Cognitive Processes of On-Line Formation of Device Models

Takahisa Furuta
Faculty of Education, Gunma University
4-2 Aramaki, Maebashi, 371 JAPAN
furuta@edu.gunma-u.ac.jp

Introduction

Since previous studies of device models (mental models) focus on what types of given models are effective for operation, it is not still very clear how models are spontaneously formed when no prior information about the structure of the target deices are given. In this study, we analyzed verbal protocols of subjects learning to operate a real-time, event-driven, black box device.

Experiment

The system used in this study was a water tank system which had two tanks connected by a pipe at the bottom. Each tank was attached with a tap, and one of the tanks had an outlet. The task was to adjust the height of water in each tank by manipulating two knobs which control each amount of water supplied by the taps. Each height of water in the tanks was indicated by colors of lamps shown on the CRT display. When the actual height of water was equal to the target height, the lamp lit red, when 5% below, then green, when 5% over, then blue, otherwise black. This device was chosen because the output(lamps) did not reflect the input(knob turning) immediately, so it was difficult for subjects to operate correctly without knowledge about its inner structure. Subjects were first required to make both lamps lit red for at least 60 seconds for two successive sessions. Then they proceeded to two transfer tasks.

Results and Discussion

Examination of the transcribed verbal protocols indicated that the subjects spontaneously generated mental models of their own when no information about the device were given. The generated models could be classified into three types: Procedural, Functional, and Others.

A model is considered to be a *Procedural model* if the subject could generate procedures to operate and predicted what consequences might be, though they failed to give systematic explanations about them.

Functional model is a functional description of the target device, rather than structural one, such as:*This device behaves like a balance beam.*

The Functional model group performed significantly better in the training sessions compared to the Procedural model group(12.0 vs. 3.7), which suggests the Functional models captured fundamentals of the target device.

	Functional Model		Procedural Model	
	Prop.(%)	Freq.	Prop.(%)	Freq.
FactReport	64	46.0	74	57.0
OwnWords	15	11.0	2	1.3
Strategic	9	6.3	13	10.0
Others	13	9.3	12	9.0

Table 1: Proportion and frequency of statements

We divided the verbal protocols into segments, and, two independent judges classified them into four categories: Fact reports, Own Word Characterization, Strategic, and Others. *Fact reports* included statements of "as is" description of the response of the device or the action of the subjects themselves, while *Own Word Characterization* included interpretations of the responses of the target device.

Table 1 shows the distribution of the four categories of statements for the Functional and Procedural group subjects. Although both groups produced almost same total numbers of statements($p>.1$), there were significant differences in distribution($p = .0158$). Of the statements produced by the Functional model subjects, 11.0 are reports using their own characterization as compared to 1.3 for the Procedural model subjects. Not only is the absolute number of statements generated by the Functional model group significantly greater than the number generated by Procedural model group, but proportionately, the Functional model group generated eleven times as many Own Word Characterization(15.1%) as the Procedural group subjects(1.3%).

Our results suggest that the role of own characterization appears to trigger generating new ideas about the structure of the system, which seems why the Functional model group succeeded in generating good models.

References

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