jul. 2021.
[83] S. Feng, W. Zheng, and H. Liu, "Demo abstract: Unobtrusive real-time shopping assistance in retail stores using smart glasses," in *Proc. 12th Annu. IEEE Int. Conf. Sens., Commun., Netw. (SECON)*, Jun. 2015, pp. 181–183, doi: 10.1109/SAHCN.2015.7338313.
[84] M. F. Diallo, "What drives store brand purchasesduring crisis periods? Evidence from panel data in four product categories," *Int. J. Retail Distrib. Manag.*, vol. 44, no. 3, pp. 301–319, 2016, doi: 10.1108/IJRDM-02-2015-0020.
[85] H.-J. Chen, "What drives consumers' mobile shopping? 4Ps or shopping preferences?" *Asia Pacific J. Marketing Logistics*, vol. 30, no. 4, pp. 797–815, Nov. 2018, doi: 10.1108/APJML-08-2017-0167.
[86] A. Bangor, P. T. Kortum, and J. T. Miller, "An empirical evaluation of the system usability scale," *Int. J. Hum.-Comput. Interact.*, vol. 24, no. 6, pp. 574–594, 2008, doi: 10.1080/10447310802205776.
[87] A. N. Tuch, E. E. Presslaber, M. Stöcklin, K. Opwis, and J. A. Bargas-Avila, "The role of visual complexity and prototypicality regarding first impression of websites: Working towards understanding aesthetic judgments," *Int. J. Hum. Comput. Stud.*, vol. 70, no. 11, pp. 794–811, 2012, doi: 10.1016/j.ijhcs.2012.06.003.
[88] J. Yuan, Y. He, Z. Qinglin, A. Chen, and H. Li, "Gender differences in behavioral inhibitory control: ERP evidence from a two-choice oddball task," *Psychophysiology*, vol. 45, no. 6, pp. 986–993, Nov. 2008, doi: 10.1111/j.1469-8986.2008.00693.x.
[89] Y. M. Hwang and K. C. Lee, "Using an eye-tracking approach to explore gender differences in visual attention and shopping attitudes in an online shopping environment," *Int. J. Hum.-Comput. Interact.*, vol. 34, no. 1, pp. 15–24, Jan. 2018, doi: 10.1080/10447318.2017.1314611.

[90] G. E. Legge and J. S. Mansfield, "The visual span for reading decreases in peripheral vision," *Investigative Ophthalmol. Vis. Sci.*, vol. 38, no. 4, p. S223, Dec. 1997.
[91] S. Shrestha, K. Lenz, J. Owens, and B. Chaparro, "'F' pattern scanning of text and images in web pages," in *Proc. Hum. Factors Ergonom. Soc. Annu. Meeting*, 2007, vol. 51, no. 18, pp. 1200–1204, doi: 10.1177/154193120705101831.
[92] Z. Huang and J. Mou, "Gender differences in user perception of usability and performance of online travel agency websites," *Technol. Soc.*, vol. 66, Aug. 2021, Art. no. 101671, doi: 10.1016/j.techsoc.2021.101671.
[93] J. C. Yang and S. Y. Chen, "Effects of gender differences and spatial abilities within a digital pentominoes game," *Comput. Educ.*, vol. 55, no. 3, pp. 1220–1233, Nov. 2010, doi: 10.1016/j.compedu.2010.05.019.
[94] İ. Tonbuloğlu, "Using eye tracking method and video record in usability test of educational softwares and gender effects," *Proc.-Social Behav. Sci.*, vol. 103, pp. 1288–1290, Nov. 2013, doi: 10.1016/j.sbspro.2013.10.458.
[95] A. M. Kimbrough, R. E. Guadagno, N. L. Muscanell, and J. Dill, "Gender differences in mediated communication: Women connect more than do men," *Comput. Hum. Behav.*, vol. 29, no. 3, pp. 896–900, May 2013, doi: 10.1016/j.chb.2012.12.005.
[96] J. Pfeiffer, J. Prosiegel, M. Meißner, and T. Pfeiffer, "Identifying goal-oriented and explorative information search patterns," in *Proc. Gmunden Retreat NeuroIS*, 2014, pp. 23–25.
[97] M. Holbrook, "Aims, concepts, and methods for the representation of individual differences in esthetic responses to design features," *J. Consum. Res.*, vol. 13, no. 3, pp. 337–347, 1986, doi: 10.1086/209073.
[98] N. Li, G. Kirkup, and B. Hodgson, "Cross-cultural comparison of women students' attitudes toward the Internet and usage: China and the United Kingdom," *CyberPsychol. Behav.*, vol. 4, no. 3, pp. 415–426, Jun. 2001, doi: 10.1089/109493101300210321.
[99] D. Cyr and C. Bonanni, "Gender and website design in e-business," *Int. J. Electron. Bus.*, vol. 3, no. 6, pp. 565–582, Dec. 2005, doi: 10.1504/IJEB.2005.008536.
[100] R. O. Deaner, S. V. Shepherd, and M. L. Platt, "Familiarity accentuates gaze cuing in women but not men," *Biol. Lett.*, vol. 3, no. 1, pp. 65–68, Feb. 2007, doi: 10.1098/rsbl.2006.0564.
[101] P. S. Amalkrishna, S. Pratap, and J. Kumar, "Observing the influence of cultural differences within India on user experience of an E-commerce application: An experimental investigation," in *Proc. 13th Int. Conf. Cross-Cultural Design Exper. Product Design Across Cultures CCD*, Jul. 2021, pp. 475–485, doi: 10.1007/978-3-030-77074-7_36.
[102] N. Ruusunen, H. Hallikainen, and T. Laukkanen, "Does imagination compensate for the need for touch in 360-virtual shopping?" *Int. J. Inf. Manag.*, vol. 70, Jun. 2023, Art. no. 102622, doi: 10.1016/j.ijinfomgt.2023.102622.
[103] P. Jayaswal and B. Parida, "The role of augmented reality in redefining e-tailing: A review and research agenda," *J. Bus. Res.*, vol. 160, May 2023, Art. no. 113765, doi: 10.1016/j.jbusres.2023.113765.

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