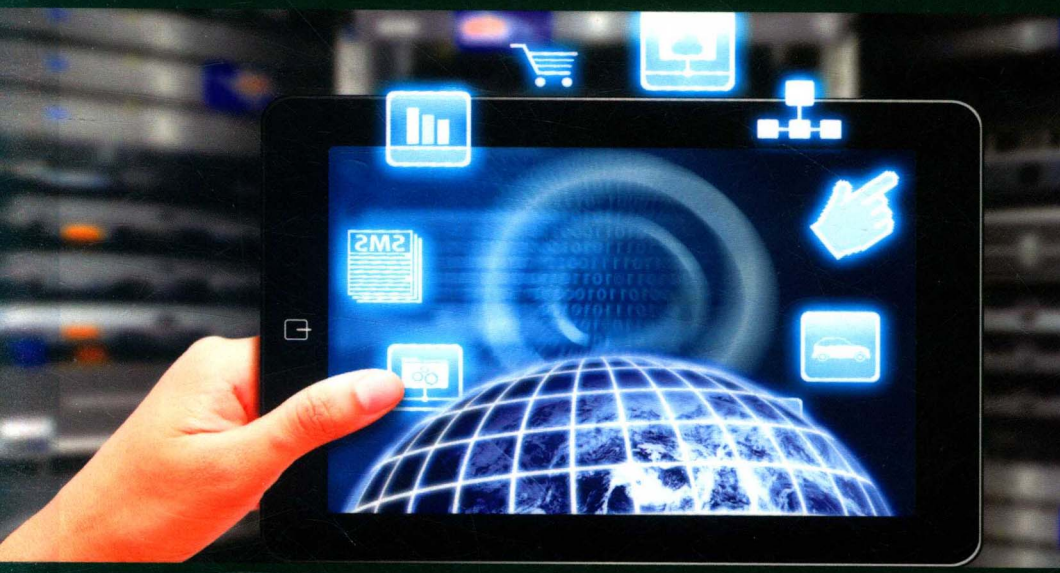
INFORMATION SYSTEMS, WEB AND PERVASIVE COMPUTING SERIES

HUMAN-MACHINE INTERACTION SET



Volume 1

Memory and Action Selection in Human–Machine Interaction

Munéo Kitajima

iSTE

WILEY

Human–Machine Interaction Set

coordinated by
Jérôme Dinet

Volume 1

Memory and Action Selection in Human–Machine Interaction

Munéo Kitajima

ISTE

WILEY

First published 2016 in Great Britain and the United States by ISTE Ltd and John Wiley & Sons, Inc.

Apart from any fair dealing for the purposes of research or private study, or criticism or review, as permitted under the Copyright, Designs and Patents Act 1988, this publication may only be reproduced, stored or transmitted, in any form or by any means, with the prior permission in writing of the publishers, or in the case of reprographic reproduction in accordance with the terms and licenses issued by the CLA. Enquiries concerning reproduction outside these terms should be sent to the publishers at the undermentioned address:

ISTE Ltd
27-37 St George's Road
London SW19 4EU
UK

www.iste.co.uk

John Wiley & Sons, Inc.
111 River Street
Hoboken, NJ 07030
USA

www.wiley.com

© ISTE Ltd 2016
The rights of Munéo Kitajima to be identified as the author of this work have been asserted by him in accordance with the Copyright, Designs and Patents Act 1988.

Library of Congress Control Number: 2015957671

British Library Cataloguing-in-Publication Data
A CIP record for this book is available from the British Library
ISBN 978-1-84821-927-4

Memory and Action Selection in Human–Machine Interaction

Introduction

I.1. The key principle of designing human–machine interaction is "know the users"

"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 a satisfactory experience. From the 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 affects significantly how he/she interacts with the devices in a particular situation. No one has the same experience. It seems there is no systematic way to practice the "know the users" principle.

"Know the users" is an important study issue not only in the field of human–machine interaction but in 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. Human decision-making is a central topic in economics. Herbert A. Simon, winner of the Nobel Prize in Economics in 1978, proposed principles of human beings' decision-making processes, the *bounded rationality principle* and the *satisficing*

此为试读,需要完整PDF请访问: www.ertongbook.com

principle [SIM 56]. Simon claimed that agents, or human beings, face uncertainty about the future and costs when acquiring information in the present. These factors limit the extent to which human beings can make a fully rational decision, thus they possess only *bounded rationality* and must make decisions by *satisficing*, or choosing that which might not be optimal but which will make them happy enough. Recently, Kahneman [KAH 03] revealed that the core process of human beings' decision-making is an integral process of so-called *Two Minds* [EVA 09, KAH 11]. Why not consider 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–machine interaction processes, we would be able to systematically apply the principle "know the user" for designing satisfactory interactions. 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 environment to be designed. 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.

I.2. Designing human–machine interaction for Two Minds

Two Minds (see Figure I.1) 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. We can easily imagine how Two Minds would work when users interact with information devices. In human–machine interactions, 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 the interaction between the slow deliberate processes and the fast automatic processes explicitly into account, we will be able to design interactions that are likely to satisfy the users' interaction experience.

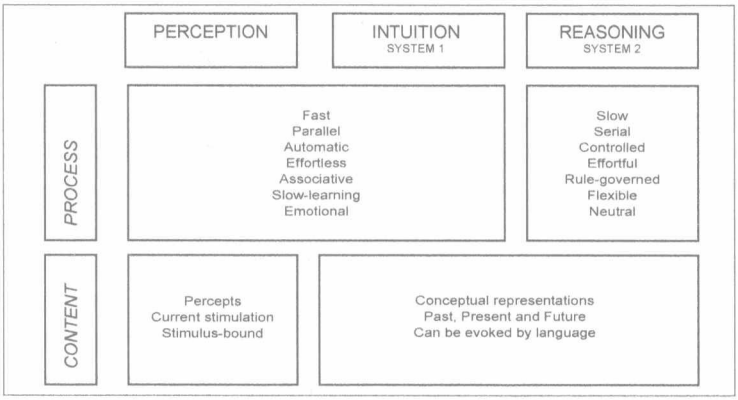


Figure I.1. *Process and Content in Two Cognitive Systems (adapted from [KAH 03])*

However, it will not be an easy 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 [NEW 90]. 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.

What does it mean for the interaction design activities of Two Minds to rely on people's behaviors? I would 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 take place at the interface of a system and a user, and the only 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

interaction designers need to take them into account appropriately in order for the designed system to satisfy the users' expectations.

Here is an example to illustrate this point. When we hear a car navigation system speaking in synthesized voice, we switch our attention to what it says and try to plan our 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 screenshot shown in Figure I.2 at some specific moment. The driver, who is not familiar with the route, is supposed to listen to the instructions and read the screen carefully, integrating the information provided from the car navigation system with the current driving situation, 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 affect the driver's on-going processes and initiate a new interactive process stream on the part of the driver.

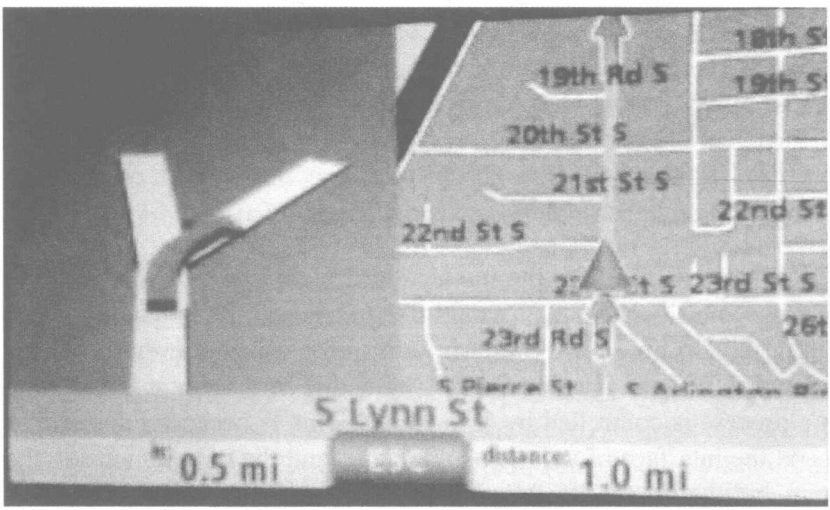


Figure I.2. *Screenshot from a car navigation system*

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 other on-going processes; some processes must be suspended and resumed at an appropriate time (with little cost), and other

processes can continue with no interference from the car navigation system (e.g. keep conversing with a person in the passenger seat).

I.3. Organization of the book

This book is organized in two parts, one part theory and another part practice.

I.3.1. *Theoretical foundation for dealing with action selection and memorization as a cyclic nonlinear process*

The first goal of this book is to extend Two Minds from its origins in behavioral economics to the domain of interaction, where the time dimension has to be dealt with rigorously; in the human–machine interaction (HMI), establishing synchronization between conscious processes and unconscious processes is crucial for the feeling of smoothness, as is the way in which memory processes and action selection processes are coordinated. The first half of the book describes the theory in detail. Chapter 1 outlines the whole view of the theory, consisting of action selection processes and memorization processes and their interactions. Chapter 2 provides a detailed description for action selection processes theorized as a nonlinear dynamic human behavior model with real-time constraints, followed by Chapter 3, which provides a detailed description for memorization processes. As the final section of the theory part, Chapter 4 discusses implications of the theory to HMIs. The most important point to understand human behavior in the ever-changing environment is that human behavior is regarded as a cycle of action selection and memorization processes that begin at one's birth and ends at one's death. In addition, action selection is carried out through a multilayered structure, with characteristic times, and a multilayered memory structure, and therefore the processes that control human behavior have to be treated as the result of nonlinear processes. Nonlinearity, or complex system, implies sensitive dependence on initial condition (SEDIC), i.e. a small variation in the initial condition, during one's infant period, develops exponentially as one grows up. Therefore, human behavior as observed in the current environment should be regarded as the result of adaptation to the current ecological environment and his/her memory that has been constructed through his/her behavioral experience that has been accumulated at the time of action selection. Action selection is carried out either by selecting or recalling one from existing

memory, or searching for an appropriate one for the current situation. However, this is not predictable as in a linear system since action selection is carried out in a complex system. This is summarized as follows:

Dynamic phenomena in a complex system
=
Structure constructed in a cyclic complex system
×
Environmental variation in a cyclic complex system

I.3.2. *Theoretically motivated methodology for understanding users*

The second goal of this book is to provide a methodology to study how Two Minds works in practice when people use interactive systems. How does Two Minds work in HMI? What is the user's performance under Two Minds? It has been proposed by Edwin Hutchins by the name of "cognitive ethnography" (CE). However, the most important thing to be understood is how the fast unconscious process and the slow deliberate process work together to create a series of decision-making events concerning what to do next and generate coherent behavior, i.e. the dynamics of Two Minds working in the ever-changing environment. The dynamics is best defined by using the time dimension explicitly. The second half of this book describes the practical aspect of the theory in detail. Chapter 5 introduces a new methodology called cognitive chrono-ethnography (CCE), which adds the time dimension to Hutchins' CE in order to practice "know the users" systematically by designing user studies based on a simulation of users' mental operations controlled by Two Minds. Chapters 6 and 7 show how CCE has been applied to understand how people navigate in real physical environments by walking and by car, respectively. As the final section of the practice part, Chapter 8 explores the possibility of applying CCE to predict people's future needs. This is not meant for understanding how people use interfaces at present but for predicting how people will want to use interfaces in the future given how they are currently using them.

I.3.3. *Conditions for sustainable HMI*

Finally, this book concludes by describing the implications of HMIs that are carried out while using modern artifacts for people's cognitive development from their births on the basis of the theories of action selection and memorization described.

此为试读,需要完整PDF请访问: www.ertongbook.com

Contents

PART 1

Theoretical Foundation for Dealing with Action Selection and Memorization

此为试读,需要完整PDF请访问: www.ertongbook.com