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Research Article

A Fuzzy Comprehensive Evaluation Study on the Performance of Age-Friendly Digital Retrofit Based on User Experience: Take the "Elder Mode" App as an Example

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To study the digital needs, activities, and experiences of elderly users, evaluate the performance of age-friendly digital retrofit, and provide a path to bridge the digital divide among elderly users. Based on the user experience perspective, the age-friendly evaluation model of the "elder mode" APP was constructed, the index weights were determined based on the entropy weight method, and WeChat, Alipay, ZOA, and ZARA of the "elder mode" were selected as the research objects. We use questionnaires and in-depth interviews to collect user data and use a fuzzy comprehensive evaluation method for empirical evaluation. The overall experience of elderly users on the four APPs is at the upper level of "generally satisfied," among which the age-friendly level of "visual experience" and "behavioral experience" is high, while the level of "interaction experience" and "value experience" needs to be improved. In particular, attention needs to be paid to the retrofit of the fault-tolerant mechanism, toughness, and error correction of digital products. The paper proposes countermeasures in terms of enhancing the compatibility of interface elements of digital products, optimizing embedded interaction procedures, improving human-computer interaction options, enhancing fault tolerance of operations, and improving age-friendly continuity and thoroughness.

1. Introduction

At present, social digitalization and population aging in China is deepening increasingly with a trend of the same frequency resonance. However, affected by the market, technology, and the physiological characteristics of the elderly, the digital integration level of elderly users are low. There is a large gap between elderly users and young people in terms of digital ownership, digital application ability, and digital experience, so elderly users are often excluded from the digital society, trapped in "digital panic" and reduced to "digital refugees." The phenomenon of "digital exclusion" seriously deprives the digital rights of the elderly, which leads to a serious problem of the "silver digital divide." In response to the digital governance challenges in the era of digitalization and aging overlap, the General Office of the State Council, the Ministry of Industry and Information Technology, and other relevant departments have successively issued an age-friendly digital retrofit policy. Meanwhile, China's digitally advanced regions, such as Beijing, Shanghai, and Zhejiang Province, are also accelerating the age-friendly digital retrofit process.

The age-friendly digital retrofit is a systematic project which not only involves the interdisciplinary fields of information science, gerontology, industrial design, psychology, pedagogy, communication, and so on but also requires the extensive collaborative participation of all sectors of politics, industry, university, and research. At present, the research on the age-friendly digital retrofit is not in-depth enough, especially the research on its performance, and the related indexes, directions, and paths need to be clarified. To this end, this paper selects mobile applications (including social, financial, medical, and governmental) commonly used by the elderly as research objects and evaluates their age-friendly retrofit performance based on the user experience perspective by jointly applying the entropy weight method and fuzzy comprehensive evaluation method. The main innovation points are as follows: (1) from the dimensions of "visual experience," "interactive experience," "behavioral experience," and "value experience," a set of general performance evaluation systems of age-friendly retrofit for "elder mode" APP is constructed. (2) Based on the fuzzy comprehensive evaluation method, the digital experience of elderly users is measured from a quantitative perspective. On the above basis, further combined with the results of in-depth interviews with elderly users, a more comprehensive measurement of the age-friendly retrofit performance of the "elderly mode" APP is achieved. The above research results provide a theoretical and practical basis for deepening the cognition of age-friendly digital retrofit, for government departments to formulate policies to bridge the digital gap for the elderly, and for enterprises to develop more perfect digital products for the elderly.

2. Theoretical Background

2.1. User Experience and Its Development in Digital Field. The concept of user experience (UE/UX) was introduced and promoted by designer Donald Norman in the 1990s [1]. As research progresses, concepts, frameworks, and systems on user experience are developed. Among them, the definition of user experience by the International Organization for Standardization (ISO) is generally accepted as "the sum of psychological, physical, and emotional responses or outcomes of users to the product, system, or service they are using or expect to use" [2]. In the context of the digital economy, the digital ecosystem integrated with digital culture, digital service, and digital thinking is gradually formed, and user experience research for the digital domain is beginning to emerge. Mahlke defines the user's digital experience as the user's perception of digital products in two categories: technical and nontechnical factors. Technical factors include system functionality, system usefulness, and system ease of use. Nontechnical factors include psychological enjoyment, visual aesthetics, and content attractiveness [3, 4]. Research on digital behavior and the digital experience of elderly users has also begun to emerge. For example, Mannheim et al. found that there seems to be a mismatch between the developed DT and the DT actually used by elderly users, and based on the "interventionist logic," it is pointed out that the digital needs, digital expectations, and digital experience of the elderly should be included in the research, design and application phases of digital products [5]. Lee and Coughlin propose the concept of age-friendly digital retrofit [6].

2.2. Influencing Factors of User Digital Experience. On the one hand, it is theoretical research. The technology acceptance model (TAM), proposed by Davis in 1989, investigates the influences that contribute to users' adoption, continued use, and experience of using new technologies by incorporating two parameters, perceived usefulness and perceived ease of use [7]. Subsequent expansion models based on TAM, including TAM2, TAM3, and STAM, have incorporated more diverse influencing factors such as age, education status, income level, gender, and technology experience into the study of user experience [8, 9]. The UTAUT (unified theory of acceptance and use of technology) identifies higher-order determinants (i.e., performance expectations, effort expectations, social influence, and convenience) as well as moderators (i.e., gender, age, voluntariness, and experience) that influence the information user experience [10]. On the other hand, it is empirical research. Researchers have empirically studied user characteristics as the main influencing factor of users' digital experience. Empirical results show that: users' age is negatively related to the duration and intensity of digital product use [11]; users' education is positively related to the diversity of digital product use [12]; users' higher mobile and crystallized intelligence corresponds to a wider range of digital technology adoption behaviors [9]; users' reduced cognitive abilities (e.g., memory, attention, and processing speed) inhibit the frequency of their digital products and, in turn, affect the user experience [10].

Recent research pays attention to the factors that affect the digital experience of elderly users. Wang et al. found that help from family members, socio-cultural, personality traits, socio-economic status, and media communication behaviors all play a role in older adults' experiences of digital use [13]. Ju et al. examined the differences in adaptability and use of the experience of digital products between male and female elderly people based on the dimensions of information accessibility, information useability, and Internet use duration [14]. In addition, the attitude of the elderly towards technology adoption, such as technology interest, technology confidence, technology anxiety, and technology resistance, as well as their digital literacy and digital skills, are also often included in the influencing factors of users' digital experience.

2.3. Performance Evaluation Based on User Experience. Early research on performance evaluation based on the user experience perspective was widely used in the field of urban construction. Baycan-Levent et al. established a multidimensional evaluation system for the "green performance" of urban spaces based on user experience [15]. Pinheiro et al. construct an evaluation system containing 36 indexes to measure the age-friendliness of cities from the perspective of users' living experiences [16]. Recently, there has been growing literature on evaluating the performance of a digital product from a user experience perspective.

First, the main evaluation objects include PC websites, online social media, mobile applications, and mobile applets. Second, the selection of evaluation indexes. On the one hand, it is a subjective index [17], mainly emotional indexes and behavioral indexes. Emotional indexes include users' attitudes and satisfaction with digital products; behavioral indexes include users' familiarity with digital products, functions they master, and learning costs. On the other hand, it is an objective index [18], including the menu depth of the website, the color matching of the interface, font size, text spacing, and navigation layout. The evaluation indexes based on the perspective of user digital experience proposed by recent research include the matching degree between user needs and digital services, the success rate of human-computer interaction, the fault tolerance of digital products, and whether they have appropriate control, feedback and instruction modes [5]. Third, the selection of evaluation methods. The evaluation method of user experience performance is mainly analytic hierarchy process (AHP). By building a multilevel logical framework, the performance of the research object can be measured. Some recent studies have begun to introduce specific evaluation models, such as the honeycomb model, radar model, bat model, and hybrid methods, such as heuristic evaluation and fuzzy comprehensive evaluation, to measure the performance of user experience.

Many achievements have been made in the theoretical research of user experience, which performance evaluation systems are based on, widely used in urban construction, digital services, and other fields. For optimizing the age-friendly digital retrofit path and bridging the digital gap of aging, the paper, from the perspective of user experience, researches on digital behavior of elderly users and clarifies the design ideas of digital products for the elderly, which is scientific and reasonable alike. Even though some new studies have started to focus on the digital experience of elderly users, there are still the following shortcomings: firstly, the evaluation indexes are mostly selected based on the visual experience of elderly users' senses but ignore the more decisive indexes such as user interaction experience, behavior experience, and value experience. Secondly, the evaluation methods are mostly based on interviews and observation methods, which are more subjective and qualitative, and lack more objective quantitative evaluation based on data, which leads to bias in evaluation results [19]. To this end, this paper takes the "elder mode" mobile application as the research object and constructs an age-friendly digital retrofit performance evaluation index system based on the perspective of user experience. On the basis of real data, the joint entropy weight method and fuzzy comprehensive evaluation method are used to evaluate the performance of the "elder mode" mobile application (APP) retrofit. And according to the results, this paper puts forward actionable, replicable, and replicable countermeasures for age-friendly digital retrofit.

3. Evaluation Index System

3.1. Age-Friendly Indexes of Visual Experience. "Interface" is an important medium to connect users and digital products. "Interface design" is defined as the overall design of human-computer interaction, interface styles, and operation features of digital products. Interface design in line with user interaction habits can bring users a good visual experience. As people age, their basic bodily functions deteriorate, and the decline in visual functions is more pronounced, including reduced visual acuity, reduced color discrimination, reduced ability to adapt to light and dark, and reduced field of vision. In an eye-tracking experiment, Castilla et al. found that older people take longer to discover website page content and navigation information than younger people, especially when the font is smaller than 10 pounds [20]. To enhance the digital visual experience of elderly users, the interactive interface design should be adapted to their weakening physiological characteristics. Previous research has shown that the key to interface design is color matching, size, and typography [21, 22].

Color matching is at the core of interface design, and reasonable color matching can create the most intuitive visual experience for users, which can not only reduce the cognitive burden of users and enhance the interest of users but also play a certain guiding function in the operation of users [23]. Research shows that the selection of long-wave colors (red, orange, and yellow) and reducing lightness differences are in line with the visual perception of elderly users, which can significantly alleviate their fatigue in the process of interaction, thus driving users to find the information they are looking for more efficiently [10]. Reasonable size and standard typesetting are also the keys to interface design [24]. Reasonable size includes the design and control of the size of all interface elements, such as text, buttons, and icons. For the elderly, large fonts, big buttons, and simple icons are more in line with their visual experience. Standard typesetting means that the interface structure is hierarchical, the logic of interface elements is clear, all elements should be balanced and not dense in layout, and maintain the coordination and unity of the whole interface style.

Based on the above discussion, this paper selects five indexes to measure the age-friendly performance in the dimension of visual experience: *color matching meets user preferences*, *font size meets user reading needs*, *font style meets user reading habits*, *icon layout is reasonable and orderly*, and *interface element structure is hierarchical*.

3.2. Age-Friendly Indexes of Interaction Experience. Interaction experience refers to the sum of the feelings obtained by users in the process of accessing, receiving, and using services, and users' perception of the value of products or services is usually expressed in the interaction experience that occurs with them. The interaction experience of different groups is heterogeneous. Elderly users prefer to interact with lightweight products, expecting designers to reduce the redundancy and complexity of products, thus reducing their cognitive load and improving the efficiency of interaction and operation [25]. In view of this, the age-friendly retrofit of digital interaction experience should be based on the learning ability, cognitive ability, and acceptance ability of elderly users and continuously improve the matching degree of digital service capability with the behavioral characteristics of elderly users [9]. Based on the TAM and user experience theory, this paper argues that the age-friendly digital interaction process should at least be reflected in the convenience of information interaction, the stability of platform operation, and the fault tolerance and error correction capability it possesses.

First, the convenience of information interaction. As the elderly age, their fine-tuning ability decreases to a large extent, so the information interaction for the elderly should not only rely on the traditional “typing” mode of contact interaction but also support more intelligent and friendly interaction modes such as high recognition rate handwriting, accurate voice (dialect) recognition, and contextual association. Second, stable operation capability for elderly users. In the real world, “system crashes” often occur due to nonstandard or misoperation of elderly users. Therefore, the robustness and smooth operation of digital products and their ability to “recover” from crashes can effectively enhance the digital interaction experience of older users [26]. Third, fault-tolerant interaction capability for older users. Studies have shown that digital panic among the elderly is likely to trigger their wrong digital behaviors. Therefore, improving the fault tolerance of digital products is the key to ensuring the digital interaction experience of elderly users. Meanwhile, establishing an error operation correction mechanism and providing appropriate guidance measures automatically by digital products when misuse occurs are also key means to improve the digital interaction experience of elderly users.

Based on the above discussion, this paper selects six indexes to measure the age-friendly performance of the interaction experience dimension: *the convenience of handwritten interaction*, *the convenience of voice interaction*, *interaction fault tolerance*, *error recovery capability*, *error operation correction capability*, and *provision of misoperation guidance measures*.

3.3. Age-Friendly Indexes of Behavioral Experience. Behavioral experience refers to the subjective feelings or evaluations produced by users when using the product, with particular emphasis on the psychological recognition brought about by “user-product” interaction. According to the research based on MOA (Motivation-Opportunity-Ability) model, behavior experience determines users' perception of the favorable factors in the product and is related to their willingness to use it in the next step [27]. Behavior experience is of great significance to product design. The factors that enhance the user behavior experience in digital products are a series of technical features related to navigation [20]. The main reasons are: navigation provides a way for information users to switch between pages or jump between functions; navigation clarifies the connection between the navigation icon and the content it leads to, and navigation expresses the relationship between the navigation content and the page the information user is viewing. Therefore, the age-friendly digital retrofit around navigation has become the key path to improve the behavior experience of elderly information users.

The research of Cao and Bai focuses on navigation depth, which believes that for older users, the jump level of completing a task is controlled within three steps at most and emphasizes that the linearized navigation process can minimize the memory burden of elderly users [28, 29]. There is also research focusing on the stylization of navigation icons. Based on experimental studies, it is found that when navigation icons are based on physical objects, the elderly have a better behavioral experience [30]. Some studies have also proposed that using simple deictics (wording) to describe the function of navigation buttons is beneficial to reduce the burden of digital cognition on the elderly [31]. In addition, in most situations, users' navigation behavior takes place on the touch screen because the reduction of the palm friction coefficient of older users will interfere with the click success rate. Therefore, embedding “big buttons” and touchscreen navigation buttons that provide “strong touch” and “high fault tolerance” are also considered to effectively enhance the digital behavior experience of elderly users [29].

Based on the above discussion, this paper selects six indexes to measure the age-friendly performance of the behavioral experience dimension: *shallow structured navigation hierarchy*, *intuitive navigation layout*, *physical navigation icons*, *indicator-like navigation cues*, *tactile navigation buttons*, and *highly fault-tolerant navigation buttons*.

3.4. Age-Friendly Indexes of Value Experience. Value experience was first introduced as an important factor influencing website usage at the CHI (computer-human interaction) conference in 2003. Currently, a relatively unified understanding of value experience in academia and industry is that value experience is a key component of user experience, which directly affects both users' information behavior decisions and performance in searching for information, and also affects information users' satisfaction and loyalty to digital products [32]. A review study also pointed out that the value experience is closely related to the emotional design incorporated into the product [33]. For this reason, the focus of enhancing the value experience is to pay attention to the emotional state of the user. Compared with the younger generation, most older adults have more sensitive emotional experiences, often resulting in feelings of loneliness due to the lack of children and family care, feelings of inferiority due to the deterioration of physiological functions, and feelings of loss due to reduced social activities [34]. The above factors are highly likely to trigger negative emotions such as loneliness, depression, anxiety, and some degree of cognitive dysfunction.

In view of this, the design of age-friendly digital products should emphasize the emotional design of digital services, meet the psychological needs of elderly users in terms of details, operations and functions, and enhance the sense of dependence and trust of elderly users in digital products. In the assessment of value experience, some scholars use indexes such as self-achievement, enjoyment, relationship, dependence, usefulness, and added value. Zhang et al. selected six indexes of feeling pleasant to use, novel design, satisfying functional needs, trusting the design, satisfying social desires, and self-satisfaction to assess the value experience of elderly users based on logistic regression [35]. Emerging research proposes that superior age-friendly digital products should improve the emotional well-being of elderly users, enhance their quality of life, strengthen their social engagement, and reduce their depressive state and loneliness [13].

Based on the above discussion, this paper selects six indexes to measure the age-friendly performance of the value experience dimension by *feeling pleasant to use*, *satisfying social needs*, *contributing to emotional health*, *self-fulfillment*, *reducing loneliness*, and *enhancing the sense of belonging*. All the indexes are shown in Table 1.

4. Methods and Calculation

4.1. Entropy Weight Method. Since the indexes describing user experience have different contributions to the overall evaluation system, the weights of relevant indexes should be determined in advance when evaluating the performance of age-friendly digital retrofit based on the perspective of user experience. The entropy weight method is based on the difference-driven theory, and the optimal weight is measured based on the dispersion degree of the index itself and the information quantity of the index, which is an objective weighting method that avoids the participation of subjective factors, and the calculated index weights are more objective.

The entropy weight method is calculated as follows:

Step 1: Construct the evaluation matrix.

Firstly, we construct the matrix S of order $1 \times n$ based on the indexes of the evaluation object, which is denoted as $S = (x_{01}, x_{02}, \ldots, x_{0n})$. The rating index is calculated as $x_{0j} = (\sum_{k=1}^{l} x_{kj}/l)$, where l denotes the number of experts scoring the rating index, $j = 1, 2, \ldots, n$. Second, the benchmark evaluation matrix T of order $(m-1) \times n$ is constructed following the $m-1$ evaluation level nodes, namely,

$$T = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m-1,1} & x_{m-1,2} & \cdots & x_{m-1,n} \end{bmatrix}, \quad (1)$$

where m is the evaluation level and n is the number of indexes. Finally, the decision matrix X (m rows and n columns) that fuses the S matrix and the T matrix is constructed, namely,

$$X = \begin{bmatrix} x_{01} & x_{02} & \cdots & x_{0n} \\ x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ x_{m-1,1} & x_{m-1} & \cdots & x_{m-1,n} \end{bmatrix}. \quad (2)$$

Step 2: Normalization of the decision matrix

Using the linear proportional retrofit method, the decision matrix $X = (x_{ij})_{m\times n}$ is primitively transformed to obtain the standardization matrix $Y = (y_{ij})_{m\times n}$. The process of standardization is to transform the absolute values of indexes into relative values and then solve the homogenization problem of each different qualitative index value, in which the positive indexes have different values from the negative indexes, but the larger the absolute values are, the better.

The positive index is calculated as follows:

$$x'_{ij} = \frac{x_{ij} - \min\{x_{1j}, \ldots, x_{nj}\}}{\max\{x_{1j}, \ldots, x_{nj}\} - \min\{x_{1j}, \ldots x_{nj}\}}. \quad (3)$$

The negative index is calculated as follows:

$$x'_{ij} = \frac{\max\{x_{1j}, \ldots, x_{nj}\} - x_{ij}}{\max\{x_{1j}, \ldots, x_{nj}\} - \min\{x_{1j}, \ldots x_{nj}\}}. \quad (4)$$

And then, the weight of the i th sample value under the j th index can be calculated for that index.

$$y_{ij} = \frac{x'_{ij}}{\sum_{i=1}^{m} x'_{ij}}. \quad (5)$$

Step 3: Calculate the entropy value of the index by using the method,

$$e_j = -\lambda \sum_{i=1}^{m} y_{ij} \ln y_{ij}, \qquad \lambda = \frac{1}{\ln m}. \quad (6)$$

Step 4: The index weights are assigned with the method,

$$a_j = \frac{u_j}{\sum_{j=1}^{n} u_j}, \quad (7)$$

where, u_j is the coefficient of variation of the calculated index with the value of $1 - e_j$, while the weight coefficient is $\sum_{j=1}^{n} a_j = 1$, $a_j \geq 0$, $j = 1, 2, \ldots, n.$. The weight vector of the index is $A = (a_1, a_2, \ldots, a_n)$.

4.2. Fuzzy Comprehensive Evaluation Method. Fuzzy evaluation is a type of method based on fuzzy mathematical theory, based on the principle of fuzzy relationship synthesis, to quantify parameters or factors that are difficult to quantify and then make a comprehensive evaluation of the subordinate rank status of the evaluated object. This method is often used in satisfaction evaluation, safety level evaluation, and performance evaluation in the field of engineering technology. Since the digital usage experience of elderly users proposed in this paper is a comprehensive and subjective feeling with certain fuzzy nature, it is suitable to choose the fuzzy comprehensive evaluation method to study the digital experience of elderly users.

The steps of fuzzy comprehensive evaluation are as follows.

Step 1: Establish the set of factors (index set) of the evaluation object, $U = \{U_1, U_2, \ldots, U_o\}$, where o is the number of factors or indexes.

Step 2: Create the evaluation set $V = \{V_1, V_2, \ldots, V_p\}$, where p is the number of evaluation levels.

Table 1: An age-friendly digital retrofit performance evaluation system based on user experience.

Target layer	Criterion layer	Weight	Index layer	Weight	Combination weight
Age-friendly digital retrofit for user experience (U)	Age-friendly indicators of visual experience (U_1)	0.3637	Color matching meets user preferences (U_{11})	0.1758	0.0517
			Font size meets user reading needs (U_{12})	0.3036	0.0638
			Font style meets user reading habits (U_{13})	0.1185	0.0522
			Icon layout is reasonable and orderly (U_{14})	0.0744	0.0462
			Interface element structure is hierarchical (U_{15})	0.3277	0.0576
	Age-friendly indicators of interaction experience (U_2)	0.3267	Convenience of handwritten interaction (U_{21})	0.3439	0.0538
			Convenience of voice interaction (U_{22})	0.1316	0.0357
			Error recovery capability (U_{23})	0.1510	0.0409
			Interaction fault tolerance (U_{24})	0.0992	0.0296
			Error operation correction capability (U_{25})	0.2209	0.0428
			Provision of misoperation guidance measures (U_{26})	0.0534	0.0269
	Age-friendly indicators of behavioral experience (U_3)	0.1623	Shallow structured navigation hierarchy (U_{31})	0.0956	0.0256
			Intuitive navigation layout (U_{32})	0.0752	0.0142
			Physical navigation icons (U_{33})	0.1724	0.0390
			Indicator-like navigation cues (U_{34})	0.1628	0.0323
			Tactile navigation buttons (U_{35})	0.3556	0.0564
			Highly fault-tolerant navigation buttons (U_{36})	0.1384	0.0334
	Age-friendly indicators of value experience (U_4)	0.1473	Feeling pleasant to use (U_{41})	0.2670	0.0627
			Satisfying social needs (U_{42})	0.1825	0.0361
			Contributing to emotional health (U_{43})	0.1354	0.0465
			Self-fulfillment (U_{44})	0.1268	0.0488
			Reducing loneliness (U_{45})	0.1430	0.0547
			Enhancing the sense of belonging (U_{46})	0.1453	0.0491

Step 3: Create the weight vector. The set of index weights for each dimension is $W = \{w_1, w_2, \ldots, w_o\}$ and $\sum_{i=1}^{o} w_i = 1$.

Step 4: Establish the fuzzy relationship matrix $R_i = (r_{ij})$, $i = 1, 2, \ldots, o$, $j = 1, 2, \ldots, p$, $\sum_{j=1}^{p} r_{ij} = 1$. The fuzzy relationship matrix is expressed as

$$R = \begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1p} \\ r_{21} & r_{22} & \cdots & r_{2p} \\ \vdots & \vdots & \ddots & \vdots \\ r_{o1} & r_{o2} & \cdots & r_{op} \end{bmatrix}. \quad (8)$$

Step 5: Calculate the fuzzy comprehensive evaluation set, namely $B = W \times R = (b_1, b_2, \ldots b_p)$.

Step 6: The evaluation set B is defuzzified to obtain the evaluation value of each index, i.e., $E = B \times H$ (H is the evaluation set V corresponding to each grade).

4.3. Calculation of Index Weight Based on Entropy Weight Method. Given that the evaluation of age-friendly digital retrofit performance from the perspective of user experience is a typical group decision problem, the weights of evaluation indexes need to be determined in advance. In this paper, to reflect the heterogeneity of the selected experts, the ambiguity of the environment, and the subjectivity of the decision information, three groups of experts (l_i) from different fields were invited, namely, senior product managers of Internet companies (l_1), software R&D programmers (l_2), elderly users with high digital activity (l_3) and corresponding family members of elderly users (l_4), 10 experts from each group, who were allowed to give their opinions based on their habits, perceptions, and preferences to give their assessment opinions.

In this paper, 5 granularity linguistic variables $m = \{C1, C2, C3, C4, C5\}$ are used to characterize the expert opinions with the meanings {*very important, important, relatively important, average, and unimportant*}, and the corresponding scores are {10, 8, 6, 4, and 2}.

4.3.1. Calculation of Weights for Criterion Layer Indexes. The data relating to expert opinions are brought into equations (1) and (2), and the decision matrix of criterion level indexes (40 rows and 4 columns) is calculated based on the MATLAB platform as follows.

$$X_1 = \begin{bmatrix} 0.0146 & 0.0252 & 0.0232 & 0.0164 \\ 0.0292 & 0.0105 & 0.0251 & 0.0310 \\ \cdots & \cdots & \cdots & \cdots \\ 0.0247 & 0.0310 & 0.0164 & 0.0292 \end{bmatrix}. \quad (9)$$

The linear proportional retrofit method was used to perform the primary retrofit operation on X_1 to form the normalization matrix Y_1, and the entropy value and the coefficient of variation of the criterion level indexes were calculated based on equations (4)–(7) to obtain the weights of the criterion level indexes, as shown in Table 1.

4.3.2. Calculation of Weights for Index Layer Indexes. Based on equations (1) and (2), combined with expert scoring, the index decision matrix X_2 (40 rows and 23 columns) and the standardization matrix Y_2 of the index layer are obtained, and the weights of the indexes of the index layer are obtained based on equations (4) to (7), respectively and the combination weights; see Table 1.

4.4. Calculation of Performance Based on Fuzzy Comprehensive Evaluation Method

4.4.1. Determine the Evaluation Object. This paper takes the digital activities of elderly groups in the Zhejiang Province as the research object and finds that the digital scenarios that elderly users often face are concentrated in four major areas: digital finance, digital social, digital government and digital medical, and the corresponding digital platforms with the highest frequency of use are Alipay, WeChat, Zheli Office APP (ZOA) and Zhejiang Appointment Registration APP (ZARA), and at the same time, all four APPs are launched for elderly users "elder mode." In view of this, this paper selects the above APP as the evaluation object to study the performance of age-friendly digital retrofit based on the perspective of user experience, which has certain typicality and representativeness.

4.4.2. Data Collection and Calculation. Based on the performance evaluation indexes of age-friendly digital retrofit for user experience, we designed a digital experience questionnaire for elderly users, collected data on the elderly user experience of four "elder mode" APPs, and conducted an exploratory study. In order to ensure the objectivity and validity of digital experience evaluation of elderly users, this paper requires users to have experience in using digital products and have used the above four types of APPs when screening survey respondents. Restricted by the screening conditions, this paper finally identified 85 survey respondents, including 49 males and 36 females, all aged 60 or older, with previous occupations including teachers, doctors, service workers, farmers, and social workers.

In this paper, the digital experience data of elderly users are collected on-site in a "one-to-one" manner. During the specific implementation, the surveyed users are helped to recall or use the four APPs on the spot according to the questionnaire content, and all indexes are explained in detail. Then, users are required to score all indexes according to their own user experience (5-point system: 1 point is the lowest, 5 points is the highest). On the basis of collecting 85 valid questionnaires, the performance of the age-friendly digital retrofit of four "elder mode" APPs was evaluated based on the fuzzy comprehensive evaluation method. Taking the evaluation of Alipay as an example, the calculation process is as follows:

(1) Establish an age-friendly digital experience evaluation index set $U = (U_i)$ ($i = 1, 2, 3, 4$ represents the 4 criterion layers), and the index layer is represented by U_{ij}; establish an age-friendly digital experience evaluation set $V = \{$*very satisfied, more satisfied, generally satisfied, less satisfied, and very dissatisfied*$\}$; establish the fuzzy relationship matrix $R_i = (r_{ij})$, calculate the score of each index U_{ij} belonging to the evaluation set V based on the user experience rating scale, and r_{ij} can be obtained after measurement and transformation; in summary, establish the fuzzy relationship matrix R_1, R_2, R_3, R_4 for the age-friendly digital experience of the criterion layer as follows:

$$R_1 = \begin{bmatrix} 0.3412 & 0.4118 & 0.1647 & 0.0353 & 0.0471 \\ 0.5294 & 0.2588 & 0.1412 & 0.0353 & 0.0353 \\ 0.2941 & 0.5294 & 0.1529 & 0.0118 & 0.0118 \\ 0.1765 & 0.4000 & 0.2706 & 0.1412 & 0.0118 \\ 0.2824 & 0.2941 & 0.4118 & 0.0000 & 0.0118 \end{bmatrix},$$

$$R_2 = \begin{bmatrix} 0.0000 & 0.0000 & 0.6588 & 0.2941 & 0.0471 \\ 0.0118 & 0.0235 & 0.5294 & 0.3765 & 0.0588 \\ 0.1412 & 0.1765 & 0.2706 & 0.3765 & 0.0353 \\ 0.0824 & 0.0941 & 0.4118 & 0.3176 & 0.0941 \\ 0.1294 & 0.1412 & 0.4118 & 0.2000 & 0.1176 \\ 0.0824 & 0.1059 & 0.2706 & 0.3294 & 0.2118 \end{bmatrix},$$

$$R_3 = \begin{bmatrix} 0.6471 & 0.2824 & 0.0588 & 0.0118 & 0.0000 \\ 0.4118 & 0.3059 & 0.1647 & 0.1176 & 0.0000 \\ 0.7765 & 0.1765 & 0.0471 & 0.0000 & 0.0000 \\ 0.1765 & 0.4118 & 0.2941 & 0.1176 & 0.0000 \\ 0.6588 & 0.3176 & 0.0118 & 0.0118 & 0.0000 \\ 0.1059 & 0.1294 & 0.5294 & 0.2118 & 0.0235 \end{bmatrix},$$

$$R_4 = \begin{bmatrix} 0.2118 & 0.3294 & 0.4471 & 0.0000 & 0.0118 \\ 0.5294 & 0.2706 & 0.1176 & 0.0824 & 0.0000 \\ 0.1294 & 0.5412 & 0.2706 & 0.0000 & 0.0588 \\ 0.2824 & 0.2000 & 0.3294 & 0.1294 & 0.0588 \\ 0.0588 & 0.1294 & 0.3412 & 0.3765 & 0.0941 \\ 0.0353 & 0.1059 & 0.2471 & 0.4000 & 0.2118 \end{bmatrix}. \quad (10)$$

(2) The fuzzy synthetic operator $M(\cdot,+)$ is chosen to calculate the criterion-layer fuzzy comprehensive evaluation set B as well as the final evaluation set A based on the formula $B = W \times R = (b_1, b_2, \ldots b_p)$:

$$\begin{aligned} B_1 &= W_1 \times R_1 = [\,0.3612 \;\; 0.3398 \;\; 0.2450 \;\; 0.0288 \;\; 0.0251\,], \\ B_2 &= W_2 \times R_2 = [\,0.0640 \;\; 0.0759 \;\; 0.4833 \;\; 0.3008 \;\; 0.0759\,], \\ B_3 &= W_3 \times R_3 = [\,0.5043 \;\; 0.2783 \;\; 0.1515 \;\; 0.0626 \;\; 0.0033\,], \\ B_4 &= W_4 \times R_4 = [\,0.2200 \;\; 0.2699 \;\; 0.3039 \;\; 0.1434 \;\; 0.0628\,], \end{aligned} \quad (11)$$

$$A = W \times B = [0.2665\ 0.2333\ 0.3164\ 0.14000.0437],$$

where W is the criterion layer weight, $B = \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix}$.

(3) Based on the formula $E = B \times H$ to defuzzify the evaluation set of the criterion layer and the target layer, the comprehensive evaluation value of each index of the criterion layer and the user experience of Alipay is obtained respectively:

$$\begin{aligned} E_1 &= B_1 \times H = 5b_{11} + 4b_{12} + 3b_{13} + 2b_{14} + b_{15} = 3.9829, \\ E_2 &= B_2 \times H = 5b_{21} + 4b_{22} + 3b_{23} + 2b_{24} + b_{25} = 2.7510, \\ E_3 &= B_3 \times H = 5b_{31} + 4b_{32} + 3b_{33} + 2b_{34} + b_{35} = 4.2177, \\ E_4 &= B_4 \times H = 5b_{41} + 4b_{42} + 3b_{43} + 2b_{44} + b_{45} = 3.4409, \\ E &= A \times H = 5a_{11} + 4a_{12} + 3a_{13} + 2a_{14} + a_{15} = 3.5386. \end{aligned} \quad (12)$$

Similarly, the user experience ratings of the other three "elder mode" APPs can be calculated (the calculation steps are not repeated), and the related results are shown in Figures 1 and 2 and Tables 2 and 3.

5. Results and Discussion

Overall, the comprehensive user experience scores of the four "elder mode" APPs are all above 3.2, which is above the level of "generally satisfied." Among them, the comprehensive score of WeChat reached 3.96 points, Alipay and ZOA ranked second and third with 3.53 points and 3.51 points, respectively, and ZARA scored 3.26 points, ranking fourth.

Combining Table 2 and Figure 1, we can find some common problems presented by the guideline level indexes of the four "elder mode" APPs in the "visual experience (U_1)" and "behavioral experience (U_3)" two dimensions of age-friendly are relatively high, while the age-friendly scores in the "interaction experience (U_2)" dimension are low, and the differences in the scores in the "value experience (U_4)" dimension are relatively obvious. It is worth noting that, except for WeChat, the other three APPs score below 3 on the "interaction experience (U_2)" dimension of age-friendly, which lies at the "less satisfied" level.

Combined with Table 3 and Figure 2, it can be seen that the "elder mode" introduced by WeChat, as a mature social network platform, is highly rated in most of the secondary indexes of user experience, especially "color matching," "font size," "navigation level" and U_{41}, U_{42}, and U_{45} of the value experience dimension are widely praised by the elderly user groups. As the largest mobile payment platform in China, Alipay has a large number of elderly users, and the performance of its retrofit for elderly users is noteworthy from the rating results, such as "font size"(U_{12}), "font style"(U_{13}), "shallow structure"(U_{31}), "physical navigation icons"(U_{33}), and "satisfying social needs"(U_{42}). However, Alipay's age-friendly retrofit in the interactive experience dimension is still lacking, including "handwritten and voice interaction" (U_{21}, U_{22}), "fault tolerance"(U_{24}), "correction capability"(U_{25}), and "guidance"(U_{26}). As a digital government service platform and medical service platform led

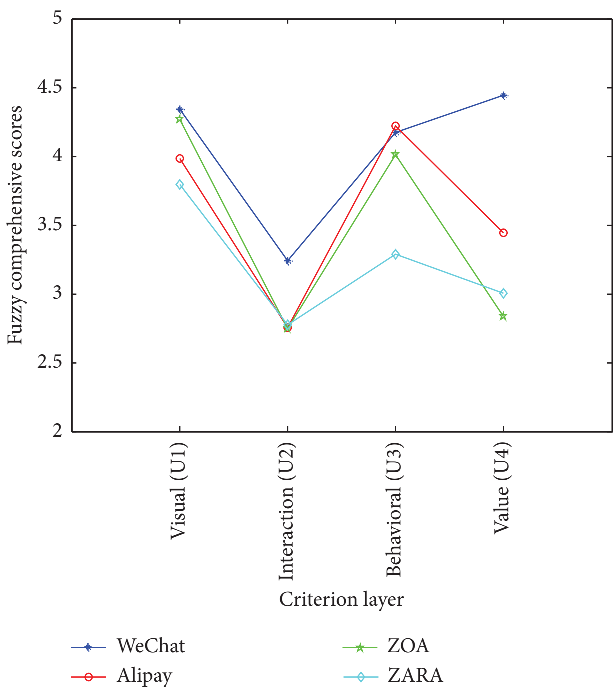

Figure 1: Scoring trend of criteria layer indexes.

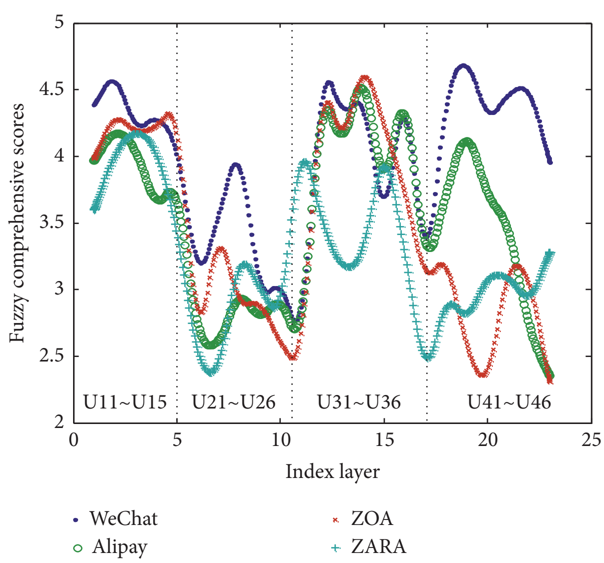

Figure 2: Scoring trend of index layer indexes.

by local governments, ZOA and ZARA have also launched "elder mode" for elderly user groups; in terms of scores, ZOA has a high level of age-friendly in visual experience and behavioral experience dimensions, and some secondary indexes even reach scores of 4.5 or more, such as U_{31} and U_{33}. In comparison, ZARA has a low level of age-friendly retrofit, with many secondary indexes scoring at or even below the average of the other three APPs.

According to the comprehensive experience of the elderly users, the scores of the criteria layer and the indexes layer of the four "elder mode" APPs obtained by the fuzzy comprehensive evaluation, and the scoring reasons and

Table 2: The criteria layer indexes and overall scores of the four "elder mode" APPs.

Criterion layer	WeChat	Alipay	ZOA	ZARA	Mean value
U_1	4.3439	3.9829	4.2696	3.7972	**4.0984**
U_2	3.2380	2.7510	2.7456	2.7743	**2.8772**
U_3	4.1698	4.2177	4.0099	3.2889	**3.9216**
U_4	4.4457	3.4409	2.8336	3.0025	**3.4307**
Overall score	**3.9698**	**3.5386**	**3.5180**	**3.2634**	**3.5725**

suggestions collected from the users during the questionnaire survey, this paper analyzes and discusses the common problems of the age-friendly retrofit of the four APPs as follows:

5.1. Discussion on the Dimension of Visual Experience. The color-matching strategies of the four APPs are similar. All of them reduce the difference of brightness to relieve the visual fatigue of elderly users and highlight the visual difference between icons and text through reasonable color difference, which can meet the visual perception needs of elderly users and facilitate their information search at the same time. The results of the fuzzy comprehensive evaluation show that "U_{11}" has a high score, and the user experience satisfaction is close to the level of "more satisfied."

The user experience satisfaction scores of font size and style of the four APPs are all above 4, reaching the level of "more satisfied" and above. In terms of details, each APP has been designed and optimized more scientifically for elderly users. For example, WeChat has increased the font size while also distinguishing "message push" with different colors for different attributes (such as official and personal). In addition to increasing the font size, ZOA also bolded the font to a certain extent, actively catering to the reading experience of elderly users. The above-mentioned measures have received positive feedback from elderly users.

The fuzzy evaluation results show that Alipay gets a relatively low score. Combined with the feedback from elderly users, we found that they prefer simpler icon arrangement and combination; that is, the same size interface should present more concise icons, and to combine the information service needs of elderly users, lay out the most commonly used icons in the front, while hiding or even eliminating irrelevant icons, so as to reduce the interference to the visual and thinking of elderly users. The research found that the icon layout of ZOA is more scientific. It classifies the common items of elderly users. On the initial interface of the APP, six icons most commonly used by elderly users, such as "health check," "intelligent guidance," and "weather forecast," are arranged. At the same time, the clever coordination between "icons" and "words" also makes the visual level more clear.

Compared with the other three APPs, ZARA got the lowest score of 3.47, corresponding to the evaluation result of "generally satisfied." Based on the feedback of the elderly users and the comparative analysis of the four APPs, it is found that for the purpose-oriented or vertical APPs (for example, the main function of ZARA is to realize registration service), the

Table 3: The index layer scores of the four "elder mode" APPs.

Criterion layer	Index layer	WeChat	Alipay	ZOA	ZARA	Mean value
Age-friendly indicators of visual experience (U_1)	Color matching meets user preferences (U_{11})	4.3882	3.9647	3.9882	3.6000	**3.9853**
	Font size meets user reading needs (U_{12})	4.6471	4.2118	4.3294	4.0353	**4.3059**
	Font style meets user reading habits (U_{13})	4.1765	4.0824	4.1765	4.2118	**4.1618**
	Icon layout is reasonable and orderly (U_{14})	4.3176	3.5882	4.2118	4.0706	**4.0471**
	Interface element structure is hierarchical (U_{15})	4.1059	3.8353	4.4118	3.4706	**3.9559**
Age-friendly indicators of interaction experience (U_2)	Convenience of handwritten interaction (U_{21})	3.5529	2.5529	3.5059	2.3294	**2.9853**
	Convenience of voice interaction (U_{22})	4.1412	3.0118	2.8588	3.3059	**3.3294**
	Error recovery capability (U_{23})	3.0235	2.6118	2.5059	2.4353	**2.6441**
	Interaction fault tolerance (U_{24})	2.9059	2.7529	2.9294	3.0118	**2.9000**
	Error operation correction capability (U_{25})	3.0824	2.9647	2.5882	2.7529	**2.8471**
	Provision of misoperation guidance measures (U_{26})	2.5529	2.5176	2.4000	4.2000	**2.9176**
Age-friendly indicators of behavioral experience (U_3)	Shallow structured navigation hierarchy (U_{31})	4.7529	4.5647	4.6353	3.4941	**4.3618**
	Intuitive navigation layout (U_{32})	4.2824	4.0118	4.0588	3.1294	**3.8706**
	Physical navigation icons (U_{33})	4.4941	4.7294	4.7412	3.2353	**4.3000**
	Indicator-like navigation cues (U_{34})	3.4118	3.6471	4.2353	4.1412	**3.8588**
	Tactile navigation buttons (U_{35})	2.6353	2.6235	2.7529	2.2941	**2.5764**
	Highly fault-tolerant navigation buttons (U_{36})	3.0000	3.0824	3.0353	2.2824	**2.8500**
Age-friendly indicators of value experience (U_4)	Feeling pleasant to use (U_{41})	4.5294	3.7294	3.2824	2.9765	**3.6294**
	Satisfying social needs (U_{42})	4.7647	4.2471	2.5294	2.7529	**3.5735**
	Contributing to emotional health (U_{43})	4.2471	3.6824	2.2471	3.1176	**3.3235**
	Self-fulfillment (U_{44})	4.4824	3.5176	3.2235	3.1059	**3.5824**
	Reducing loneliness (U_{45})	4.5412	2.6824	3.1294	2.8824	**3.3088**
	Enhancing the sense of belonging (U_{46})	3.9529	2.3529	2.3059	3.2824	**2.9735**

logical relationship between "information-modules" should be highlighted in the visual presentation, and the strong and low-frequency comparison should be used to improve the sense of hierarchy and guidance. In fact, ZARA does not highlight the hierarchical structure of each element of the interface "Registration—Hospital Selection—Department Selection—Doctor Selection," thus interfering with the visual experience of elderly users.

5.2. Discussion on the Dimension of Interaction Experience. Based on the scores of the secondary indexes of the interaction experience (U_2) dimension in Figure 2 and Table 3, it is found that the performance of the four APPs is relatively weak in terms of age-friendly, and most of the user experience satisfaction is at the level of "less satisfied" and "generally satisfied." This result shows that the age-friendly ability of digital interactive experience needs to be strengthened.

Two indexes, convenience of handwriting interaction (U_{21}) and voice interaction (U_{22}), were used to characterize the level of age-friendly in human-computer interaction. The results show that except for WeChat, which scored a high 4.14 on the U_{22} index (perhaps related to its feature "listening to text messages"), the rest of the scores are not optimistic, and the overall score is "generally satisfied" and below. Based on user feedback and comparative research on APPs, it is found that the handwriting and voice interaction of the four APPs still completely depends on the operating system of the mobile device itself. However, in most cases, the "elder mode" APP and the operating system of the mobile device fail to effectively interact; that is, when elderly users interact with handwriting or voice in "elder mode," the "information interaction unit" is still the "ordinary version" mode, The corresponding interaction mode is generally "Nine Palace" or "26 format" keyboard, and no age-friendly interaction program for elderly users has been developed.

Error recovery capability (U_{23}) is used to characterize the toughness of the APP in terms of interaction with elderly users. The score results show that the average score of U_{23} of the four APPs is only 2.64, which is the level of "less satisfied." The study found that most elderly users are not proficient in the operation of APPs and sometimes have an insufficient understanding of the content of the services they provide, especially in the face of some pop-up ads or "plug-in" installation interference scenarios, which will intensify some elderly users' fear of digital products. At the same time, due to the digital anxiety of some elderly users, the wrong operation and irregular use of digital products often occur, which seriously affects the interaction experience of elderly users. The resilient interaction mechanism of "error recovery" for elderly users can help them quickly return to the original interface or state of the APP and clear the malicious interference plug-in. But according to user feedback, the current elderly version of the APP rarely has the above-mentioned "toughness" ability.

Three indexes, U_{24}, U_{25}, and U_{26}, are used to characterize the tolerance of the APP to the occurrence of misoperations during the interaction. The results show that ZARA gets a high score of 4.2 on the U_{26} (this is related to the "one key to get manual help" function for elderly users), while the rest of the scores are mostly lower than 3 points, belonging to the level of "less satisfied," indicating that the interactive error tolerance ability of the elderly APPneeds to be improved. Further study found that the fault tolerance of the four APPs did not differ from the ordinary version, and they were not optimized according to the information behavior and habits of the elderly users after misoperation; that is, they did not provide a misoperation correction mechanism, no clear solution for misoperation, and the misoperation was irrevocable.

5.3. Discussion on the Dimension of Behavioral Experience. About U_{31}, WeChat, Alipay, and ZOA get a rating of 4.5 or more, and ZARA scores only 3.4. The study shows that in most cases, users only need to go through 3 or fewer navigation jumps to complete a target task in WeChat, Alipay, and ZOA. As a purpose-oriented digital platform, ZARA's "registration" task requires users to go through 6 steps, such as "making an appointment," "adding a patient," and "selecting a hospital." The redundant intermediate processes and links greatly increase the operational burden of elderly users.

In addition to ZARA, the other three APPs scored high in U_{32}, reaching the level of "more satisfied." Further research found that WeChat uses "list navigation layout," Alipay and ZARA use "springboard navigation layout," and ZOA uses a "springboard + list navigation layout." According to Gestalt psychology theory, for equally important content items, the use of a grid or list navigation layout is conducive to enhancing the user's feelings and behavioral experience. However, in order to highlight more important content items, intuitive irregular layout forms should be used. As far as ZARA is concerned, the "registration" task is obviously a more important content item, but ZARA does not have an intuitive layout.

The U_{33} scores of WeChat, Alipay, and ZOA are higher, and the U_{34} scores of ZOA and ZARA are higher, all above 4 points, close to the level of "very satisfied." Based on user feedback, the navigation icons are explained in the form of "objects" or "information tips" to facilitate older users' understanding of the operation process. For example, ZOA interprets, classifies, and marks "personal service," "legal person service," and "convenience service" according to "hot spot navigation," "department navigation," and "main body navigation," which is conducive to the user's understanding of the operation process and can significantly improve the user's behavior experience.

The U_{35} can be interpreted as the physical feedback given by the navigation buttons to elderly users, while the U_{36} reflects the tolerance of the navigation buttons to the usage habits and comprehension of elderly users. The scores of the above two indexes are in the range of 2.2 to 3.1, corresponding to the satisfaction level of "less satisfied" and below. This result shows that the four APPs did not make targeted modifications to the age-friendly of navigation buttons, and the user experience was not satisfactory.

5.4. Discussion on the Dimension of Value Experience. According to the results in Figure 2 and Table 3, it is easy to find that the secondary indexes of the value experience dimension, WeChat get high scores, except for U_{46}, the scores of U_{41}~U_{45} are above 4.2, and the corresponding level is "more satisfied." In fact, WeChat, as a widely used social platform, has a large number of information users. According to the feedback of older users, they have begun to make more attempts on WeChat. In addition to daily chat, they will also join "group chat," grab "red packets," send "friends circle," and think that they are beginning to master and use the above functions provided by WeChat more and more skillfully and feel the fun and convenience of digital life. In comparison, the scores of Alipay, ZOA, and ZARA on the secondary indexes of the value experience dimension are not ideal. Except that Alipay gets a high score of 4.2 on U_{42} (perhaps related to social attributes such as "ant forest"), the scores of other indexes are low, and the overall level is at the level of "less satisfied" or below.

According to user feedback, the reasons for the poor value experience are not only related to the attributes, positioning, and services of the digital platform itself but also to its insufficient degree of age-friendly retrofit: For one, some age-friendly features are optimized only on the initial page of the APP and return to the normal version when entering the secondary or tertiary pages. For example, the "Social Security Page" (secondary page) and "Retirement Eligibility Confirmation Page" (tertiary page) of ZOA have not been reformed in terms of text and icon presentation in an age-friendly manner. Secondly, the four APPs are still complicated in some processes and logic and fail to simplify according to the actual needs and usage scenarios of elderly users, who still have a high burden of operation, understanding, and memory, resulting in their sense of achievement, acquisition, belonging and happiness being suppressed, and their satisfaction with value experience is not high.

6. Conclusions

(1) age-friendly digital retrofit of the visual experience occupies the greatest weight in digital retrofit projects and is the foundation and prerequisite for enhancing digital age-friendly. It should be noted that the retrofit of the visual dimension of age-friendly is not just to emphasize color, increase the font size and enlarge icons. It is necessary to take care of the aesthetics and coordination of the overall page of digital products and prevent the occurrence of problems such as "too large font size crowding other elements" and "too large icons covering other effective information."

(2) The retrofit of the interactive experience dimension is the key to affect the performance of age-friendly digital products. This paper suggests developing embedded handwriting or voice (dialect) interaction recognition programs for elderly users, increasing the interaction interval, extending the interaction length, and enhancing the associative prompting, and assisted interaction of words, phrases and sentences based on AI technology. Optimize the human-computer interaction options. Some experiments show that the interaction

mode of selection can improve interaction efficiency. It is suggested to select "selection box" instead of "input box" as far as possible. For general information, default options can be provided in the input box; Establish a feedback mechanism to extend the length of stay of "suggestive" information, with a stay time of 7 to 10 seconds being conducive to older users' understanding of the interactive content; Enhance operational fault tolerance, such as using text and voice prompts to clarify the buttons and the changes produced after clicking them and provide feedback in the form of secondary reminders or secondary confirmation for sensitive or irrevocable interactive operations.

(3) Cultivate digital usage habits of elderly users' and build an intuition-based elderly users behavior experience. First, it is suggested to shorten redundant or unnecessary navigation jump steps and control the navigation depth within 3 steps as far as possible. Second, optimize the navigation layout. For the same type of content, it is recommended to use a grid or list navigation layout. In order to highlight important content items, an intuitive, irregular layout should be used. Third, provide appropriate navigation guidance to inform users of their location and next steps, such as using physical icons for prompting and tactile buttons for feedback.

(4) Improve the age-friendly level of digital products in the value experience dimension. First, further simplifying nonessential functional options for digital products and front-loading functional units commonly used by older users. Second, to strengthen the continuity and thoroughness of the retrofit of age-friendly digital products, not only focusing on the initial interface of age-friendly but also suggesting the development and design of "elder mode" and "normal version" of digital products in two completely separate sets. Thirdly, adopt obvious signs to mark sensitive information on digital products, such as "officially certified," "unaudited," "advertising," and other categories to enhance elderly users' trust and sense of security in digital products. Fourthly, some simple entertainment modules or social functions can be added to enhance the enjoyment of digital use for elderly users.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Disclosure

A small portion of this paper was published in an academic conference paper. This paper adds more content, such as a literature review, index system, experimental process, empirical analysis, and countermeasure suggestions.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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