Analysis of the Interaction Design of Intelligent Transportation APP Based on Cognitive Psychology

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ABSTRACT
Under the context of the increasingly congested urban traffic and the growing popularity of intelligent transportation applications, this paper critically examines the usage of intelligent transportation applications, including usage features, usage requirements and user research. Meanwhile, this paper analyzes the relationship between cognitive psychology and interaction design, and uses cognitive psychology tools and theories such as information processing and usability design to study the status quo of interaction design of intelligent transportation applications. This paper concludes that interactive designers should make the representation model closer to the mental model of users, simplify product operation information, match relationships and visibility between products and users and allow for user faults to improve usability. This paper also proposes possible future research directions that the segmented needs of specific groups should receive more attention, such as student users, commuter users, and older users.

Keywords: *Interaction design, Intelligent transportation, Cognitive psychology*

1. INTRODUCTION

With growing urbanization, an unprecedented proportion of the planet's population now lives in cities. As cities become more crowded, some of them are on the brink of a major shortfall in resources and infrastructure capacity, under a problem termed "urban diseases". Traffic congestion is one of them, and worsening traffic often bothers urban dwellers. For example, the average travel time in New York City increased by 5 minutes per day in 2021. It is now widely recognized – in New York and in other metropolitan regions – that expansion of road capacity to relieve congestion is no longer possible or desirable. The costs of expansion have become too excessive, both in monetary and community impact terms. This has led to more interest in managing traffic rather than merely accommodating it [1]. Promoting intelligent transportation can effectively alleviate traffic congestion. Intelligent transportation applications, which are part of intelligent transportation systems, help optimize trips. For example, they provide users with real-time updates on when the next bus or train will arrive, or whether a bike-share station has bikes available.

Interaction design is an important part of an application. Users are more easily attracted to it if it has a good interactive experience. However, the interaction design of intelligent transportation applications, which mainly serve as carriers of information transmission, is often ignored. It is often the case that the programmers or developers pay too much attention to how to cram as much information as possible into their applications instead of making the information transmission process simple and efficient.

Based on cognitive psychology, this study takes intelligent transportation applications as the research object and analyzes their usage, so as to explore how cognitive psychological principles can guide the interaction design of intelligent transportation applications and make them more efficient and user-centered. This paper tries to provide references for future research and development of the interaction design of intelligent public transportation applications, and promote the construction of smart cities and improve citizens' awareness of public transportation travel.

2. USAGE ANALYSIS OF INTELLIGENT TRANSPORTATION APP

In the 1980s, a small group of transportation professionals recognized the impact that the computing and communications revolutions of the Information Age could have on surface transportation. The idea of intelligent transportation was born[2]. After the 21st century, intelligent transportation applications gradually

emerged in the United States and became popular in other parts of the world. Typical applications include Transit, Moovit, MyMTA and Citymapper, which not only provides bus timetable but also modulates the way users travel around their cities[3].

2.1 Usage Features of Intelligent Transportation APP

The product goal of intelligent transportation applications is to solve the problems people encounter when taking public transport. Compared with other applications, intelligent transportation applications have the following salient features:

A. High frequency of use

The users of intelligent transportation applications are mostly people who commute by public transport every day, and those who use public transport occasionally usually don't go out of their way to download an application.

B. fixed time of use

Intelligent transportation applications see a rise in their use at certain times of the day (e.g., rush hours on weekdays).

C. strong purpose of use

Users of intelligent transportation applications tend to have a strong purpose, which is to get the latest transport information. They seldom open the applications when they are not taking public transport.

2.2 Usage Requirements of Intelligent Transportation APP

According to the survey, the basic needs of users for intelligent transportation applications include: providing the arrival time of the next bus or train, the navigation route to the bus or subway station, and the detailed information about the commuting route. All intelligent transportation applications should meet the above basic needs. In addition, with the further development of urban public transportation and the continuous expansion of user groups, users' needs for intelligent transportation applications are also more diversified. For example, during the current COVID-19 pandemic, many users are looking to intelligent transportation apps to provide real-time traffic information or forecasts of peak traffic in order to avoid crowded times and maintain social distance. There are also users who want to integrate more civic life service functions in intelligent transportation applications, such as lost and found information, promotion of urban cultural activities, etc.

2.3 User Research of Intelligent Transportation APP

2.3.1 User's Physiological Characteristics

Different individuals have different physiological conditions. Field research shows that the users of intelligent transportation applications are mainly young people. These users are healthy, agile, and have strong learning abilities, so the obstacles to operating the application are relatively small. For the elderly, however, their cognitive function gradually declines, and their vision, hearing level and learning ability all decline. At the same time, in terms of vision, the lens of some elderly eyes gradually turns yellow over time, making it difficult for them to distinguish green from blue. Therefore, the mixed-use of green and blue needs to be reduced in interaction design. As part of the user-centered design, the differences in the user's physiological condition should be fully considered in the design.

2.3.2 User's Psychological Characteristics

The psychological characteristics of users mainly refer to the inner feelings of users in the process of using the product, including the satisfaction, comfort, and identity of the product. Because young people are easy to accept new things, designers can consider more cutting-edge and fashionable designs for the interaction design of such users.

When users use intelligent transportation applications, due to their differences in knowledge, culture, habits and cognitive levels, some people will not use them correctly. Therefore, designers must take into account the differences in users' cognitive levels, and there must be necessary prompting texts and keep the usage process as concise and clear as possible.

3. COGNITIVE PSYCHOLOGY AND INTERACTION DESIGN

According to Solso Robert L. and others, cognitive psychology is the study of perception, memory, thinking, and information processing — indeed, all of human cognition[4]. David Groome points out that cognitive psychology is about the mental processes involved in acquiring and making use of the knowledge and experience gained from our scenes, and also those involved in planning action[5].

3.1 Interrelationship of Cognitive Psychology and Interaction Design

The impetus for any design project can be understood in terms of creating and changing "affordances" [6]. If designers want to create "affordances", they need to carefully observe the emotions and usage characteristics

of the users when using the product. For example, when we enter or leave a room and see a doorknob, we will consider whether we should push or pull it, and turn it to the left or to the right. This kind of basic information is supposed to be conveyed to the users at the beginning of the design. In a word, user-centered design should let the needs and habits of the users drive the design.

Table 1. User Cognitive Design Properties

Cognitive properties	Concrete manifestation	Design points
Perceptual properties	Users are accustomed to cognitive graphics	Have clear operation process Provide prompting texts
	Users are accustomed to generalization	Differentiate and layer information
Attention properties	Users are accustomed to paying attention to the allocation of efficiency	Use induced color, size contrast, etc. to achieve eye-catching effects
Memory properties	Users are accustomed to recognition	1. Better to use the menu than the description 2. Provide icons to help memory
Thinking properties	Users are accustomed to process information based on their emotions	1. Increase the user's experience of beauty 2. Increase the user's sense of achievement and provide more feedback

Human cognition has a series of laws (Table 1), which provide a theoretical basis for designers to understand the psychological and physiological factors of users. Through the above cognitive psychology analysis, this study summarizes the basic design principles that need to be paid attention to in cognitive design as follows (Table 2):

Table 2. Basic Principles of Cognitive Design

Basic principles	Connotation
Visibility	Users can visually know the state of the system or product and the actions to take
Good conceptual pattern	Designers provide users with good conceptual patterns, which have consistency of operation and results, and produce a consistent image of the system
Good correspondence	A definite correspondence can be established between actions and results, actions and effects, the state of the system and what is seen
Predictability	Users can predict the outcome of their actions

Cognitive psychology in a broad sense refers to the study of people's advanced psychological processes, especially cognitive processes. Interaction design borrows heavily from the field of cognitive psychology with regard to cognition, memory and perception [7]. From the analysis of the human cognitive process (Figure 1), attention and thinking are the two most important elements in cognitive processes.

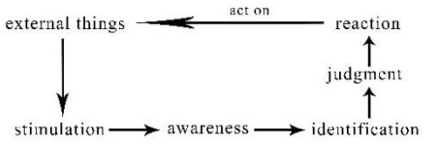

Figure 1 Cognitive Process

Perception is the reflection of human beings on objectively existing things, and of course, there is also an understanding of feeling. Sensation is the stimulation of human organs from objective things. Usually, perception is reflected by the fusion of many senses.

Attention is a high degree of concentration in the senses and mind, involving the selection of objective objects and the process of instant memory. Extracting the message to be conveyed by the product is done through selection. In the interaction design, there is a high degree of attention between the user and the product, only in this way can the user better get the information the product wants to convey.

Attention is especially important in interaction design. First of all, attention is highly concentrated in a short period of time, so the time to obtain information is fleeting. If people cannot get the information they need within this time, there will be no interaction between people and products. Second, attention is a process that cannot contain much information, so some information cannot be noticed by the user. For example, information in the upper left corner of a web page is more likely to be noticed by users, but not in the lower right corner.

The human brain controls actions through thinking. Thinking arises from human cognitive behavior. Thinking is the agency between people or between people and products.

Cognitive psychology provides a systematic research basis for interaction design to study user characteristics and behaviors. To a large extent, the processing modes of human-computer interaction input, coding storage and cognitive processes are the same [8]. In today's society, the primary communication between humans and machines can no longer meet the more and more advanced needs of users, and users want to be able to participate in interaction design.

3.2 Characteristics of Interaction Design Based on Cognitive Psychology

Based on the above research analysis and summary of cognitive psychology, we can draw the design characteristics of interaction design based on cognitive psychology: First of all, the design is developed around the user, and the designer should integrate the user's feelings about things in nature into the design while interacting with the design. People's perception of things must be completed under certain conditions. While things in web design that are dynamic are more attractive to humans, they are very difficult for us to recognize. Because of the different colors, the degree of stimulation of this dynamic effect on the human eye is different. For example, in mobile phone applications, bright colors will make people feel excited and excited, while colors with lower brightness will give people a calm feeling.

Second, try to communicate information efficiently with the least cost. Because the attention time of people mentioned above is very limited, and it may also be necessary to consider the mental and psychological state of people at that time, so we should try to display as much useful information as possible for users and make it concise and clear, in addition, we should ensure that all these useful information can be quickly noticed by users. As mentioned earlier, the distribution of human attention on the screen is from top to bottom and from left to right.

Finally, the use of symbols should be in a familiar character language. Attention in the user's mind is mostly short-term memory, so designers need to continuously stimulate consumers' attention and memory during the design process, and let users slowly adapt to the product under such long-term stimulation. To allow users to receive product feedback on the human body.

4. APPLICATION OF COGNITIVE PSYCHOLOGY IN THE INTERACTION DESIGN OF INTELLIGENT TRANSPORTATION APP

4.1 Application of Information Processing

One of the most fundamental applications of cognitive psychology in interaction design is the theory of information processing. The ultimate goal of design is to make people meet their needs in the process of using the product. Every designer has three models for understanding the product: the implementation model, the representation model and the mental model[9].

A. Implementation model

How the product works is called the "implementation model". The manifestation in the product is the ultimate

goal of the structural and mechanical factors, and the manifestation in the computer and electronic information is the coding of the program.

B. Representation model

Representation models are about how designers present the functionality and information of a product to consumers. It does not need to describe exactly how the product or program works; its purpose is to guide users on how to use the product correctly.

C. Mental model

When people use an application, they do not know the specific implementation process and internal structure of the product, so they will have a relatively simple corresponding process in their brains. For example, in the process of using a washing machine, people do not need to know the principle of decontamination. They only need to know that they can take out the clean clothes after putting them in for a few minutes. This is a basic mental model. The difference between the above models is shown in Figure 2.

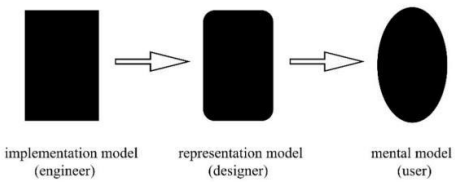

Figure 2 Comparison of Model

The user's mental model is created through long-term practical experience and the accumulation of time. Mental models are very different from how the real product works. If the representation model of the product is getting closer and closer to the user's mental model, the product will be more user-friendly, effectively reducing the difficulty for users to use, and more catering to people's physical and psychological satisfaction.

This principle has been implemented in the interaction design of intelligent transportation applications. The principle that they achieve real-time tracking of buses or subways is by integrating wireless, electronic, and automated technologies. This is the implementation model of intelligent transportation applications. However, users cannot and do not need to understand these complex technologies, all they care about is when the bus or subway will arrive, and they want to understand this intuitively and clearly. For example, they are often most interested in knowing how long the bus or subway will be in the station, and how far it is from the station. Therefore, interaction designers usually prioritize this basic function when designing intelligent transportation applications, and put the arrival time in a large font or special color in the upper left most prominent position. In addition, considering the user's mental model, interaction designers usually present site information in the form of a number line, and mark the current location of the next bus or subway on the number line. This form is very intuitive, and it is the embodiment of the representation model being close to the mental model.

4.2 Application of Usability Design Principles

The principle of usability design is to let users understand the use method and operation process of the product, understand how the product works, and judge what to do next according to the operation process and status[10]. This facilitates the interaction between the product and the user. Based on the human information processing model, there are the following design principles:

A. Simplify product operation information:

As mentioned earlier, the users of smart transportation applications are usually commuters who take public transportation during rush hour. They have limited time, so they can't consume too much time or distract themselves from the application, they just want to get the information they need as quickly as possible. Therefore, intelligent transportation applications should be designed to simplify operations as much as possible, and even many of them have no interface such as menus, and can automatically locate and push real-time bus or subway information as soon as they are opened.

B. Matching relationships and visibility between products and users:

Visibility means to let the user know what the specific function is to do during the operation and to give the user clear feedback. It is necessary to ensure the necessary matching between users and products, allowing users to perceive the state of the system through sight, hearing, and touch. For example, in an intelligent transportation application, when a bus or subway arrives at a station, in addition to the concise text prompts, there will be voice assistance or vibration reminder functions, which are used to ensure the necessary matching.

C. Fault tolerance:

Interaction designers need to consider the possibility of misoperation caused by incomplete information acquisition by users during the use process. There is therefore a need to provide convenient remedies for possible erroneous operations. At the same time, factors that may cause user operation errors should be considered at the beginning of the design, and the influence of such factors should be minimized, for example, different operations can be distinguished by different prompt text colors and fonts. In intelligent transportation applications, users often make mistakes

including mistyping a ride station or destination, so designers usually imitate the search engine's search box, with a cross-check button in a prominent position. Once the user makes a mistake, they can immediately clear search results. In addition, these types of applications now often provide auto-location features that automatically locate nearby sites to avoid user input errors.

5. CONCLUSION

With the increasing popularity of intelligent transportation applications, cognitive psychology now has a wide range of applications in its interaction design. In conclusion, as intelligent transportation applications are more and more widely used in cities, it is necessary to study and improve their interaction design. The theories of information processing and usability design of cognitive psychology can provide useful guidance for its interaction design, so as to achieve the purpose of user-centered design, increase the market share of intelligent transportation applications, and encourage more people to choose public transportation. However, intelligent transportation applications are not yet fully popularized, user demand development is not perfect, and interaction design research in related fields is not sufficient. In future research, more in-depth and detailed research can be conducted on the segmented needs of specific groups, such as student users, commuter users, and older users.

REFERENCES

[1] Zupan J M, Perrotta A. An exploration of motor vehicle congestion pricing in New York[J]. Regional Plan Association, New York. wbro. oxfordjournals. org, 2003.

[2] Weiland R J, Purser L B. Intelligent transportation systems[J]. Transportation in the new millennium, 2000.

[3] Tavmen G. Data/infrastructure in the smart city: Understanding the infrastructural power of Citymapper app through technicity of data[J]. Big Data & Society, 2020, 7(2).

[4] Solso R L, MacLin M K, MacLin O H. Cognitive psychology[M]. Pearson Education New Zealand, 2005.

[5] Groome D, Eysenck M. An introduction to applied cognitive psychology[M]. Psychology Press, 2016.

[6] Maier, J.R.A., Fadel, G.M. Affordance-based design methods for innovative design[J], redesign and reverse engineering. Res Eng Design 20, 2009.

[7] Kolko J. Thoughts on interaction design[M]. Morgan Kaufmann, 2010.

[8] Xu Wei. User-centered design approach: opportunities and challenges of human factors practices in China[J]. Ergonomics.2003(04).

[9] Alan Copper. About face: the essentials of interaction design[M]. Wiley, 2014.

[10] Gould J D, Lewis C. Designing for usability: key principles and what designers think[J]. Communications of the ACM, 1985, 28(3): 300-311.