Cognitive deviations of information symbols in human-computer interface

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Abstract

In the design of information symbols in human-computer interface, one meaning usually has several design forms. In order to solve cognitive deviations generated during information exchange, in the paper, we tested the recognition rates of common information symbols. The testing results indicated that users under different cultural backgrounds showed significant differences in information symbol cognition. Users prefer to clear and concise information symbols. Users are inclined to understand the surface meaning of information symbols. Through the study of the recognition rates of typical information symbols, we established the perceptual confusion models of information symbols. Based on different models, designers can improve cognitive deviations of existing symbols and design information symbols, which are consistent with user cognition, for reasonable human-computer interaction.

Keywords: human-computer interface, information symbol, cognitive deviation, perceptual confusion

1 Introduction

Human-computer interface (HCI) is the communication medium or means between humans and the computer system, the two-way information exchange platform of various symbols and actions between human and computer. Therefore, various symbols are the important recognition language of information interaction. With the rapid development of interactive multimedia information, the information symbol design is extremely important. Information symbol recognition plays an important role in the interaction between user and interface. Information symbols with poor recognition directly affect interaction means, thus leading to cognitive deviation as well as mistaken understanding and selection [1]. In the paper, we studied cognitive deviation of information symbols, investigated user recognition of information symbols, explored cognitive deviations of various information symbols and proposed the perceptual confusion cognitive model of information symbols.

2 Information symbols in human-computer interface

2.1 SYMBOL INTERACTIVE MODEL

Saussure [2] defined linguistic symbol as the combination of the signifier and the signified the overall formed by signifier and signified. The relation between the signifier and the signified is arbitrary. The combination of the signifier and the signified is stabilized through social conventions to form the social conventions among social members. Initially, the combination of the signifier and the signified are random, indicating that the combination of a form and a meaning is accidental. During the frequent uses in daily life, the accidental relation is gradually evolved into the stable relation. In the evolution of linguistic symbols, firstly, concepts are defined. Each object is named and corresponding symbols are defined. Secondly, various symbols are connected together to form stable combinations. Thirdly, the relation between a name and a meaning is determined and forms social conventions. In this way, the relation between a symbol and symbol-caused experience is standardized.

In 1954, Wilbur Schramm proposed a famous information interactive model [3] to describe the information communication way that people transmit information and realize meaningful communication through symbols, namely, information source - encoding - symbols - decoding - sink, as shown in Figure 1. In the so-called encoding process, an information sender converts his mood and intention into transmittable symbols according to certain rules. In the so-called decoding process, the symbol receiver gets the meaning of the symbols from the sender through his own life space. A symbol is the intermediary of information interaction. In a certain information interaction system, a symbol has a definite meaning. Symbol combinations follow certain rules, so as to ensure smooth information transmission through symbols. In this way, designer encoding results are consistent with decoding results by receivers. Otherwise, if mutual conventions among people disappear and the transmission process is hampered.

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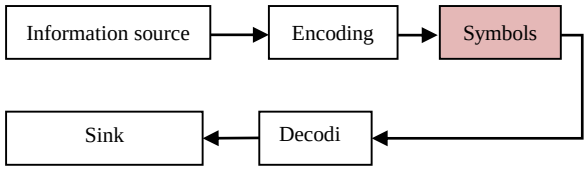

FIGURE 1 An interactive model of information symbols

2.2 RECOGNITION OF INFORMATION SYMBOLS

In the Oxford English-Chinese Dictionary [4], symbols have several basic meanings of text, graphics, images and other visual symbols. In human-machine interface, information symbols belong to graphic symbols, which can convey information. Based on different information types in human-machine interface, information symbols can be divided into text symbols, icon symbols, index symbols, and emblems.

According to symbol design theory, an effectively designed symbol should be not only easily instantly recognized, but also convenient to memory and cognition [5, 6]. Moreover, according to symbol design theory, the familiar concepts are subjected to strangeness treatment and the common and standard concepts are also "creatively corrupted". Then, the new, childish, and vibrant prospect is conveyed through the designed information symbols [7]. In other words, a good visual symbol should be not only easily recognized, but also be reasonably creatively designed. In the creative graphic expression, designers should enhance the recognition of information symbols by the design language.

For example, in the design of the symbol of "entrance", it is necessary to analysis the understanding of the word "enter". Ten entrance symbols from British Railways (BR), London Transport (LT), World Cup (WC), International Union of Railways (UIC), The International Council of Graphic Design Associations (ICOG), the Design of Public Information Symbols of Dreyfuss and Sim are provided in Figure 2. The results of professional fitness analysis and user survey indicate that the most easily recognized symbols are BR and ICOG1. ICOG3 may be mistakenly recognized as "exit" and makes users confused.

As the information conveying way in convey interactive interface, recognition is an important evaluation indicator of the designed symbols [8, 9]. During the graphical symbol creation process, it is necessary to analyse cognitive deviations of information symbols from the perspectives of perception, attention, and memory and then propose the easily instantly recognized symbols with visual impact and without semantic deviation. Therefore, through the study of cognitive deviations of information symbols, the differential analysis of existing information symbols from the perspective of perceptual confusion symbols can contribute to the reasonable design of information symbols.

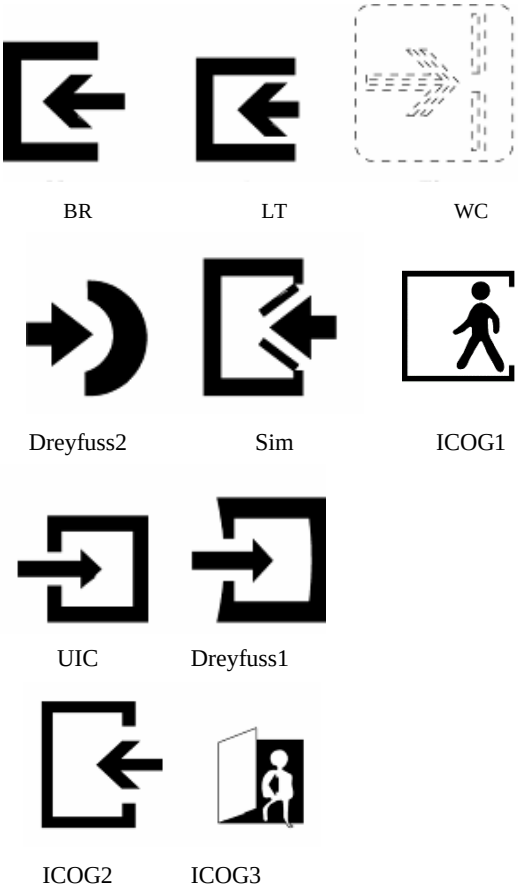

FIGURE 2 Different expression forms of "entrance" symbols

3 Cognitive deviation study of an information symbol

3.1 METHODS

For information symbols represent visual information, simple questionnaire and interview methods can be used to study cognitive deviation. In the questionnaire design, the graphical method is adopted. The interviewees read the symbols and give the symbol meaning. Through the interview, the understandings of various symbols from the interviewees are grasped and personal opinions on information symbols of the interviewees are recorded.

3.2 MATERIALS AND QUESTIONNAIRE DESIGN

Common information symbols are firstly extracted and selected as study objects, so that the interviewees are familiar to the symbols. In the acquired symbols, one concept often has several information symbols or even eight symbols. One concept has different expression forms in different industries and application fields.

FIGURE 3 Information symbols acquired from different interactive interfaces

In the interactive interface of various mobile terminals (mobile telephone and tablet) and different devices (printer, car navigator, camera, and daily electronic devices), investigators extracted common information symbols and collated the acquired symbols. The symbols with single expression form were removed, including "ON" and "OFF". After eliminating colour difference and 3D effect removal, we obtained the testing symbols, as shown in Figure 3.

According to the definition of each information symbol, all information symbols are classified into marks, product symbols, multimedia symbols, outdoor symbols, daily symbols, network symbols, document symbols, and instruction symbols. Representative symbols are selected from the common multimedia devices, classified and organized, as shown in Table 1.

TABLE 1 Classification of information symbols

Types	Information symbols
Marks	Positioning map, objective, label, favourite, and grade
Product symbols	Call, photography, video, TV, and phone
Multimedia symbols	Movies, picture, music, volume, voice, equalizer
Outdoor symbols	Train, car, airplane, and dangerous good
Daily symbols	Trash, search, map, compass, clock, lock, unlock, password, rain, and power
Network symbols	Signal, Internet, WIFI, Bluetooth, download, upload, e-mail, information, user, and groups
Document symbols	Pie chart, oscillatory graph, histogram, slide, documents, cut, save, set, tools, and file view
Instruction symbols	Circle and cancel

3.3 PROCEDURE

In the collected information symbols, one concept may have several expression symbols, which lead to different psychological feelings of interviewees. According to age and gender of interviewees, we designed the questionnaire for college students who are sensitive to information symbols of multimedia devices. College students are aged 19-23 years old, including 28 men and 28 women. We obtained 55 questionnaires, including 50 valid questionnaires.

The main survey contents can be divided into three parts: the cognition of different information symbols with the same meaning, understanding and cognition of information symbols, cognitive deviations of similar symbols. After the survey, partial participants are interviewed.

3.4 SURVEY RESULTS

The mathematical and statistical analysis of survey data gives the following results.

3.4.1 The cognition of different information symbols with the same meaning

When users select some common information symbols, such as positioning map, wireless network, and movies, the majority of the users can select the most common symbols and avoid the interference from other symbols, as shown in Table 2. However, when the confusing information symbols coexist, participants can only choose the best answer according to their own experiences. For example, many Chinese are accustomed to considering the symbol of paper clip (📎) as the bookmark. Although the stripped symbol (🔖) is used as the bookmark in many APPs, Chinese users often improperly select the symbol of paper clip (📎) as the bookmark because the stripped symbol (🔖) does not meet the Chinese cognitive habits. In addition, if the information symbols are highly similar, participants tend to select concise icons. For example,

among the symbols with the meaning of "user", most participants select the two most simple and clear options.

TABLE 2 Cognitive deviations of different icons with the same meaning

Types	Information symbols	Participant number of various symbols	Percentages	Meanings	Information symbols	Participant number of various symbols	Percentages
Positioning map		38	76%	Labels		13	26%
		3	6%			21	42%
		4	8%			13	26%
		5	10%			3	6%
Movies		0	0	Users		2	4%
		23	46%			8	16%
		14	28%			4	8%
		7	14%			3	6%
		6	12%			15	30%
						18	36%
Wireless network		33	66%			6	12%
		3	6%			8	16%

3.4.2 Understanding and cognition of information symbols

In the questionnaire, information symbols with recognition difficulty are selected as the questions about understanding and cognition of the meanings. If participants cannot understand the meaning of the information symbol at a glance, it is believed that the symbol has no inherent cognitive thinking.

As shown in Table 3, users tend to understand and select the verbal meaning or to select the superficial meaning of information symbols. On the contrary, the extended meaning of the symbol is seldom considered. For example, the symbol of "  " in the phone is often used to denote power, but users often understand the symbol of "  " as "lightning", the superficial meaning of the symbol.

TABLE 3 Cognitive deviations of different icons with the same meaning

	Types	Participant number of various symbols	Percentages
	Files	13	26%
	Place	15	30%
	Store	12	24%
	Classify	7	14%
	Others	3	6%
	Scan	27	54%
	Direction	6	12%
	Measurement	6	12%
	Search	8	16%
	Others	3	6%
	Connection	23	46%
	Circuit	13	26%
	Network	4	8%
	Relation	10	20%
	Power	5	10%
	Lightning	25	50%
	Danger	20	40%
	Thunderstorm	0	0
	Outbox	5	10%
	Upload	35	70%
	Top	5	10%
	Up	5	10%

3.4.3 Cognitive deviations of similar symbols

The analysis of cognitive deviations of different symbols under different meanings indicates that confusing symbols are prone to lead to cognitive deviations among participants. As shown in Table 4, the GPS symbol is "  ", but most participants select "  ". The clipboard symbol is "  ", but most participants select the symbol "  ".

TABLE 4 Cognitive deviations of similar symbols

					
Documents	35	16	18	15	17
Print	0	6	19	8	17
clipboard	9	22	7	20	8
					
GPS	24	10	7	11	3
Record	9	9	5	9	36
Position acquisition	10	10	31	26	4
					
Mobile data	10	42	2	4	23
Cancel	1	3	7	38	12
Refresh	34	1	35	2	9
					
Tile	10	42	2	4	23
Details	1	3	7	38	12
Medium icon	34	1	35	2	9

3.5 INTERVIEW AND DISCUSSION

Interviews are made after the questionnaire survey is completed. When single participant is interviewed, participants have no definite concept for many information symbols, thus leading to difficulty in the questionnaire survey. The reason of the difficulty can be interpreted in the following three aspects. Firstly, participants have obscure understanding of symbols. Secondly, the recognition of information symbols is poor. Thirdly, participants have limited information symbol cognition and cannot grasp the meanings of information symbols. However, in interviews, participants indicated that easily confused information symbols could not affect their selection deeply. Therefore, information symbol confusion has little effect on cognition. The cognition levels of participants determine the selection of information symbols.

4 Cognitive deviation study of an information symbol

Cognitive deviations of information symbols can be analysed from the cognitive perspective. When a plan is developed to start the implementation according to a certain goal, another goal, plan, or action shows favourable conditions, thus resulting in perceptual confusion. In the design of symbols and command words, distinct symbols should be adopted to avoid visual error, which is named perceptual confusion [10, 11]. Perceptual confusion is one type of cognitive error. Li Leshan [12] divided the users' operation errors into two types: in-attention and over-attention and believed that users' error type could be used to predict the users' intent and to find the thought process of the users. The user errors are divided into four types: slip caused by double capture, forgetting caused by interruption, weakened intentionality, misperception, and over-attention. Norman [13, 14] divided operation errors into the three types: error, slip and mistake. Reason [15, 17] believed that there were 8 basic error types: false sensation, attention failure, memory slip, inaccurate recall, misperception, error judgment, inferential error and unintended actions According to the analysis results of cognitive deviation experiment, we established a cognitive model of perceptual confusion. Perceptual confusion caused by information symbols can be further interpreted as ambiguity, subjective idea, relation misconception, morphological resemblance, complex morphology, and multiple meanings, which lead to recognition difficulty. Information symbols should be designed according to the above reasons of perceptual confusion to reduce cognitive deviation of information symbols (Figure 4).

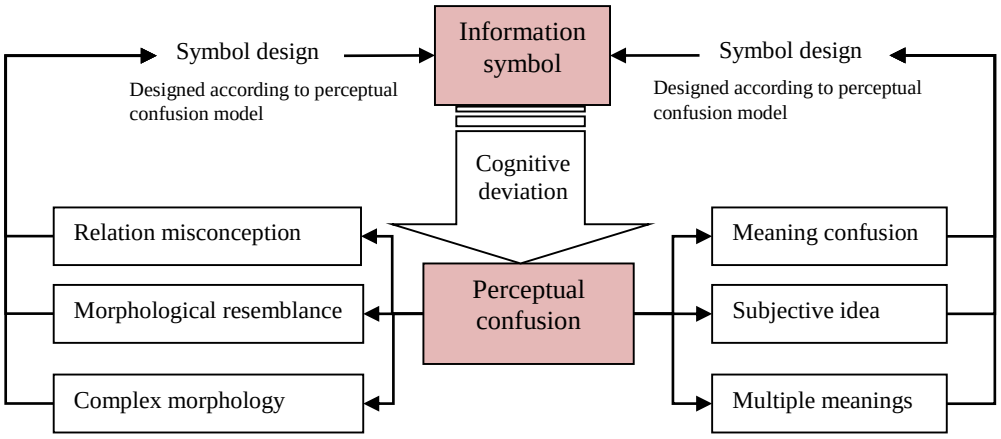

FIGURE 4 Perceptual confusion model of information symbols

5 Conclusions

1) Information symbol design should meet users' habits and cognitive model. Users under different cultural backgrounds show significant difference in cognition of information symbols;
2) Users prefer to clear and concise information symbols, which can avoid excessive cognition burden;
3) Users are prone to grasp the superficial meanings of information symbols and seldom consider its extended meaning;
4) Based on the study of cognitive deviation, we established the perception confusion models of information symbol. According to different perception confusion models, designers should design proper information symbols with less cognitive deviation for smooth human-computer interaction.

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