Designing Interactions for Two Minds with the *Real* Brain Model "MHP/RT"

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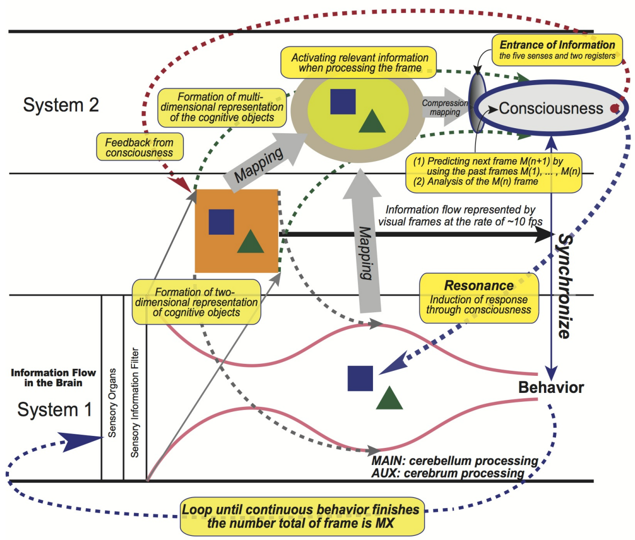

Figure 1: MHP/RT: Model Human Processor with Realtime Constraints [7].

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Abstract

In the early 1980's, Card, Moran and Newell [2] proposed an architecture model, Model Human Processor, in order to simulate users interacting with then-modern workstations equipped with WIMP for the purpose of demonstrating, *e.g.*, a GUI screen editor running on the new innovative workstation is superior to traditional line editors. Nowadays, however, interactions between users and information systems have become tremendously richer than those that MHP dealt with 30 years ago. This paper introduces a *real* brain model MHP/RT, Model Human Processor with Real Time constraints [7] shown in Figure 1, that is capable of simulating users of modern interaction systems. The key idea is that users are engaging in so-called the Two Minds [3, 4] processes when interacting with the modern interaction systems. This paper argues that *time* is *the* dimension to be designed well in order for the interactions to be perceived smooth and rational by the users, *i.e.*, to be matched with the users' Two Minds processes.

Author Keywords

MHP/RT, Two Minds, brain model, simulation

ACM Classification Keywords

H.5.m. [Information Interfaces and Presentation (e.g. HCI)]: Miscellaneous

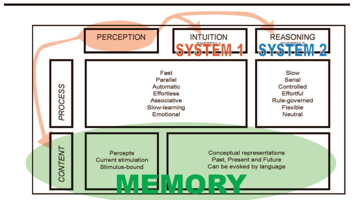

Figure 2: Two Minds [3].

TIME SCALE OF HUMAN ACTION

Scale (sec)	Time Units	System	World (theory)
10^{7}	months		SOCIAL BAND
10^{6}	weeks		
10^{5}	days		
10^{4}	hours	Task	RATIONAL BAND
10^{3}	10 min	Task	
10^{2}	minutes	Task	
10^{1}	10 sec	Unit task	COGNITIVE BAND
10^{0}	1 sec	Operations	
10^{-1}	100 ms	Deliberate act	
10^{-2}	10 ms	Neural circuit	BIOLOGICAL BAND
10^{-3}	1 ms	Neuron	
10^{-4}	100 µs	Organelle	

Figure 3: Newell's time scale of human action; adapted from Newell (1990) [8], Figure 3-3, on page 122.

Introduction

A necessary condition for creating well-designed interactions is to start the design process from the consideration of how a user's brain works while he/she is interacting with the to-be designed environment. In the interaction, the brain produces a series of moment-by-moment decisions concerning what to do next in the given state of the environment.

Recently, Kahneman [4, 3] revealed the core process of human beings' decision-making is an integral process of so-called Two Minds [3] (See Figure 2). Two Minds refers to the following two systems; System 1, the automatic and fast unconscious decision-making process driven by the cerebellum and oriented toward immediate action, and System 2, the deliberate and slow conscious decision-making process driven by the cerebrum and oriented toward future action. It is obvious that the Two Minds processes have to be taken into account seriously when designing interactions.

However, it will not be an easy and trivial task because there is a huge difference in processing speed between the two systems; rational processing with System 2 typically takes minutes to hours, whereas experiential processing with System 1 typically extends from hundreds of milliseconds to tens of seconds [8] (See Figure 3). A large part of human beings' daily activities are immediate actions and are therefore under the control of System 1. System 2 intervenes with System 1 to better organize the overall outcome of the processing through consciously envisioning possible futures.

Designing for Two Minds

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.

This paper introduces MHP/RT, which is a *real* brain model comprising of the unconscious processes, System 1, and the conscious processes, System 2, at the same level, as a basis for designing interactions for the modern interfaces. MHP/RT is different from the goal-oriented *rationalistic* cognitive architectures such as ACT-R [1] in which the conscious processes are considered as the processes to control people's behavior and the unconscious processes are considered subordinate to the conscious or intentional processes. It is known, however, that almost 70% of people's behavior is unconscious, therefore ACT-R is capable of simulating only 30% of people's behavior. This is a potential weakness of the goal-oriented cognitive architectures in general, and their inapplicability to dealing with daily human behavior.

Figure 4: Screenshot from a car-navigation system.

Two Minds – Environment Interaction

An Illustration

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 4 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 automatically executable action sequences for the maneuver; when to start reducing speed, when to start braking, and so forth.

Table 1: Four Processing Modes [6]

	System 2 Conscious Processes		**System 1 Unconscious Processes**	
	Before	*After*	*Before*	*After*
Time Constraints	none or weak	exist	none or weak	exist
Network Structure	feedback	feedback	feedforward + feedback	feedforward + feedback
Processing	main serial conscious process + subsidiary parallel process	main serial conscious process + subsidiary parallel process	simple parallel process	simple parallel process
Newell's Time Scale	Rational / Social	Rational / Social	Biological / Cognitive	Biological / Cognitive

When the navigation system starts its own process 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 negatively 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.

Four Processing Modes of Human Behavior

In [6], the authors introduced Four Processing Modes of *in situ* human behavior that are derived by augmenting the theory of decision-making, Two Minds [3], by taking into account the different nature of decision-making before the boundary event and after the boundary event, that is captured by Newell's time scale of human action [8]. An example of boundary event is the provision of an instruction to the driver such as "Slight right turn $\cdots$." Table 1 shows the resultant Four Processing Modes of *in situ* human behavior; at each moment along the time dimension human behaves in one of the four modes and he/she switches among them depending on the internal and external states. These four modes specify how System 1 and System 2 work together to generate a series of coherent behavior in the ever-changing environment.

Decision-making processes before the boundary event and those after the boundary event are significantly different in terms of the impact of real time constraints on the decision-making processes. Considering that decision-making is the result of the workings of System 1 and System 2, there are four distinctive behavior modes,

1. conscious behavior before the boundary event,

2. conscious behavior after the boundary event,
3. unconscious behavior before the boundary event,
4. unconscious behavior after the boundary event.

Interaction Design along "T"

How can we study people's behaviors, which are characterized by Two Minds working dynamically along the time dimension? We considered that the problem, understanding human beings' daily behavior selections, should reduce to understanding relationships between *active knowledge at the time the behavior was undertaken* and *overtly observed behavior* by taking into account Two Minds and interactions between System 1 and System 2. We came up with a solution to this problem in the form of a study methodology, called CCE. Cognitive Chrono-Ethnography combines three concepts. "Cognitive" refers to Two Minds and CCE deals with Two Minds. "Chrono(-logy)" is about time ranging from ~100 msec to days, months, and years, and CCE focuses on such time ranges. "Ethnography" indicates that CCE takes ethnographical observations as the concrete study method. The specific questions CCE tries to answer are: Which pieces of knowledge were activated?; Under which conditions were those pieces of knowledge activated?; and How had the knowledge been formed?

A typical CCE study is conducted as follows [7, 5]: first, defining the study question in the form "what such-and-such people would do in such-and-such way in such-and-such circumstance" and identifying behavior shaping factors by resorting to established brain activity models such as MHP/RT; second, select study participant, called elite monitors, through carefully designed screening procedures; third, conduct ethnographical field study for data collection followed by a series of retrospective interviews where the collected behavioral records will be used as triggers for having remind the participants their active memory at the time the data were recorded; lastly, deriving the answer for the question by conducting appropriate analyses.

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