IASDR07
INTERNATIONAL ASSOCIATION OF SOCIETIES OF DESIGN RESEARCH THE HONG KONG POLYTECHNIC UNIVERSITY 12TH TO 15TH NOVEMBER 2007

PERCEIVING AFFORDANCES THROUGH PERCEPTUAL INFORMATION

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ABSTRACT:

The purpose of this study was to explore how users perceive the affordances of an object from specific operation tasks. These affordances can be specified in terms of perceptual information. To this end, the eye-tracking technique was employed to capture what product parts uses' fixation focused on when using a product for specific operational tasks. The results show that, for physical-behavioral tasks, users were more interested in the physical properties that presented the affordance for product parts' operation-ability and assembly-ability; for functional tasks, users were more interested in the artificial signs that presented the affordance for product parts' functionality. In addition, this study proposed a feasible approach to exploring how users perceive affordances, which is contributive to applying the concept of affordance in product design.

Keywords: affordance, product design, eye tracking

1. INTRODUCTION

The concept of affordance proposed by Gibson (1979) describes certain relationships between actors and their environment. Actors perceive directly through visual information what objects afford in the environment. Also, they perceive what the objects can be used to do in relation to their own sizes as human individual. For example, a flat board that is rigid and knee-high to the actor can be sat on, but being knee-high for a child is not the same as it is for an adult (Gibson,1979). The meaning of the chair is caused by its physical appearance, rather than its internal structure or color. In this view, the perception of affordance is relative to the physical-behavioral relationship between the user and the object (You et al., 2007), which conveys what can be done with the object, i.e. its usefulness, to the user. In general, users can judge whether the usefulness of an object, its affordance, suffice for their requirements or not by looking at it with their intentions or goals in mind. A useful design is one that functions to enable its users to complete their jobs and accomplish their goals efficiently (McGrenere et al., 2000). Though affordance exists whether it is perceived or used (Turner, 2005; Gaver, 1991), the affordance of an object is available only when it fits in with users' requirements, and is perceived by them.

The concept of affordance as a notion of direct-perception in product design suggests that the interface of a product could help users operate the product in an intuitive manner. However, the application of the concept of affordance in design practice has diverged from Gibson's original idea (Stone et al., 2005; You et al., 2007). The perception of affordance is determined in part by the observer's culture, social setting, and experience (Gaver, 1991; McGrenere et al., 2000). Many recent products involve the use of images created through semiotic techniques. As Hartson(2003) stated with the term cognitive affordance, the artificial icons, signs or texts about a product are effective ways to specify the affordance of a product, i.e. its functionality. Furthermore, affordance is determined by perceptual information (Gaver, 1991; McGrenere et al., 2000). In this view, both the physical properties of and the artificial signs about a product provide the information that specifies the affordances of the product. The aim of this study was to explore the roles played by the physical properties of and the artificial signs in a product in presenting its affordance to guide users to operate it properly.

2. METHOD

The eye-tracking technique was employed to capture information about which part of a product gaze focused on when operating the product. This was to identify the information on affordances that the users were interested in when carrying out operational tasks.

2.1 MATERIAL AND PROCEDURE

In this study, a vacuum cleaner serving as the test product was put on a table. Two subjects each wearing a headband of an eye-tracking system stood in front of the table, at a distance that was close enough to reach and operate the parts of the vacuum cleaner when carrying out the operational tasks designed for this study, as shown in Figure 1. Due to this eye-tracking system is as depth-calibrating limitation, the subjects were shown the instructions for the operational tasks written on pieces of paper with each instruction on one piece of paper. Only the relevant product parts for one operational task were put on the table. The subjects were asked to determine how to handle the parts correctly by looking at them before they actually performed the operational tasks. They were also asked to keep their heads as stable as they could when they made their judgments on the operational tasks. Every 4ms, the participants' visual line of gaze on the parts was recorded. Data analysis mainly focused on the subjects' regions of gaze on the parts when judging straight operations for the tasks. The data was not analyzed to examine how they actually performed the operations.

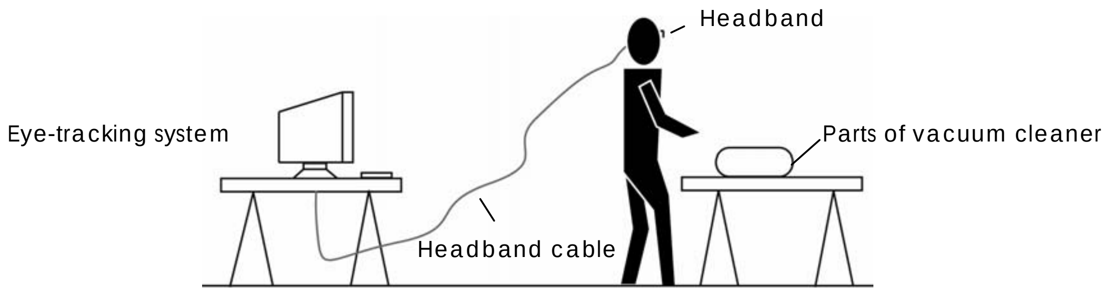


Figure 1Setting of experiment

2.2 PARTS OF VACUUM CLEANER AND OPERATIONAL TASKS

The parts of the vacuum cleaner are shown in Figure 2; and the operational tasks in this study are described below:

(1.) Attaching the flexible pipe to the main body of vacuum cleaner; (2.) Attaching the inhalant pipe to the floor brush; (3.) Attaching the flexible pipe to the inhalant pipe; (4.) Plugging in; (5.) Turning on; (6.) Adjusting the suction; (7.) Turning off; (8.) Storing the plug; (9.) Taking the dust box out; (10.) Opening the cover of the dust box; (11.) Putting the dust box into the fillister of the main body.

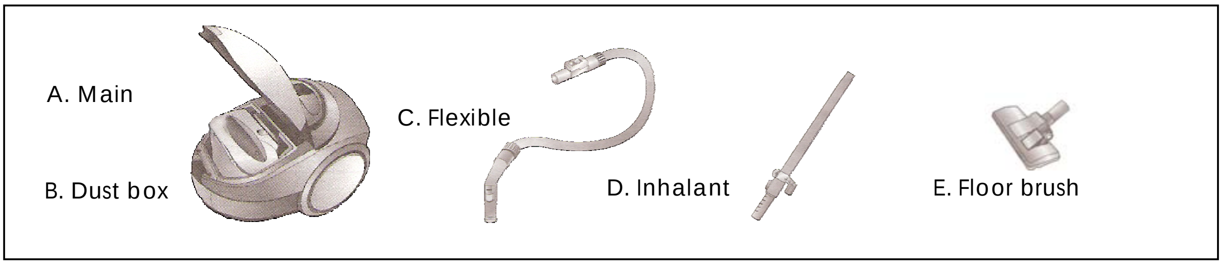


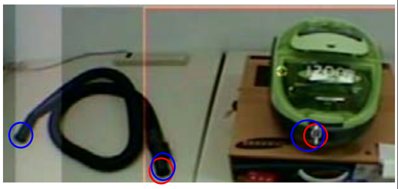
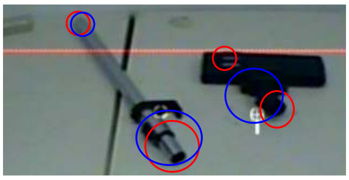
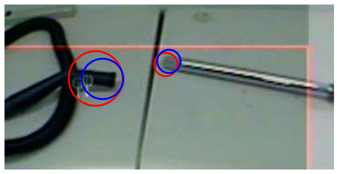
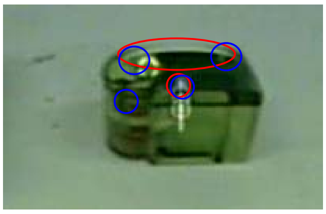
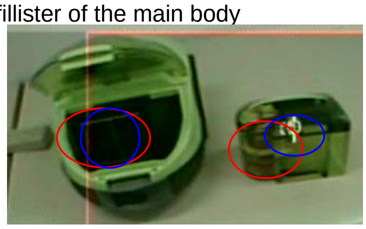
Figure 2 Parts of vacuum cleaner

3. ANALYSIS AND RESULTS

The raw eye-tracking data captured were dynamic pictures. In this study, the subjects' major regions of visual focus were shown in static pictures. We mainly analyzed and marked the subjects' major regions of fixation on the relevant parts when they made their judgments on each task, as shown in Table 1. Subject A's regions of fixation are marked with red circles; subject B's with blue ones. In addition, the tasks designed for this study could be grouped into two types, physical-behavioral tasks and functional tasks. Physical-behavioral tasks emphasize the physical relationships between the user and the object, or between two certain parts. For example, in task 1, the subjects had to grab and hold part C, and attach it to the main body of the vacuum cleaner. As the circles indicating the regions of the subjects' fixation in task 1, the users mainly focused on the physical properties of the parts. These physical properties of provided information to effectively present the affordances for the parts' grab-ability and assembly-ability. Functional tasks emphasize the functionalities of the parts. An example is task 5, in which the subjects were asked to turn on the vacuum cleaner. It is about what happens when users press a button on a product. As shown in table 1, the subjects' fixation in task 5 mainly focused on the artificial signs of the parts. Also, similar fixations were identified in task 6, 7 and 8. The artificial signs provided information to effectively present the affordance for the parts' functionality.

Figure 3 summarizes the main information type in the subjects' major-different regions of fixation in the tasks and the main-required affordances for each task. For tasks 1, 2 and 3, the physical properties of the parts seem to be the important information about affordances for operation-ability

Table 1 Major region of subjects' of fixations in the tasks

1. Attaching the flexible pipe to the main body of vacuum cleaner 	2. Attaching the inhalant pipe to the floor brush 	3. Attaching the flexible pipe to the inhalant pipe 
4. Plugging in 	5. Turning on 	6. Adjusting the suction 
7. Turning off 	8. Storing the plug 	9. Taking the dust box out 
9. Taking the dusk box out 	10. Opening the cover of the dust box 	11. Putting the dust box into the fillister of the main body 

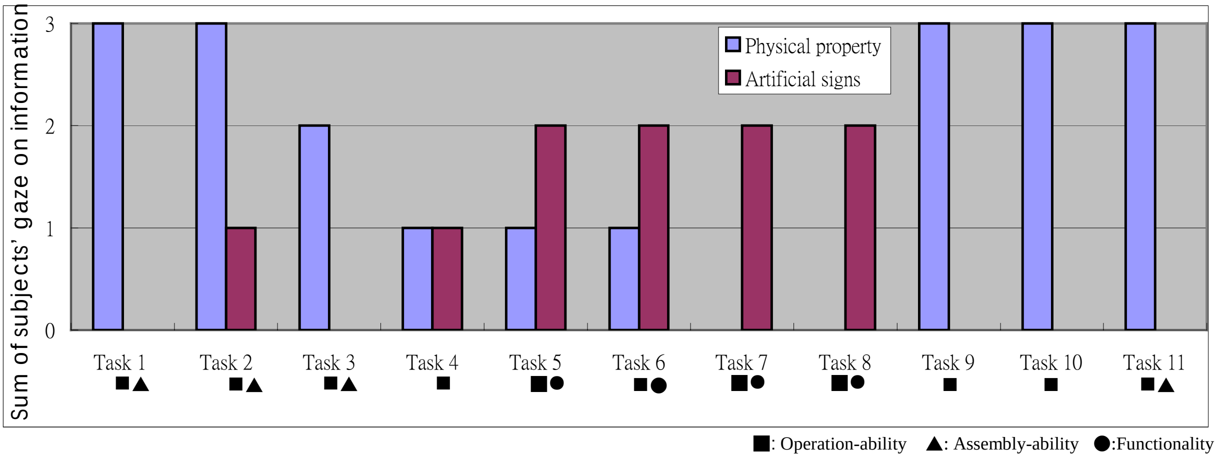


Figure 3 Sum of information for affordances in subjects' major regions of gaze in the tasks

and assembly-ability. In tasks 9, 10 and 11, the physical properties of the parts seem to be the important information for affordances about operation-ability and assembly-ability. In the case of this study, operation-abilities include grab-ability, press-ability, and pinch-ability. In tasks 5, 6, 7 and 8, information about affordances for functionality and operation-ability were required. However, functionality was the major affordance, and the artificial signs seem to give the necessary information. On the basis of the results above, the relationships could be described below:

- When handling physical-behavioral tasks, users were more interested in the physical properties that presented the affordances for the product parts' operation-ability and assembly-ability.
- When handling functional tasks, users were more interested in the artificial signs that presented the affordance for the product parts' functionality of parts of a product.

4. DISCUSSIONS

Perceptual information plays an important role in conveying the affordance of an object to its users. As the results from tasks 1, 2 and 3 presented in Table 1 show, although affordances for grasp-ability and assembly-ability were required for the tasks, the subjects' fixation mailly focused on the physical properties of attachment points. The reason might be that the main actions of these tasks were to assemble two parts; therefore, these physical properties where are the most important information for. In addition, the major affordance in tasks 5, 6, 7 and 8 was the functionality; therefore, although the tasks involved physical behaviors, the artificial signs gave the most important information. In tasks 9, 10 and 11, the grab-ability was the major affordance and the subjects' fixation mainly focused on the physical properties of the grab points. In design practice, the designer cares more about what actions users perceive to be possible than what is true (Norman, 1999). Hence, designers should purposely reveal specific affordances in order to facilitate user-product interaction.

In this study, the eye-tracking system was employed to capture information about the users' fixation. Some limitations of the system are described below. Firstly, due to the system's depth-calibrating limitation; time and the scan paths of the subjects' fixation on the parts could not be measured and analyzed. The results proposed in this study were produced by analyzing information about the major regions of the subjects' fixation on the parts, rather than the accurate positions of the subjects' fixation. That is, in this study, we just examined the major regions of the subjects' fixation on the parts, and the other positions of the subjects' fixation were disregarded. Doing this made it possible to identify the information about the affordances the users perceived for the tasks in a reasonable manner. It is nevertheless worth studying how users perceive information about specific affordances for operational tasks by examining the accurate positions, and the time and scan paths of the subjects' fixation. This would made it possible to identify, for specific tasks, the relationship between fixation time and fixation positions.

Secondly, the subjects had to keep their heads as stable as they could when they made judgments on the operational tasks. That might have affected the positions of their fixation on the parts. This can be changed by adjusting the experimental design in future studies. Finally, this study just mainly analyzed the major regions of the subjects' fixation on product parts before they actually performed the operational tasks. What their fixation focused on when they actually performed the operational tasks is worth studying as well.

5. CONCLUSION

This study proposed an approach to explore the application of the concept of affordance in product design. Affordance can be specified in terms of perceptual information (Gaver, 1991; McGrenere et al., 2000). Hence, investigating perceptual information is a feasible way to apply the concept. This study primarily investigated perceptual information with an eye-tracking system. Although the eye-tracking system used in this study has limitations, the problem might be overcome by changing the experimental design or by employing more suitable eye-tracking systems in future studies.

The information in a product, including its physical properties and artificial signs, can specify its affordances for particular tasks. The physical properties of the product highlight its physical relationship with the user, or the physical relationship between its component parts; the artificial signs highlight its functionality, for instance, what would happen after pressing a button on the product. Designers should purposely strengthen such information to specify a product's affordances for specific tasks. The relationship between information on affordances and specific tasks is worthy of further study. This will contribute to making user-product interaction more intuitive, and therefore more spontaneous.

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