The 3rd International Conference on Educational Innovation and Philosophical Inquiries (ICEIPI 2022)
DOI: 10.54254/2753-7048/3/2022299

Application Research of Cognitive Load Theory in User Experience Design—Take the User Experience Design of Takeaway Deliverymen in Unmanned Distribution Business as an Example

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Abstract: **Purpose**: Based on the cognitive load theory to guide the design practice, taking Segway unmanned delivery business as a case to explore new ideas of intelligent hardware user experience design, in order to reduce the cognitive load of takeaway deliverymen and improve the sense of experience. **Method**: Through literature research, the concept and relationship between cognitive load and user experience are clarified, and then how cognitive load affects user experience is expounded. According to the three factors that influence the psychological load proposed by John Sweller and combined with the process of unmanned delivery business and the design practice of human-computer interaction, this paper analyzes which factors affect the psychological load of deliverymen and how to reduce the cognitive load through design. **Result:** After optimizing the design, the main factors affecting cognitive load: task complexity and cognitive cost decreased significantly. **Conclusion:** Reducing the cognitive load of takeaway deliverymen can effectively improve the delivery efficiency , and enhance the overall sense of user experience.

Keywords: User experience, Cognitive load, Unmanned distribution, Artificial intelligence

1. Introduction

With each innovation of interaction mode and form, its design concept and practical method have launched a new exploration and attempt.The terminal unmanned distribution robot business (hereinafter referred to as unmanned distribution business) is different from other product interaction forms, especially the special role played by the takeaway deliverymen. It not only involves overlapping tasks and complex processes through online and offline, but also involves multiple scenes, roles and contacts. For example, the deliveryman should contact the mobile phone end and the robot end in the interactive path from receiving the order to placing the food to the robot box; Multiple factors such as multitasking, time pressure, unfamiliar addresses, reminder phones, and interface cognitive impairments play a role in the experience of being both the pick-up user and the delivery user.It is found that the cognitive load theory is very suitable for solving the problems encountered by the deliverymen in the unmanned distribution business, and has an important guiding significance. This study attempts to apply the theory to the role scenario of takeaway deliverymen , analyze the whole link and process, find out the reasons that affect cognitive load, and improve and optimize user

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experience through design, so as to provide a new design idea and practical method for the user experience design of intelligent hardware products.

2. Definition of the research scope of cognitive load theory

Cognition refers to the process and ability of acquiring knowledge and solving problems, namely the process and ability of information processing. Load usually refers to the maximum bearing or accepting capacity range of the machine when overcoming and under external pressure, which is extended to the proportion of resources occupied. Here specifically refers to the resources occupied by various brain functions in the process of cognitive information processing. The research assumes that learner's cognitive system presents a multidimensional structure in the process of dealing with specific tasks, which determines the efficiency of cognitive system. It is composed of the interaction results between the cognitive difficulty carried by the information task itself and the learner's knowledge structure, as well as measurable dimensions such as specific environment and psychological state. This measurable multidimensional structure is called cognitive load. Nowadays, cognitive load theory has been widely used in psychology, pedagogy, design and other fields, and has achieved some research results.This paper is mainly based on the research results of psychologist John sweller: the cognitive resources of the brain are limited. When the cognitive resources consumed in the information processing process exceed the total amount of individual cognitive resources (cognitive overload), the ability to obtain information and deal with problems will be reduced [7]. Cognitive resources here include attention resources (emotions), working memory capacity, and schema related to the processing of working memory information.

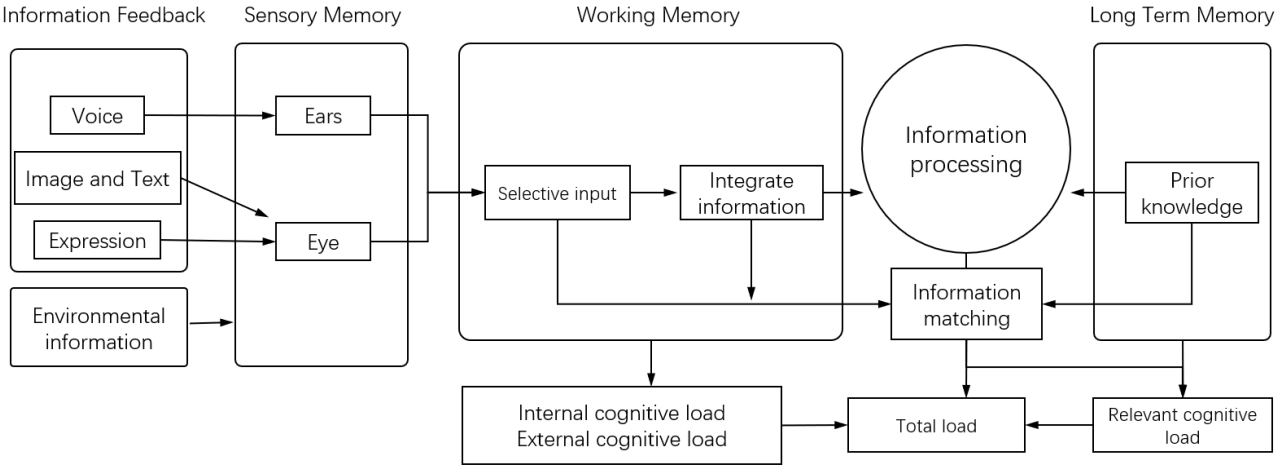

Figure 1: Relationship Diagram between Cognitive Load and Working Memory Theory in Human-Machine Interaction (Self-drawn by the author)

3. Relationship between user experience and cognitive load

Although user experience has become a hot word in the Internet era, it is difficult to define user experience accurately so far. It is generally believed that Norman[1] first proposed user experience. He believed that user experience should first be usability, then be simple and elegant with pleasure, and even bring extra surprise.With the continuous expansion of user experience in terms of content and architecture, the meaning of user experience is also expanding. For example, James Garrett[2] expanded the definition of user experience, including user experience on brand characteristics, information availability, functionality, content and other aspects. Leena arhippainen[3] thinks that user experience includes information about the use environment, user emotions and expectations,etc.

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Recently, the definition of ISO 9240-210 is generally accepted: perception and response to the use or participation of products, services or systems [4]. To sum up, some emphasize the reasons for the user experience, some focus on the composition of the user experience, and some regard the user experience as an extension of usability. However, which definition can accurately describe the user experience is still controversial, because the user experience interacts with the environment and others constantly, and the user experience is almost everywhere.

This paper is mainly based on Norman's definition of experience, assuming that cognitive load has direct and indirect impact on the usability, simplicity, elegance and pleasure of user experience. According to the current research, the significant consequences of cognitive overload is that the subject's efficiency of cognitive information or problem solving is reduced, the error rate is increased, the sense of experience is poor. For example, Fig [9] investigated the influence of cognitive load brought by information and symbolic elements, and found that cognitive overload makes the experimenter spend more time to understand the test model. Xu [10] and others studied the recommender system users' behavior intention of re-use through experiments, and found that when the complexity exceeded a certain degree, the users with cognitive overload had a significant negative impact on the pleasure and behavior intention of re-use. However, the high cost of information cognition, low work efficiency and poor experience have a direct negative impact on the subject psychology (expectation, demand and emotion) and the functional system (usability, functionality and purpose) of user experience. Therefore, it is of great guiding significance to study the cognitive load theory and explore its structure and formation mechanism for the user experience design of takeaway deliverymen in unmanned distribution business.

4. user experience design research of takeaway deliverymen in unmanned distribution business based on cognitive load theory

John Sweller proposed cognitive load classification according to different causes: internal cognitive load, external cognitive load and relevant cognitive load [11]. Internal cognitive load refers to the load formed by the interaction between the information of learning material and the learner's professional knowledge; External cognitive load is the load that is not related to cognitive goal caused by improper design; Relevant cognitive load refers to the load generated by the construction of schema and automation (such as reorganization, abstraction, comparison and reasoning, etc.). Relevant cognitive load produces load, but it alleviates the total load. The superposition of these three is the total cognitive load. In this paper, the cognitive load problems encountered by takeaway deliverymen in the specific delivery process of unmanned distribution service will be studied and analyzed from the three aspects: external cognitive load, internal cognitive load and relevant cognitive load, and specific solutions will be proposed.

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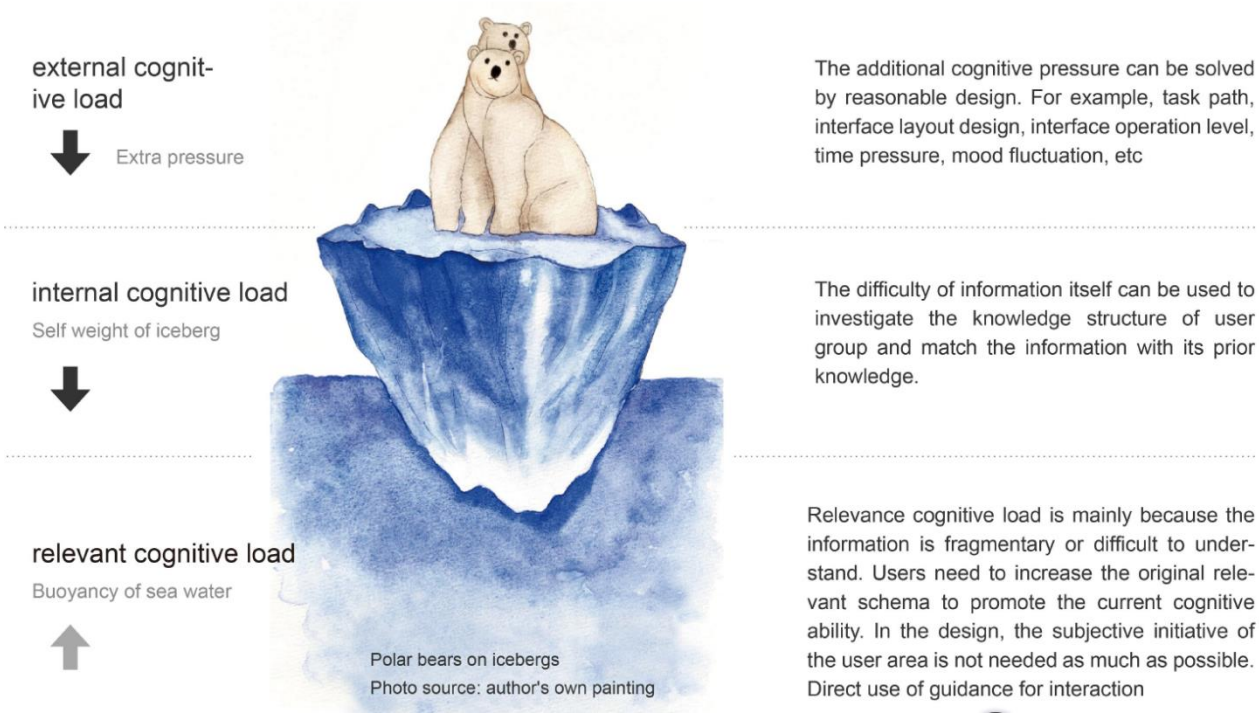

Figure 2: Classification relation diagram of cognitive load based on John Sweller (the picture is referred to the network and drawn by the author)

4.1. Problems and solutions of internal cognitive load

The internal cognitive load mainly depends on the matching degree between the cognitive information content and the user's internal knowledge structure. For example, when the user is stimulated by information, the relevant schema in the original long-term memory will be matched in the processing process, so the burden of working memory will be reduced, otherwise, the working memory will be increased. There are two main aspects of internal cognitive load in unmanned distribution business: ① In terms of task process, the distribution path is relatively complex, which is caused by the complexity of the task itself. ② The cost of cognition is too high. In particular, there is a certain cognitive difficulty for novice takeaway deliverymen to carry out terminal unmanned distribution. This is the problem of the matching degree between the cognitive subject's prior knowledge structure and cognitive content. In view of the above two problems, combined with the actual situation of unmanned distribution business, the first solution is to study the task path of unmanned delivery business and the complexity of the information interaction content itself. The second is to investigate the knowledge structure of deliverymen, to study whether they have relevant information cognitive experience, and then design and package the information content to better match the prior knowledge structure of the takeaway deliverymen (relevant schema construction in long-term memory). The design scheme is as follows:

4.1.1. Transfer the complexity of task to reduce the difficulty of task.

The cognitive complexity of information content itself is generated by the essential attributes of information, which is difficult to change. Cha Xianjin and others believe in their research that the internal cognitive load brought by the cognitive difficulty of information content itself is difficult to be improved simply through the organization and presentation of information, but information quality is an important dimension of information content, and the relationship between information quality

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and internal cognitive load can be studied [7]. In order to improve the quality of information acquisition and work task of deliverymen, we adopt the design method of complex transfer to simplify the task process and interface information, and complex transfer all tasks that can be completed by computer system or robot, so as to reduce the complexity of information and task. For example, in the aspect of the work process of the takeaway deliveryman, the tasks, levels and paths that affect the external cognitive load are complicated and transferred. As shown in Figure 2, the system program has completed most of the tasks that the deliveryman should have finished, including contacting the user to pick up the meal, helping the deliveryman to distribute the takeaway orders to the robot case and corresponding to the relevant boxes, etc. The complex transfer of human-machine interface, as shown in Figure 2, includes the input of the user ordering information database, which reduces the time for the takeaway deliveryman to fill in the user address and telephone information when placing food. In the user take meal interface, the user only needs to input the verification code to open the corresponding takeaway box. The complex transfer design of tasks does not really reduce the difficulty of information itself, but helps users complete part of the replaceable tasks, and improves the quality of information acquisition and task completion.

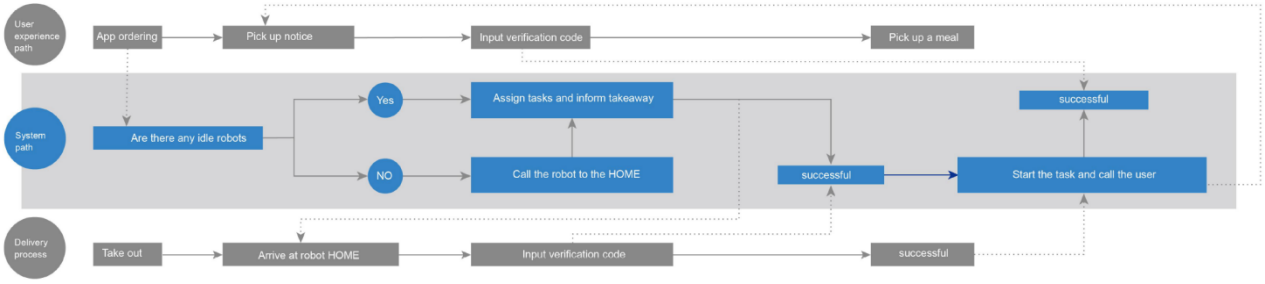

Figure 2: Complex transfer diagram of unmanned distribution user experience design system (Self-drawn by the author)

Figure 2: Schematic diagram of interface complex transfer (Self-drawn by the author)

4.1.2. Match the design model of information content and human-computer interaction to the mental model of the takeaway deliveryman

Gray and others investigated the behavior of the users of the knowledge base, and considered that the knowledge base is an important kind of knowledge source. The work with high intellectual requirements will consume the individual's cognitive resources, and the cognitive resources can be released with the help of the knowledge source [12]. In the interview, we found that although deliverymen have less experience in using AI intelligent products, they are quite familiar with takeaway cabinets, and many deliverymen also have relevant experience in delivery. In the long-term memory and existing schema structure of deliverymen, they have the cognition of express cabinets, and have the relevant understanding of the operation and use of express cabinets. If the unmanned

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distribution robot is used as a express cabinet, it is actually a mobile express cabinet. Therefore, the solution is to imitate the delivery process and pattern of the express cabinet from the business process of unmanned distribution, and match it to the mental model of the deliverymen and the original related schema, so as to reduce the internal cognitive load of users.

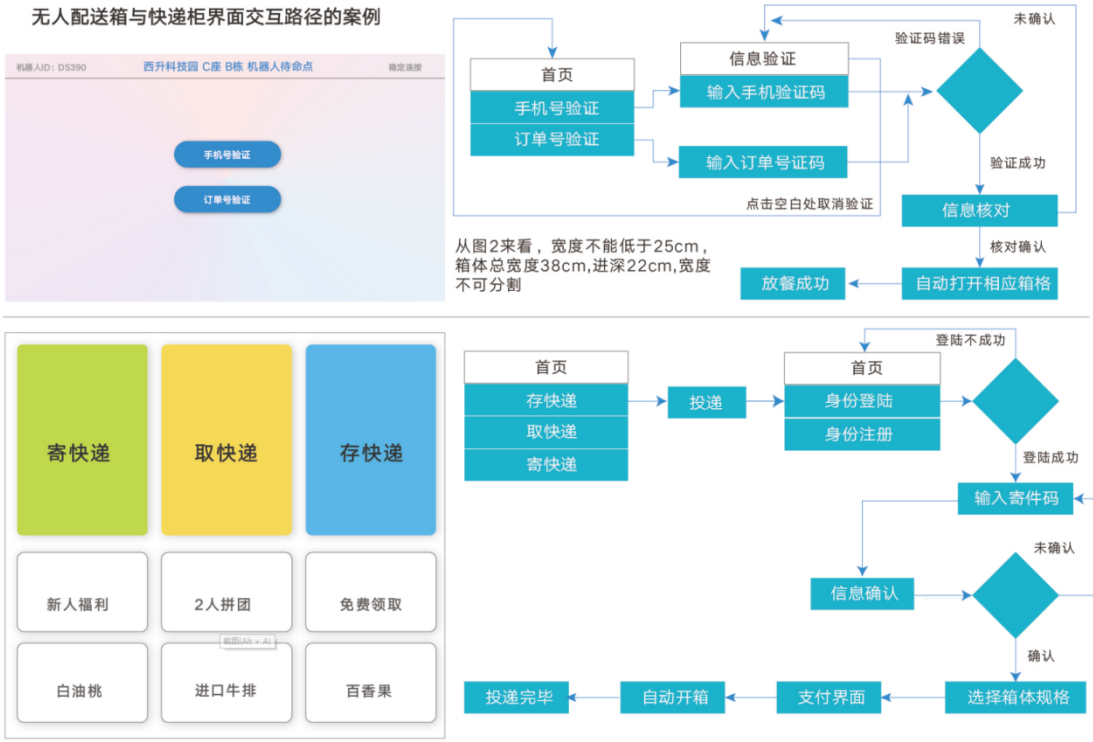

Figure 2: Interface design and process of unmanned distribution robot with express cabinet as the design reference

4.2. Problems and solutions for external cognitive load

The influence factors of external cognitive load are mainly the organization and presentation of cognitive information. The emergence of external cognitive load is not related to the information content itself, mainly because of the additional cognitive load caused by the information designer's problems in organizing information and presenting way. Combined with the above problems, the unmanned distribution business needs to be considered from two levels. ① From the perspective of the whole business process, a reasonable task flow chart design can clearly grasp the context of the whole business, find and solve the problems and additional pressure brought by the non-task itself. On the one hand, it is necessary to investigate whether the task flow of the distribution work is smooth. On the other hand, it is required to refine the priority of tasks and clarify the level and order of tasks. ② From the perspective of human-computer interaction interface, the external cognitive load is mainly the problem of information graphic design and presentation, redundant interface text and graphic elements; Too many information tasks and contents; Lengthy interface hierarchy and interaction path will lead to additional load brought by non-task difficulty.

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4.2.1. Reduce the external cognitive load of takeaway deliverymen in terms of the whole business process.

The first thing is to improve the task efficiency. In the process of sorting out the task flow, we need to pay attention to the fluency of the takeaway task, and the problem of the matching number of robots is a typical one. For example, the problem of waiting for free boxes due to insufficient ratio in peak period. In order to reasonably solve the problem of robot number matching, two aspects of design are done. The first is to distribute orders through the system, that is, after the user places an order by mobile phone, the order quantity information is distributed to the system, and then the robot box is distributed by the system. The second is to take a certain floor as an example to calculate the number of takeaway orders in each period of time by means of research and statistics. Taking the working days of each week as a cycle, calculate the maximum order quantity in the peak hours of each day, and then get the number of robots required in the peak period. A reasonable matching number of robots is beneficial to reduce the problem of deliverymen waiting for robots in the order peak period, and alleviate the problem caused by non-task itself.

The second thing is to refine the task priority. Clear and well-organized tasks, which can greatly reduce the cognitive load pressure of deliverymen. Liang [13] investigated the system exploration behavior of ERP users, and believed that task diversity would consume users' cognitive resources. When task diversity increased, users' cognitive load would increase as well. The author believes that if there is a clear task order and priority, then multiple tasks can be completed one by one in an orderly way, which can greatly reduce the external cognitive load. For example, in order to help the deliveryman to clarify the distribution order and priority of tasks in multiple delivery orders, the Meituan take-away APP uses the design of map visualization to help users reduce the load. In terms of task priority, it mainly considers that the order whose delivery time is about to end is the priority order. If the time difference is not big, it mainly considers the reasonable arrangement of routes. At the same time, the visualization of map interface is easier for users to get information than text. The inherent characteristics of information graphics are intuitive and general, which is the also the advantage of information graphics over words and language [14]. Therefore, the same intuitive and general design method is also adopted in the unmanned distribution business. The order of tasks is marked in the eye-catching position with numbers, and the specific location information of distribution is summarized as the robot site of a certain community and a certain unit, which effectively reduces the external cognitive load of users on the interface.

4.2.2. Reduce the external cognitive load of the takeaway deliverymen from the interface design.

Xin Xiangyang [15] divides the rules of design decision-making into behavior logic and physical logic, and calls "reasonable organizational behavior as the basis for decision-making" as "behavior logic". He believes that planning behavior process according to behavior, purpose and habit can better fit the user's possible and ideal behavior path, and can better emphasize the user's experience.The interface interaction design of the unmanned distribution robot is to guide and drive the user's interaction path through the user's behavior logic. As shown in Figure 4, the path sequence between the interface levels is designed according to the steps of the deliveryman placing the food. After each step is completed, it will jump to one level to minimize redundant information and return options. The deliveryman only needs to be goal-oriented and complete the simple process of inputting the verification code -- checking the order information -- placing the food (automatically opening the corresponding box) to complete the task. Through the goal to drive and guide the interaction path, the interface operation and cognitive cost are effectively reduced. In addition to optimizing the path and level, the presentation of interface information content also directly affects the external cognitive load.

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The results of Guo Yi's [15] eye movement experiment of web page picture text and complexity show that the two design factors of interface picture text ratio and interface complexity have a significant impact on cognitive load. Complexity is the main factor that produces cognitive load. In the interactive interface design of unmanned distribution business robot, the minimalist design concept is adopted, and the design method of information classification is used to highlight the key points and strengthen the sense of picture layers, which effectively improves the integrity, order and coherence of the cognitive information elements.

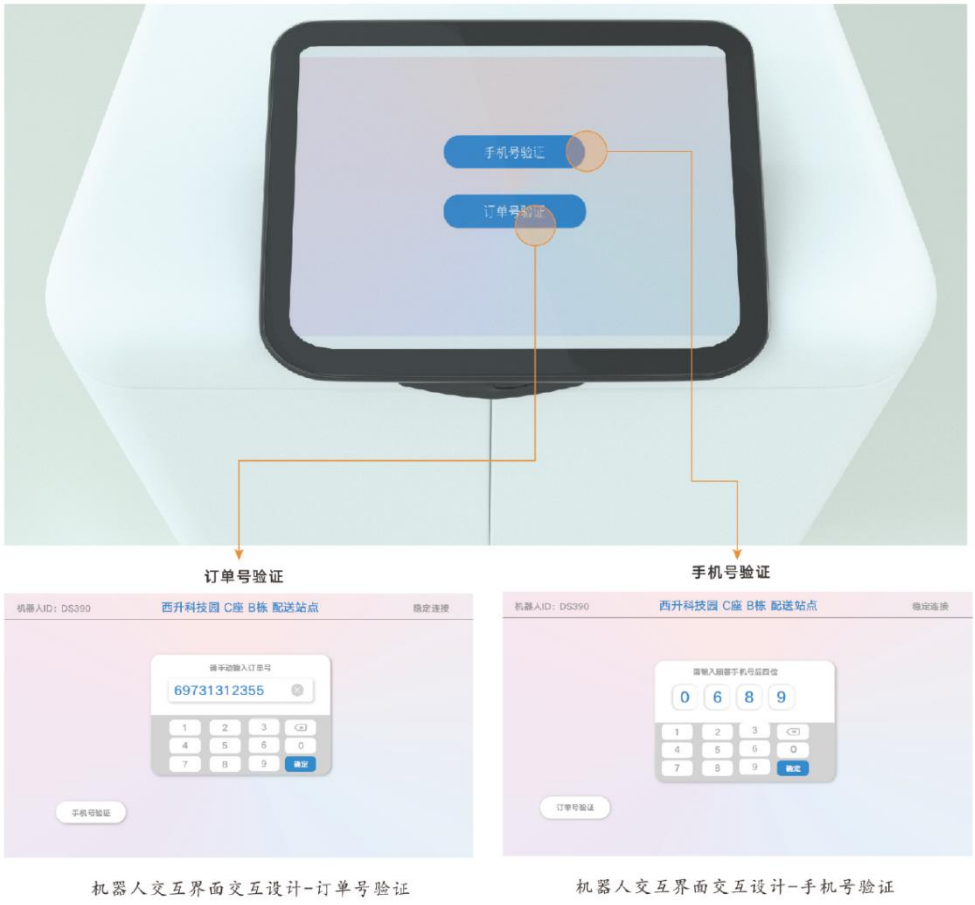

Figure 4: Interactive path diagram of the goal-oriented robot interface (Self-drawn by the author)

4.3. Problems and solutions of relevant cognitive load

Relevant cognitive load is different from the other two cognitive loads. In the information processing, the cognitive subject promotes the cognition of the overall information by packaging, combining and sorting information, etc. Although the related load is increased in the process of "information packaging", the cognition of the overall information has a promoting effect. Studies have shown that emotions play an important role in related cognitive load. For example, Moreno[17] found in his study that learners' emotions have a significant impact on the input of cognitive resources. Only when the working memory resources of users are left can this resource be invested in the more advanced information processing and schema building process. Then what affects users' emotions and psychological states? Experiments conducted by Zhang Yiting et al. [16] show that task complexity and time pressure have direct influences on self-efficacy, state metacognition and mental effort respectively, while task complexity and time pressure have significant impact on cognitive load. In the process of delivery tasks, complex tasks, delivery time pressure, call for orders and other factors

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affect the mental state of deliverymen. Therefore, reducing the complexity of the task (complex transfer) and alleviating the time pressure so that deliverymen can have more resources to invest in relevant cognitive load when the overall load is increased are the keys to effectively reduce the overall cognitive load. Because internal cognitive load, external cognitive load and relevant cognitive load are a whole, they are in reciprocal relationship. In the previous problem solving of internal and external cognitive load, the task complexity of the deliverymen and the related problems affecting users' emotions have been reduced through complex transfer, which will not be repeated here. The following two schemes are given from motivating user resource investment and diagram construction.

4.3.1. Use the method of incentive mechanism to improve the motivation of users to invest related cognitive load

Task motivation has a significant impact on the degree of investment in cognitive resources, and it is also an important factor affecting learning[17]. It is very common in design to use the promotion mechanism to improve the related cognitive load of users. For example, users are encouraged by the way of character upgrading and growth in games. Using red packets to stimulate the enthusiasm of users during reading information web pages. The incentive mode adopted in the unmanned distribution business mainly refers to the stimulation mode of the promotion mechanism of Didi Taxi App. The biggest pain point of Taxi App is the waiting time. Aimless waiting will create a sense of idle aversion. Didi taxi Taxi designs the interface of waiting for the arrival of the car into game animation. The increasingly close targets filling the user's sense of idle aversion, which has the same stimulating effect on the upcoming arrival of the taxi and the anticipation of the completion of the task in the game. Clark Hull found in a 1934 experiment in mice that the speed of running closer to the exit was faster than near the entrance, an effect known as the target approaching effect. In the unmanned distribution business, the takeaway rider and the food picking user APP interface formally use this method for reference. The visibility of the robot's running route, progress and status makes the upcoming distribution task have an incentive and promotion mechanism.

Figure 5: Meituan Rider App Delivery Page (Meituan APP)

Figure 6: Unmanned Delivery Mobile Terminal Interaction Prototype (Self-drawn by the author)

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4.3.2. Pay attention to the learning process of deliverymen in tasks (the construction process of schema structure)

Relevant cognitive load is related to the deep construction of user schema [18].In the process of cognition or task, information graphics or symbols can be used to help users process information and complete the process of schema construction, and users can get familiar with task operations more quickly after repeating the task for many times. For deliverymen, the task is repetitive. In order to reduce the internal cognitive load, this paper introduces that for the new deliverymen , information packaging and metaphor design techniques are used to match the original prior knowledge (schema structure stored in long-term memory) of takeaways, so as to promote the cognitive cost of the novice deliverymen. Schema construction and learning process here is to accumulate task knowledge in multiple tasks and help deliverymen to build new schema structures. Schema construction is conducive to improve the work efficiency of takeaway deliverymen.

5. Conclusion

In the future, with the increasing shortage of labor force, the terminal unmanned distribution robot will provide more transportation capacity. As a mature research achievement in the field of cognitive psychology, cognitive load theory has a very deep research on people's cognitive structure, process and psychological behavior. It is an important theoretical basis for studying the experience process of deliverymen in unmanned distribution business and putting forward targeted design scheme, which greatly improves the accuracy and scientificity of design. With the progress of brain neuroscience research, we will be more looking forward to the specific brain neuron operation mechanism of cognitive psychology, and use the initial stimulation and reflection of human perception information to design multimodal natural human-computer interaction. Technology drives the innovation of interaction mode and aesthetic cognition, but human behavior, cognitive psychology and brain neuroscience are still the important theoretical basis of design innovation, which is of great guiding significance for the new human-machine interaction.

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