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How do we program the home? Gender, attention investment, and the psychology of programming at home

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Abstract

We report a series of studies investigating the choices that users make between direct manipulation and abstract programming strategies when operating domestic appliances. We characterise these strategic choices in terms of the Attention Investment model of abstraction use. We then describe an experiment that investigates the estimation biases influencing the individual parameters of that model. These biases are linked to gender in a way that explains some gender differences in discretionary appliance use. Finally, we suggest design strategies that might compensate for those gender-linked estimation biases, and therefore make programmable features of future homes more accessible to a wider range of users.

Keywords: End-user programming; Gender HCI; Home automation; Domestic technology; Appliance design; VCR; Attention investment

1. Introduction

There has been a great deal of research investigating the digitally augmented "home of the future". This research has included the construction of many demonstration facilities showcasing new technologies and appliances, generous funding from manufacturers, and a few experimental observations of short-term residents as they learn to control such advanced domestic technologies. This has been complemented by important social and economic research understanding the context and consequences of technology deployment in the home (Harper, 2003). The engagement of traditional computer science with this market opportunity has typically involved the transfer and adaptation of office technologies (such as networking and GUIs) to the slightly different application domains of home media consumption and social communication. A more recent trend has been the application of machine intelligence techniques to monitor and predict the behaviour of residents, thereby offering either predictive behaviour (for example smart alarm clocks (Isbell et al., 2004) and light switches (Brumitt and Cadiz, 2001)), or remote monitoring and surveillance (for example the remote monitoring of the elderly and disabled by family members and healthcare professionals; Consolvo et al., 2004; Mynatt et al., 2000).

In our view, much of this research has neglected a valuable opportunity and requirement, that it will be necessary for somebody to program and configure home technologies. The appliances in a networked home will need to communicate with each other, and even standalone appliances need programming to define their future behaviour (for example, cooking appliances and media recording devices). We expect to see significant growth of research interest in this problem, from many perspectives. For example, Grinter et al. (2005) investigate "digital housework" such as the collaborative demands of maintaining advanced network technologies within a home. This research provides a valuable focus on technical challenge, complementing ethnographic studies of more commonplace and unremarkable practices within the home. In the research we present here, however, we take

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a specific technical focus on the challenges likely to be faced by individuals, from the research perspective of end-user programming. The objective is to provide design advice for those groups developing programming techniques for context aware ubiquitous computing (e.g. Sohn and Dey, 2003).

If residents in the home of the future are to have significant control over their technological environment, they must be given the power to specify home automation functions. Many stand-alone devices already allow users to make a choice between direct manipulation (in which the effect of user actions is immediately visible as feedback) and abstract notation (in which the user expresses requirements in some form of language, defining behaviours that will take place in the future). Where appliances interact (for example through networking), the complexity of such choices can only increase in future.

In this paper we aim to provide insight into the extent to which domestic appliances should include abstract programming functionality, and whether this should be realised through the design of new interaction devices (such as the AutoHAN Media Cubes; Blackwell and Hague, 2001) or whether standard personal computers are adequate, in which case conventional approaches to end-user programming might be sufficient. We build on our work with Attention Investment (Blackwell, 2002, 2006) and our program of research in the home looking at programming and gender (Rode et al., 2004, 2005) which we will introduce in the following sections.

2. Attention Investment model of abstraction use

The Attention Investment model of abstraction use is a systematic account of the decision process involved when a user programs an appliance to do something ahead of time or repeat a complex sequence of actions, rather than simply achieving the same end by directly pressing the buttons at the right time. Typical programming tasks of this kind include programming a VCR to record a broadcast movie, or programming a speed dial code into a telephone.

People have different motivations for programming. Some people, such as computer scientists, program appliances because it is fun, or because it is their habit to explore all the esoteric features of everything they buy, or perhaps because they are so familiar with the kinds of procedure that will be involved as to find them extremely easy. In contrast, other people are very reluctant to engage in programming tasks, even if it might save them a lot of time and effort compared to doing things by direct manipulation. The decision process is therefore a cost-benefit analysis, typical of Simon's (1956) rational choice models of human behaviour. Simon observed that people seldom take the time to find an optimal solution, instead "satisficing", thinking about the problem only long enough to find a solution that is satisfactory rather than optimal. In the same way, people might choose to carry out actions manually by direct manipulation, rather than creating a program to automate them, if this will require less mental work. In the Attention Investment model, the "utility function" that is being optimised is a function of cognitive effort, which might be informally described as a quantity of concentration, but which we describe simply as "attention".

Programming and direct manipulation represent two alternatives for completing a task, where the alternatives differ in terms of the time and attentional resources required. Programming involves a certain amount of concentrated attention to understand or form a suitable abstract specification of the required action, whereas direct manipulation usually involves a longer period of less effortful attention. The cost part of the Attention Investment equation is the amount of up-front time and attention required if the abstract alternative is chosen. The return part of the investment equation is the saving that this produces, by reducing the amount of time and attention that would otherwise be occupied in future direct manipulation. However this is not a guaranteed investment. If the program is incorrect, or the specification is faulty, then the anticipated savings might not be achieved, or might even result in further costs in future (for debugging or repair). Of course, this risk can be reduced by further up-front effort, analysing the situation, reading manuals, testing, and so on. But all such effort requires further investment of time and attention, and reduces the proportional "profit" that will result from having chosen an abstract strategy.

Most users do not spend a long time deciding between the likely benefits of an abstract programming strategy rather than a direct manipulation strategy. There are so many possible considerations involved that even thinking about the right strategy might take more time and effort than the task itself. The greatest payback for Attention Investment might be not to spend time on this decision at all, but simply to make the same choice you did last time you made a similar decision. This is described by cognitive scientists as a "bounded rationality" model, where the amount of time spent on the rational decision process is bounded by a limited amount of time available for reasoning. In terms of human behaviour, bounded rationality models account for the fact that people do not always want to spend a long time weighing up alternatives, but often act instead on the basis of heuristic shortcuts or previous biases (Russell and Wefald, 1991; Gigerenzer and Selten, 2001). In previous work we implemented a bounded rationality simulation of choices between direct manipulation and abstract strategies that confirmed this as a plausible model of the Attention Investment theory (Staton, 2005). If rational reliance on biases leads users to repeat previous choices, then programmers will tend to choose an abstract strategy, while non-programmers will tend to choose direct manipulation.

The Attention Investment model is related to other descriptions of end-user strategy such as Carroll and Rosson's Paradox of the Active User (1987) which