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Perceived Affordances in Older People with Dementia: Designing Intuitive Product Interfaces

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Abstract. The objective of this study was to examine the relationship between intuitive interactions and perceived affordances in product interfaces among older people with dementia. Experiments were conducted by examining the cooking time in the user interfaces of microwave ovens, and the participants involved 25 older people with mild dementia. The results showed that a simple arrangement of bottoms was more desirable for presenting visual information, but the usabilities of these interfaces were undesirable.

1. Introduction

Dementia is a neurodegenerative condition among the elderly. In most patients, dementia begins with the atrophy of the hippocampus, which is closely associated with memories. Patients in the early stages of dementia often cannot remember recent events. This study started with improving the intuitiveness of product interface designs can alleviate the problems that older patients with dementia are faced with in operating common everyday products. This enables such patients with dementia to experience a more independent live and decreases the burden of their family members and relevant healthcare personnel, thereby enhancing the quality of life.

Of the various theories related to user–product interactions, the theory of affordance proposed by perceptual psychologist Gibson [1] is dissimilar to theories in the fields of linguistics, cognitive sciences, and human factors engineering. Specifically, it pertains to a design perspective that emphasizes direct correspondence between perception and intuitive use and has become increasingly important in the field of human-machine interactions. The concept has also been applied to virtual interface designs. According to related literature, the perception of affordances, when applied to design, involves two dimensions, namely the observer's motor skills [2, 3] and experiences and culture [4, 5]. The perceived affordances of users are affected by their physical motor skills and by prior experiences and knowledge. Blackler et al. [6] asserted that intuitive interactions are based on a user's past experiences and are both fast and non-conscious. To achieve intuitive usability, designers must understand user characteristics to accurately design elements that promote intuitive interactions. Immediate interactive behavior is produced when user ability matches the affordances of an object [7]. However, the motor and cognitive skills of older people with dementia differ from those of ordinary users. As their cognitive ability deteriorates or fails completely, such patients may rely increasingly on their innate perceptions to interact with the external environment. The perspectives of direct perceptions and intuitive, natural interactions noted by the theory of affordances are highly applicable to the design of user interfaces for older people with dementia and exhibit tremendous development potentials. Therefore, this study explored the intuitive usability regarding the affordances established between products and older people with dementia. In addition, the relationship between intuitive interactions and perceived affordances was examined.

2. Method

The objective of this study was to examine the intuitive usability of user interface elements and shapes for older people with dementia. Experimental testing was performed through the user interfaces of microwave ovens. The participants were older people with mild dementia. The experimental task is to input cooking time. Patients with mild dementia and acceptable communicative and cognitive functions were nominated by their physicians to participate in this study.

2.1. Test interfaces and experimental procedure

We examined current microwave oven models to compile different shapes and arrangements of buttons for inputting cooking time. Nine different test interfaces were created

(Figure 1) using graphics software to draw the basic contours of the buttons. These interfaces were differentiated by whether there was a border around the button, whether the button shape was round or square, and whether the buttons were arranged in one, two, or three columns. The test interfaces were installed on a tablet computer with a 10-inch touch screen. During the testing, these interfaces were displayed one at a time on the tablet. The test interfaces involved a custom program that recorded the amount of time a participant took to complete a task and determined whether the task was completed accurately.

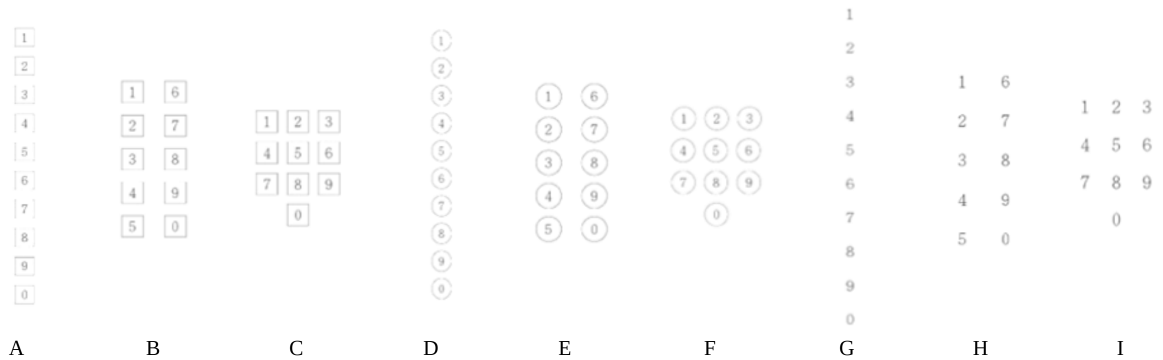

Figure 1. Test interfaces for inputting cooking time.

The custom program recorded two different times. First, the time elapsed before a participant touched the screen on the first attempt (i.e., the initial reaction time) was recorded to analyze whether the test interface features can elicit intuitive use. Second, the time elapsed before a participant completed the task (i.e, the task completion time) was recorded to analyze the usability of the test interface. At the beginning of the test, the participants each sat in front of a 10-inch touch-screen tablet and read the task instructions displayed on the screen. In the first test stage, the participants were asked to input a specified cooking time. If participants did not understand the written instructions, verbal explanations of the task were provided. After the participants confirmed that they understood the task, they manipulated the test interface on the tablet computer. No time limit was set for completing the task. The test interfaces for inputting cooking time were displayed one at a time in a random order on the screen. Video recording equipment was used to capture the entire test process. Some participants forgot the goal of the task or did not understand the test instructions. When this happened, researchers verbally guided the participants to complete the task.

2.2. Experimental task and participants

The experimental task is to input cooking time with no time limits imposed on the participants. The different cooking times were displayed in a random order, and the participants were asked to input the cooking times for each test interface. This test protocol was designed to reduce the learning effect to ensure the results more accurately reflected the intuitive operability of each test interface. After completing each task, the participants pressed a “confirm” button to signal that he or she was finished. The custom program then recorded the time elapsed.

To ensure that the participants did not forget the instructions of the cooking time task, the target cooking time was displayed in each test interface. The tests were performed in a hospital clinic. Hospital neurologists nominated 25 participants who had mild dementia, demonstrated acceptable communicative and cognitive functions, and were experienced in using home appliances. The participants averaged 81.8 years (SD = 7.2 years) of age. The definition of mild dementia was based on a score of 0.5 or 1 in the clinical dementia rating scale. Regarding cognitive skill assessments, patients who scored moderately low in short-term memory function, long-term memory function, and hand-eye coordination were chosen as the participants.

3. Results

3.1. Initial reaction times

For each of the nine test interfaces, the mean initial reaction time of the 25 participants was calculated and compared. As shown in Table 1, the mean reaction times for Interfaces C and F were relatively slow. The post-hoc ANOVA results also showed significant differences between the mean reaction times of Interfaces E, F, and H. Generally, the buttons arranged in a 3x3 configuration elicited lower levels of intuitive operability among the participants. Nonsignificant differences in reaction times were observed between the buttons arranged in one and two columns or between the buttons of different shapes.

3.2. Task completion times

For each of the nine test interfaces, the mean task completion time of the 25 participants were calculated. The average task completion times of the nine test interfaces were determined to be nonsignificantly different (Table 2). This indicated that the user interface designs with different button arrangements or shapes did not differ significantly in their usability levels.

Table 1. Anova results for the initial reaction times of the cooking time task.

Initial Reaction Times in the Cooking Time Task					
Interfaces	Average Time	SD	N	Sig.	p
A	8.12	4.95	25		0.545
B	8.83	6.25	25		
C	9.48	7.76	25		
D	8.94	6.79	25		
E	7.85	5.57	25	＊F	
F	10.46	4.34	25	＊E、H	
G	9.12	7.06	25		
H	8.02	3.26	25	＊F	
I	9.00	5.36	25		

3.3. Observational analysis

Analyzing the observational data of the cooking time task (Table 3) compiled the number of participants who failed to complete the task accurately and the reasons for their failures. The most common reasons for the failing the task were (a) the participant did not understand how to input cooking time and therefore pressed the incorrect buttons (e.g., the participant did not understand that inputting a cooking time of 2:30 required sequentially pressing the buttons 2, 3, and 0); (b) the participant forgot the goal of the task and pressed the incorrect buttons; (c) the participant inadvertently pressed the incorrect buttons because of age-related cognitive decline; and (d) the participant did not successfully complete the task after failed attempts.

Table 2. Anova results for the completion times of the cooking time task.

Completion Times in the Cooking Time Task					
Interfaces	Average Time	SD	N	Sig.	p
A	19.90	12.53	25	A	0.942
B	18.75	12.82	25	B	
C	18.53	13.44	25	C	
D	17.91	11.60	25	D	
E	17.17	12.41	25	E	
F	19.26	9.63	25	F	
G	21.10	18.68	25	G	
H	19.10	8.88	25	H	
I	18.87	11.01	25	I	

Table 3. Observation records of the cooking time task.

Observation / Test Interface	Number of participants who failed to complete the task accurately	Percentage	Reasons
A	6	24%	• Inadvertently pressed the wrong button • Did not understand the task • Did not understand how to input cooking time
B	4	16%	• Did not understand the task • Inadvertently pressed the wrong button • Did not understand how to input cooking time • Did not complete the task
C	2	8%	• Did not understand the task • Inadvertently pressed the wrong button • Did not understand how to input cooking time
D	3	12%	• Did not understand the task • Did not understand how to input cooking time
E	2	8%	• Did not understand the task • Did not understand how to input cooking time
F	6	24%	• Did not understand the task • Inadvertently pressed the wrong button • Did not understand how to input cooking time
G	6	24%	• Did not understand the task • Inadvertently pressed the wrong button • Did not complete the task • Did not understand how to input cooking time
H	2	8%	• Did not understand the task • Did not understand how to input cooking time
I	3	12%	• Inadvertently pressed the wrong button • Did not understand how to input cooking time • Inadvertently pressed the delete button

4. Discussions

The study results showed that the interface with the 3x3 configuration of buttons attained lower levels of intuitive operability, but the mean task completion time using this interface differed nonsignificantly from those of the other interfaces. In addition, Interfaces A, E and H were more likely to entice participants in their initial encounters with the interfaces, but the usabilities of these interfaces were undesirable. This indicated that a simple arrangement of bottoms was more desirable for presenting visual information, thereby facilitating older users to process the information more effectively; hence, their initial reaction times were reduced. However, the different button arrangements and shapes did not result in significant differences between the task completion times. This finding accords with those of Chen and Liu [8]. Therefore, the present study confirmed that although a simple and clear arrangement of interface elements resulted in more intuitive reactions among the users, these interfaces were not necessarily more intuitive to use. Analyzing the observational data showed that the most common reason for user mistakes was that the participants did not understand how to input the cooking time. Blackler et al. [6] asserted that intuitive interactions are based on a user's past experiences and are both fast and non-conscious. Thus, a product with operating styles that match user experiences can enhance the usability of the product.

5. Conclusion

This study examined intuitive interactions between older people with dementia and user interfaces from the perspectives of perceived affordances. The results showed that simple user interfaces are more likely to elicit intuitive reactions among older people with dementia, but this does not necessarily equate to facilitating the intuitive use of such interfaces. The prior experiences of users are crucial to intuitive use; hence, user interfaces should be designed to comply with users' prior experiences. Understanding user characteristics is the key to designing elements that promote intuitive interactions. However, older people with dementia may experience temporary short-term or long-term memory loss because of their disease condition, causing them to forget how to operate once-familiar products. Therefore, designers may experience difficulty accounting for the prior experiences of this user group, and they may need to instead examine the direct relationship between users and product external features noted in the theory of affordances.

In the present study, we tested and analyzed the effective data of 25 older patients with mild dementia. The findings enabled proposing a model describing the perceived affordances between in the intuitive interactions of product interfaces and older people with dementia, despite participant selection being a notable limitation of this study. In addition, the physicians advised us to avoid subjecting the participants to complex interface operating procedures and a high amount of test interfaces. Therefore, we could not adopt comprehensive operating procedures, such as asking the participants to place food in the microwave, turn on the microwave, input cooking time, adjust cooking power, and wait for the food to finish cooking. The experimental tasks were designed to involve abbreviated instructions. Subsequent studies are suggested to increase the number of participants and examine additional tasks and user interfaces, thereby providing research implications for designers to create user interfaces that are intuitively interactive for older people with dementia.

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