Cognitive Relevance Mechanism Analysis of DHCI Structure and Composition

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Abstract. Organizational conflict and phenotypical conflict are fundamental reasons that reduce human-computer interactive efficiency through digital interface. In order to solve these problems, doing research on cognitive relevance mechanism of DHCI structure and composition is necessary. This paper first constructed theoretical model between DHCI information design and user cognition. Second, introduced current research status of related field both domestic and foreign. Finally, proposed an experiment plan on 3 different smart phone App designs, elaborated the experiment objective and procedure. This research provided a new thinking way for DHCI information design.

Keywords: DHCI · Interface structure · Interface composition · User cognition · Cognitive relevance

1 Contradiction Mechanism of DHCI Information Design and User Cognition

In recent years, digital human-computer interface (DHCI) has been widely used in many fields, which has greatly alleviated the crisis in information presentation space, which exists because of information expanse. Information presentation mode has been changed from tile-type entity presentation forms into blocks, hierarchical integration forms. Users no longer need to frequently go back and forth between multiple panels, but interactive problems between human and machine/computer have not been fundamentally resolved. On the contrary, new issues such as information loss, focus chaos has intensified. Well, how these phenomena happened?

Superficially, the users' low searching efficiency is caused by unreasonable interface visual presentation; the users can't find their objectives. But this kind of thinking way neglects the effect of information structure, which has obvious guiding effect on the users. For example, by the influence of the mental schema of the Gestalt psychology, information blocks usually cause uniting process of the information-in-block and selective shield of the information in other blocks. As the result, closely related information should apply the nearest, grouped presentation mode. Another example, super link can improve information connectivity, on the other side, the possibility of

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information loss grows greatly. The users may leave their objectives farther and farther because of easy link, even completely change their target.

1.1 Organizational Conflict Between Interface Information and User Cognition

In the environment of digital information, organizational conflict between interface information and user cognition is caused by flexible information requirement and rigid interface structure. Human's information requirement has 3 dimensions— information, relation and time dimension, information and relation could group together easily because of time axis. But DHCI just has 2 dimensions—information and relation, it's flat type. Against dynamic information requirement in our brain, the information structure on the interface is fixed and static. Users need to frequently jump from one level to the other to remedy the loss of time axis. So, dimension difference is the root of organizational conflict that influences our memory schema to extract and match information.

1.2 Phenotypical Conflict Between Interface Information and User Cognition

Phenotypical conflict reflects in the discrepancy between theoretical route and the realistic route. In principle, users get their goals according to the prepared information structure. But actually, the information to people is concrete and graphical, users need to read the figures first to decode the meaning. It's prone to be disturbed by image influence, people's attention schema may not in line with their searching objective.

As shown in Fig. 1, the balance between user and DHCI contains two parts—structure balance and composition balance. Structure balance arises from time dimension loss on the interface, and composition balance arises from figuration of design and conceptualization of cognition and structure. As an analogy, information structure and composition are like the bone and the flesh, the figure we could see relies on the support of bone, but this kind of support effect can be easily omitted because of its concealment.

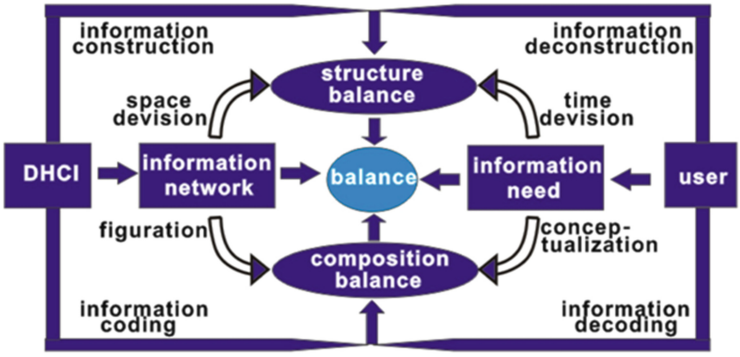

Fig. 1. DHCI structure and composition relevance mechanism

In the end of the analysis, information structure has leading impact on the composition, and the composition is the performance of structure. Then, the problem appears, how the information structure and composition of interface affect people's cognition? This article intends to start a research in order to solve this problem.

2 Research Situation in China and Abroad

In related field, scholars in China and abroad have done much detailed research and got some achievement, which can be listed as follows:

In the field of information process, researches were conducted on information filter, information compression technologies. Some described a large-scale implementation of a video recommendation system in use by the largest media group in Latin America [1]. Some designed methods to solve the afore-mentioned problems for patent retrieval [2–4]. Some presented and illustrated a procedure for similarity analysis of the large data compression [5]. Some proposed methods through reducing the principal component vector to cut the amount of information [6, 7].

In the field of information visualization field, some analyze the visualizing large, heterogeneous data in hybrid-reality environments [8]. Some elaborated data flow under different time scales through concrete examples [9, 10]. The use of graph ordering algorithms for visual analysis of data sets using visual similarity matrices was proposed [11].

In the field of human-computer interactive field, some researched visual analysis instruments that influence cognition and decision-making [12, 13]. Some studied interactive learning materials in mathematics or other fields [14, 15]. Some studied a number of foundational concepts related to interaction and complex cognitive activities syncretized into a coherent theoretical framework [16, 17].

In the field of image thinking and cognitive science, many researches were about the image thinking and cognitive organs [18–21]. Affective design were also interested in the origins and models that arose consumer lure [22–32].

In summary, current studies paid more attention to data transferring, information filter, information compression fields, and the technologies are relatively mature enough to provide an effective guarantee for DHCI fundamental construction. And research on information visualization and human-computer interaction were mainly about information processing mechanism of computer, the real study about user cognition is very limited, and most of the small amount ones are about entity design and functional layout, the popularity of the results is very finite. In the field of design cognition research, users' affective quantitative technology was widely used in product design, users experience and related studies, and established some emotional design and prediction models for cognition. But in DHCI field, affective element is just one factors that influences users' cognition, information structure is the key element that leads users' searching behavior. The existed method is not suitable to DHCI information design and cognition relevance analysis, we need to study more about information structure, and forbid to mix it with composition, but this kind of study is not enough.

3 Cognitive Relevance Experiment Design of Information Structure and Information Composition

3.1 Experiment Design

The experiment is planned to test under the premise of the same composition variables, how the structure discrepancy influence cognitive effect. Smart phone interface is chosen for cognitive relevance study of information structure and information composition. The reason of this choice is because smart phone interface has become into one of the most familiar DHCI in our daily life with the flourish of mobile service. Choosing the App layout of smart phone as the typical example of DHCI information structure also shows great similar characteristics with webpage interface and system interface, which presents great public awareness and universal conclusion.

Experiment task is designed as finding pointed App in different information structures, and main cognitive index are searching time and correct rate. Experiment applies the same App icons as the composition to control the discrepancy of information composition to cognitive effect.

This experiment applies single probe change examine paradigm, single task experiment. It requires subjects remember App icon first, then find the target App icon on the interface. This experiment contains 3 different kinds of information structures. Among them, structure 1 is constitute of 75 App icons, 5 parallel pages and 4 shortcut keys (Fig. 2), 75 App icons are exhibited on 5 pages respectively, shortcut keys are posited at the bottom of the interface. Each searching risk is started with an initial page not locating the objective (except the shortcut keys), subjects can shift from pages through clicking the ◎ mark on the interface. Its information structure can be abstractly represented in Fig. 3. The white circle represents form element, which means group or node in structures, while the black circle represents goal element, which here means App icons.

Fig. 2. Structure 1 interface

Structure 2 consists 1 main page, 4 shortcut keys and 7 files, each file contains 9 App icons (Fig. 4). Different from structure 1, subjects can get into sub-pages through clicking files, and get back to the main page through clicking blank space. Choose the

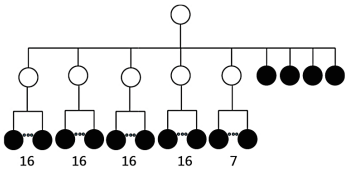

Fig. 3. Abstract structure 1

Fig. 4. Structure 2 interface

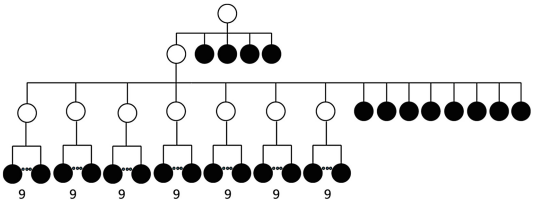

Fig. 5. Abstract structure 2

non-objective page as the initial page except the shortcut key to ensure the integrity of the route. The App layout in structure 2 are very different from structure 1. Its information structure can be abstractly represented in Fig. 5.

Structure 3 contains 2 parallel pages, each page have 6 files, which accommodate 4 to 6 App icons, no shortcut key design (Fig. 6). Subjects can use the ◎ icon to shift from main pages at the middle lower part of the interface; Meanwhile, they can also get into the sub-page through clicking the file, and get out of it through clicking the blank space just like the operation in structure 2. Attention is paid to set the initial page for searching to ensure the route integrity. Interface layout is set different from structure 1 and 2 to forbid memory effect. Its information structure can be abstractly represented in Fig. 7.

The experiment is planned to apply 3*75 within-subjects design. Factor 1 is structures, with 3 levels—structure 1, 2 and 3; Factor 2 is 75 App searching task.

Fig. 6. Structure 3 interface

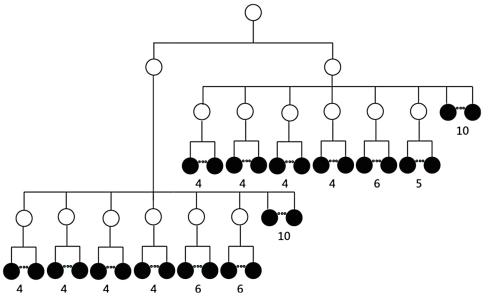

Fig. 7. Abstract structure 3

This experiment will last 3 days, in each day 1 structure 75 searching is tested, App presentation turn is pseudorandom, and the experiment procedure is shown in Fig. 8.

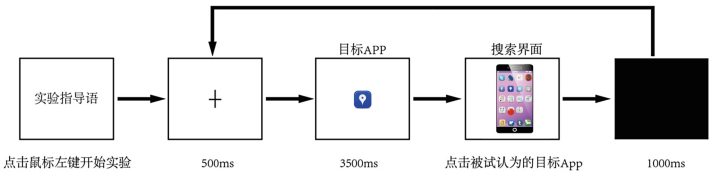

Fig. 8. Experiment procedure

This experiment is planned to use E-prime software for programming. The subjects are to be told the test content and train before formal experiment. First present the target App icon, and start to timing. Subjects remember the objective and press the preset key to enter the test smart phone interface. Then the timing of memory part is over and the timing of searching part is on. Subjects are asked to press the preset key when find the goal, then finish the time keeping of searching part, record the App icon clicked. And

then defer 1 s to get into the next task. Make 15 tasks a group, and take a break of 1 min after each group. When 3days' experiment is over, ask the subjects immediately how is their feeling about the difficulties of the 3 layouts, set 3 levels of hard, medium and easy, with the mark of 3, 2, 1. The subjects are required to score their hardness evaluation.

3.2 Experiment Destination

(1) Variance analysis of memory and searching time under 3 structures

Under 3 different structures, subjects' reaction can be divided into memory and searching stages individually. The time consuming during searching stage can reflect the relationship between DHCI information structure and cognitive performance, while the time consuming during memory stage can testify the experiment reliability from another aspect. Moreover, concerning concrete searching route, more complex compare analysis can be extended.

(2) Mistake and difficulty analysis under 3 structures

Analyze the trend and reason of the subjects' mistake discrepancy, and explain the potential cause of mistake when choose the same icons or routes in further. According to the subjects' scores of hardness evaluation, it can be understood that how introspect and instant activities data correlate with one another. And from this result, we can study more hidden cognitive mechanism of our brain through further electroencephalogram (EEG) or event related potentials (ERP) experiments.

(3) The influence from information composition to structure

In these 3 kinds of structures, No. 1 has 2 levels, while No. 2 and 3 have 3 levels. Through this experiment design, we can compare the sophisticated cognitive differences of compositions in the same structure or level.

4 Summary

Concerning the conflict mechanism between design and cognition, 2 views of information structure and composition was proposed to discuss and analyze this problem. Information structure, as the strut of interface information, manage the composition format but easy to be omitted. This paper intended to divide the information structure and composition effects in cognitive process by controlling the experiment variables, so as to study the related mechanism. This study could provide theoretical reference and intelligent supply for human-computer interaction research in many fields such as design science, information science, cognitive science, system science and ergonomics.

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