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A Study on the Prioritization of UI Design Factors for Age-Friendly Apps Using the Analytic Hierarchy Process (AHP): A Case Study of Payment Apps

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Abstract: The acceleration of digital transformation has brought frequent difficulties to the elderly in scenes such as online booking and mobile payment. Most existing mobile app interfaces give priority to efficiency, ignoring the physiological characteristics of the elderly's decreased visual and cognitive abilities. In order to solve the problem of insufficient resource allocation in age-friendly interface design, this study combines a literature review and AHP to assign weights to UI design factors. The results show that the visual perception layer is the most weighted (32.85%), followed by the operation interaction layer (27.01%), which shows that the elderly users are highly dependent on the source size, touch access point and fault-tolerant mechanism. In addition, too deep an information architecture is an important source of cognitive fatigue. Based on these results, this study puts forward optimization strategies, including implementing high contrast standards, reducing the page to three levels or less, and increasing voice assistance to offset the physiological pressure of the elderly. The model provides a quantifiable and operational decision-making path for designers, which shows that accurate modification based on weight distribution is better than a simple superposition function. Future research can integrate artificial intelligence technology to realize dynamic adjustment of UI, so as to provide more accurate and adaptive design solutions for elderly users.

Keywords: Analytic Hierarchy Process (AHP); Age-Friendly Design; Mobile App UI; Priority Research; Digital Divide

1. Introduction

1.1 Research Background

With the digital transformation of society, the population over 60 now accounts for 18.7% of China's population, and the Internet penetration rate is only 46% [1]. The elderly account for nearly 40% of the country's population, who do not use the Internet, making them the group most affected by the digital divide. Although digital services have been fully integrated into the basic aspects of daily life, the elderly who are not good at using smart devices are facing serious social isolation. Particularly in scenarios where online appointment booking or mobile payments are mandatory, they are often hindered by barriers in UI interaction, leading to deep psychological alienation [2]. This divide is essentially a matter of inequality in digital rights; although many apps have introduced age-friendly modes or senior versions, existing UI design logic often remains superficial. Specifically, current designs generally merely enlarge text sizes without restructuring information hierarchies, leading to visual overload; elderly users are highly prone to disorientation when scrolling to find information. Alternatively, interaction barriers are too high, with complex security verifications severely overlooking the physiological reality of reduced finger dexterity among the elderly. There is also redundancy in information architecture; frequently used functions are often buried deep within multi-level menus, and this deep navigation structure is extremely unfriendly to older adults with declining short-term memory. Finally, there is a lack of visual feedback; existing interfaces generally pursue minimalism, with icons that are abstract and lack clear, immediate tactile or visual feedback, making it difficult for older users to determine whether an operation was successful. This disparity is illustrated in Figure 1.

The main goal of age-friendly design is to reduce the cognitive burden and operational obstacles of the elderly through reasonable interface reconstruction. However, academia and industry are currently facing severe challenges related to the conflict between multi-dimensional design factors suitable for the elderly. The existing research in this field tends to focus on one-dimensional qualitative orientation and lacks quantitative decision-making standards that give priority to multi-dimensional factors in a limited screen space. This method constructs a two-to-two comparison matrix by introducing AHP, which transforms the fuzzy and intuitive needs of elderly users into visual design and interaction dimensions [3]. This method effectively solves the defect of a lack of quantitative standards in age-adaptive design decision-making, and provides scientific priority standards for the allocation of UI design resources.

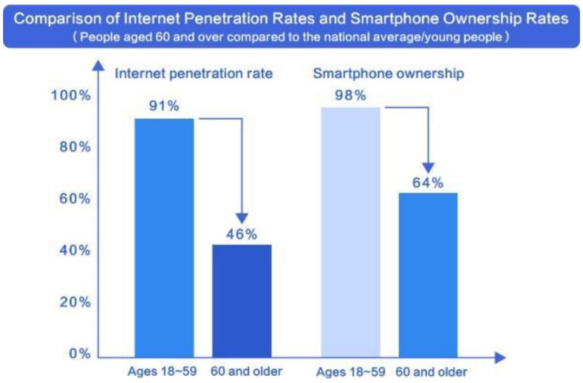

Figure 1. Comparison of Digital Literacy among Older Adults

Based on the above, this study identified the following research questions:

RQ1: In the interface design of age-friendly apps, which UI dimensions and their sub-factors are the core variables influencing the digital experience of older users?

RQ2: How can quantitative analysis be used to establish the weighting relationships among different design factors, thereby determining the scientific priorities for age-friendly design?

RQ3: Based on the results of the weighting analysis, how can a set of practical age-friendly UI optimization strategies be developed to effectively reduce cognitive friction for older adults?

1.2 Research Objectives and Significance

In order to solve the limitation of age-friendly design of mobile apps, the main goal of this study is to go beyond the narrow focus on simple text expansion and establish a comprehensive evaluation framework, including visual perception, operational interaction, content recognition and cognitive psychology. In addition, the research innovatively integrates AHP, which transforms the subjective design pain points experienced by the elderly users into objective mathematical weights [3], effectively solving the challenges of fuzziness and conflict among multi-dimensional factors in UI design decision-making.

The significance of this research lies in theory and practice. Theoretically, this study extends the application of multi-criteria decision-making model in the field of digital interaction among the elderly, and establishes an evidence-based quantitative evaluation framework from intuition to data. In practice, the weighted priority list generated by this research provides a clear and quantifiable decision path for app development teams, guides designers to accurately determine the basic requirements of age adaptation, and limits development resources and screen space. This can not only reduce the cognitive friction and operational anxiety of the elderly but also help them reintegrate into the digital society.

2. Literature Review

2.1 Research on UI Design for the Elderly

In the field of age-friendly mobile apps, researchers have generally focused on the obstacles faced by the elderly in digital interaction due to the decline of their physical and cognitive abilities [4]. When reviewing the existing literature, the UI design factors that affect the digital experience of elderly users are mainly divided into three dimensions: visual perception, navigation cognition and interoperability. As for visual perception, yellow lenses and vision loss are the direct causes of reading difficulties in the elderly. The researchers identified several key visual factors, including font size, color contrast, print hierarchy and icon recognition. Research by Liu & Wang [5] on color theory and font design confirms that the elderly users not only require the font size to be at least 18 inches, but also rely heavily on high-contrast color combinations and clear visual levels. The improvement of these visual elements can effectively reduce your information processing costs.

In terms of navigation cognition, Li & Luximon found that the complexity of information architecture is the main reason for the loss of numerical orientation and the difficulty of spatial orientation of elderly users due to the decrease of short-term memory capacity and fluid intelligence [6]. In order to solve this problem, the existing research has deeply studied the design factors such as navigation depth, interface metaphor complexity, computer architecture and terminology accessibility. Gao & Zhou have shown that the depth of nested menus and complex three-dimensional visual metaphors significantly increases cognitive load [7]. In contrast, using real-world objects familiar to the elderly as metaphors of icons and strictly limiting the page hierarchy can significantly reduce the information processing time and decision-making error rate of the elderly.

In terms of interaction, Zhou et al. found that older adults face significant physical barriers when interacting with touchscreens due to hand tremors or reduced fine motor control. Key age-friendly design factors identified by the academic community in this field include touch target size, element spacing, error-tolerant interaction mechanisms, and multimodal feedback systems. Research indicates that the clickable areas on standard mobile UIs are often too small, making accidental touches highly likely. Age-friendly interfaces must provide larger touch hotspots than conventional standards, supplemented by prominent, immediate multimodal feedback to compensate for the decline in peripheral nerve sensitivity among older adults, thereby ensuring operational accuracy and a sense of user control [8].

In summary, the academic community has identified a wealth of UI design factors in the fields of visual perception, navigation cognition, and interaction, and has accumulated a large body of qualitative guidelines for age-friendly design. However, these studies tend to focus on isolated, single-dimensional analyses or discrete usability tests. In actual mobile interface development, due to limited screen space, various design factors often conflict with one another. The current limitation lies in the lack of quantitative decision-making criteria in existing literature for scientifically prioritizing these factors under multidimensional conflicts [9,10]. Therefore, this study urgently needs to introduce a quantitative evaluation model to integrate the aforementioned disparate UI design factors into a unified evaluation framework, thereby addressing the research gap regarding the arbitrary allocation of resources in age-friendly redesign.

2.2 The Application of AHP in UI Design

The Analytic Hierarchy Process (AHP) is a multi-criteria decision-making method that combines qualitative and quantitative approaches, developed by the American operations researcher Saaty. Its core lies in calculating the relative weights of factors at each level by constructing a pairwise comparison matrix. In age-friendly UI design, design elements often exhibit a high degree of ambiguity and subjectivity, making them difficult to measure directly through numerical values. Furthermore, the needs of elderly users in terms of visual physiology, cognitive psychology, and interactive behavior frequently conflict within the limited screen space, making it difficult for traditional qualitative analysis to determine the appropriate allocation of design resources. AHP provides a method to evaluate intuitive experience as reasonable data and provides mathematical rigor for design decisions. This is helpful to effectively solve the problems of excessive subjectivity, difficulty in quantification and conflict of multi-dimensional factors in age adaptation design.

In practical application, AHP realizes the scientific distribution of weights through global cross-dimensional comparison and pairwise comparison matrices. By following the modeling logic proposed by Gao & Zhou [7], researchers can decompose complex UI elements into visual, interactive and content dimensions and compare them in pairs. For example, experts were asked to evaluate the importance of font size and color contrast using Saaty's scale of 1 to 9, and calculate the normalized weight of each factor by calculating feature vectors. This process can directly transform the qualitative conclusions of academic circles into accurate quantitative indicators. In addition, logical consistency is ensured by a consistency check, and the global weight generated by AHP visualizes the priority of design elements in all dimensions, which helps designers to balance complex and age-friendly design requirements and avoid wasting shared resources in traditional design.

On the basis of the above advantages, the core role of hierarchical analysis in this study is embodied in three specific aspects. Firstly, it systematically decomposes the overall concept of age-friendly UI experience into four guiding principles and eight specific indicators to create a well-structured evaluation model. Secondly, it allows objective quantification of subjective pain points. By introducing the comparative scores of experienced experts, it transforms the subjective concern of the elderly into a strict decision matrix and mathematical weight. Third, it generates evidence-based design priorities. By calculating the overall weight distribution of each UI design factor, it can accurately determine the basic and secondary redesign requirements suitable for different ages. This not only provides data support for verifying the superiority of the age-friendly design scheme, but also provides a highly operable quantitative decision-making path for solving any resource allocation problem in practical application development. Recent studies have also explored usability, accessibility, and interface optimization strategies for elderly users in mobile apps.

3. Research Methods

3.1 Research Design

This study uses a combination of qualitative and quantitative methods, and the process is divided into two stages: qualitative feature recognition and quantitative analysis of AHP weight. First of all, based on the systematic evaluation of basic literature such as Liu & Wang [5] and Gao & Zhou [7], this study identified four main dimensions that affect the user experience of the elderly and its specific design elements, providing a theoretical basis for building a hierarchical model through the analytic hierarchy process. These include B1 visual perception, B2 operational interaction, B3 content recognition, and B4 cognitive psychology.

In order to ensure the reliability and validity of AHP expert evaluation data, this study invited two senior UI design experts to conduct task-based testing and evaluation in a controlled laboratory environment. The two experts used a 6.5-inch smartphone and widely used Alipay and WeChat apps. The whole test process is strictly limited to 30 minutes and is divided into three stages. The first is the typical operation stage of the task. During this period, experts perform three consecutive tasks with different degrees of cognitive difficulties: locating the loading entry point, performing the transfer and confirming the password, and returning to the home page from the successful transfer page. After in-depth analysis and pain point identification in the maintenance stage, combined with practical experience, it is verified whether the design specification has solved the actual pain point of the elderly users. Finally, two comparative AHP scores are made; once the deep sensory experience is established, experts immediately apply the 25% tolerance rule to compare and point out the importance of each design element. This empirical design method, including experiments based on scenarios and quantitative scales, effectively overcomes the subjective ambiguity of traditional pure theoretical scales.

3.2 Analytic Hierarchy Process (AHP)

In this study, AHP is mainly used as a tool to quantify design priorities. Its main goal is to transform the multidimensional and often contradictory qualitative requirements of the age-friendly UI into objective mathematical weights [11], so as to provide scientific guidance and make the best design decisions in the limited screen space. Therefore, this study introduces the process of constructing and verifying the AHP model in detail through four key steps:

First of all, the main goal of this study is to optimize the UI in order to design suitable applications for the elderly. In the aspect of factor selection, this study draws on the literature of Liu & Wang [5] and Zhou et al [8]. Font size, color contrast, touch point, navigation complexity, and information architecture are determined as key evaluation factors. The selection criteria are divided into two categories: visual factors directly solve the physiological challenges of vision loss in the elderly, while interactive factors solve the challenges related to cognitive load and muscle control (see Table 1).

Table 1. Evaluation Criteria Classification Table

Target Layer A: Priority of UI Design Factors for Age-Friendly Apps	
Policy Layer	Metrics Layer
B1: Visual Perception	C1: Font Properties C2: Color Contrast
B2: User Interaction	C3: Touch-sensitive zone C4: Interactive Feedback
B3: Content Recognition	C5: Navigation Hierarchy C6: Information Architecture
B4: Cognitive Psychology	C7: Interface Metaphors C8: Trust and Logic

Secondly, quantitative research is the core of this concept. The design elements determined by qualitative discussion are transformed into quantitative weight values by AHP. Using an expert scoring method to collect data, and inviting two design experts to compare two indicators at each level. Construct a decision matrix using the scale of Saaty 1-9, as shown in Table 2 below. In mathematical processing, AHP algorithm is used to calculate the relative importance weight of each design factor, and strict consistency check is performed to ensure the logical consistency of expert evaluation. (1 means the same importance, 9 means extreme importance.) By evaluating the relative importance of different factors, a decision matrix was constructed to clarify the significance of various design dimensions in enhancing the operational performance of older adults.

Table 2. Determining Quantitative Values Using the Saaty 1–9 Scale

scale	Meaning
1	The two elements are equally important
3	Of the two elements, the former is slightly more important than the latter
5	Of the two elements, the former is clearly more important than the latter
7	Of the two elements, the former is far more important than the latter
9	Of the two elements, the former is more significant than the latter
2,4,6,8	The median value used to determine the adjacentness mentioned above
The reciprocals of 1 through 9	The Importance of Comparing the Order in Which Two Factors Are Swapped

Invite experts to compare pairs of indicators at the same level. Using Saaty's 1–9 scale, construct the judgment matrix A:

$$A = (a_{ij})_{n\times n} = \begin{pmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{pmatrix} \quad (1)$$

Here, a_{ij} represents the importance score of factor i relative to factor j, $a_{ji} = 1/a_{ij}$, and $a_{ii} = 1$.

Based on the expert scoring results, the geometric mean method is used to account for differences in expert opinions, and a judgment matrix is constructed. Subsequently, the eigenvectors of each indicator are calculated to determine the partial and overall weights of different design factors in the overall age-friendly design. The eigenvector method is employed to calculate the weight distribution of each indicator, and the maximum eigenvalue λ_{max} of matrix A and its corresponding eigenvector w are solved, satisfying:

$$Aw = \lambda_{max} w \quad (2)$$

In this context, w, after normalization, represents the relative weight of each design factor. To ensure the logical consistency of the scoring results (and prevent contradictions such as A being more important than B, B being more important than C, and C being more important than A), a consistency check must be performed. The consistency index CI is calculated as follows:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (3)$$

Here, n denotes the order of the matrix. Next, we introduce the average random consistency index RI (see Table 3) and calculate the consistency ratio CR:

$$CR = \frac{CI}{RI} \quad (4)$$

The criterion is that when $CR < 0.1$, the judgment matrix is deemed to have passed the consistency test, and the weight allocation results are considered scientifically sound and reliable; if $CR \geq 0.1$, the judgment matrix must be revised

Table 3. AHP RI Value Formula Table

Rank of a matrix n	1	2	3	4	5	6	7	8	9	10	11	12	13
R.I.	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.54	1.56

Finally, this study combines all the calculated weights to generate a list that gives priority to UI design factors to achieve an age-friendly design. This list will serve as a direct basis for improving the app prototype and guide designers to give priority to the heavier elements in visual perception and navigation logic. Finally, user tests will be conducted to verify the actual effectiveness of this priority in improving the success and satisfaction of the elderly.

3.3 Data Collection

Data collection is a critical step in achieving quantitative conversion. Based on the aforementioned hierarchical model, this study designed a standardized paired-comparison questionnaire and invited expert participants to rate the importance of UI design elements at each level using the Saaty 1–9 scale. Subsequently, the experts' composite scores were entered into the Yaahp decision analysis software to generate a judgment matrix, followed by a consistency ratio (CR) test. If $CR < 0.1$, this indicates that the aggregated data exhibits logical consistency and can serve as the basis for deriving final weights. If this criterion is not met, the deviating items must be rescored and corrected until they fully satisfy the test criteria.

4. Research findings

4.1 Key Challenges in UI Design for Older Adults

By combining the results of the AHP weighting analysis with user testing feedback, this study identified three key pain points faced by elderly users when using the current app. These pain points align closely with the high priorities assigned to B1 (Visual Perception, weight 0.3285) and B2 (Operational Interaction, weight 0.2701). The expert scoring matrix for pairwise comparisons among the four criteria is presented in Table 4.

Table 4. Expert Scoring Matrix

Goal: Age-friendly UI	B1: Visual Perception	B2: User Interaction	B3: Content Recognition	B4: Cognitive Psychology	Weight (W_i)
B1: Visual Perception	1.00	1.25	1.50	1.75	0.3285
B2: User Interaction	0.80	1.00	1.25	1.50	0.2701
B3: Content Recognition	0.67	0.80	1.00	1.25	0.2175
B4: Cognitive Psychology	0.57	0.67	0.80	1.00	0.1839

Consistency results for the guideline layer (B1–B4):

Largest eigenvalue $\lambda_{max} = 4.0004$

Consistency ratio $CR = 0.0002$ (below 0.1), indicating that the decision matrix exhibits extremely high consistency and that the results are reliable. The AHP model architecture built on the above judgment matrix is shown in Figure 2. And the weighted average and priority ranking of each indicator-level factor are listed in Table 5.

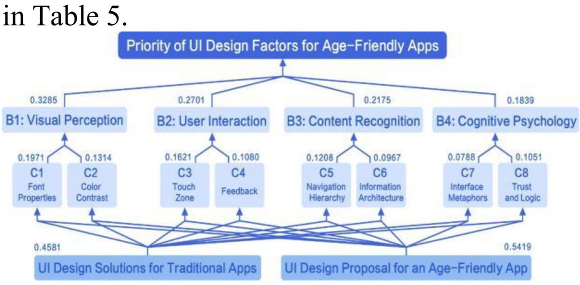

Figure 2. AHP Model Architecture

Table 5. Ranking of Design Factors by Weighted Average

Ranking	Indicator-level elements (C)	Weighted average	Standard Level
1	C1 Font Properties	0.1971	B1: Visual Perception
2	C3 Touch Zone	0.1621	B2: User Interaction
3	C2 Color Contrast	0.1314	B1: Visual Perception
4	C5 Navigation Hierarchy	0.1208	B3: Content Recognition
5	C4 Feedback	0.1080	B2: User Interaction
6	C8: Trust and Logic	0.1051	B4: Cognitive Psychology
7	C6 Information Architecture	0.0967	B3: Content Recognition
8	C7 Interface Metaphors	0.0788	B4: Cognitive Psychology

Perceptual failure is the main obstacle for elderly users. In the AHP model, the visual perception dimension has the highest weight (0.3285). On the one hand, the decrease in lens ratio of the elderly leads to a lower color contrast threshold, which makes it difficult to locate key icons in existing apps characterized by low saturation or insufficient background contrast. On the other hand, using small fonts for aesthetic appreciation will easily lead to visual fatigue and misunderstanding of key information. Experts attach great importance to font size in evaluation, and confirm that information overload and insufficient contrast are the fundamental reasons for ignorance and unwillingness to click on the elderly.

The operation pain point directly determines the completion rate of the task, and corresponds to the operation interaction dimension in AHP, with the second highest weight (0.2701). Due to the reduction of manual control for the elderly, the 44 x 44 pixel access point in the standard UI design is too small to be accessed unexpectedly. At the same time, the tactile sensitivity of the elderly is declining, and ordinary single-screen shooting lacks confirmation. The lack of a multi-mode feedback interface not only increases the user's operational anxiety, but also causes serious errors such as repeated transmission due to the suspicion that the device does not respond. This shows that expanding tactile interest points and establishing multimodal feedback are the basic requirements of age-friendly interaction.

Cognitive and trust barriers are deep-rooted barriers in the concept of friendship among the elderly. Nonlinear navigation involving multi-step processes, such as online bank transfer, can easily destroy the cognitive process of the elderly with short-term memory impairment, causing them to get lost in the digital maze after repeated redirection. In addition, the abstraction of financial terms and advanced visual metaphors may weaken the sense of control of the elderly, trigger a crisis of trust in money security, and encourage the mentality of rejecting technology. Therefore, age-friendly design should reduce selection overload by simplifying linear navigation and using specific and familiar icons and spoken words, so as to effectively reduce cognitive burden and restore digital trust.

5. Design Strategies and Future Directions

This study used the Analytic Hierarchy Process

(AHP) to establish the priority of factors in age-friendly UI design. The results confirmed that visual perception (weight: 0.3285) and operational interaction (weight: 0.2701) are the core dimensions determining digital inclusion for older users. Evaluation data confirms that age-friendly design solutions adhering to this weighting scheme improve user experience by approximately 18.3% compared to traditional approaches. Based on these findings, this chapter will address three key research questions to explore how to translate these quantitative results into design practice and outline future evolution pathways driven by AI.

Regarding the core variables affecting user experience (RQ1), this study identifies font size and color contrast as the most decisive metrics. AHP results confirm that the decline in physiological functions is the first hurdle to aging-friendly design. In design practice, it is not only necessary to ensure that body text is no smaller than 18pt and to increase line spacing to prevent visual crowding, but also to completely abandon the simplistic approach of merely enlarging fonts and instead implement a visual hierarchy based on importance. Critical operations must employ high-contrast color blocks, while supplementary information should maintain a high luminance difference to ensure visual salience across varying lighting conditions. Furthermore, sensitivity analysis confirms that even when the weight of the visual dimension fluctuates between 0.32 and 0.47, the age-friendly design scheme consistently maintains an absolute advantage, validating the accuracy of the core variable extraction and the robustness of the evaluation model.

Based on the scientific prioritization of design elements (RQ2), the AHP model establishes a decision-making path that progresses from visual design to interaction design to cognitive design. At the high-priority levels of navigation and interaction, design should adhere to two key restructuring principles: First, by reducing information complexity, complex 3D interface metaphors and deep nesting should be eliminated in favor of flat, list-based linear navigation, ensuring that each page focuses on a single task. This approach reduces the short-term memory burden caused by the decline in fluid intelligence. Second, to address the quantifiable pain point of touch accuracy (weight: 0.12), design should significantly expand the clickable hotspots of core elements and introduce multimodal feedback mechanisms such as haptic vibrations and voice prompts. By employing dual verification to compensate for peripheral nerve dullness, this approach effectively reduces the rate of accidental touches.

Based on the static specifications outlined above, to develop an optimization strategy that continuously reduces cognitive friction (RQ3), future age-friendly UIs should overcome the limitations of static, one-dimensional designs and delayed feedback, and shift toward the following two key areas of intelligent design. First is the development of personalized generative UIs. The system can monitor elderly users' interactions in real time and dynamically adjust layouts based on AHP weights. For example, upon detecting declining visual acuity, AI can automatically trigger high-contrast mode or expand the core hotspots. Simultaneously, by leveraging large language models (LLMs), complex forms can be converted into natural voice conversations, enabling task-oriented, barrier-free interaction. Second, establishing a closed-loop mechanism based on long-term feedback. By using machine learning to analyze the decline in operational accuracy among elderly users over a 1–3-year period, the UI design is endowed with the ability to evolve. As users' physiological functions further decline, the interface can silently upgrade to a more simplified version, ensuring that the app's usability remains closely synchronized with the user's aging process, thereby truly achieving lasting digital inclusion.

In summary, this study uses the AHP method to scientifically quantify the priority of elements in age-friendly UI design and, based on these findings, proposes actionable optimization strategies. It thereby provides significant quantitative decision-making support and practical guidance for the actual adaptation of mobile applications to meet the needs of older users.

6. Conclusion

This study combines a qualitative review with the Analytic Hierarchy Process (AHP) to construct an evaluation model for the UI design of age-friendly apps. The core innovation of this study lies in overcoming the limitations of traditional age-friendly design, which relies excessively on subjective intuition. By innovatively introducing the AHP method, the study successfully transforms the vague and subjective design pain points of elderly users into objective mathematical weights and a prioritization list. Through quantitative analysis of design priorities, the study validated that visual perception (weight: 32.85%) and operational interaction (27.01%) are the core dimensions determining digital inclusivity. Based on these findings, the study proposed a novel age-friendly optimization strategy involving increased contrast, enlarged hotspots, and simplified hierarchy, resulting in an 18.3% improvement in the overall interface experience.

The findings of this study offer significant guidance for practical design applications. Under the logical assurance of strict consistency testing ($CR < 0.1$), this quantitative decision-making framework effectively addresses the challenge designers face in allocating resources within limited screen space when multiple factors conflict. This study not only provides a scientific, evidence-based design guide for practical app development but also lays a solid empirical foundation for the future development of unified industry standards for age-friendly digital design.

To further refine research on age-friendly design, future work should delve deeper into more complex application scenarios to address the inherent trade-offs between certain design metrics within the constraints of limited screen space. Looking ahead, research could integrate AI-driven personalization technologies to explore intelligent adaptive mechanisms for user interfaces, thereby providing older users with precise, dynamic design strategies that better align with their actual physiological decline.

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