A Closer Look at Exploratory Learning of Interactive Devices

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Abstract

This paper describes a new rational framework for modelling exploratory learning of interactive devices, first presented in Young & Cox (2000). The framework has been used as a basis for analysing a number of protocols taken from participants exploring a simulated central heating timer that provide examples supporting the framework. The results suggest that the framework can successfully explain episodes of the participants' behaviour during exploration and also what they learn from it. Finally, we describe the modeling work (in progress) in Soar (Newell, 1990) and COGENT (Cooper & Fox, 1998) implementing the framework.

The Framework. The framework described here provides a rational account of exploratory learning. Before describing how it works in practice, we outline the basic structure of the framework. It consists of an iterative cycle of three stages as shown in Figure 1. In the first stage all applicable possible things to do, or exploratory acts (EAs), are identified and their predicted efficiency calculated. Efficiency is defined as the ratio of the predicted increase in information that would be gained by carrying out the action, divided by its cost which is usually identified as the time taken to perform it. Secondly, the one with the highest efficiency is chosen and thirdly, it is executed. The cycle is then repeated until such time as the goal is met.

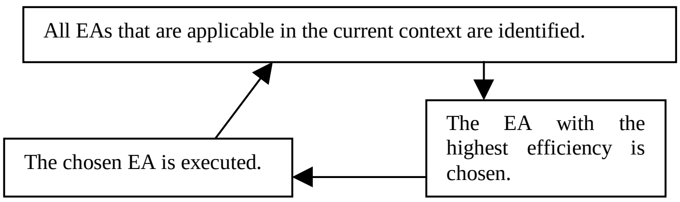

Figure 1: The Rational Framework for Modelling Exploratory Learning (EA = Exploratory Act)

As a starting point we concern ourselves with a user engaged in unstructured or free exploration of an interactive device. It is hypothesised that the user makes a decision between a number of EAs he can do, based on the cost of performing one of these changes and the expected gain. These EAs can be internal or external activities such as a) understanding something more about the layout, b) understanding something more about a component of the device, c) clicking a button, d) understanding a change that takes place on the display, e) forming a hypothesis (i.e. if I do X, Y will happen), and f) performing an experiment (to test a hypothesis).

Presuming the user has never encountered this device before, we can imagine that the EA he might choose to do is to understand something about the layout. This EA is likely to be chosen a number of times as the user looks at the layout of the various interface items and their relations to each other. A further number of internal EAs might follow as the user notices and considers the various labels on the interface items. At some point, simply looking and noticing things about the interface itself will not offer the same amount of information that one might expect in the first instance and so the user will choose to perform an action. The reason this action might be chosen could be as a result of a particular hypothesis that has been proposed that the user wishes to test, or alternatively, simply to see what happens. After each EA, the user chooses the next EA to perform depending on which EA offers the highest efficiency, or return for cost, in the current situation.

The Protocols. The protocols reported here were taken while participants explored a simulated central heating timer. In addition to the usual interface items one might expect there was a button called test. This button led to a screen where the participant could 'probe' each day and see what the behaviour of the device will be.

Case Study 1 – P1. Initially, P1 has a look around the display and then chooses to click on the test button. She mistakenly believes that this will give her some tasks to undertake. She quickly realises her mistake and goes back to the main screen of the device. She notices that the device is telling her that the heating is set to *off* and she says that she's going to click on the *24 hours* button. She follows this with a remark that she sees that the device is now indicating that the heating is on. This sequence illustrates how, from all the possible things she could try in the situation, she decides to click the *24 hours* button with a view to seeing what it does.

After this initial orientation phase, P1 sets herself the task of setting the heating to come on and go off on Monday. When she has achieved this, she tries to change the settings so that the heating comes on and goes off for some of the other days of the week. Throughout the exploration period she becomes more and more confused about how various aspects of the device work and is sometimes sidetracked into performing experiments to investigate what a particular button does or how it works.

Looking at this interlude in more detail, we see that the next episode begins with P1 clicking *Auto* and noticing that the event buttons are enabled. She then selects *ON1* and clicks the *day* button setting the event to Monday. Then, clicking on *Advance*, she remarks that "that's how I make the numbers change". She then generalises this knowledge to the *Back* button hypothesising that clicking it will make the time go backwards. She performs an experiment to check this hypothesis and clicks the *Back* button several times saying "….and how I make them go back". There are a number of similar episodes where P1 successfully learns how to use other parts of the device.

Case Study 2 – P2. Analysis of the protocol shows that P2 initially orients himself to the device and explores the basic button functions. He then tries to set up a pattern of on and off times for Monday and after an initial misinterpretation, learns to use the test screen to find out the behaviour of the heating system. The next task he tries to do is to set up an on and off pattern for Tuesday. While trying to achieve this goal, he discovers the cyclic nature of the day button and the groups of days that can be selected.

The protocol also shows that from about this time he starts to redundantly reselect an event after he has set the time and day for the event. This suggests that he is using the interface as a command composition interface and that he sees this reselection of the event button as a communication that *this* is the setting he wants, rather than seeing the interface as the state-setting interface that it really is.

One of the other errors P2 makes while using the device is to set up a pattern of on and off times, say for the weekend, on the same event buttons that have been used for a different pattern, say for Monday through Friday. When he came to probe the test screen to see the result of his programming, he was surprised to find that the original settings had been deleted. (This error has also been made by many of the participants using the device in other studies.) Our proposition that he believes that the interface communicates commands rather than sets states explains why he makes this error.

The Model. Models of exploratory learning are currently being built in COGENT (Cooper & Fox, 1998) and Soar (Newell, 1990). The aim of these models is not to replicate, button-press for button-press, the behaviour of the participants discussed in this paper, but to identify sequences of behaviour similar in nature to what has been observed. For example, given a free-exploration situation, we would expect the model initially to conduct device-oriented exploration and then to attempt self-imposed tasks such as mini-experiments to test hypotheses. These hypotheses regarding how the device works may have been built as a result of observing the feedback from a particular button press, or from generalising knowledge about the function of one button to another. Furthermore, analysis of the knowledge acquired by the model is expected to show that device-oriented knowledge is easily acquired but that an accurate understanding of task-oriented knowledge is less common. In addition, the framework predicts that there will be a difference in the knowledge acquired by those conducting free and focused exploration and it is expected that the implemented models will show this. This prediction is supported by evidence found by Trudel and Payne (1995) when they compared the performance of people who explored a digital watch under those two conditions.

Discussion & Conclusions. Previous research (Cox & Young, 2000; Draper & Barton, 1993; Trudel & Payne, 1995) has suggested that participants spend most of their time engrossed in device-oriented exploration and do not set themselves realistic tasks spontaneously. The protocols discussed here suggest that this distinction may not be so clear cut. P1 and P2 do seem to set themselves task-oriented goals but often become sidetracked into acquiring device-oriented knowledge when they are unable to complete their task-oriented goal. A number of episodes are explained in detail to illustrate that the protocols can be described using the framework and that using the framework as a basis for analysing the protocols is a useful tool in understanding both what people do during exploration and what they learn from it. This suggests that the framework will be successful as a basis for developing models of exploratory learning of interactive devices.

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References

Cooper, R., & Fox, J. (1998). COGENT: A visual design environment for cognitive modeling. *Behaviour Research Methods, Instruments and Computers*, 30, 553-564.

Cox, A. L., & Young, R. M. (2000). Device-Oriented and Task-Oriented Exploratory Learning of Interactive Devices. *Proceedings of Third International Conference on Cognitive Modeling*, University of Groningen, Groningen, Netherlands.

Draper, S. W., & Barton, S. B. (1993). Learning by exploration, and affordance bugs. *Proceedings of Interchi '93*.

Newell, A. (1990). *Unified Theories of Cognition*. London: Harvard University Press.

Trudel, C.-I., & Payne, S. J. (1995). Reflection and Goal Management in Exploratory Learning. *International Journal of Human-Computer Studies*, 42, 307-339.

Young, R. M., & Cox, A. L. (2000). A New Rational Framework for Modelling Exploratory Device Learning ... but does it Fit with ACT-R? *Proceedings of 7th ACT-R Workshop*, Carnegie Mellon University.