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AN ANALYSIS OF INFORMATION VISUALISATION DESIGN BASED ON COGNITIVE THINKING AND VISUAL THINKING

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Abstract. *Objective:* In the context of experientialism, information visualization design has become one of the main forms of presenting information. From the perspectives of cognitive thinking and visual thinking, we explore and design a visual design that is more in line with human subjective behavior, thereby optimizing user experience and improving reading efficiency. *Methods*: First, the relevant theories of information visualization are explained. Then an information visualization design model based on cognitive thinking was constructed. Secondly, the relevant individual subjective initiative rules contained in cognitive thinking and visual thinking are expounded and a design strategy is proposed to optimize the information level through cognitive thinking and create a display form combined with visual thinking. Finally, we took the drug instructions of Ganmaoling Granules as an example to conduct design practice and conduct design evaluation. *Conclusion*: Information visualization design guided by cognitive thinking and visual thinking can effectively optimize the user's reading experience and improve the user's reading efficiency. It is a feasible path to assist and optimize information visualization design.

Keywords: *Cognitive thinking, visual thinking, information visualisation, user experience.*

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1. Introduction

With the development of society, people have to deal with a large amount of lengthy and complex information every day. In order to improve work efficiency, people need to understand this information quickly and accurately. Therefore, the closer the expression form of information is to human behavior, the better the reception effect of the terminal will be. At present, information visualization design has become a major trend in information transmission. Displaying information to readers through graphic aids can improve readability and reading efficiency while ensuring information accuracy. In the era of experientialism (Liu, 2019), design pays more attention to people's subjective feelings and the focus of information visualization research has gradually shifted to user cognition and usability analysis. Many scholars have also proposed related design methods and practices. For example, the information visualization design of smart campus (Abidin *et al*., 2021), the visualization design of garbage classification, the information visualization interface design of sports APP, etc. The above research has a positive impact on the development and application of information visualization. However, the current research on the process of users obtaining information Visual design research is not in depth. Guided by cognitive

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thinking and visual thinking, the author attempts to construct a standard paradigm for information visualization design, providing designers with corresponding methods to quickly carry out information visualization design from the perspective of optimizing user experience.

2. Overview of information visualisation

2.1. The concept of information visualisation

Information visualization design is an interdisciplinary comprehensive discipline that emerged under the rapid development of computer-aided design, graphics, statistics, visual communication design and other disciplines (Zhang, 2013). Information visualization combines rigor and beauty and has a more intuitive and comfortable viewing experience compared to traditional data information charts. For users, information visualization is a time-consuming process. Through the rational use of graphics, colors, formats, text and other visual elements, it can effectively stimulate users' understanding and cognitive ability, allowing users to quickly and efficiently grasp the information group. Key points and the correlation between information (Schön & Wiggins, 1992). At present, information visualization has become one of the main ways of data statistics and information presentation.

2.2. User classification for information visualisation

The end user in information visualisation design is the target user of the design. Correctly determining the end-user's abilities and needs can ensure that the information visualisation design is sound. However, end-user comprehension and goal orientation vary from person to person, because different types of users bring different variables that affect the designer's decision-making in practical tasks such as information screening and determining presentation methods (Dorst & Cross, 2001). Categorisation based on the needs of end users can be broadly divided into three categories: understanding users, using users and research users.

2.2.1. Understanding User

Understanding users generally refer to science popularization objects and their reading behavior is often accompanied by a certain degree of spontaneity and non-necessity. This type of user does not directly participate in related activities, but wants to expand knowledge, prevent potential problems and form cognitive reserves by understanding the content (Akner-Koler, 2000). Due to objective factors such as age, education, major, etc., this group’s ability to read and understand information differs greatly and the lower limit is lower. In order to satisfy this type of users to the greatest extent, the threshold for information communication should not be too high. For example, in drug instructions, most of these users are medical enthusiasts or common sense learners. They hope that the contents of the instructions are simple and clear so that they can accurately understand and reasonably guide medication behavior.

2.2.2. *Usage user*

Usage uses are the most important audience group, with the characteristics of universality, amateurism and necessity and a large base. In terms of personnel

influencing factors, using users are similar to understanding users, so their requirements for information expression are basically the same. For drug instructions, users are mostly patients or people who need medicines. In order to implement medication quickly, they are eager to obtain necessary information efficiently.

2.2.3. Research user

Research users refer to professional practitioners and related researchers. This group of people has strong understanding and professionalism. Research users are familiar with the content of information conveyed and can make quick judgments. Among users of drug instructions, many research users are doctors and pharmacists and they have a deeper understanding of drug instructions than other users. Research users usually quickly browse necessary information and then delve into information that other users pay less attention to, (see Table 1).

Table 1. Visualized user classification based on user needs

User Type	User Features	User requirements
Understanding User	Spontaneity, non-necessity, amateurism	Information is easy to read and creates a simple knowledge base
Usage user	Universality, amateurism, necessity	Easy to read information and efficient access to necessary information
Research user	Professional, understanding	Scan the information quickly and uncover potentially valuable information

2.3. Basic flow of information visualization

Lu et al. (2016) proposed a visualization model based on user cognition in the study of information visualization. The model includes four levels: strategic layer, scope layer, structure layer and presentation layer. Each level is an extension and development of the previous level. This model can also be used as a design process for information visualization (see Figure 1). The strategic layer is used to raise questions; the scope layer studies the cognitive abilities and actual needs of target users to determine the content and level of information communication; the structural layer is the visual logic for building information graphics; the presentation layer is to present the final visual design. In addition, at different levels of the construction process, designers can propose methodologies to solve specific problems.

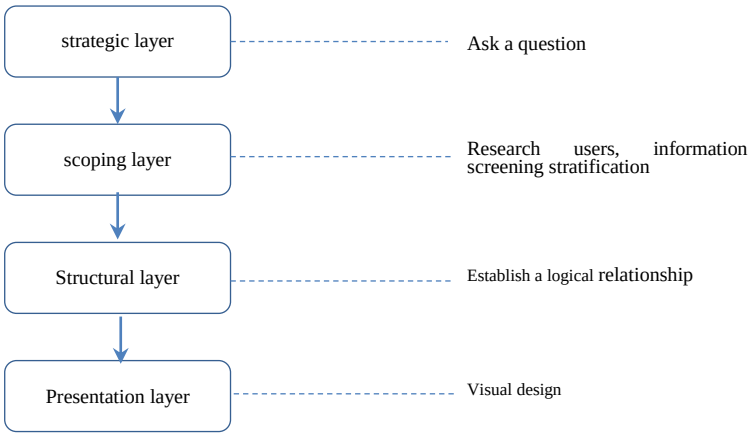

Figure 1. Design flow of information visualization design
Source: Lu et al. (2016)

3. Cognitive thinking and visual thinking

3.1. Cognitive thinking

Cognitive thinking plays an important role in product image modeling design. It deduces human-centered product design solutions through in-depth research on users' cognitive characteristics, which mainly includes aspects such as the shape of the product that fits the situation and the expression of product connotation (Toyong *et al*., 2021). This also shows that if you want the design to be deeply rooted in people's hearts, it is very important to introduce cognitive thinking.

Cognition mainly involves the user's individual information processing such as attention, memory, imagery and experience. In fact, cognitive systems build bridges between individuals and products, information and the environment (Zhang, 2014). Zhang et al. (2015) mentioned in their research on cognitive thinking that cognitive thinking in design requires designers to think about the two issues of "knowing what to do" and "knowing what". In other words, excellent product design should be able to quickly attract users' attention and stimulate independent interest and understanding. After using the product, a memory can be formed in the mind and transformed into operational experience, eventually forming the behavior of using the product unconsciously.

3.2. Visual Thinking

The visual system opens the door for humans to observe the world (Yin, 2020). It combines human rational experience and can reflect human intuitive feelings. Visual thinking was first proposed by American psychologist Rudolf Arnheim (Lyu, 2015). Visual thinking uses imagery as a medium and is more intelligent and creative than ordinary abstract thinking. In design, the research on visual thinking mainly focuses on visual processes and visual experiences. These studies reflect people's subjective visual logic when facing things (Li & Wang, 2020). Especially in designs with information transmission tasks, the reasonable use of visual thinking can allow users to receive information along the preset direction and make decisions quickly.

3.3. Design model based on cognitive thinking and visual thinking

Visual thinking and cognitive thinking are interconnected and influence each other (Norman, 2004). Vision often serves as the antecedent of cognition and the consequences of cognition provide valuable acquired experience for vision. When carrying out design work, both should be utilized reasonably. The design model guided by cognitive thinking and visual thinking constructed based on the information visualization design process is shown in Figure 2. First, the objective world is recognized through the visual system. This process is dominated by visual laws and acquired experience (visual experience in visual thinking) provided by the cognitive system. Then we enter the beginning of the cognitive system, that is, the attention mechanism. This process will introduce the main information screened into the memory mechanism and then the memory layer will carry out secondary screening and part of the information will be combined with the relevant experiences stored in the human brain to form a deep memory. Deep memories of multiple layers of research and individuality are the main motivations for behavior.

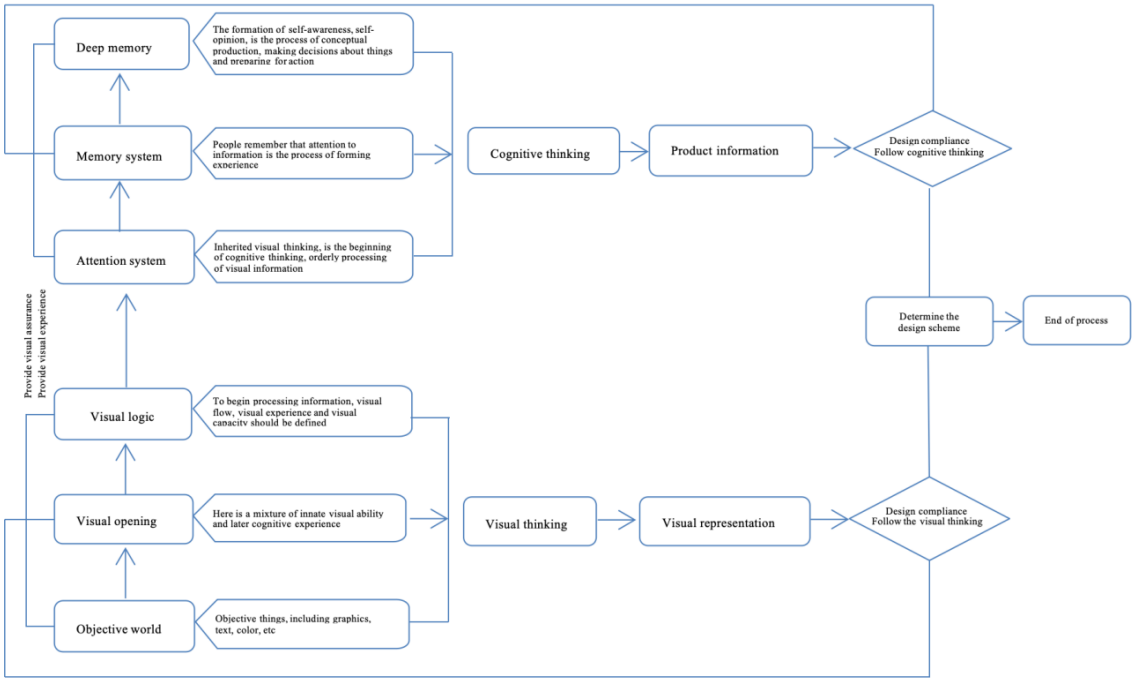

Figure 2. Visual design model under the combination of cognitive thinking and visual thinking

3.4. Enlightenment of cognitive thinking and visual thinking on information visualization design

1) Use cognitive thinking to optimize information reception: because human attention mechanisms often have thinking patterns and the amount of information entering the memory mechanism at the same time is limited. Cognitive thinking can be used for information stratification to optimize information reception.

2) Use visual thinking to improve the display form: visual thinking can guide the user's attention, memory and action. There are laws in human vision. How to use visual design techniques to make information viewable appear to users according to the information level set by designers is worth studying. At the same time, the design needs to conform to the user's visual experience and have aesthetic.

4. Information visualization design strategies based on cognitive thinking and visual thinking

4.1. Information hierarchy design based on cognitive thinking

4.1.1. Pay attention to functional and information levels

Discussing the attention mechanism from the perspective of cognitive thinking (Xu *et al*., 2020), it can be divided into four steps from top to bottom: attracting attention, selecting attention, secondary selecting attention and supplementing attention. Getting Attention: This is the process by which the human brain begins to receive information. Choose to note: People solve problems and explore information in utilitarian ways. Note for the second choice: This is a process of searching for information and its utilitarianism is weakened. Supplementary attention: This is the tail end of the attention mechanism, which is accompanied by incidental attention and accepts the remaining information to complete the attention.

Information visualization design divides complex information groups into information levels based on user needs. This level should match the attention function (see Figure 3). The subject of the message should be made clear in the process of attracting attention, allowing users to identify whether they need to continue receiving the message. Selecting attention corresponds to the first-level information, which has key guiding significance for solving problems. In the second selection, please note that the second-level information is listed. It is not necessary, but it will be helpful to solve related problems. Additional attention should be paid to the third-level information, which may be ignored by some users due to low usage, but it should also be found in the information group when needed.

4.1.2. Select attention to drive client creation

The different actual needs of various users will lead to deviations in the interpretation of information and directly affect attentional functions (Lakoff & Johnson, 1999). Specifically, attentional function is a subjective system that is deeply influenced by individual knowledge structures. Once attention is attracted, different types of users will have greater differences in choosing to pay attention. Therefore, it is very difficult for information visualization design to meet the needs of multiple types of users at the same time. If designers pursue the inclusivity of information graphics too much, it may result in no clear design focus and the loss of the design meaning of information visualization. Faced with this dilemma, targeted design can be carried out to create corresponding reading ends for different types of users. Each end tailors the information level based on the actual needs of the target users and completes the visual design. The design process of the information visualization client can be referred to Figure 4.

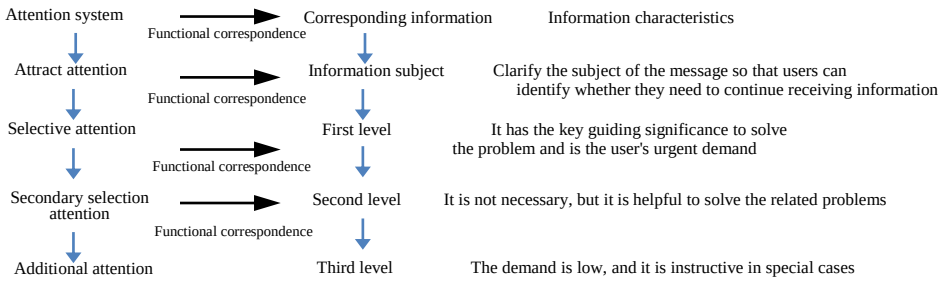

Figure 3. Information hierarchy matching attention system

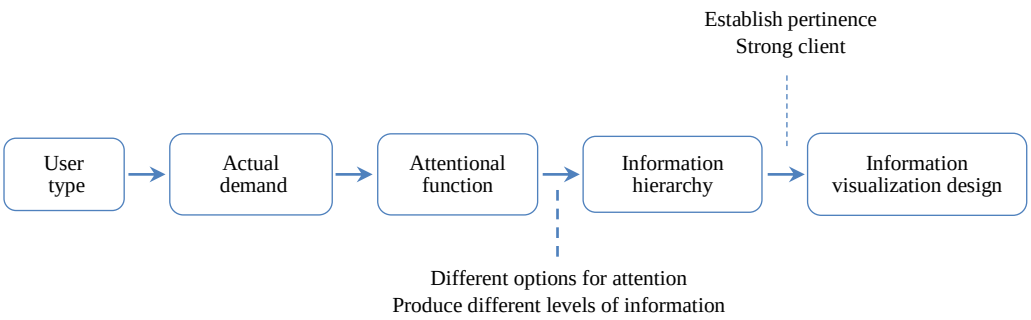

Figure 4. Design flow of information visualization client

There are currently many related design examples. For example, a certain photography APP provides a photographer's end and a user's end. Under different attention choices, there are large differences in content and design between the two, as shown in Figure 5. For conventional drug instructions, when considering market demand and user scale, it should serve more understanding users and usage users and meet their cognitive needs as the design goal.

Figure 5. Welcome pages for different clients of a photography APP

4.1.3. Memory function and information capacity

The memory function considers the user's reception effect after paying attention to the information, that is, the person's memory after working for a short period of time. Parameters involved include information capacity, time pressure and memory accuracy. Test the quantitative relationship between the three (the accuracy of memory can be measured by the accuracy of individuals reciting the information after receiving it). In information visualization, graphics and text are the main units of expression, so they are used as experimental information types (Yang *et al*., 2023). Under the same time pressure, the more time it takes, the higher the memory accuracy will be. The audience's memory ability for graphics is also much stronger than text, which also determines that information visualization design should be dominated by graphics.

4.2. Visualization construction based on visual thinking

4.2.1. User Visual Process

People have developed certain reading habits through long-term reading and there will also be a certain logical flow of people's eyesight. When reading, people's general visual habit is from left to right, top to bottom. The first glance often falls on the upper left part and then starts to move to the right and then to the lower left and lower right (Cao, 2002). It can be seen that the upper left and upper middle areas have the greatest attention effect, which are the best viewing areas (see Figure 7). This inspired the layout design of information visualization, that is, placing important information in a high-quality visual field and the information level decreases as the visual field level decreases, so that the preset information layer conforms to the visual process,

effectively strengthening the thinking guidance role of the visual diagram (Xu & Song, 2011).

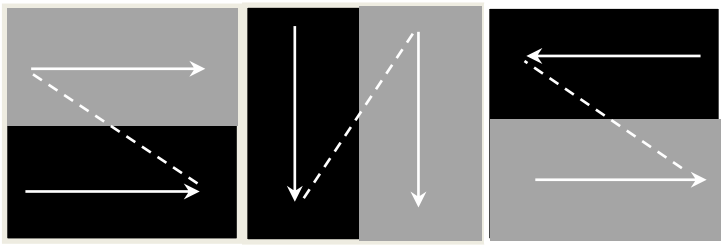

Figure 7: Visual process of user reading

4.2.2. User's visual experience

As the saying goes, “seeing is believing”, people have great trust in their eyes and this trust is constantly generated through long-term exploration and cognition (Deng *et al*., 2016). When acquiring new information, people will connect or compare it with similar old knowledge in their memory and then think about and identify the current things. For example, when seeing “◯”, people will think of information such as a sphere and correctness. Therefore, in information visualization design, the visual expression of elements should strictly consider the visual experience of the public.

4.2.3. Visually prominent design

When faced with information, people will subconsciously regard its formal differences from other information as visual emphasis. There are three main forms of visually prominent design, namely color mutation, graphic mutation and size mutation. In information visualization design, visual prominence can be used to enhance text expression and enhance users' awareness of key information (Hassan *et al*., 2022). The design ideas under visual thinking are shown in Table 2.

Table 2. Design ideas under visual thinking

Name	Serviceable item
Visual flow	Prototype planning
Visual experience	Auxiliary graphic design, color design, font selection, etc
Visual outburst	Emphasis on information focus, detail design

5. Design Practice

5.1. Current status of research on drug instructions

Take the instructions for Ganmaoling Granules as an example to start the design practice of information visualization. Drug instructions play an important role in guiding medication and should ensure that users can receive guidance information quickly and accurately. Through market research, it was found that existing drug instructions are often in the form of pure text and lack visual thinking. Therefore, the following shortcomings are caused.

1) The design language is not novel. It strengthens the obscurity of drug instructions and weakens users' desire to read (Huang, 2015).

2) Information expression is not intuitive. Extends the distance for users to reach the end of cognition.

3) The logical relationship is not clear. The missing information expresses the key points, that is, the primary and secondary relationship of the information is unclear (Gui, 2019).

4) The environment for receiving information is not easy. Patients are often nervous when seeing a doctor and long for the doctor's comfort to relieve their emotions. Drug instructions should have a certain positive emotional orientation.

It can be seen that information visualization design of drug instructions is a good medicine to optimize user experience (Zainal *et al*., 2008).

5.2. Information level of drug instructions

The user's attention function reflects the priority of user needs. Through research, we first calculate the degree of attention that relevant users give when viewing various information in drug instructions and obtain the order of user attention, as shown in Figure 9. Based on this, three levels are divided and the amount of information at each level is controlled within 8 to ensure the reading efficiency of information at each level (see Figure 10). Level 1 is the bottom-level information of drug instructions, which can basically guide medication behavior. Level 2 is some attributes of drugs. Level 3 is supplementary information, which completes the drug insert.

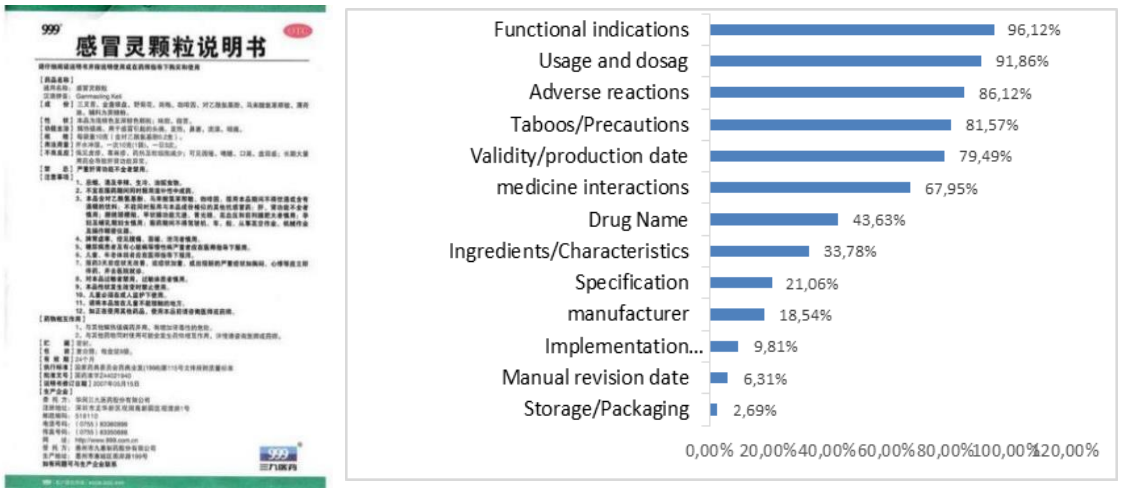

Figure 9. Investigation on the information attention of Ganmaoling granule manual

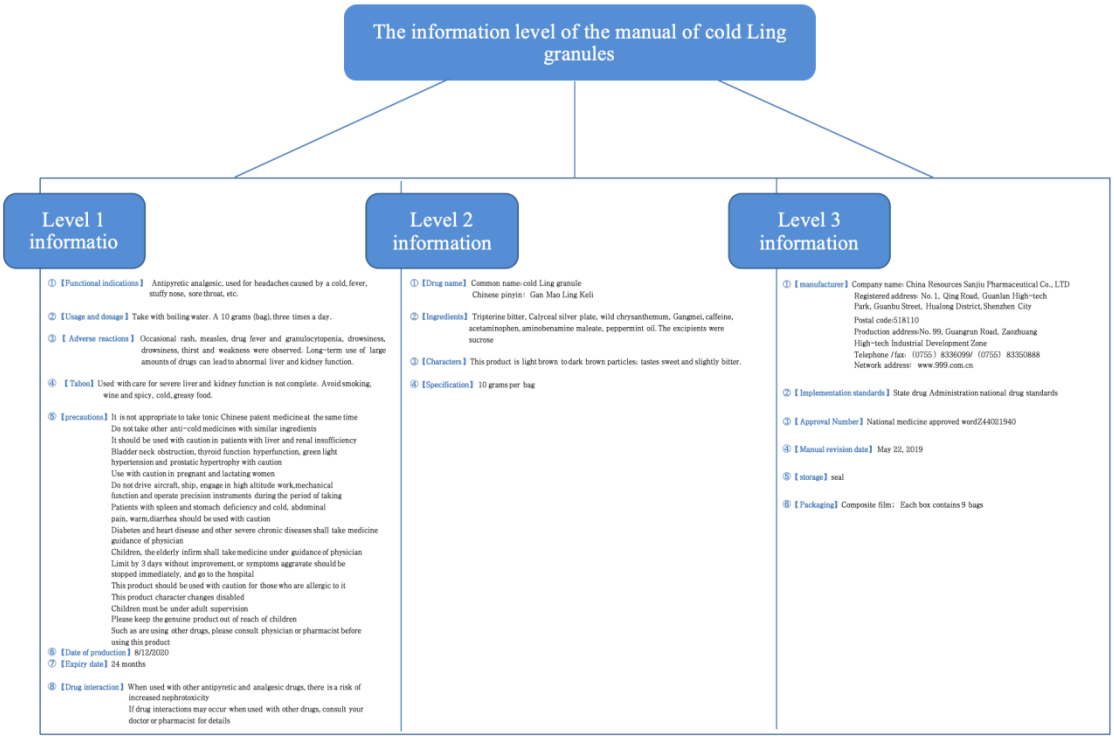

Figure 10. Information hierarchy of Ganmaoling granule instruction based on user requirements

5.3. Visual Design

Complete the information visualization design of drug instructions from the perspective of visual thinking (see Figure 11).

Figure 11. Information visualization design of drug instructions

5.4. Design Evaluation

Select 10 people to participate in the design evaluation of the visual design of drug instructions.

5.4.1. Usability Testing

Usability testing can intuitively understand whether the design conforms to human cognition and visual rules and effectively solves pain points that affect the efficiency of information transmission. Considering that people will have memories and experiences of the information they have read, they were divided into 2 experimental groups with 5 people in each group. Group 1 (tested 1-5) read the package insert of the existing drug and recorded the time it took to read all the information. Group 2 (tested 6-10) read the new design case and recorded the time it took to read all the information. Usability test 1 is shown in Table 3. The above test is for people who need to read the instructions completely. When users want to take medication quickly, they often only read the first level of information and stop paying attention. Let the two groups of subjects browse the three items of information: functions, indications, usage and dosage and adverse reactions from the old and new drug instructions and calculate the time consumed, as shown in Table 4. When people read the drug instructions under the information visualization design, compared with It saves nearly 1/3 of the time compared to the existing drug instructions. In the case of emergency reading, it saves more than half of the time. From the perspective of user needs, an improved design was completed.

Table 3. Usability test 1

	Tested 1	Tested 2	Tested 3	Tested 4	Tested 5
reading time	1min12s	11min30s	1min24s	1min16s	1min9s
	Tested6	**Tested7**	**Tested8**	**Tested9**	**Tested10**
reading time	46s	51s	39s	56s	47s

Table 4. Usability test 2

	Tested 1	Tested 2	Tested 3	Tested 4	Tested 5
reading time	12s	19s	25s	28s	23s
	Tested6	**Tested7**	**Tested8**	**Tested9**	**Tested10**
reading time	9s	11s	8s	12s	12s

5.4.2. Comfort rating

Information visualization design should also give users visual comfort and generate positive emotions. Let 10 people evaluate this, 9 of them were positive, no one was negative and 1 was noncommittal (see Figure 12).

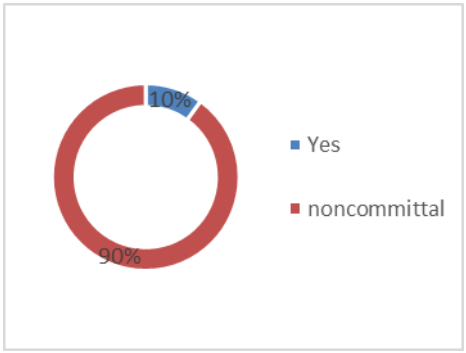

Figure 12. Comfort evaluation of drug instructions

6. Conclusion

Starting from the law of individual subjective initiative, this article proposes a design strategy for information visualization design and puts it into practice. It demonstrates in detail the influence process of cognitive thinking and visual thinking on information visualization design and rationally uses the two to create an individual-friendly design strategy. Visualization cases of subjective behaviors. In the context of an era where experience is paramount, no matter how information visualization appears in the future, it will be a reliable tool for humans to understand the world and create the future. It is the responsibility of the relevant designers to design visual views with a high-quality experience. It is hoped that the design thinking method proposed in the article can be of certain help to the development of information visualization.

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