A Design Method for Developing Combined Products in the Digital Convergence Era

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• Key words: Integrating Mental Models, Combined Products, Digital Convergence, Design Method

1. Introduction

In the digital convergence era, combining products to provide multiple functions has became a trend. It is commonly believed that combined products could be more convenient than single products in terms of saving time and cost; however, it is also true that an increase in information could cause design issues of users' cognitive uncertainty, ambiguous product identity, and confusion of new interaction. This research suggests a new design method for developing combined products to address the issues. The main ideas of the method are analyzing users' current mental models of each product and integrating them together to keep consistency among users' mental models. Three aspects of the mental model, **function**, **form**, and **interaction**, are suggested to solve three issues: users' cognitive uncertainty, ambiguous product identity, and confusion of interaction respectively. Appropriate visual and physical interactions can be designed through the method for users who had never experienced a complex information structure before.

The iPhone design, a MP3 Mobile Phone, is selected as the case to evaluate this method. This project is a co-op based project by Motorola and Apple to develop a new combined product. The three research questions for the project based on the method are: 1) how can a Mobile Phone and the iPod be combined? 2) how can the character of both be preserved? and 3) how are new interactions possible?

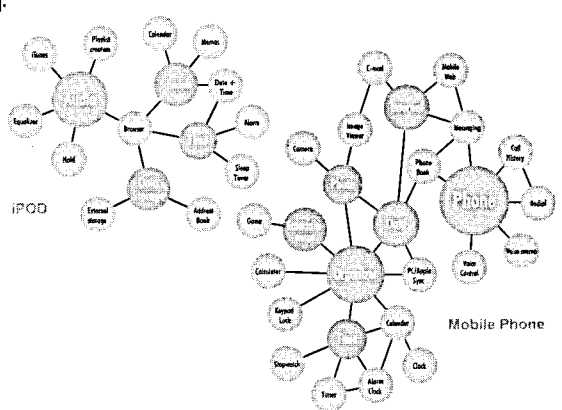
To answer these three questions, online surveys, interviews, and video observation are conducted to infer three user's aspects of mental models: a function-cluster model, an form-image model, and a navigation model. Among them, the function-cluster model is used to combine two mental models of each product. The new integrated function-cluster model is used for a target mental model to explore new interactions of the iPhone design. To keep the form identities of each product, the experiences with the form-image are analyzed together since a identity of a product is formed by experiences through the form-images. Activity analysis and state-transition diagrams are used to develop new interactions, and usability tests are conducted to evaluate the interactions of new mental models.

2. Mental Model

Mental models are a representation of real or imagery situations. Humans develop internal models through interactions emphasizing the structural aspect of models [1]. Mental model can be defined as the cognitive layout that people use to organize information in their memory [2]. Designers often use mental models as analytic tools to describe user's perceptions, expectations and assumptions during the design process. The common use of mental model is to develop a **current mental model** and a **target mental model** [1]. A **Current mental model** represents users' current understandings and perceptions of the existing product or service, and a **target mental model** can be designed to anticipate users' mental images that the designer wants the users to have.

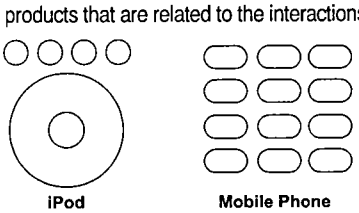
2-1. Current Mental Model

Current mental models are inferred with the three aspects, **function**, **form**, and **interaction**, through on-line surveys, interviews, and video observations. A function-cluster model in Figure 1 for **function** is induced from on-line surveys and observations. Trajectory Mapping is used to make this model [2].



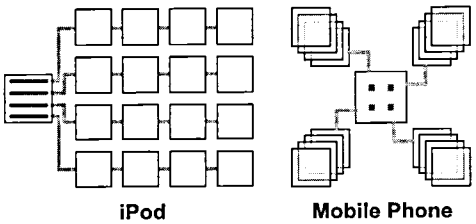
[Figure 1] Function-Cluster Models for iPod and Mobile Phone

The form-image model in Figure 2 for **form** is a summary of subjects' sketches. Each subject is asked to draw the image or shape of the products without seeing them. They are easily reminded by the images of the products that are related to the interactions.



[Figure 2] Form-Image Models for iPod and Mobile Phone

Figure 3 is a navigation model to infer user's **interaction** models. This model shows how subjects understand the whole structure of information of each product.

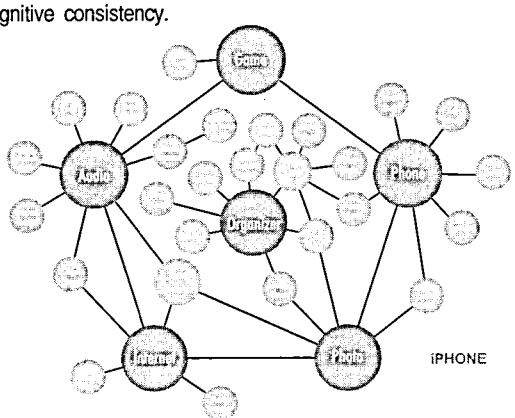


[Figure 3] Navigation Models for iPod and Mobile Phone

In addition, the operation models associated with form-image and navigation models are considered to understand the users' mental models. For example, a user generally memorizes a phone number with finger movements.

2-2. Target Mental Model

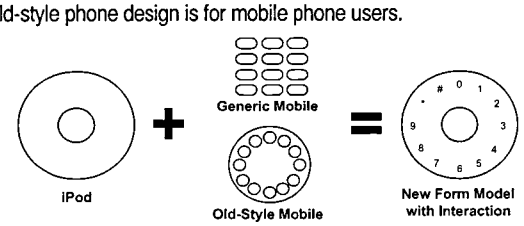
To predict new mental model for the combined product, the combined **function-cluster** in Figure 4 is developed with function-cluster models, and other target mental models such as **form** and **interaction** are sequentially developed within the context of a **target mental model** in Figure 4. The shared functions between products are used to make connections for cognitive consistency.



[Figure 4] Combined Function-Cluster Model (Target Mental Model for GUI Design)

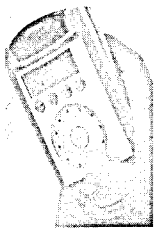
3. Prototyping

Prototyping is a process to design new experiences based on the target mental model in Figure 4. Integrating two distinct operations, rubbing the circle of the iPod to navigate and tapping the buttons of a mobile phone to input and navigate, is a main concern for prototyping since the operations are such dominant mental models of each one. Figure 5 is a new iPhone interaction design which has a combined interface to incorporate two distinct mental models. The unique circle is for iPod users and the button layout from the old-style phone design is for mobile phone users.



[Figure 5] Combined Form Model with Interactions (Target Mental Model for Interaction Design)

4. Evaluation



[Figure 6] Working Prototype

The formal usability test is conducted to evaluate the prototype with four user groups. Insights from the test are that 1) users' unique habits to explore the functions for tasks are still effective, 2) the shapes of interfaces determine the users' behaviors, and 3) iPOD users have distinct characters from other groups that are adaptive to accept the new. Figure 6 is a working prototype developed with Embedded Visual Basic for usability tests and Table 1 is a summary of the results.

Index		User 1	User 2	User 3	User 4
		iPod / Cell / PDA	MP3 / PDA	MP3	MP3 / Cell
Task	Making a phone call	She enters the number using key pad. If the combination of number is complex, it maybe hard to her.	She cannot easily figure out how to operate.	She enters the number using menu structure instead of number things directly.	She enters the number using key pad.
	Playing Music	She easily navigates it.	She cannot navigate up and down.	She easily navigates it.	After 3 time mistake, she figure out how to navigates it.
Post - question naire	Multi - Function Dial Pad	If I am not a iPod user, I may not be able to figure out the dial interface intuitively.	It is fun experience though, it is a different metal model with me and the size is bigger than normal keypad.	The circle dial one is strange to her, because she never use it before.	I feel I need time to get familiar with it to reduce the mistake I might made. But I like it.
	Changeable labeled button	If it can provide more clear guide, it is good idea.	The strange things to her is why only one button is changed.	If the term of the label is described well, it is good.	I think it is good, because "enter " and "Call " has a similar meaning, so it doesn't confuse me.

[Table 1] Summary of Usability Test

5. Conclusion

Three innovations are found through the method. The first one is integrating two function-clusters to merge two mental models. Users can extend their mental models of the products to accommodate new products. Combining two different visual interactions based on two navigation models is the second innovation. Sequential-based GUI using Focus + Context technique is design for the iPhone. The third one is merging two different types of interaction experiences. iPOD uses unique interface for navigation with a circle shaped dial and that shape was also applied to the old-style phone. New physical interactions are designed for two functions, navigation and dial, together in one interface by integrating two behaviors, rubbing and tapping. However, a problem that the combined UI does not meet the mobile phone users' mental model remains as future work.

6. Acknowledgment

This research was in part conducted by the co-op based project for the class, Cognitive Human Factor, by Ken Douros, a manager in Human Interface Lab at Motorola.

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