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THE ROLE OF ACTIONS IN USER-PRODUCT INTERACTION

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ABSTRACT:

The increasing attention on interaction rather than interface in recent design researches gives rise to design approaches that place the emphasis on embodied actions. While many tangible interaction concepts have been developed, the role of actions in user-product-interaction is not fully explored. This study aims to explore the meaning of action in product design, and the connection between actions and design intents. Based on the concepts in the theory of affordance and activity theory, an everyday activity for personal hygiene, hand-washing, is analyzed to understand the types of actions involved in product design and their purposes in this activity. We proposed that there are at least three types of intended actions, namely, functional action, operational action, and emotional action, which are made possible by the supporting physical structure of products to fulfill users' requirements on different interactive level. The embodied

interaction between a product and its users not only contribute product's function from the aspect of utility and communication, it can also satisfy user's need from social or aesthetic aspect. From the view point of action as a key design element, this paper outlines an analytics framework of user-product-interaction to elucidate the new role of actions and its implication in the design of industrial products.

1. INTRODUCTION

Traditionally, the profession of product is commonly seen as "form giving", and the focus of product design is on the form of designated objects. Through the physical forms, product functions and designers' intents are realized, and users' needs are fulfilled as well. From the beginning of the electronic era, products gradually became more powerful and interactive. Then, the growing trend of incorporating digital technology into consumer products has led to a new type of products. Not only did products themselves become complex, their operation became diverse and designable. This change in products affects how they are used, and more importantly how they are designed (Frens 2006). Thus, a shift in design research and practice has taken place from a focus on the formal issues to a focus on the user-product interaction.

Under the influence of information processing model in the literature of Human Computer Interaction (HCI), current interaction design approaches for products are mainly based on cognitive science that draws analogy between human mental activity and computation, and assume the behavior of users is dominated by the outcome of their information processing in the brain, in other words, the interpretation of product appearance. As a result, the interaction design for physical product usually centers on providing feasible interface designs for better communication and usability. By emphasizing the mental model and needs of the user, visual cues and metaphors are carefully selected and integrated into product form. This design theme is generally categorized as human-centered design, which is developed to overcome the poor design, especially the design of software product (Norman 2005). As the increasing criticism on the information processing approach in interaction research and design, this mainstream design theme is questioned and alternative theoretical frameworks are considered (Kuutti 1996).

In addition, the increasing attention on interaction per se rather than interface in recent design researches gives rise to design approaches that place the emphasis on the action of embodied agents directly, but not on the media to make operating instructions comprehensible. While many

tangible interaction concepts have been developed (Ishii and Ullmer 1997), the role of actions in user-product-interaction is not fully understood yet. Many actions in product handling planed by designers are often “generated from or subservient to abstract reasoning” (Dourish 2001). We believe that a systematic analysis of the connection between externalized user behavior and design intents in different scenarios can reveal the significance of actions in design; hence opportunities emerging form the action-centered design perspective can be further explored.

This study aims to explore the meaning of actions in product design, and the impact of action-center approach on interactive product design and development. From the view point of action as a key design element, this paper outlines an analytics framework of user-product-interaction to elucidate the new role of action and its implication in the design of industrial products or other interactive systems.

2. BACKGROUND

In responding to the narrow understanding of human behavior as an automatic and inevitable consequence of human cognitive process, and to the neglect of actual world where people stay in and interact with, a new theoretical foundation in interaction design is needed. Among various alternative theories have been brought into design practice and research, the theory of affordance and activity theory are has b

Researchers argue that the rationalistic thinking is insufficient as a theoretical basis for today’s interaction design. Their reaction is primarily to the narrow understanding of human behavior as an automatic and inevitable consequence of human cognitive process, and to the neglect of actual world where people stay in and interact with (Dourish 2001). In reflection to the need for a new theoretical foundation in interaction design, various theories have been brought into design practice and research. Among these alternatives, the theory of affordance and activity theory deal with the issues directly related to object-mediated actions in our daily life, and can provide explicit explanation of human behavior. In this section, we will focus on the theoretical underpinning about human actions in these two theories, and explore possible directions for action-centered design.

2. 1. THEORY OF AFFORDANCE

The term affordance was coined by Gibson (1966) in his theory of direct perception to denote the use-value of an object with reference to the physical condition of its potential user. Underlying his direct perception theory, Gibson (1979) argued 'The object offers what it does because it is what it is', and this term was created to stress the reciprocal possibilities between objects and users rather than what users perceive about the objects.

To Gibson (1976, in Gibson 1982), products are not 'a patchwork of forms' to users, but the possibilities of actions. An affordance is a resource that an object offers to its user who possesses the appropriate ability to take action. Through interacting with environmental objects, users can activate sequences of possible actions to approach their goals. Thus, he suggested designers should pay attention to the functional actions existing among product-user-system instead of the abstract form or graphics.

There are three fundamental characteristics in Gibson's affordance concept. The first, affordance is about the action possibility available in the present user-product system. Secondly, the existence of affordances is independent of the user's awareness, need and expectation. And thirdly, the existence of affordances directly relates to physical condition of a particular user. The notion captures the link between actions, product feature and user ability in our everyday experience. In addition, it externalizes the required condition to support certain human behavior, which is useful for exploring user-product-interactions.

It is worth mention here that the concept of affordance as many designers understood today is not Gibson's original concept (real affordance), but what Norman (1999) later called 'perceived affordance', so different implementing approaches are taken. The comparison and clarification of these two concepts have been discussed thoroughly elsewhere (Gaver 1991; McGrenere and Ho 2000). In this study, we follow Gibson's definition that affordance is the action possibility of certain features of objects with reference to certain user conditions. In other words, affordance is a three-way relationship among user, object, and action. As You and Chen (2007) point out that affordances are for action, not information; thus the core of affordance concept in design lies not in communicating the design intention for designers, but utilizing seemly countless actions supported by the features of products to fulfill needs of different users with different conditions. Hence, instead of focusing on the communication issues, the affordance-based design approach inclines to seeking the utility of actions and providing the requisite features in products to await the emergence of functional affordances for target users.

Based on one of our previous studies on affordance-based interaction design (You, et al. 2007), action is a means to achieve intended outcome, and is driven by users' needs and available affordances. Every action users takes will modify the physical surroundings or change users' own conditions, either way will eventually lead them to their goals. Through interactions, the condition of the overall user-product-system changes constantly, which causes the available affordances (possible actions) to change dynamically until the goal is reached.

However, in the theory of affordance, Gibson focused mainly on the existence and perception of object-mediated action possibilities; leaving issues like the purpose and consequences of actions, and the action selection untouched. In order to use 'action' as an element in design, some ideas found in activity theory are adopted as supplementary in the study to deal with other action-related issues that Gibson's theory comes short.

2. 2. ACTIVITY THEORY

Activity theory was developed within Soviet cultural-historical psychology. Recently it is applied in various fields involving human action (Bærentsen and Trettvik 2002). Kuutti (1996) describes today's activity theory as 'a philosophical and cross-disciplinary framework for studying different forms of human practices as development processes, with both individual and social levels interlinked at the same time'. This theory defines a task-oriented view of human behaviors, and the basic unit of understanding human consciousness and behavior is human activity. In general, human activities can be categorized into three levels: activity, action and operation; each reflects a different level of objective world. As shown in figure1, the highest level of collective activity is driven by an overall motive; the middle level of individual (or cooperative) action is governed by a conscious goal; and the bottom level of automatic operations is triggered by the conditions (Kuutti 1996). Based on this structure, the action described in Gibson's affordance theory is only the operational level of human behavior.

Activity level	Directed by	Example
Activity	Motive	Building a house
Action	Goal	Fixing the roofing
Operation	Condition	Hammering

Table 1: Three levels of human activity in activity theory (Kuutti 1996)

Activity theory and Gibson's theory of affordance share the idea that consciousness is not a set of discrete disembodied cognitive acts. Consciousness is located in everyday practice; only through acting people can perceive their environment (Nardi 1996). In addition, they both focus on the object-mediated human action; thus give a useful handle to understand what actions are, and what they can achieve in the interaction (Albrechtsen, et al 2001).

However, unlike affordance theory viewing human action as purely motor capabilities, activity theory takes purposeful acts (activity) as the basic unit to analyze the objective world and reflect different needs of people. Everyday activity is the mediating link connecting the user and the environmental objects. The action between human and the objective world can be governed by both material and cultural means. Hence, it can broaden the discrete and single-purposed action view in the theory of affordance, and place the embodied action into a meaningful context for people to understand and adopt.

In a similar fashion, Norman (2005) proposes an activity-centered design (ACD) approach for product and interface design. In this approach, a hierarchy of activity with four levels, namely, activity, task, action, and operation are provided. To illustrate, mobile phones are described as a device to supporting a unitary activity, communication, which integrated several related tasks: looking up numbers, dialing, talking, note taking, checking calendar, etc. Each task is composed of actions, and actions are made up of operations. In Norman's activity-centered design, human activities reflect 'the possible range of actions, of conditions under which people are able to function, and the constrains of real people'; thus the ACD approach requires a deep understanding of people, technology, objects, and the reasons for the activities. Under this view point, successful products are those fit gracefully into the underlying activity, supporting interaction in a manner understandable by people.

3. THE HAND WASHING ACTIVITY

Based on the understanding of correlative literature, a common daily activity, hand washing, is selected to analyze what actions are involved, and how these actions can affect the design of the mediating tool for hand washing activity, the faucet. By examining the well-accepted hand washing guidelines, to see how the actions considered appropriate link to the purpose of the activity, and which features in nowadays products can support users to accomplish the intended purpose through the course of user-product interaction. The ultimate goal of this investigation is to

connect design intent and the final product through indented user action, and to understand the value of user action in product design.

3.1 OBSERVATIONS

As suggested by Taiwan government information office for SARS prevention, there are five steps as shown in figure 1 to properly washing one's hands, which include wetting , rubbing, rinsing, cleaning the handle (by holding water with palms and pouring water over it), and finally wiping hands dry and using the same paper towels to wipe the faucet handle. Children are taught to follow these steps to keep their hands clean and ultimately to prevent the spread of disease (Centers for Disease Control 2007).

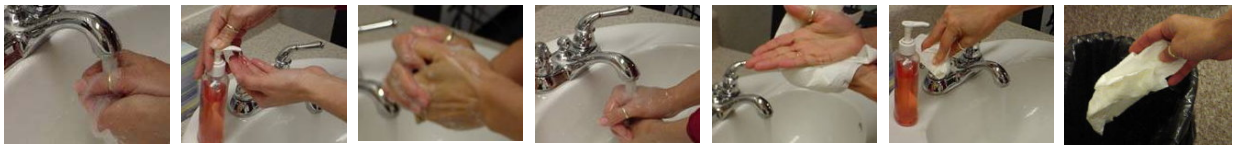
Wetting | Rubbing | Rinsing | Cleaning the handle | Wiping hands and faucet with paper towels

Figure 1: Hand-washing steps suggest by the department of health in Taiwan

Wetting | Applying soap / Rubbing | Rinsing | Turning off water with paper towels | Drying hands

Figure 2: Hand-washing techniques suggest by CUHK (2005)

Other two similar hygienic guidelines are provided by Chinese University of Hong Kong (CUHK 2005) and Mohave County Information Technology Department (MCITD 2001). The former hand-washing steps includes wetting, applying soap (and rubbing), rinsing, shielding one's hand with paper towels and turning off water, drying hands (Figure 2); the later includes wetting hands, applying soap, rubbing hands, rinsing, wiping hands dry, shielding one's hand with paper towels and turning off water, and discarding paper towels (Figure 3).



Wetting	Applying soap	Rubbing	Rinsing	Drying hands	Turning off water with paper towels	Discard paper towels

Figure 3: Hand-washing practice suggest by MCITD (2001)

3.2 ANALYSIS

According to activity theory, these steps described above play important parts to reach different goals, all contribute to a higher motive; thus an activity is formed. To complete a hand-washing activity, besides the users who physical perform the tasks, other supporting objects and environment recourses are needed, such as faucet, soap, paper towels, and even the underneath water supply infrastructure. Form the view point of faucet design alone, we can first categorize above-mentioned actions by whether faucets are involved or not. Some of them can be executed without handling faucets, e.g. applying soap, rubbing hands, drying hands; while some of them require the coexistence of users and water faucets, e.g. turning water on, controlling the volume of water flow, and turning off. By this way, two major tasks in hand-washing are identified: controlling water and cleaning hands. Once users' hands are washed, it is consider hygienic and well-mannered to wipe hands dry, which becomes a subsequent behavior; thus two other tasks, handling paper towels and drying hands, are added in the hand-washing activity. In addition, we also become aware of actions regarding cleaning faucet handle in the guidelines. Hence, these hand-washing procedures suggested in section 3.1 can roughly be decomposed to five main tasks including: controlling water, cleaning hands, cleaning the faucet handle, handling paper towels, and drying hands.

Following the hierarchical structure suggested in activity theory, these hand-washing procedures can be modeled into as a three-level hierarchy. The hand-washing activity suggested by department of health in Taiwan is decomposed to five actions; and each action can be further decomposed to operations as shown in table 2. In the same way, the other two procedure suggested by CUHK (2005) and MCITD (2001) can also be decomposed to actions (or main tasks), and then divided into different operations. As shown in table 3 and table 4.

Activity	Action	Operation
Hand-washing	Control water	Turn on water
		Turn off water
	Clean hands	Wet hands
		Apply soap
		Rub hands
		Rinse hands
	Clean faucet handle	Cup one's hands
		Drain water through fingers
		Wipe faucet handles with paper towels
	Handle paper towels	Take clean paper towels
		Discard paper towels
	Dry hands	Wipe hands dry with paper towels

Table 2: The structure of hand-washing activity based on CDC (2007) guideline

Activity	Action	Operation
Hand-washing	Control water	Turn on water
		Turn off water
	Clean hands	Wet hands
		Apply soap
		Rub hands
		Rinse hands
	Handle paper towels	Take clean paper towels
		Shield one's hand with paper towels
		Discard paper towels
	Dry hands	Wipe hands dry

Table 3: The structure of hand-washing activity based on CUHK (2005) guideline.

Activity	Action	Operation
Hand-washing	Control water	Turn on water
		Turn off water
	Clean hands	Wet hands
		Apply soap
		Rub hands
		Rinse hands
	Handle paper towels	Take clean paper towelS
		Shield one's hand with paper towels
		Discard paper towels
	Dry hands	Wipe hands dry

Table 4: The structure of hand-washing activity based on MCITD (2001) guideline.

3.3 SUMMARY

Even though the overall purpose of these hand-washing guidelines is the same, the required actions and the sequences of operations are slightly different. By examining these tables, we can point out the subtle differences. First, users' operations to clean the faucet handle with water before touching it in table 2 is replaced by the operation to shield one's hand with paper towels as a part of the 'handling paper towel' action in table 3 and table 4. Since users turn the faucet on with uncleaned hands, if they then turn off the faucet with clean hands, they will get their hands dirty again. To avoid contaminate users' hands, two different tasks (goals) are suggested to either prevent direct contact with the faucet handle, or clean the handle before touching it; thus different operations are required to realize these two different conscious goals.

Second, the operation to wipe the faucet handle before toss away paper towels in table 2 is not explicitly shown in table 3 and table 4. This operation, if not acting properly, may contaminate one's cleaned hands again, which makes no sense in the activity aiming to clean one's hands and prevent the spread of germs. However, it shows a courtesy to the next user, hence are encouraged and expected in the hand-washing practice.

Figure 4: Different types of faucet design. From left to right: extended lever faucet, faucet with a control aide, faucet with a wall-mount infrared sensor, and infrared sensor faucet.

Third, different hygienic facility available for users will affect users' action selection and operation sequence to realize the same motive. For instance, if paper towels are not available or not within reaching distance, directly touching the handle will be inevitable. However, if the faucet is equipped with an extended lever handle, a faucet control aide, or even an infrared-activated system (as the products shown in figure 4), the interaction for washing one's hands will differ from

what have been discussed above. There is no need for users to grab the faucet handle (some design may not even have handles); thus the operations to shield one's hand with paper towels in the guidelines from CUHK (2005) and MCITD (2001) may not be necessary.

Fourth, the courtesy acts, such as cleaning faucets for the next user we observed in this study, are to fulfill the social expectation and the user's self-responsibility. They serve an emotional function rather a hygienic function in the hand-washing practice. We believe certain human actions in user-product interaction are for some higher value or purpose, but not for the product function. These social or personal aspects of hand-washing practice are not emphasized in the official hygienic guidelines that are chosen for analysis in this study. However, the actions to wash one's hands in religion practice and rituals as a way to purify or tranquilize one's body and mind are well accepted nowadays. In addition, the experiences that kids love to play with water in various fashions (Figure 5) also shed some light on the possible meaning of hand-washing activity, besides the hygienic purpose, and provide us a another perspective on action in design.

Figure 5: The actions for fun

4. THE FRAMEWORK OF ACTION IN USER-PRODUCT INTERACTION

From the observation and analysis of hand washing processes, actions (as operations in activity theory) such as grabbing a faucet handle, twisting a handle, depressing a lever, and rubbing hands, can directly contribute to the cleaning function of the activity by providing force and movement. In addition, actions in this user-product-interaction can also be a signal to activate certain automatic function provided by products, such as to wave or appear in front of an infrared sensor to turn on the faucet. Furthermore, actions can be a courtesy act to fulfill self or social expectation, or just a pleasant act without concerning the hygienic function of the practice.

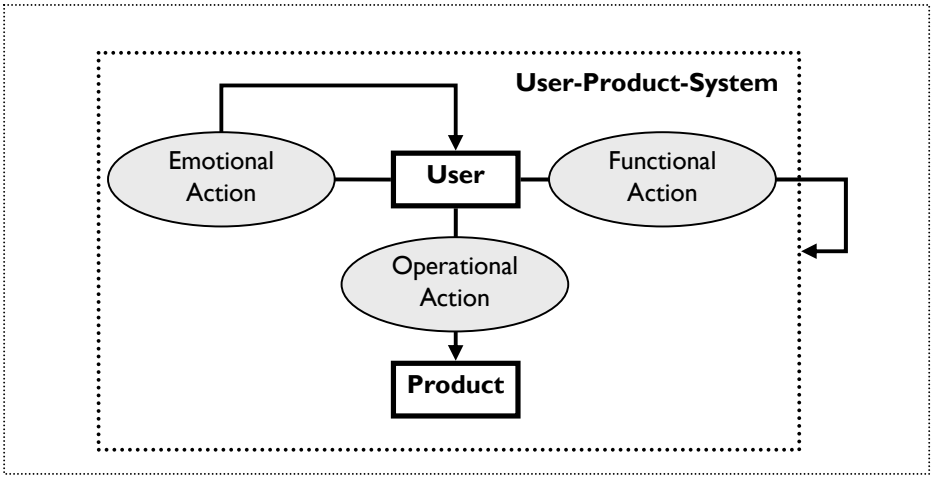


Figure 6: Three types of intended actions in user-product-interaction

Base on this understanding, we proposed that there are at least three types of intended actions in the interaction design, namely, functional action, operational action, and emotional action, to respectively fulfill users' requirements on the utility, the communication and the personal value in the process of interaction. From the action-based design view point, the product provided by designers should be able to support users in the user-product interaction to complete the tasks which achieve the goals associated with an activity. Hence product designers not only provide users with form to look at or admire, more importantly, through physically arranging the structure and the shape of artifacts, designers can modify the affordances to provide users with a collection of well-planned actions beforehand and await the needs of users.

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