Cognitive Chrono-Ethnography: A Methodology for Understanding Users for Designing Interactions Based on User Simulation with Cognitive Architectures

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Abstract. A handful cognitive architectures have been proposed in the BICA society that are capable of simulating human beings' behavior selections. The purpose of this paper is to discuss the importance of designing interactions between users and the information provided to users via PC displays, traffic road signs, or any other information devices, and to suggest biologically-inspired cognitive architectures, BICA, are useful for designing interactions that should satisfy users by taking into account the variety of interactions that would happen and defining requirements that should satisfy user needs through user simulation using a cognitive architecture in BICA. A new methodology of defining requirements based on user simulations using a cognitive architecture, Cognitive-Chrono Ethnography (CCE), is introduced. A CCE study is briefly described.

Keywords: human beings' behavior selection simulation, Two Minds, human–computer interaction, interface design

1 Designing Satisfactory Interactions between Users and Information Devices

1.1 "Know the Users" in Human-Computer Interaction

"Know the users" is the key principle for designing satisfactory interactions. Users interact with information devices in order to achieve the states where they want to be. During the course of interactions, users expect to have satisfactory experience. From design side, this can be accomplished by applying the principle, "know the users", and by designing interactions accordingly to provide as much satisfaction as possible to the users through their experience of using the information devices. However, it is often hard to practice this principle due to the diversity of users. Each user has his/her own experience in using interaction devices, and his/her past experience should affect significantly how he/she would interact with the devices at a particular situation. Since no one has the same experience, it seems no systematic way to practice the "know the users" principle.

1.2 "Know the Users" in Behavioral Economics

"Know the users" is an important study issue in the other domains such as behavioral economics. How does a user decide to purchase a new tablet PC for daily use? He or she selects one from a number of candidates in order to realize the states where he/she wants to be. This situation is very similar to the one described above. In the field of economics, the user's decision-making process has been studied extensively. Recently, Kahneman [2] revealed that the core process of human beings' decision-making is an integral process of so-called Two Minds [1, 3]. We suggest that human brains would work similarly when people interact with information devices as when they engage in economic activities. If Two Minds is also working in human-computer interaction processes, we would be able to systematically apply the principle "know the user" for designing satisfactory interactions.

Two Minds refers to the following two systems; System 1, the automatic and fast unconscious decision-making process, oriented toward immediate action, and System 2, the deliberate and slow conscious decision-making process, oriented toward future action. We can easily imagine how Two Minds would work when users interact with information devices. In human-computer interaction, users deliberately consider what to do next and perform a series of actions on the device automatically. At the same time, they pay attention to the device's feedback and plan future actions accordingly. What we need to understand is how users switch between the slow and the fast processes of Two Minds, and explain and predict the behaviors we observe. The users' behaviors change depending on how the interaction is designed. The smoother the switching, the more the users would feel satisfaction. By taking into account explicitly the interaction between the slow deliberate processes and the fast automatic processes, we will be able to design interactions that surely satisfy the users' interaction experience.

1.3 "Know the Users" in BICA

Another domain that is relevant to "know the users" is a branch of robotics which studies "biologically inspired cognitive architectures (BICA)." Its purpose is to design an autonomous system that is capable of working in the ever-changing environment. We can simulate people's behaviors by using an appropriate cognitive architecture. We showed above that the smoothness of switching between the slow and the fast processes is important for satisfactory interaction design. This is a time-critical dynamic aspect of human-computer interaction, which behavioral economics cannot address but any models working on appropriate cognitive architectures would be able to deal with.

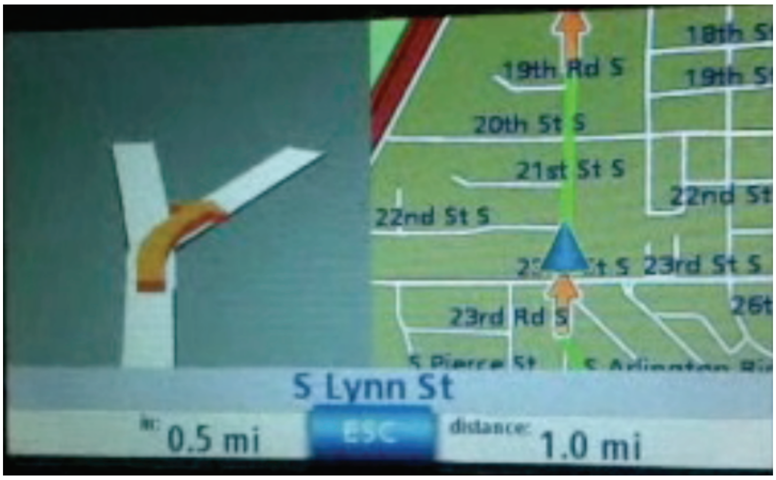

Fig. 1. Screenshot from a car-navigation system.

1.4 Two Minds and Cognitive Architecture

What does it mean to the interaction design activities that Two Minds resides behind people's behaviors? We'd like to suggest that Interaction design is about designing time for the user in terms of a series of events that the user will be provided at a specific time T, by taking into account the fact that the user's process is controlled by Two Minds. This is because interactions happen at the interface of a system and a user, and the only and unique dimension that the system and the user's Two Minds can share is the time dimension. The user decides what to do next by using his/her Two Minds at time $T - \alpha$, carries it out at time T, the system responds to it at $T + \beta$, and this cycle continues. The system's response at $T + \beta$ needs to take into account how the user's Two Minds would process it. He/she may expect the system's response for consciously confirming or unconsciously matching whether he/she did right or not, or he/she may expect it for consciously planning or unconsciously triggering the next action. The user's expectations can become diverse but interactions designers need to take into account them appropriately in order for the designed system should satisfy the users' expectations.

Here is an example to illustrate the point. When you hear the car-navigation system start speaking in synthesized voice, you switch your attention to listening to what it says and try to comprehend it for planning your driving for the near future. The navigation system is designed to speak, for example, "Slight right turn in point five miles on South Lynn Street" with the screen shown in Figure 1 at some specific moment. The driver, who is not familiar with the route, is supposed to listen to the instruction and read the screen consciously and carefully, and integrate the provided information from the car-navigation system with the current driving situation for imagining and planning the immediate-future driving and creating a sequence of actions for the maneuver; when to start reducing speed, when to start braking, and so forth. When the navigation system starts speaking at time T “Slight right turn ...”, it should intervene the driver’s on-going processes and initiates a new interactive process stream on the part of the driver.

This interaction must be designed well by taking into account whatever Two Minds processes the driver engages in so that the newly initiated process does not interfere with the other on-going processes; some processes must be suspended and resumed at a proper timing with little cost, and the other processes should continue with no interference from the car-navigation system (*e.g.*, keep conversing with a person in the passenger seat). We can simulate switching between the unconscious automatic fast processes and the conscious deliberate slow processes by using an appropriate cognitive architecture developed in BICA such as proposed by us [4, 5].

2 Cognitive Chrono-Ethnography: CCE

As described above, “know the users” can be practiced systematically by designing user studies based on a BICA simulation of users’ mental operations controlled by Two Minds. By operationalizing this idea, we have developed a new methodology to study users, Cognitive Chrono-Ethnography.

2.1 CCE Steps

Figure 2 shows a typical flow of a CCE study. The purpose of a CCE study is to answer the study question in the form “what such-and-such people would do in such-and-such way in such-and-such circumstance?”

We start with an ethnographical filed observation. We visit the field where our target users engage in the activities we are to support by using information devices. Then we look into the results of observation to identify parameters that are related to the fast processes, *e.g.*, slamming on the brakes, and the slow processes, *e.g.*, planning detour by using a navigation system. Then we take an appropriate cognitive architecture and map the parameters on the cognitive architecture. We then run simulations to see how the parameters could be related with users’ behaviors, *e.g.*, planning detour would slow down the initiation of slamming on the brakes by approximately 100msec. Through the simulations, we identify significant parameters that need to explore in detail by conducting a field study by a number of selected participants. For instance, we may recruit six participants who use a car navigation system daily for planning detour and six who don’t. In addition, a half of the six participants are good at recognizing hazardous situations and the other half are not. These are the steps for preparation (shown in the purple area in the figure).

Then we record the participants’ behavior in the field of the activities. We collect the following data in a CCE study: behavior observation records created by investigators, behavior measurement records (*e.g.*, a pin microphone to

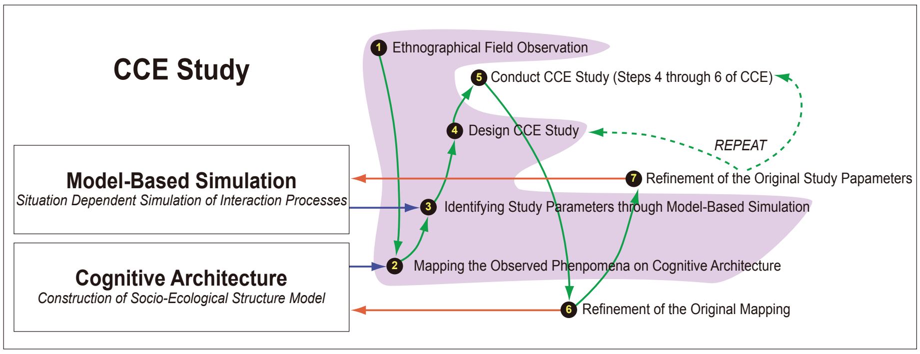

Fig. 2. CCE steps and brain models.

record their vocalization, a small ear-mounted camera to record the scene they are viewing, and an electrocardiograph to record their physiological responses to the events), on-site self-reports (participants themselves take photos, brief notes, and voice recording concerning their activities while their memories of the events remain fresh). After the recording, we conduct retrospective interviews. Using behavioral observation records, behavioral measurement records, and on-site self-reports, we have the participants describe their recorded behavior as detail as possible. We then compile the results of retrospective interviews to identify commonality among the participants who have the same behavioral features.

We may design a next CCE study to extend the result of the initial CCE study. We need to redo the steps 2 and 3 shown in the figure to design a new CCE study.

2.2 An Example of CCE Study

We'd like to illustrate the train station navigation study [4] to show how an actual CCE study was conducted. We were interested in how elderly passengers use guide signs at railway stations when they wanted to use facilities, *e.g.*, toilets, coin-operated lockers, *etc.*, or they had to transfer to another line. We identified critical parameters including such cognitive functions as *planning* for searching something necessary at train stations, *attention* for selectively focussing on task relevant information from the environment, and *working memory* for keeping the task relevant information active for performing actions smoothly. We conducted simulations by mapping these cognitive functions on our cognitive architecture [4], and derived ideas for a field study; people who don't have any problem in these cognitive functions would perform navigation tasks at train stations smoothly, on the other hand, people who have any problems in these cognitive functions would show some problems. We wanted to understand what people who don't have sufficient level of attention, for example, would do to accomplish searching for a toilet task, for instance. In this study, we found that the participants with weak attention tended not to use complicated signboards because they had difficulty in coordinating the slow process to decide which direction to go by comprehending signs and the fast process to gather information from the environment that changes rapidly as they walked.

Since the mental processes for accomplishing train-station-navigation task are slower than those for the tasks to follow the directions of a car navigation system, the detailed workings of System 1 and System 2 would be different. However, since both share the time-critical features of interactions between human beings (passengers or drivers) and the environments, the case study suggests that more suitable interactions design will be possible for those with specific cognitive characteristics for performing the tasks the interactions design should support satisfactorily. For example, for those with information gathering problem, or attention problem, the critical indications, which are signboards in the case of train station and navigation directions in the case of car navigation systems, have to be placed where they expect to find them.

3 Conclusion

A handful of models concerning brain functioning have been proposed in such a community as BICA. From now on, while designing a CCE study, one can select an appropriate brain functioning model for the study interest from the pool of models there. CCE is proved effective for studying dynamic Two Minds activities through several case studies. In the future, wide use of it is expected, and we expect that people use well-designed interactions in their daily lives with great satisfaction and feel happiness being with them.

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