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Mobile Application Design for the Elderly to Check Subjective Cognitive Change

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Abstract: - This study aimed to detect changes in cognitive levels early and design a user interface (UI) for mobile applications. This helps prevent cognitive degradation by continuously assessing cognitive changes in the elderly through changes in activities of daily living. Case studies were conducted prior to the application of the UI design. The concept and functions of the application were classified as 'everyday check,' 'easy for everyone,' and 'comfortable to see' according to the evaluation function, UI, and graphical UI design and were carried out based on previous design guidelines. After prototyping, the application prototypes were produced through the design tool Adobe XD. The usability evaluation was conducted with a heuristic test checklist based on Jakob Nielsen's heuristics. Through this evaluation, positive results of high-quality application design were achieved. This was marked by creating beautiful icons and images and customizing them for the elderly, considering their visual and perceptive characteristics. This study is expected to help prevent mild cognitive impairment and dementia by checking cognitive changes through their daily life patterns and using them periodically.

Keywords: Cognition, Subjective Checklist, Elderly, Mobile Application Design

I. INTRODUCTION

Mild Cognitive Impairment (MCI) is considered an intermediate stage in the transition from normal aging to dementia and refers to a complex clinical condition in which independent daily activity is possible, but memory disorder is the chief complaint [1]. The risk of developing dementia in individuals with MCI is very high, approximately 50-80% compared to 1-2% in normal elderly people [2],[3]. Additionally, dementia gradually progresses by experiencing subtle cognitive changes over a period of 10 years or more before being diagnosed [4],[5]. Since MCI has memory disorder as its main symptom, it is likely to include a variety of patient groups, including not only 'high-risk dementia patients' but also 'patients with memory impairment due to depression'. Because of the heterogeneous nature of this MCI group, continuously identifying changes in their gradual cognitive mechanisms is very important for the early diagnosis and intervention of dementia.

In the case of older adults with MCI, their level of daily living ability is preserved, and their performance decline is known to be a predictor of faster functional deterioration and progression to Alzheimer's Disease (AD) [6]. According to the results of related previous research, this decline is related to a decrease in cognitive function and daily living skills, especially instrumental daily living skills. Instrumental daily living skills refer to relatively complex daily tasks such as doing housework, shopping, and managing money. MCI primarily shows a decline in instrumental daily living skills without impairment of physical daily living skills such as toileting, personal hygiene, and eating [7]. In particular, as the decline in cognitive function becomes more severe, instrumental daily living skills appear to decline [8].

Although previous studies have been conducted on the relationship between ‘daily life’ and ‘cognitive function of the elderly,’ there is a lack of research on daily life activities and patterns that need to be continuously identified to maintain cognitive function in the home environment.

Accordingly, Jeong & Kim [9] created a checklist that includes both physical and instrumental activities of daily living, while also checking changes in cognitive function through daily life activities, including lifestyle habits and social activities. The checklist consists of six areas (a total of 11 items) including subjective cognition and language skills, reading and writing, Internet use and learning, housework and understanding TV content, and drinking. Jeong & Kim [9] mentioned that by monitoring these changes in daily life activities, it will be possible to discriminate the decline in cognitive function of the elderly at home and to screen and manage MCI or mild AD early.

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Recently, more than half of all elderly people are using smartphones [10], and following this trend, the use and utility of smartphone applications in diagnosis, treatment, and education are increasing significantly in the medical field [11]. However, older people feel uncomfortable using smartphone applications due to a decline in physical and cognitive functions such as memory, attention, visual perception, and spatial perception due to aging. In addition, most smartphone user interfaces are designed for young users, making them difficult for older people to use. Therefore, it is necessary to design the interface taking into account the physical and cognitive functions of not only young users but also elderly users so that all age groups, including the elderly, can use the application efficiently.

In this study, we intend to develop Jung & Kim's [9] 'Checklist of Overall Cognitive Changes in the Elderly,' which was created to identify daily life patterns for general elderly people and home-based elderly people with mild cognitive impairment, as an application with the consent of the original authors. In addition, through the results of previous research and case study analysis, we aim to design a 'Cognitive Change Check Application According to the Daily Life Patterns of the Elderly' by constructing an interface that is easy to use for anyone, including the elderly, without restrictions of time and space.

II. METHODS

A. Smartphone-based mobile app

The design of 'What do I do every day?', an application to check cognitive changes according to the daily life patterns of the elderly, was created by constructing an interface that is easy for anyone, including the elderly, to use without being restricted by time and space. Before undertaking the full-scale application design, we established guidelines for the application by visually and functionally analyzing the icons and GUI designs of related applications (Barthel Index, ADL Guideit, Barthel ADL Index) through case studies. The interface was designed to match the Samsung Android OS Google interface, which holds the highest market share (31.49%) in the Mobile Vendor Market Share Worldwide. The screen mode was set to the commonly used portrait mode UI.

The overall menu structure of the application 'What do I do every day?' is shown in Figure 1. It is largely divided into a login page and a main page, with the substructure of the main page divided into 'My page', 'Checklist description', 'Testing by item', and 'Export results'. The menu structure was designed to allow easy navigation to the desired screen at any time through the menu bar, considering the UI items' navigation. Figure 1 is a flowchart representing the screen flow of a portion of the application as a block diagram, divided into a login page and a main page.

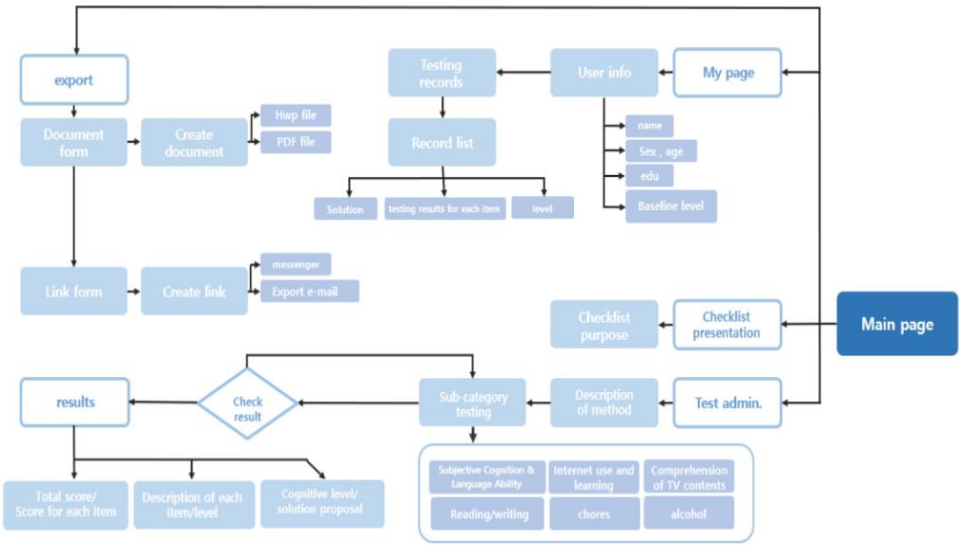

Figure 1. Application screen flow

B. Implementation of a preliminary model for a smartphone-based mobile app

Figure 2 is a preliminary model (specification: 360 width x 640 dp height) of the application screen designed using Adobe XD, a prototyping tool. A heuristic evaluation was conducted to assess the User Experience (UX)

design and usability of the ‘What do I do every day?’ application prototype. The heuristic evaluation was divided into two categories: related experts and application users. Considering the effectiveness of the evaluation, the number of subjects for heuristic evaluation should be 3 to 5 (Nielsen & Landauer, 1993), so the evaluation was conducted with 3 relevant experts (two experts with Ph.Ds in speech and language pathology and one person from the industrial design industry) and 4 application users (over 65 years old).

Fig 2. Preliminary model on the application screen

III. RESULTS

The application design heuristic evaluation was conducted in a noise-controlled environment where the evaluator and the examiner met face-to-face one-on-one. Before the evaluation, the application concept was briefly explained, and then the evaluation was conducted for approximately 10 to 15 minutes. In addition to the 5-point scale evaluation, the opinions of the evaluation subjects were collected through a column for writing improvements or requirements.

Based on the results of the evaluation conducted with related experts and application users, the pros, cons, and improvements of the prototype were derived. As a result of the expert evaluation, it received a high rating in the 'usability and design' category with 4.6 points out of 5. It received high praise in the 'design tailored to the elderly' category, including simple and consistent menu composition, use of highly identifiable red color, use of icons in comfortable colors, and use of images that help understand the evaluation. Table 1 shows some of the expert heuristic evaluation results.

As a result of the evaluation by the application users, it received a high rating in the 'design' section with 4.3 out of 5 points, but there was feedback that the font size was overall too small. In addition, it received a favorable rating in the evaluation function that allows individuals to understand the elderly's cognitive status by checking 'health conditions and diseases that affect cognitive function' and 'level of daily life activities that require cognitive ability'.

It also received high praise for the appropriate placement of the basic elements on the screen, the comfortable colors of icons and images, and the fact that it does not cause eye fatigue. However, since the content focuses on providing evaluation, there were also opinions suggesting it would be beneficial to add training content such as cognitive exercises in addition to the evaluation function. Table 2 shows some of the heuristic evaluation results from the subjects.

Table1. The results of Professional Heuristic Checklist Evaluation

1. visibility of system status					
Num	check-list	rater			mean
		A	B	C	
1	When you first turn on the app, do you see content that best suits	5	4	4	4.3

	the app's purpose?				
2	Is there something unique about this application that makes it recognizable just by looking at its layout?	4	5	4	4.3
3	Are there appropriate text and images beautifully laid out?	5	5	5	5
Total mean		4.5			

*1: Not at all ~ 5: Very much so

Table2. Example of heuristic evaluation results for target audience

Num	check-list	rater				mean
		A	B	C	D	
1	When you first looked at the application assessment, did you know what the purpose of the test was?	4	5	4	4	4
2	Are the font and pictures appropriately placed?	5	5	5	4	4.7
3	Are the pictures detailed and familiar?	4	4	5	5	4.5
4	Is the font easy to read and is the letter placement appropriate?	4	4	4	3	4.7
5	Are the number of colors presented appropriate and beautiful?	5	5	4	4	4.5
6	Does it provide appropriate information so that your eyes do not get tired when using it?	4	5	5	4	4.5
7	Are the order and flow of use intuitive?	4	5	4	4	4.2
8	Were there any unnecessary or annoying operations while using it?	5	5	4	5	4.7
9	Are the methods for using each function easy?	4	5	4	5	4.5
10	Is the help provided adequate?	4	4	4	5	4.2
11	Is it easy to use yourself?	5	4	4	5	4.5
12	Is it more convenient than the paper pencil method?	4	4	4	5	4.2
13	Are the test results easy to understand?	4	4	4	4	4
14	Do you think this test is appropriate for repeated use?	5	4	4	4	4.2
15	Would you be willing to use this test if it were released?	5	4	4	5	4.5
Total mean		4.3				

*1: Not at all ~ 5: Very much so

IV. Discussions

This study sought to propose the design of a mobile application interface that would enable home-based seniors, including those with mild cognitive impairment, to identify patterns in their daily life activities without constraints of time and space, and to confirm changes in their cognitive levels accordingly.

First, through a literature review, we examined the relationship between the cognition of the elderly and daily life activities, the informant-based cognitive change scale, the visual and perceptual characteristics of the elderly, UI design, and the status of smartphone use among the elderly. Based on previous research on application development, the background and necessity of the research were established. We investigated and analyzed domestic and international daily life activity evaluation application cases, reviewed information structure design, UI, and GUI, and examined existing design elements that could be applied along with potential improvements. As a result, it was confirmed that most of the applications were simply evaluating the Barthel index and did not include design elements that considered the visual characteristics of the elderly. Existing applications had inconveniences in screen layout composition and screen switching, and there was a lack of information or explanations about the application, making it difficult for older people to use it ‘on their own’ and ‘easily.’

Second, to address these shortcomings, we reviewed previous research on application development for the elderly and the principles of universal design, deriving design guidelines for an application that checks cognitive changes

according to the daily life patterns of the elderly. We classified the evaluation function, UI, and GUI aspects into the domains of 'check every day,' 'easy for everyone,' and 'easy for anyone to see.' Based on this, we designed the application function and information structure and created a wireframe. A detailed design was carried out. In this process, the screen layout was designed so that the elderly would have no difficulty using the application on their own, and intuitive and highly visible icons and images were created to aid their understanding. After the GUI design work was completed, a prototype of the application ‘What do I do every day?’ was created using Adobe XD, a prototyping tool.

Third, to verify the user experience design and usability of the ‘What do I do every day?’ prototype, a usability evaluation was conducted targeting related experts and application users. Based on the evaluation results, the pros, cons, and improvements of the prototype were derived. The evaluation results indicated that the design was comfortable and highly complete, making it easy for the elderly to use on their own without causing eye fatigue.

Through this study, we proposed an app that allows users to easily check their daily life patterns alone without time and space constraints by utilizing the design of a mobile application with a customized interface for the elderly that takes into account their visual perception and cognitive functions. By using this regularly, we expect to be able to monitor cognitive changes and detect cognitive decline early, helping to prevent mild cognitive impairment and dementia.

The limitations of this study are as follows: First, due to the nature of the study, it was completed at the prototype design stage without implementing actual functions or establishing a database. Therefore, formal implementation, verification, and professional usability evaluation are needed to determine whether the mobile test has the same effectiveness as the paper-and-pencil test. Additionally, there is a need to secure big data on general elderly people by age and years of education through continuous evaluation and integrate it into the application.

Second, in addition to the cognitive change evaluation items proposed in the study through daily life activities, further research on content composition is needed to motivate and interest the elderly in using the applications.

V. Conclusion

This study aimed to design a mobile application interface to help home-based seniors, including those with mild cognitive impairment, track daily life activities and cognitive changes without time and space constraints. A literature review established the need for the app, highlighting existing applications' lack of user-friendly design for the elderly. Most apps evaluated only the Barthel index and overlooked elderly-specific visual needs, causing usability issues. To address these, the study derived guidelines from universal design principles and previous research, resulting in a detailed app design and prototype named 'What do I do every day?' Usability evaluations showed the prototype was comfortable and easy for elderly users. This app design can help monitor cognitive changes and detect early cognitive decline, aiding in the prevention of conditions like dementia.

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