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An interface layout optimization strategy for a smart outpatient medical service platform considering the cognitive characteristics of the elderly in the digital age

Fan Wang[1], *Liping Jiang*[1,*], *Wenjing Dai*[2], *Fei Ma*[3] *and Qian Zhang*[4]

[1] Xinhua Hospital, Shanghai Jiao Tong University School of Medicine, Shanghai, China, 200092

SUMMARY: *In response to the problems such as slow information recognition, difficult path judgment, and insufficient operation confirmation faced by elderly patients when using the smart medical service platform in digital outpatient services, this article, based on the cognitive characteristics of the elderly, studies the interface layout optimization strategies for the outpatient smart medical service platform. By combining the continuous task process of the outpatient department, an analysis model including cognitive load, page information burden, information item weight, and path switching cost is constructed. The optimization methods combining task priority ranking, three-zone stable layout, dynamic navigation prompts and feedback reinforcement are proposed. The evaluation results show that the optimized interface can reduce the average task completion time from 128 seconds to 96 seconds, increase the task success completion rate from 78.4% to 91.8%, and significantly improve the process understanding score and satisfaction. The research indicates that reconfiguring the page organization logic based on the cognitive characteristics of the elderly can help improve the usability and elderly-friendly level of the outpatient smart platform.*
Povzetek: Članek obravnava optimizacijo postavitve vmesnika pametne ambulantne platforme za starejše uporabnike v digitaliziranem zdravstvenem okolju. Na podlagi kognitivnih značilnosti starejših, poteka ambulantnih nalog in organizacije informacij predlaga strategije za razvrščanje nalog, stabilno območijsko postavitev ter povratne informacije. Rezultati vrednotenja kažejo krajši čas izvajanja, manj napak in boljše uporabniško razumevanje procesa.

KEYWORDS: *Elderly cognitive characteristics; Service platform; Interface layout; Elderly-friendly design*

1 Introduction

Digital technology continues to be integrated into the medical service system. The outpatient process has gradually shifted from traditional window-based processing to online appointment, intelligent triage, self-check-in, examination query, payment and ticket collection, and report retrieval integration. The smart medical service platform has thus become an important support for daily patient reception in hospitals [1]. After introducing this platform, the integration level of the entire workflow has been enhanced, and the way of information interaction between doctors and patients has also changed. For those accustomed to using smart terminals, it means saving time and simplifying service channels; however, many elderly people may think that this

*13868311990@163.com
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change does not necessarily bring convenience. Due to the characteristics of medical treatment scenarios, such as physical pain, psychological anxiety, and heavy tasks, if the platform design is complex, the information is scattered, and the guidance is unclear, it may lead to elderly users being unable to correctly understand the operation procedures of registration, payment, and test appointment within a short period of time, resulting in delays in completing the process and causing patients to hesitate in decision-making or be interrupted, ultimately reducing their medical efficiency or even making it impossible for them to complete the entire medical process independently.

The problems of the elderly are not only due to lack of usage experience, but more often caused by changes in cognitive processing traits as they age. For example, problems such as decreased visual search ability, reduced working memory capacity, poor attention persistence, and inability to adapt to new icons and multitasking switching can quickly be exposed during human-computer interaction. All of these will be quickly reflected in the interface interaction process. Moreover, the medical treatment process often has a clear goal orientation, a compact process, and few opportunities for error correction, which means that patients need to understand the information displayed on the screen, identify the function buttons, and confirm the completion effect within a short period of time [3]. Therefore, interface design is not only an aesthetic issue but also a key factor affecting information accessibility, task success, and trust. If the interface design overly focuses on scientificity while neglecting the cognitive rhythm of the elderly, even if all functions are realized on the platform, new problems may arise in real life.

Current research on intelligent medical consultation systems of medical service centers mainly focuses on integration, service process optimization, and system operation efficiency, and the design for elderly adaptability often remains at issues such as font size, color brightness, button size, etc. [4]. However, there are few studies on interface object layout design based on the cognitive characteristics of the elderly, especially lacking a design approach that takes a global perspective to coordinate the design of the medical treatment task flow, information architecture, and page layout. For elderly patients, what they pay more attention to is whether they can directly find the correct entry point, whether the content prompt of the current stage is clear and understandable, and whether there are redundant and chaotic interference sources on the page. It is not just a single problem of a certain element being too large [5]. That is to say, the optimization of the service platform should not be limited to local repairs, but should return to the patient's knowledge system and real medical experience, re-examining issues such as the priority setting of information, the rationality of functional zoning, and process connection.

The main focus of this study is to analyze how digital medical service platforms can meet the needs of the elderly, especially the impact of their unique cognitive characteristics on interface design. To this end, we have conducted explorations in the following areas: discovering the cognitive characteristics of the elderly; Organize the medical treatment process and information; Improve the usability of information. What we ultimately hope to achieve is to derive the best solution from the above process to meet the needs of hospitals in serving the elderly.

2 Literature Review

2.1 Research Status of Outpatient Smart Medical Service Platform

On the road of medical informationization development, the application of intelligent service platforms can basically integrate functions such as appointment, calling, payment, report inquiry, and consulting services into one system, in order to shorten the average length of hospital stay for patients, reduce the pressure of first visit, and improve the efficiency of outpatient work [6]. The organic linkage between the mobile client, vending machine, and backend server has expanded from the study of individual functions to the research on optimizing the entire process, collaborative service supply, and patient experience. On the one hand, research will be conducted on the center's management of medical treatment sorting, reduction of idle time, and visualization display; On the other hand, some scholars believe that it is an effective tool for hospital refined management, and suggest that smart platforms can use information exchange to improve outpatient models, and patients' medical paths can shift from scattered to clustered and from collection to guidance.

The current research subjects mainly focus on three aspects: first, the design of functional structure and systemization, that is, how each part collaborates through functions such as appointment - call - payment - report retrieval to ensure the smoothness of the entire business process; second, the analysis of platform operation performance, including the diversion situation before and after the application of the platform, call machine load, waiting time length, and patient satisfaction, etc. Third, from the user perspective, it focuses on factors such as clear interface, convenient operation, and quick feedback that affect the platform usage experience [7-9], illustrating that the value of intelligent medical services lies not only in the technical application level, but also in whether it can help patients accurately understand and implement various diagnostic and treatment behaviors.

However, these studies still have obvious common deficiencies: first, scholars mostly discuss from the perspective of medical institution management and system construction, emphasizing the completeness of its functions and the circularity of the workflow, but pay insufficient attention to the practical differences among different age groups [10]; second, discussions on the issue of adaptability to the elderly only stop at superficial aspects such as enlarging font size, bolding colors, and voice announcements for elderly-friendly design, and do not conduct research on interface hierarchical relationships, information density, functional zoning, and process correlation [11]. Ultimately, in the outpatient scenarios with tight time constraints, strong coherence, and high cognitive load, the interaction barriers encountered by the elderly do not merely stem from single-point control devices, but more from the conflict between the overall interface design and cognitive rhythm [12]. Therefore, research should be based on the cognitive characteristics of the elderly, and be based on the consistency analysis model of interface layout, task process, and information organization to conduct a secondary examination and research on the intelligent medical service platform end.

2.2 Research on Cognitive Characteristics of the Elderly and Design of Age-Friendly Interfaces

Recently, research on the use of digital products by the elderly has expanded from general usability assessments to discussions on issues related to cognitive features, interactive challenges, and environmental factors. Most studies indicate that elderly people's barriers to using health monitoring devices, patient networks, telemedicine, and mobile health management devices are not simply due to "not knowing how to use" or "not knowing". The deeper reason is due to a series of factors such as sensory organ dysfunction, lack of concentration, decline in short-term memory, and decreased information processing speed that occur with age [13], which prompts friendly design for the elderly population to no longer be limited to simple font size enlargement, but gradually expand to interface structure, information hierarchy, operation steps, and other aspects.

Currently, most studies have focused on the attention paid to the basic interaction methods of the elderly. Earlier studies concentrated on the research on the impact of button size, font size, and button position on the usability and error-proneness of touchscreen devices. They found that in the face of smaller touch targets, complex screen transitions, and a large amount of visual information, elderly users are more likely to experience mis-touches, hesitation, or termination [14]. This kind of exploration provides clear guidance directions for design and explains that basic interface elements do indeed have an important impact on the operation of elderly users. However, most existing studies only solve the problems of whether they can click and whether they can see, and rarely discuss how to find and understand the logical relationships of the page [15].

Some other studies have begun to focus on cognitive stress and the understanding process of the interface. Based on these research results, the elderly usually encounter difficulties in handling complex multi-level menus, abstract image identifiers, professional vocabulary, and task processes across pages [16]. Wildenbos et al. proposed a new framework for usability issues in mobile health, and they found that for elderly users, it is not a single factor that determines their usage experience, but multiple factors including cognitive level, motivation, physical condition, and interface design that jointly determine the effectiveness of their use; in addition, Nurgalieva et al. after systematically studying the touch screen design criteria proposed that simplifying hierarchy, reducing information density, and ensuring consistency can reduce the cognitive burden of the elderly [17]. Therefore, making the elderly-friendly design is not simply about amplifying certain factors, but the core is to enable the elderly to quickly make page judgments within a short period of time and complete target operations along a clear direction.

In the medical and health field, scholars have found that the difficulties faced by elderly people in using digital technology are related to their health concepts, past experiences, levels of anxiety, and environmental stress [18]. When interface prompts are too brief, term expressions are too professional, and operation feedback is not clear enough, even if elderly users can enter the system, they may not be able to successfully complete consecutive tasks such as appointments, inquiries, and payments. Some studies have begun to advocate improving the usage experience of the elderly group through familiarization design, inclusive design, and co-creation design, emphasizing that in terms of information naming, function organization, and interaction methods, it is necessary to be as close as possible to their existing life experiences and enhance the comprehensibility and acceptance of the solutions through user participation [19]. These achievements have broadened the research perspective of age-friendly interfaces and also made "user-centered" no longer remain at the principle level.

However, regarding the outpatient intelligent medical service platform focused on in this article, there are still several gaps in the existing research [20-23]. Firstly, many research subjects are general health applications, patient portals, or home health systems. The frequent, continuous, and time-limited task characteristics of the outpatient scenario have not been fully incorporated into the analysis. Secondly, although existing studies have discussed factors such as font size, color, buttons, and feedback, they still pay insufficient attention to the interface layout itself. Lack of overall introduction to the cognitive speed of the elderly and hospital procedures that are suitable for them; Secondly, although some studies have mentioned user willingness, satisfaction, and other aspects, there is little literature exploring the impact of page layout, core function ranking, guide icon placement, error prompt methods, and other factors on user achievement of goals. Therefore, optimizing the design of intelligent interfaces for medical services based on the cognitive characteristics of elderly users still has high practical significance and research value. To facilitate the presentation of relevant research results, the main viewpoints and suggestions are summarized in Table 1.

Table 1: Cognitive Characteristics of Elderly Users and Focus Areas for Adaptive Age-friendly Interface Design

Research Direction	Representative References	Main Content	Implications for This Study
Acceptance and use behavior of medical terminals among older adults	[1][12]	Focuses on willingness to use, barriers to use, and conditions for the promotion of self-service medical terminals and integrated health kiosks	Optimization of smart outpatient platforms should not be limited to functional deployment, but should also consider the practical operational threshold faced by older users
User experience of patient portals and health platforms	[3][21][22][24]	Discusses usage differences, the influence of health literacy, and engagement issues among older patients using patient portals	The design of outpatient platforms should address information comprehension, task continuity, and the development of user confidence
Basic interface design elements for touchscreens	[5][10]	Examines how button position, font size, and touch interaction affect the operational performance of older adults	Interface layout optimization should take clarity, stability, and low mis-touch rates as basic requirements
Touchscreen design and age-friendly guidelines for older adults	[7][9][13]	Systematically summarizes age-friendly design principles and practical experience for mobile and touchscreen interfaces	These studies provide support for hierarchy simplification, information focus, and consistency control in platform layout design
Usability barriers and cognitive load research	[6][8][14][16][17]	Analyzes the main barriers faced by older users from the perspectives of cognition, perception, motor ability, and task complexity	This study should discuss layout issues by integrating cognitive characteristics with outpatient task processes
Familiarity, inclusiveness, and co-design	[11][18][19][20][23]	Emphasizes familiarity transfer, user participation, contextualized design, and digital equity	Platform optimization should not remain at the level of technical logic, but should return to the real medical treatment scenarios of older users

3 Optimization of Cognitive-Driven Interface Layout for the Elderly

3.1 Identification of Cognitive Characteristics and Demand Analysis of Elderly Users

The design of the interface of the outpatient intelligent medical system not only needs to increase font size or add reminder text, but also needs to understand the thinking state of elderly patients during use and analyze their actual needs based on this. The problems in the digital experience of the elderly mainly lie in slow visual search, weakened short-term memory, increased cost of attention switching, and lack of understanding of complex symbols and deep navigation. When these issues occur in the hospital environment, they will be combined with a series of consecutive tasks such as appointment, payment, registration, and result inquiry, causing users to forget the current step they are on. This will lead to confusion in information-rich areas and even result in giving up using the process due to repeated confirmations.

To avoid making judgments on the needs of elderly users based on experience, cognitive characteristic identification can be based on task performance indicators. For a typical medical treatment task, a cognitive load index for elderly users can be constructed, as shown in Equation (1):

$$C_i = \alpha\frac{T_i}{T_0} + \beta E_i + \gamma R_i \tag{1}$$

In the formula, C_i represents the cognitive load index of the i-th task, T_i is the average time taken by elderly users to complete this task, T_0 is the benchmark completion time, E_i is the operation error rate, R_i is the number of repeated confirmations or retrials, α, β, and γ are weight coefficients, and $\alpha + \beta + \gamma = 1$. When the value of C_i increases, it indicates that the task imposes a higher understanding and operational pressure on elderly users under the current interface layout.

Based on this, it is also necessary to analyze the information burden of the page itself. If the number of visible information items on a single page, the number of step levels, and the number of key points to be remembered are respectively denoted as N_j, S_j, and M_j, then the page task burden value can be expressed as:

$$L_j = \mu N_j + \nu S_j + \rho M_j \tag{2}$$

In the formula, L_j represents the information pressure on the jth page; μ. ν and ρ respectively represent the corresponding weights. This formula indicates that if there are multiple visual elements and a high level of path hierarchy on the interface, users will need to remember more information, resulting in a higher cognitive load for elderly users.

The design improvement of the interface of the outpatient intelligent medical treatment system cannot be solved simply by enlarging the font size or prompts, but by understanding the thinking process of the elderly in seeking medical treatment, and inferring the real needs from it. The problem of elderly people's digital experience is caused by factors such as slow visual search speed, weakened short-term memory ability, and increased attention conversion costs. At the same time, they are also not easy to understand complex symbols and deep guidance. Once they appear in medical settings, it causes confusion in a series of operations such as booking, payment, reporting, and finding results, making it difficult for them to remember what operation is being carried out. In places with too much information, they feel lost and give up the entire process due to repeated confirmation.

3.2 Information Organization and Interface Adaptation in the Medical Treatment Task Process

For intelligent medical information systems, the organization of information is not only about layout of content, but also determines whether elderly people can understand, choose paths, and take action in a shorter period of time. Compared with conventional applications, hospitals have characteristics such as clear goal orientation, continuous processes, and rapid changes in status.

After patients make an appointment for registration, they go through processes such as admission registration, waiting, payment and examination, and obtaining reports. The page tasks also change along with the medical treatment process. If the layout is still based on a fixed menu format, all functions need to be presented in a long-term side-by-side manner, which is a continuous search, comparison, and memory process for elderly users. This cognitive load will accumulate with the increase in switching times. Therefore, we need to start from the perspective of the medical treatment process and reasonably change the information organization form in the interface to ensure that the information such as "what step is being done, where to go next, and how many steps have been completed" is always visible on the interface.

To describe the changing states of outpatient tasks at different stages, the task state vector of the t-th medical treatment stage can be recorded as

$$S_t = [Q_t, U_t, M_t, R_t] \tag{3}$$

In the formula, Q_t represents the core task category of the current stage, U_t indicates the urgency of the task, M_t represents the amount of memory information required to complete the task, and R_t indicates the degree of impact on the subsequent process after an error occurs. The meaning expressed by Equation (3) is that the page cannot use a uniform density, uniform priority, and uniform entry to carry out all stages of tasks, but should adjust the information display method according to the changes in S_t. When U_t and R_t are high, the interface should highlight a single main task and reduce auxiliary entries; when M_t is high, the key information should be combined for presentation to reduce the demand for cross-page memory.

During the information organization stage, the platform needs to calculate the priority of various information items. Let the importance of the i-th information item on the page be W_i, and its calculation formula is

$$W_i = \alpha F_i + \beta T_i + \gamma C_i - \delta D_i \tag{4}$$

Among them, F_i represents the usage frequency of the information item in the outpatient process, T_i represents the relevance to the current task, C_i represents the strength of its support for task completion, D_i represents the interference degree with the main task, and α, β, γ, δ are weight coefficients. According to Equation (4), contents such as sign-in entry, waiting status, outstanding fees, and examination time usually have higher W_i values and should be placed at the visual center or in the front area of the page; news push, promotional notifications, and extended services, although also exist, have higher D_i values and are more suitable to be compressed into the low-interference area.

To meet the visual search needs of the elderly, we need a stable and reasonable layout. We divide the hospital outpatient system webpage into three main parts: the upper part is the current status display area, the return to home button and the manual assistance button; the middle part is the current only target and its important description; the lower part contains some infrequently used functions and additional information. Among them, Bj represents the layout carrying capacity of the jth block, which can be expressed as

$$B_j = \sum_{i=1}^{n} W_i \cdot L_{ij} \tag{5}$$

In the formula: L_{ij} represents the weight coefficient by which the i-th information item is allocated to region j; if critical information is distributed in the intermediate working area, the page center will quickly form; while less critical and weaker information items will be moved down or compressed, and the main task will be less likely to be disturbed. This equation indicates that the division of regions is not based on intuitive visual balance, but rather adjusts the organization of information according to the importance of the task. For older users, such a stable structure is more crucial than a fancy appearance, because it can reduce the cost for them to have to relearn every time they encounter a new page.

There are also obvious chain-like development characteristics in outpatient work, so the interface connection not only needs to focus on the performance of a single page, but also needs to take into account the smoothness between pages. Let the page transition cost from p to q be K_{pq}, then there is

$$K_{pq} = \mu H_{pq} + \nu E_{pq} + \rho G_{pq} \tag{6}$$

Here, H_{pq} represents the page hierarchy, E_{pq} represents the additional click count, and G_{pq} represents the psychological cost of understanding a new page. μ, ν, and ρ are coefficient values. The pain points for elderly users are not about clicking on a certain function, but rather not knowing "where I am at this step" after opening a new page. Therefore, the core of path optimization is not to minimize the number of pages, but to reduce the value of G_{pq} and ensure that after each jump, users can immediately see their current location, the result of the previous step, and the next operation. Thus, the design principle proposed is: all page elements (title, step list, completion prompt, and next button) should be presented in the same location, rather than scattered everywhere.

Based on the above analysis, an information organization and interface setting model for the medical consultation process can be obtained, as shown in Figure 1.

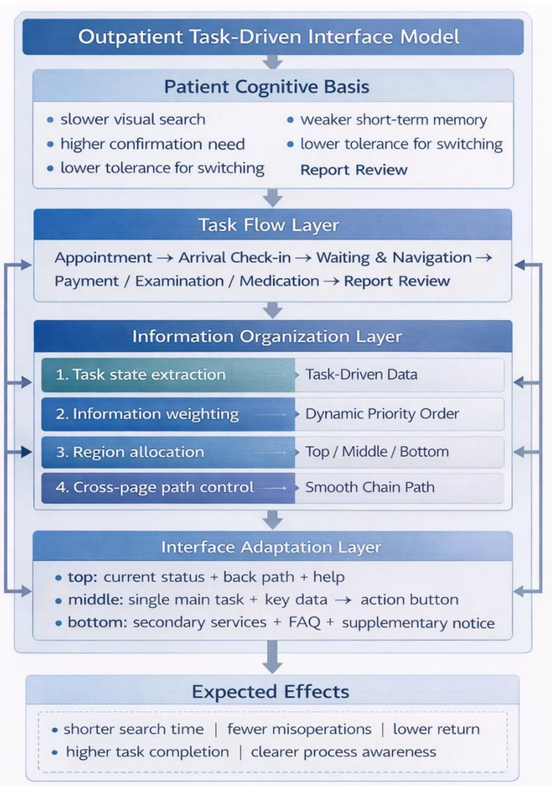

Figure 1: Information Organization and Interface Adaptation Framework within the Medical Treatment Task Process

As shown in Figure 1, during the process of achieving a goal, these steps are not independent of each other but are interconnected to jointly complete the generation of the web page and the reasonable layout of web information. For example, in a certain step Ut is relatively large, meaning that during the admission process, registration verification is required. This indicates that the system should place the registration code, registration button, clinic reminder, human assistance, etc. as much as possible in the primary functional area, while other information can be displayed at a lower priority. After the user makes a payment and initiates the test, the page will automatically place the payment status, test item number, and test location at the top and provide a next step prompt to avoid the user searching for the test site after making the payment. After this processing, the interface is no longer a simple stack of static pages, but rather a form of organization that changes with the work process. To address the issue of whether a certain page is suitable in the current state, an interface adaptation function can be defined:

$$A_t = \lambda \frac{\sum W_i^{main}}{\sum W_i} + \theta \left(1 - \frac{K_t}{K_{max}}\right) + \kappa P_t \tag{7}$$

In this model, $\sum W_i^{main}$ represents the cumulative value of the information weight of the main functional area, $\sum W_i$ corresponds to the total information weight of the page, K_t reflects the average cost of path conversion at the current stage, K_{max} is the maximum allowable operation cost threshold of the system, P_t is used to measure the completeness of page status feedback, and λ, θ, κ respectively represent the adjustment coefficients of different dimensions. With the increase of at, it indicates that this boundary is more friendly to the cognitive rhythm and tasks of the elderly. Equation (7) also proves that interface design is not only about simplifying the amount of information and placing buttons, but also about considering multiple aspects such as the focus on the main task, path conversion costs, and completeness of status prompts.

In summary, in the process of medical task flow, the adaptability of information and interface should be based on a continuous system of "task stage identification - information calculation - fixed layout of the area - cross-page path control", rather than a process of repairing the traditional page locally. Only by ensuring that the hierarchical relationship of each page corresponds to its workflow, ensuring that each step of conversion has its purpose, and maintaining key information within a perceptible range, can the digital medical center service system complete the evolutionary process from "available" to "age appropriate".

4 Interface Layout Optimization Strategy for the Smart Medical Treatment Service Platform in Outpatient Clinics

If we want to improve and optimize the interface of intelligent medical systems, we must shift our attention from "function stacking" to "function combinations that switch according to task requirements", especially in the elderly user group. The usability of the system not only depends on the font size or key area, but also includes factors such as easy access to commonly used tools, clear identification of the current location on the switching page, and clear and intuitive feedback after performing operations. Based on the previous discussion of user cognitive characteristics and the medical treatment process, this section proposes an optimization system consisting of task priority setting, interface area planning, navigation path simplification, and feedback mechanism strengthening. Its overall architecture is shown in Figure 2. This system takes the cognitive limitations of elderly users as the base parameters and the status of the medical treatment process as the adjustment basis. Through dynamic layout algorithms, it outputs the presentation schemes for each page, and continuously optimizes the interface configuration parameters based on user interaction data.

During the layout optimization process, page modules should not adopt a fixed sorting method, but should be recalculated based on the current medical treatment stage for display priority. Let the layout priority value of the i-th function module in the current state be R_i, then there is:

$$R_i = \alpha P_i + \beta S_i + \gamma E_i + \delta A_i \tag{8}$$

In the formula, P_i represents the task weight of the module in the outpatient process, S_i indicates the degree of relevance to the current stage status, E_i represents the intensity of the error operation risk, A_i represents the access frequency of the elderly users for this module, and α, β, γ, δ are weight coefficients. The higher the R_i value, the more the module should be close to the main view area of the page. After this processing, on the homepage before the appointment, "Appointment Registration" and "Registration Record" can be highlighted, and after arriving at the hospital, it automatically switches to "Sign-in Confirmation" and "Waiting Room View", and after the diagnosis and treatment, "Payment", "Check-up Arrangement", and "Report Query" are pushed to the visual center. The main and secondary areas of the page are no longer determined subjectively by the designer, but are driven by the real-time task status.

After the module sorting is determined, the area allocation needs to be completed. Considering the visual search habits of elderly users, the page can be stably divided into the top navigation area, the main task area in the middle, and the bottom auxiliary area. If $x_{ij} \in \{0,1\}$ represents whether module i is allocated to area j, then the overall layout objective function can be written as:

$$\max Z = \sum_{i=1}^{n}\sum_{j=1}^{m} x_{ij}\left(\mu R_i + \nu V_{ij} + \rho C_{ij}\right) - \lambda \sum_{j=1}^{m} D_j \tag{9}$$

Among them,V_{ij} represents the visual saliency matching value when module i is placed in region j,C_{ij} represents the degree of support for task continuity of this placement method, D_j represents the congestion penalty term of region j, and μ, ν, ρ, λ are adjustment parameters. The significance of Equation (9) lies in that layout optimization does not merely increase the salient elements, but emphasizes the key tasks while controlling the page congestion degree, so that high-priority modules are concentrated in the central main task area, and the path description and help entry are stably retained at the top, while low-frequency services and explanatory information are pushed to the bottom area.

After the page structure is determined, the navigation hierarchy needs to be compressed. Once the page framework is established, the navigation hierarchy needs to be streamlined. The common operational difficulties in medical appointment systems are not usually caused by click actions, but rather by the confusion of directions after page transitions. Based on this, the complexity of the navigation system can be quantified as:

$$G = \sum_{k=1}^{L}(\eta h_k + \theta b_k + \kappa u_k) \tag{10}$$

Where L is the level of the required number of layers to complete a given medical and health service activity; Hk represents the navigation depth at the k-th level; Bk represents the probability of each branch path being selected by the user; UK represents the cognitive load required for understanding on the page; η. Both θ and κ are moderating variables. Assign different weight values to indicators in different aspects. We hope to ensure service quality and improve work efficiency while maintaining a lower overall evaluation value G. At the specific implementation level, it is necessary to simplify redundant intermediate pages, prevent the task process from being dispersed to different functional modules, and display the coherent information prompt of "current progress - executed steps - subsequent operation guidance" in real time at each operation node.

Thus, elderly users do not have to rely on memory to trace page relationships, but can directly obtain path judgment from the current interface. Figure 2 shows the overall framework of the interface layout optimization strategy for the outpatient intelligent medical service platform.

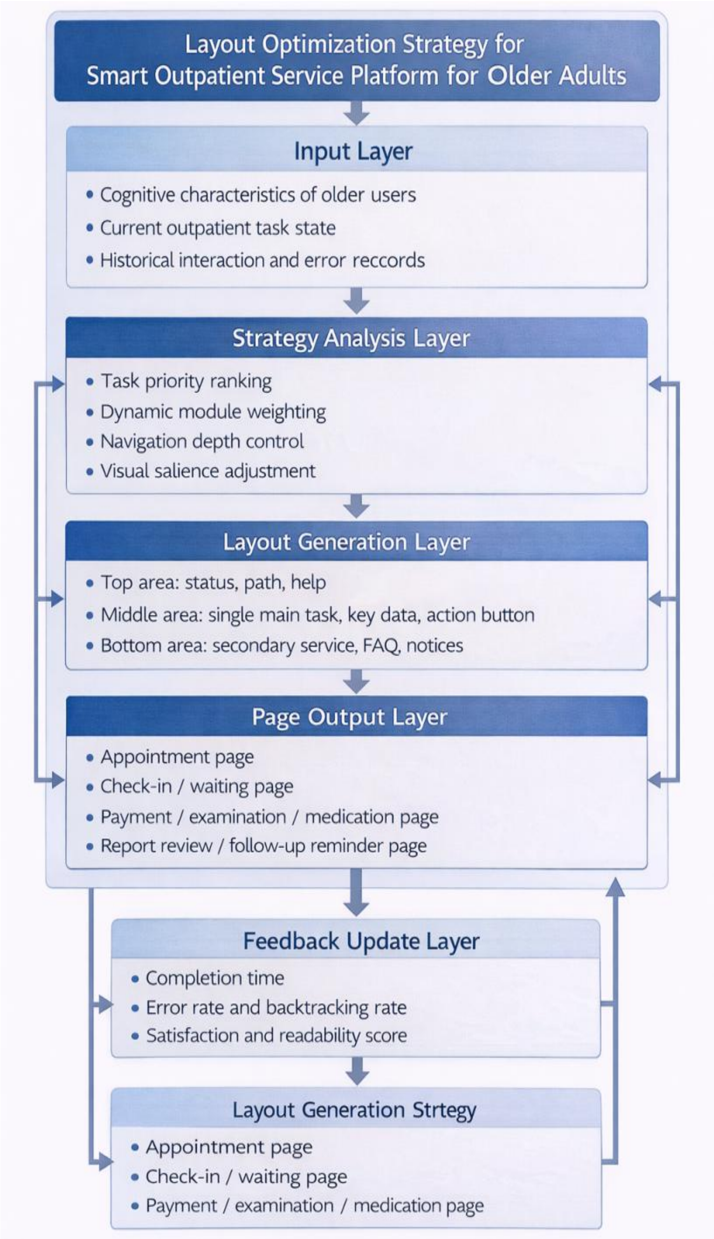

Figure 2: Framework for Interface Layout Optimization Strategy of the Outpatient Smart Medical Service Platform

Apart from layout calculation, feedback reinforcement is also an indispensable part of platform optimization. Elderly users tend to rely more on confirmation information in medical treatment scenarios. If the submission result is unclear and the rollback path is not clear, even if the task has been completed, it is prone to result in repeated clicks or repeated inquiries. Based on this characteristic, the interface feedback gain can be defined as:

$$F_t = \phi Q_t + \psi B_t + \omega H_t \tag{11}$$

In the formula, Q_t represents the clarity of result confirmation, B_t represents the clarity of the fallback path, H_t represents the accessibility of the manual assistance entry point, and ϕ, ψ, and ω are weight coefficients. From an operational perspective, the system should provide clear feedback to the user's primary nodes, such as successful submission, payment completion, clock in completion, report generation, and other key processes; At the same time, the platform should also save all operation traces for users to trace and view. This can avoid repetitive behaviors caused by forgetting.

From the perspective of overall design, optimizing the interface of the outpatient intelligent service system is not simply a process of adding various design elements, but a technical system construction process that can be quantitatively evaluated, self adapted, and continuously iterated and updated. By utilizing methods such as task prioritization, interface optimization, simplified navigation paths, and enhanced responsiveness interaction, this framework can transform the cognitive characteristics of the elderly into design specifications. The interface produced in this way not only has good visual consistency and readability, but also can quickly identify the desired target in practical medical scenarios, reduce the risk of accidental touch, and help the elderly smoothly complete the digital medical service process.

5 Optimization Effect Evaluation

5.1 Evaluation Design

To verify the effectiveness of the designed outpatient interface optimization plan, the team used multiple evaluation methods to examine the entire operation process of elderly users, not only focusing on whether the interface is simple and easy to use, whether the operation process is convenient, how many times there are misoperations, and whether the path is uniform, but also paying attention to factors such as users' cognitive load and satisfaction. The focus of this study is to investigate whether the optimized interface can effectively improve work efficiency and reduce error rates in key stages such as appointment registration, on-site call, on-site number finding, payment, and document printing in pre screening triage; The second is to determine whether the reconstructed information architecture can effectively enhance the awareness and control of the medical process among elderly patients, and enable them to make accurate decisions between pages.

This experiment adopts a comparative experimental design method. Compare and study the prototype interface of the hospital's outpatient intelligent service system with the new interface obtained by prioritizing application tasks, three column layout, real-time guidance prompts, and strengthening feedback mechanisms; There were a total of 120 participants, including 90 elderly people aged 60 and above, who were the subjects of this evaluation; Next is a total of 30 people aged 40 to 59, used to verify whether the optimization effect is mainly targeted at the older age group. Similarly, elderly people in this age group were randomly divided into a control group and an experimental group, with 45 people in each group. In order to avoid judgment bias caused by previous use experience, we will conduct balanced treatment in grouping by asking them about the frequency of using intelligent terminals, past Internet diagnosis and treatment experience and education level during the recruitment process.

We set up a rigorous experimental environment to simulate the workflow of an actual hospital and designed four consecutive task modules: online registration and department matching, on-site registration and waiting room status inquiry, post diagnosis and treatment fees and confirmation of testing items, and consulting diagnostic information and making follow-up appointments. All participants are required to complete the same series of tasks, and the task order is strictly set according to the real-life medical process to ensure the coherence and consistency of the process. We conducted experiments using standard mobile terminals in a standardized network environment, providing only basic operating instructions. The researchers only issued task instructions and did not participate in any operating instructions to minimize human interference. In order to address the environmental adaptation issues that elderly people may encounter, we set up an adaptation period before the formal testing, but did not disclose any information about the interface objects or correct answers for the formal testing.

The data used in this study comes from system operation logs, screen recording files of operation processes, user touch trajectories, and feedback information from survey forms after completing tasks. Statistical analysis was conducted on various indicators, including task time consumption, task success rate, number of errors, number of page returns, interruption rate, and number of requests for help. In addition, we also considered several subjective perception dimensions such as interface readability, process rationality, operational clarity, and overall experience level. For the convenience of comparing the improvement degree of each evaluation factor, the improvement degree of the reduction factor is defined as:

$$\mathrm{I_r} = \frac{\mathrm{X_b} - \mathrm{X_o}}{\mathrm{X_b}} \tag{12}$$

In the formula, $\mathrm{X_b}$ represents the mean value of a specific indicator under the reference interface, while $\mathrm{X_o}$ represents the mean value of the corresponding indicator under the improved interface. This formula is applicable to indicators where smaller values are better (such as task completion time, error operation frequency, and return operation count). For positive evaluation indicators such as operation success rate and user satisfaction, the following conversion formula is used:

$$\mathrm{I_p} = \frac{\mathrm{Y_o} - \mathrm{Y_b}}{\mathrm{Y_b}} \tag{13}$$

Among them, $\mathrm{Y_b}$ and $\mathrm{Y_o}$correspond to the average value data before and after optimization respectively. By using formulas (12) and (13), the results in different measurement units can be converted into comparable relative improvement ratios. In the final evaluation stage, a comprehensive efficiency coefficient CE for interface optimization needs to be established:

$$\mathrm{CE} = \sum_{\mathrm{k}=1}^{\mathrm{n}} \mathrm{w_k\, Z_k} \tag{14}$$

In the formula, $\mathrm{Z_k}$ represents the performance parameters after normalization, and $\mathrm{w_k}$ indicates the proportion of each parameter. Considering the operational characteristics of the online medical diagnosis system, the task execution duration, operation accuracy rate, frequency of incorrect operations, number of returned operations, interface usability score, and user experience score were selected as the key evaluation dimensions. The weight distribution was dynamically adjusted according to the priority of frequently used scenarios. When the comprehensive efficacy indicators of the experimental group were significantly better than those of the control group, it indicated that the optimized interface design not only enhanced the interaction experience of the single page, but also significantly improved the overall adaptability of the system in complex task processes.

We employed a mixed method to conduct our research process, including the use of descriptive statistics and differential testing techniques. In order to measure continuous data such as duration consumption, frequency of erroneous operations, and number of rollback actions, we first conducted normality checks, and then selected independent sample t-tests or non parametric tests as the main tools based on their results. For categorical data such as task completion rate and dropout rate, we will also use chi square test to study the differences between different age groups and populations with different digital abilities, and use a hierarchical comparison method to verify whether the improvement plan has a significant improvement effect on the support of the elderly and those unfamiliar with digital technology. In addition, we also followed the research ethics guidelines, and all participants' information was protected for privacy. Before the experiment, we informed them that the experiment was only for improving human-computer interaction design and did not involve the field of medical diagnosis, and obtained their verbal consent. This evaluation method can accurately reflect the actual effects caused by interface improvement and provide a basis for us to further understand the research results.

5.2 Evaluation Results

Research shows that intelligent medical service platforms optimized for elderly users have improved in terms of usage effectiveness, usability, and user experience; But the original interface has problems such as difficult recognition of function buttons, multi page switching, and lack of secondary confirmation. In contrast, the new solution uses task-based presentation, a three column interface, and a high-frequency prompt mechanism to ensure smooth main workflows while avoiding issues such as accidentally interrupting processes.

Table 2: Comparison of Overall Operational Performance between the Original Interface and the Optimized Interface

Interface Version	Average Task Completion Time (s)	Average Number of Mis-taps	Average Number of Backtracks	Task Completion Success Rate (%)	Satisfaction Score (1–5)
Original Interface	128	2.6	3.1	78.4	3.42
Optimized Interface	96	1.4	1.7	91.8	4.31

From Table 2, it can be seen that the new interface has made progress compared to the original interface, such as reducing the time required to complete the same task (128s → 96s), indicating improved efficiency; And the number of accidental touches and rollback times have also been reduced to 1.4 and 1.7 times respectively, proving that preventing accidental touches and simplifying the process are the key points of this new design. Secondly, the task completion rate increased from 78.4% to 91.8%, and the user satisfaction score also increased from 3.42 to 4.31. The above results indicate that in addition to improving efficiency, this modification is also beneficial for elderly users to master and be willing to adopt; However, observing the overall performance alone is clearly insufficient, and a more detailed study and analysis of the applicability of the above modifications in various common registration processes are needed. Figure 3 shows an example of the changes in four typical registration tasks.

Table 3: Comparison of Results between the Original Interface and the Optimized Interface under Different Outpatient Tasks

Task Type	Interface Version	Average Completion Time (s)	Task Success Rate (%)	Average Number of Mis-taps
Appointment Registration	Original Interface	112	84.6	1.9
Appointment Registration	Optimized Interface	86	94.1	1.0
On-site Check-in and Waiting Status Viewing	Original Interface	135	76.8	2.8
On-site Check-in and Waiting Status Viewing	Optimized Interface	98	90.7	1.5
Post-consultation Payment and Examination Confirmation	Original Interface	141	74.3	3.1
Post-consultation Payment and Examination Confirmation	Optimized Interface	106	89.2	1.8
Report Access and Follow-up Reminder	Original Interface	124	77.9	2.5
Report Access and Follow-up Reminder	Optimized Interface	94	93.0	1.3

As shown in Table 3, the optimization effect can be reflected in any task, and the improvement is more significant in the two tasks of "hospital check-in and waiting view" and "post diagnosis payment and examination confirmation". The reason is that these two processes rely more on page situation prompts and next step guidance, and the original interface has serious problems of scattered entrances and unstable guidance. The problems of scattered entrances and unstable prompt positions in the original interface were quite obvious. After optimization, the main task was concentrated in the central area, and the top of the page was also added with current status and path reminders. Elderly users can complete the judgment more quickly after entering a new page. In contrast, the appointment registration task itself has a clearer structure, and after optimization, there is still an improvement, but the extent is slightly lower than that of the consecutive tasks in the middle and later stages. Thus, it can be seen that the layout optimization of the interface has a more significant supporting effect on chain tasks. In addition to operational efficiency, this paper also focuses on the understanding of page structure by elderly users and the changes in their psychological burden. The relevant results are shown in Table 4.

Table 4: Comparison of Interface Cognitive Load and Process Understanding Results

Indicator	Original Interface	Optimized Interface
Process comprehension score (1–5)	3.28	4.36
Correct recognition rate of current status / %	71.5	90.4
Help entry usage rate / %	26.7	12.9
Midway abandonment rate / %	14.8	6.1
Readability score (1–5)	3.54	4.42

Table 4 shows that optimizing the interface also performs well in reducing cognitive stress. Both the process comprehension score and the readability score increased by nearly 1 point, and the accuracy rate of current state recognition improved to 90.4%, indicating that the layout design of the status area at the top of the page and the single main task area in the middle has indeed enhanced the ability of elderly users to grasp the medical treatment process. The call rate of the help entry and the abandonment rate during the process decreased simultaneously, which also indicates that the users' independent completion ability in the page has improved, and they no longer frequently rely on additional assistance.

By combining the results of the three groups, it can be found that the interface layout optimization strategy proposed in this study is not a local improvement in a single indicator, but forms a mutually reinforcing effect at the three levels of task efficiency, error control and cognitive support. The platform maintains the completeness of functions while placing key information in a position that is easier to be recognized, and handling the page relationships more clearly. This is exactly the support that elderly users need in the digital outpatient scenario.

5.3 Discussion

From the interface optimization experiments conducted using design methods, it can be seen that there have been significant improvements in various performance indicators, including task execution time, number of operational errors, number of rework attempts, and success or failure of tasks. This is not just about simplifying the dialogue on the interface, but also finding a processing mode that can deeply match elderly information. Although the original version does not lack any missing features, there are still some issues: lack of centralized function points, unclear hierarchy, and broken guidance, which require users to first determine which "executable items" are and what "work focus" they are currently working on, and then simulate the page logic. For young people, such additional search and decision-making processes may result in minimal time delays, but for older people, they can generate significant psychological pressure, leading to hesitation or accidental actions, as well as multiple exits back and forth. Therefore, by utilizing various means such as task sorting, establishing a three-level visual hierarchy relationship, and setting workflow status prompt signs, the "main task goal" is always placed in the central area of the field of view, thereby reducing the need for unnecessary information comparison and greatly saving the mental and time costs of path selection, thereby achieving dual improvement in efficiency metrics and task performance.

From the perspective of the degree of differences among various projects, optimizing registration, call number inquiry, fee reimbursement, and inspection report viewing has achieved good results, which is also in line with our common sense judgment of the outpatient process. These nodes are in the middle stage of medical behavior, with significant time constraints and involving many interfaces. Patients not only need to be informed of the current progress in a timely manner, but also need to predict the next steps. Without necessary information prompts, more operational obstacles may arise. The original interface often encountered problems such as navigation confusion, complex functions, or unclear feedback in such key positions. However, the optimized interface uses the top status bar, main workspace, and bottom attachment area as a stable layout form, classifying and sorting the original discrete information factors, which shows better advantages in continuous operation; Starting from the appointment registration, due to its relatively simple operating rules, although it has been optimized, there is still a certain degree of improvement, but not as significant as the impact on the backend of the process, indicating that boundary reform is more helpful for multi-step linked tasks.

At the same time, subjective evaluation indicators also have a significant impact. The improvement of process understanding, interface readability and satisfaction is not only an improvement in the emotional level, but also forms a more stable expectation of the use of the platform. Under the Internet plus medical scenario, the core problems faced by the elderly are not completely useless, rather than worrying about "making a mistake", "not knowing how to do it" or "not knowing what will happen after doing it". If the system interface can clearly display the current status, operation results, and next steps, the user's demands will be responded to, and therefore the psychological burden will naturally be reduced. Moreover, reducing the frequency of use and interruption rate of auxiliary devices also proves that optimization suggestions are not simply shifting the operational threshold to the user side, but rather strengthening the interpretation of page information and process guidance, allowing elderly patients to successfully complete operational behaviors without any assistance.

Unlike many current clinic websites that emphasize the design concept of functional overlay and system integrity, the elderly friendly transformation revealed in this study from the perspective of cognitive load should go beyond the shallow transformation of simple text enlargement, voice navigation, and button color visualization, and instead incorporate process complexity, information hierarchy depth, and cognitive load into the same dimension for reconstruction, which is the key. In other words, determining whether an interface truly meets the needs of elderly users is not determined by whether a certain control is "visible enough", but by whether the entire system can precisely guide users' limited attention to the core task nodes. It is precisely this systematic design concept that makes the method proposed in this study more effective in practice than the common superficial improvement schemes.

Of course, this study also has certain limitations. Although the evaluation scenario was as close as possible to the outpatient process, it still belongs to a controlled testing environment. The emotional fluctuations, physical conditions, and accompanying intervention of elderly users in the real hospital may further affect the operation performance. Although the sample includes participants with different levels of digital experience, the differences among the elderly, those with high anxiety, or those with significant decline in auditory and visual functions can still be further subdivided. Future research can combine real hospital log data with long-term tracking to further test the stability and mobility of the dynamic layout in different specialized outpatient clinics and different terminal forms. Overall, the assessment results of this paper indicate that optimizing the task-driven interface layout based on the cognitive characteristics of the elderly can indeed improve the usability of the outpatient intelligent medical service platform. This also provides a relatively clear technical direction for digital medical systems to move from "usable" to "more suitable for the elderly to use".

6 Conclusion

In the context of continuous digitalization of medical services and continuous onlineization of outpatient processes, the intelligent medical service platform has gradually transformed from an auxiliary tool to the core interface in outpatient operations. Whether the platform can truly achieve the functions of diversion, efficiency improvement, and convenience for the patients largely depends on whether the interface layout conforms to the cognitive patterns of the patients, especially whether it can respond to the actual needs of the elderly group in visual search, information understanding, path judgment, and operation confirmation. Based on this issue awareness, this article analyzes the relationship between the cognitive characteristics of the elderly and the outpatient task process, and discusses the interface layout optimization within the specific context of the digitalization transformation of elderly-friendly digital medical services, attempting to provide more technical support for the transition of outpatient intelligent platforms from "function availability" to "smooth use".

During the research process, based on the review of relevant studies on outpatient intelligent medical service platforms and elderly-friendly interface design, this article further transforms the cognitive characteristics of elderly users in the digital outpatient scenarios into analyzable interface problems, focusing on the coupling relationship between information density, path hierarchy, status prompts, feedback positions, and task priorities. Therefore, we have designed the core design principles of task status recognition, information filtering, spatial balance allocation, and path simplification by combining pre screening, registration, waiting, medical billing, examination receipt, and result query. We have also provided corresponding strategies such as plugin sorting optimization, main thread priority, path connection prompts, and result reinforcement feedback mechanisms. These suggestions are more focused on interface reconstruction compared to traditional visual optimization, in order to reduce the decision-making burden and redundant operations of elderly patients.

After the improvement of the above methods, there have been significant improvements in work efficiency, operational errors, rollback frequency, task completion, process satisfaction, and patient satisfaction; Especially in a series of continuous operations such as hospitalization registration, inquiry of waiting information, settlement, and laboratory confirmation, significant results have been achieved. The improved interface has a better effect. This indicates that for elderly users, the key to their user experience when operating on a digital health management platform is not the size of a single controller or the readability of text, but whether the overall interface can continuously provide status prompts, intuitive operation guidance, and data structures that conform to their cognitive patterns. So for the elderly, it's not enough to just make the software look like an elderly person to solve all problems. We should redesign the interaction mechanism based on cognitive features.

The main purpose of this study is to integrate the cognitive characteristics of the elderly, clinic operation processes, and the arrangement of objects in the interface into a comprehensive evaluation system, so that the improvement of the service platform is not only based on individual intuition or general principles, but also has a clear structural framework as a reference. This method has important reference value for the aging adaptation of hospital mobile app software, vending machines, and multiple machines serving together. This also reminds us that the construction standards for informationized hospitals should not only focus on system utilization and functional coverage, but also pay attention to whether certain age groups can stably, smoothly, and comfortably complete key actions in real scenarios.

The current research results are mainly derived from the situation in the laboratory. However, in the real environment of medical clinics, changes in patients' psychological stress levels, physical conditions, support from family members, and diversity of treatment procedures in different departments can all have a significant impact on the effectiveness of the system. Therefore, future research should combine real operational information of medical institutions, conduct long-term tracking studies, and conduct multi machine comparative experiments to continue optimizing adaptation and adjustment methods for elderly users, users unfamiliar with technology, and users with special sensory needs; At the same time, we will delve into the application of language interaction assistance, warning function prompts, personalized interface settings, and other functions, and coordinate their use in the intelligent medical service system. Only by comprehensively unifying the cognitive consistency, behavioral rationality, and technological applicability of intelligent medical service centers can we truly provide effective assistance to the elderly, enabling them to understand and use it easily.

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