Research Center for Work, Safety
and Human Engineering
Technion-Israel Institute of Technology

Institute of Information Processing
and Decision Making
University of Haifa

Attention and Performance XVII:

Cognitive regulation of performance: Interaction of theory and application

Beit Oren, Israel July 7-12, 1996

he International Association for the Study of Attention and Performance

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Organizers: Daniel Gopher and Asher Koriat

The central theme for the A&P XVII is Cognitive Regulation of Performance, with special emphasis on the interaction between theory and application. The topics to be covered include top-down regulatory processes and mechanisms of attentional control, strategies of performance, conscious appraisal of the world, pursuit of intentions, and the interplay between controlled and automatic processes in skilled performance. We shall be examining existing and prospective applications of cognitive research while also considering the challenges that real-world problems pose for basic research in cognition. We believe that the time is ripe for face-to-face encounter between basic and applied research in cognition, and we firmly believe that such an encounter holds the promise of being mutually stimulating and rewarding.

Four sessions are planned, each concentrating on a particular topic. Each session will begin with one or two "focus on application" papers which will replace the tutorial papers that have traditionally introduced a topic at A&P Symposia. The aim of these focus papers is to provide up to date review of progress in an applied area of cognitive regulation, in which a significant and successful exchange can be shown to have occurred between theory and application. These papers are delivered by scientists who have bridged the basic and applied domains in their own work, and are recognized for their contributions to both areas. Other contributors, invited participants and observers, are scientists who belong either to the basic science and/or to the applied research communities.

Topics for Sessions

Session 1. The Presentation and Representation of Information

Exploration of the different modes of organizing and representing information used by experts and novices, and how these modes vary with task demands. Examination of the implications of these modes for the design of displays, and for the processes by which human operators form mental models of situations and operating systems.

In modern technology, human operators are required to interact with systems of ever increasing complexity and dynamics. Computers, cars, video systems, and plant control rooms, are just a few examples of such systems. A proper representation of the system, i.e., an efficient mental model of the system and its governing operations, is critical for effective response and work procedures.

How are these mental models constructed? How do they affect performance? What are the differences between expert and novice representations? How do different knowledge bases and interaction procedures affect representations?

Similarly, the need to externalize and display complex worlds, combined with the rich technological possibilities for designing displays create an important opportunity for research on the design of sophisticated displays. What are the guidelines for designing displays for the human operator? What are the factors that affect the ability of operators to perceive and interpret complex phenomena, and make useful inferences?

Session 2. Cognitive Regulation of Acquisition and Performance

This session will concentrate on such topics as the choice of strategies for performing a task in accordance with task demands, the allocation of attention to different tasks, the on-line monitoring of task performance, and the control over one's actions. These topics represent some of the main challenges of applied psychology to basic cognitive research. The issues involved are the nature and extent of strategic control in proficient performance, and the ability to develop these capabilities with proper training. Of special significance is the interplay between strategic, top-down, control and automatic, bottom-up, processes in proficient behavior.

Examples of applied tasks which call for dynamic regulation include:

(a) Monitoring and supervisory behavior in industrial process control rooms such as power plants, the chemical industry, or air traffic control towers.

(b) Interaction with dynamic systems, responding to time changes and control dynamics. Examples are flying, navigating, driving, etc.

Session 3. Consciousness and Behavior

A key question in human performance concerns the dependability of subjective monitoring of one's own performance and capacities of subjective reports in general. Effective functioning depends critically on the accuracy of one's subjective assessment and on the ability to regulate one's performance accordingly.

Self monitoring occurs at many stages of information processing. For example, people monitor the extent to which they have mastered different tasks and allocate study time or set performance objectives accordingly. They assess the likelihood that an unrecallable piece of information will be recovered and decide whether to continue searching for it or give up. They judge whether a planned act has already been performed in order not to repeat it. Many errors often ensue from insufficient or inaccurate monitoring of behavior.

Subjective reports constitute a very important source of information in many field applications, and their dependability is a major concern. This can be clearly seen in the judicial system, which is highly dependent on witnesses' accounts of their experiences. However, subjective reports are also relevant in many managerial and decision making positions. In the design and evaluation of engineering system, human performance specialists traditionally rely both on subjective and behavioral measures. These often do not coincide. How should discrepancies between subjective measures and performance measures be treated? What are the sources of such discrepancies?

Session 4. Special Populations

Attention control and cognitive functions are greatly impaired as a result of aging and a variety of neurological and brain disorders. How has basic research in cognition been applied to these types of problems? How can research in this area reciprocate basic research? The focus will be on problems of two aspects of control: a) Rehabilitation of control on a task which was impaired due to neurological disease or brain damage; b) Using controlled processes to perform a task that had previously been performed automatically.

Attention and Performance XVII: Cognitive regulation of performance: Interaction of theory and application

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Schedule of Conference Events

Saturday, July 6

19:00-21:30 **Reception**

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Sunday, July 7

08:30-09:00 **Welcoming address - Daniel Gopher and Asher Koriat**

Session 1: Presentation and representation of information

A. Chair: Stephen Monsell, *University of Cambridge, UK*

09:00-10:00 1. Focus on application:
The certainty of viewpoint invariant information in visual recognition tasks
Irving Biederman, Suresh Subramaniam, Peter Kalocsai, Moshe Bar, *University of Southern California, USA*

10:00-11:00 2. **Frame of reference for navigation**
Chris Wickens, *University of Illinois, USA*

11:00-11:30 ***Coffee break***

11:30-12:30 3. **Attention to location and objects affects reaction times and motion perception**
Shinsuke Shimojo, *University of Tokyo, Japan*

12:30-14:00 ***Lunch***

B. Chair: Gery d'Ydewalle, *University of Leuven, Belgium*

14:00-15:00 4. **Attending: A dynamic systems perspective**
John Flach, *Wright State University, USA*

15:00-15:30 ***Coffee break***

15:30-16:30 5. Focus on Application:
Mental models in theory and practice
Neville Moray, *Universite de Valenciennes, France*

16:30-17:30 *6.* **Specifying relations between research and the design of human-machine interactions: An illustration from the planning and control of multiple task work in medical reception**
John Long, *University College London, UK*

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Monday, July 8

Session 2. Cognitive regulation of acquisition and performance
A. Chair: Wolfgang Prinz, *Max-Planck Institute, Germany*

08:30-09:30 1. Focus on Application:
An integrative system of metacognitive components involved in retrieval from human memory
Thomas Nelson, *University of Maryland, USA*

09:30-10:30 2. **Examining individual differences in the adaptive use of strategies in an air traffic controller's task**
Lynne Reder and C. Schunn, *Carnegie-Mellon University, USA*

10:30-11:00 ***Coffee break***

11:00-12:00 3. **Cognitive strategies in team performance: A game theoretical approach**
Ido Erev and Daniel Gopher, *Technion, Israel*

12:00-13:00 ***Lunch***

B. Chair: Sylvan Kornblum, *University of Michigan, USA*

13:00-14:00 4. **The strategic regulation of memory reporting: Mechanisms and performance consequences**
Morris Goldsmith and Asher Koriat, *University of Haifa, Israel*

14:00-15:00 5. **Individual and group protocols for training complex skills in laboratory and applied settings**
Wayne Shebilske, *Texas A&M University,* Barry Goettl and J. Wesley Regian, *Armstrong Laboratory, USA*

15:00-15:30 ***Coffee break***

15:30-16:30 6. **The haptic glance: A route to rapid object identification and manipulation**
Roberta Klatzky, *Carnegie-Mellon University, USA* and Susan Lederman, *Queen's University, Canada*

17:30 ***Visit to Ceasarea***
Dinner in Ceasarea

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Tuesday, July 9

1. A day - trip
2. Evening: Banquet

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Wednesday, July 10

Session 3. Consciousness and behavior
A. Chair: Philip Merikle, *University of Waterloo, Canada*

09:00-10:00 1. Focus on Application:
Assessing our own competence: Heuristics and illusions
Robert A. Bjork, *UCLA, USA*

10:00-11:00 2. **Retroactive bias in memory**
Larry Jacoby, *University of Texas, USA*

11:00-11:30 ***Coffee break***

11:30-12:30 3. **The development of metacognitive knowledge in children**
Wolfgang Schneider, *University of Wuerzburg, Germany*

12:30-14:00 ***Lunch***

B. Chair: Daniel Algom, *Bar Ilan University, Israel*

14:00-15:00 4. **Subjective experience as a basis for metacognitive judgments**
Colleen Kelley, *Macalester College, USA*

15:00-16:00 5. **Prospective time judgments and workload**
Dan Zakay, *Tel Aviv University, Israel*, Richard A. Block, *Montana State University, USA*, and Yehoshua Tsal, *Tel Aviv University, Israel*

16:00-16:30 ***Coffee break***

16:30-17:30 6. **Probing knowledge bases,**
Ronald Fisher, *Florida International University, USA*

Walking tour

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Thursday, July 11

Session 4. Special populations

a. Aging

Chair: David A. Rosenbaum, *Pennsylvania State University, USA*

08:30-09:30 1. Focus on Application:
Applying cognitive research to aging
Fergus Craik, *University of Toronto, Canada*

09:30-10:30 2. **Attentional flexibility and aging**
Arthur Kramer, *University of Illinois, USA*

10:30-11:00 *Coffee Break*

11:00-12:00 3. **Aging, circadian arousal and inhibitory control of cognition**
Lynn Hasher, *Duke University, USA*

12:00-13:30 *Lunch*

b. Neurological Disorders

Chair: Karalyn Patterson, *MRC Applied Psychology Unit, UK*

13:30-14:30 4. Focus on Application:
Theory-driven neuropsychological rehabilitation: The role of attention and competition in recovery of function after brain damage
Ian Robertson, *MRC Applied Psychology Unit, UK*

14:30-15:30 5. **Regaining control of eye movements**
Heiner Deubel, *Max Planck Institute, Munich, Germany*

15:30-16:00 *Coffee Break*

16:00-17:00 6. **Preserved semantic access in neglect patients**
Elisabetta Ladavas, *Universita di Bologna, Italy.*

Association Lecture

Chair: Asher Koriat, *University of Haifa, Israel*

18:30-19:30 7. **Some lessons from symbolic computational modeling of human multiple-task performance**
David Meyer and David E. Kieras, *University of Michigan, USA*

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Friday, July 12

Concluding Address and Discussion
Chair: Daniel Gopher, *Technion, Israel*

09:00-10:00 1. **Concluding Address**:
Raymond Nickerson, *Bolt Beranek & Newman, Cambridge, USA*

10:00-10:30 ***Coffee Break***

10:30-12:00 2. Open discussion

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Note: Lectures are 45 minutes long, followed by 15 minutes discussion

Acknowledgment

The International Association for the Study of Attention and Performance, its Executive Council and the organizers of Attention and Performance XVII, thank the following organizations for their support which made this meeting possible:

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University of Haifa

Technion - Israel Institute of Technology

Israel Academy of Sciences

Israel Ministry of Science and Art

The S. Neaman Institute for Advanced Studies in Science and Technology

The *Samuel Neaman Institute for Advanced Studies in Science and Technology* is an independent pubic policy research institute. The institute which is housed at the Technion - Israel Institute of Technology was established in 1978 to assist in the research for solutions to national problems in science, technology, education, economy, industry and social development. As an interdisciplinary think-tank, the institute draws on the faculty and staff of Technion, other institutions and scientists in Israel and foreign specialists, the institute serves as a bridge between academia and decision makers through research, workshops and publications.

The institute undertakes sponsored advanced research, formulates invitational workshops, implements continuing education activities on topics of significance for the development of the state of Israel and maintains a publication program for the dissemination of research and workshop findings.

Attention & Performance XVII (July 7-12, 1996)

Abstracts

Irving Biederman
Suresh Subramaniam
Peter Kalocsai
Moshe Bar
University of Sourthern California, Los Angeles, Californina, USA
The certainty of viewpoint invariant information in visual recognition tasks

Robert A. Bjork
University of California, Los Angeles, USA
Assessing our own competence: Heuristics and illusions

Fergus I. M. Craik
University of Toronto, Toronto, Canada
Applying cognitive research to aging

Heiner Deubel
Max-Planck Institute, Munich, Germany
Maintenance of saccadic accuracy: How many systems?

Ido Erev
Daniel Gopher
Technion - Israel Institute of Technology, Haifa, Israel
Cognitive strategies in team performance: A game theoretical approach

Ronald P. Fisher
Florida International University, Miami, FL, USA
Probing knowledge bases

John M. Flach
Wright State University, Dayton, OH, USA
Attending: A dynamic systems perspective

Morris Goldsmith
Asher Koriat
University of Haifa, Haifa, Israel
The strategic regulation of memory reporting: Mechanisms and performance consequences

Lynn Hasher
Duke University, Durham, NC, USA
Aging, circadian arousal and inhibitory control of cognition

Larry L. Jacoby
New York University, New York, NY, USA
Retroactive bias in memory

Colleen Kelley
Macalester College, St. Paul, MN, USA
Subjective experience as a basis for metacognitive judgments

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Susan J. Lederman
Queen's University, Kingston, ONT, Canada
The haptic glance: A route to rapid object identification and manipulation

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University of Illinois, Champaign, IL, USA
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Yehoshua Tsal
Tel Aviv University, Tel Aviv, Israel
Prospective time judgments and workload

Raymond Nickerson
Concluding Address

The centrality of viewpoint invariant information in visual recognition tasks

Irving Biederman, Suresh Subramaniam,
Peter Kalocsai, and Moshe Bar
University of Southern California
Los Angeles, USA

Often a major reason for having humans in a complex human-machine system is that people can readily classify visual images, even when they are novel. A geon structural description (GSD) representing a viewpoint invariant characterization of an object's parts and the relations among the parts is sufficient for most entry-level classifications and, somewhat surprisingly, the overwhelming majority of highly similar subordinate classifications (excluding faces) that people can make quickly and accurately. Even confusions in the identification of highly similar objects, such as infrared images of tanks, can be modeled in such a manner. GSDs allow invariant recognition despite rotations in depth. Different GSDs offer readily available perceptual boundaries, whether or not a culture has chosen to coin common linguistic expressions for these distinctions. That most important shape differences can be expressed by GSDs means that GSDs can provide a framework for training people on how to distinguish among highly similar objects, as evidenced by J. J. Gibson's success during WWII in training aircraft spotters.

Assessing Our Own Competence: Heuristics and Illusions

Robert A. Bjork
University of California
Los Angeles, USA

The reading we take of our own competence is arguably as important in many real-world contexts as is our actual competence. For example, in settings where on-the-job learning can be disastrous from a personal or societal standpoint, such as air-traffic control, police or military actions, and nuclear-plant operation, it can be imperative that we possess the skills and knowledge we think we possess. Individuals who overestimate their own current level of skill and knowledge pose a unique hazard to themselves and others. More broadly, the reading we take of our current level of learning and knowledge in a given domain determines such important matters as how we allocate our time, whether we seek further study or practice, whether we volunteer for or avoid certain assignments, and whether we instill confidence in others.

A variety of recent findings demonstrate, however, that humans frequently mis-assess their own competence, and that such mis-assessments typically take the form of overconfidence. At the root of such overconfidence, it is argued here, is a misinterpretation of the meaning and predictive value of certain objective and subjective indices of current performance. That misinterpretation, in turn, rests on a misunderstanding of some fundamental characteristics of humans as learners. One goal of the present paper is to characterize the types of illusions of comprehension and competence to which learners fall prey. A second goal is to outline the practical implications of such findings for the optimization of training, instruction, and performance. A final goal is to examine, from a theoretical standpoint, how the modal mental model humans have of themselves as learners differs from what research has revealed about the functional architecture of humans as learners and rememberers.

Applying cognitive research to aging

Fergus I. M. Craik
University of Toronto
Toronto, Canada

Modern research on cognitive aspects of aging has its roots in the work of two prominent investigators--Alan Welford and James Birren--both of whom stressed the interaction between theoretical, lab-based work and real-life problems in industry and society. There is therefore a strong tradition in this area to apply laboratory findings to real-world issues, although it may be true to say that recent work in cognitive aging is driven more by ideas and findings in mainstream cognitive psychology than by a desire to solve practical problems. The present paper will therefore focus primarily on the POTENTIAL for application of several current themes in the area of cognitive aging.

One such theme is that of automaticity and control. A number of researchers have suggested that automatic, habitual processes are unimpaired in older people, whereas novel, conscious, controlled processes show deficits. One example is Hasher and Zacks' view that inhibitory processes are less effective in the elderly. Another perhaps more general viewpoint is that of Jacoby and his colleagues who postulate an age-related impairment in attentional and recollective control. Jacoby has also devised a procedure whereby automatic and controlled processes may be separated, thereby allowing for an assessment of age differences in each. A second theme centers on the notion of declining attentional resources in the elderly, and the linked notions of a consequent difficulty with processes that must be "self-initiated" as opposed to processes that are compensated by receiving good environmental support (Craik 1983, 1986). The idea that failing performance can be compensated for by an increase in external support is particularly appropriate for application. Other themes to be discussed include the older person's greater vulnerability to distraction, greater difficulty with source and contextual information, and greater difficulty in retrieving fine-grained information from both episodic and semantic memory. Finally, some parallels will be drawn between normal aging and some classes of neuropsychological patients.

In all cases, these theoretical/empirical themes will be discussed briefly, but the major emphasis will be on how the ideas have been applied to practical issues, or how they could be applied.

Maintenance of saccadic accuracy: How many systems?

Heiner Deubel
Ludwig-Maximilians-University Munich
Munich, Germany.

The saccade, used by primates to inspect their environment, is often considered as one of the most simple sensorimotor responses. For this system to function properly, it is essential that its accuracy is preserved continuously, even under changing visual and motor conditions. Accordingly, saccades are adaptive, and many workers have emphasized the automatic nature of saccadic adaptive control. In contrast to this view, my presentation will summarize recent behavioral investigations demonstrating the amazing flexibility and complexity of saccadic adaptivity, and discuss its clinical implications.

Specifically, our investigations of the adaptive control of saccade metricity and dynamics indicate that different aspects of the saccadic response are controlled individually by separate adaptive systems. Moreover, several sets of response parameters are available simultaneously and can be adjusted separately by appropriate conditioning. So, reflexive saccades (i.e., eye movements triggered by the sudden onset of a peripheral target) can be adapted independently of the intentional scanning saccades, suggesting the existence of at least two partially independent pathways for saccadic control. As a consequence, the selection of the actual response parameter is context-specific: it can be selected dependent on whether the saccade is a reflexive response to the onset of a target, is a predictive saccade, occurs during scanning, visual search or in an overlap paradigm, or is a saccade to a memorized or an acoustical target. These results indicate that higher-level, cognitive mechanisms participate in saccadic adaptivity.

The second part of the presentation discusses consequences of these findings for the interpretation of sensorimotor performance in patients with central lesions. For cerebellar lesions, for example, hypermetria of the saccadic response is frequently observed and has been taken as a clinical sign of the disease, evidence for the cerebellum being part of the adaptive mechanism. However, our investigations of the oculomotor performance of cerebellar patients demonstrate that the amount of response dysmetria is strongly dependent on the context in which the saccade is made. This supports the view that the cerebellum is involved in the control of saccades in a way that depends on the mode of saccade elicitation.

Cognitive strategies in team performance: A game theoretical approach

Ido Erev and Daniel Gopher
Technion - Israel Institute of Technology
Haifa, Israel

In high-workload environment complex task are often performed by teams of workers. Dividing the responsibility between workers is especially crucial to deal with cognitively demanding tasks. The present paper proposes a theoretical approach that facilitates precise abstraction and prediction of performance in these settings.

The suggested approach is built upon the observation that "cognitive strategies" of individual team members can be considered as example of "game theoretical strategies". Thus, based on understanding of the cognitive capacities and the strategies available to the team members, game theoretical tools can be utilized to predict team performance.

Four studies are summarized that demonstrate the power of the suggested approach. Among the issues considered in these studies are : (1) speed accuracy tradeoff in team work, (2) the effect of motivation to reach consensus between team members, (3) the effect of shared responsibility, (4) the effect of competition between team members, and (5) training during team work. Each of these examples is related to a broad category of real life situations.

Probing knowledge bases

Ronald P. Fisher
Florida International University
Florida, USA

Conducting an investigative interview, as a police interview with an eyewitness of a crime, provides an excellent opportunity to test theories of cognition in a practical setting. Toward that goal and also to apply psychological research to a societally-relevant problem, I began this research by conducting a task analysis based on several tape recorded police interviews of victims and witnesses of crime. The various cognitive sub-tasks in the interview include, among others, witnesses' retrieving autobiographical experiences and converting recollections into responses, and interviewers' comprehending and notating witnesses' responses and formulating questions. My evaluation of typical police interviews suggested that police questioning procedures often violate generally accepted principles of cognition (e.g., by overloading working memory) thereby militating against effective interviews. I therefore developed an alternative set of interview guidelines to be more in keeping with these principles of cognition. The resulting interview guidelines, called the Cognitive Interview (CI), was compared to conventional police interview procedures in several laboratory and field tests. In these studies, witnesses observed a real crime (field) or a film of a simulated crime or a live innocuous event (laboratory) and were later interviewed with a CI or with a procedure duplicating the typical police interview. Invariably the CI elicited considerably more (50% -100%) correct information than did the standard police interview, and at equivalent and high levels of accuracy (proportion correct responses = .85). This pattern held across a wide variety of criminal (e.g., robbery) and non-criminal events (car accident, foods eaten at an earlier meal, child's game) and respondents (children, young adults, and the elderly; students and non-students). Although the CI enhanced witnesses' descriptions (recall) of the event, it had no effect on their identifications (recognition) of target people (e.g., the robber) when presented in the context of a lineup or photoarray.

Current research in the CI examines whether it functions by enhancing the witness's retrieval of the event from memory or whether it facilitates communication between the witness and the interviewer. A second more applied study attempts to adapt the CI to a long-term survey in which respondents attempt to recall their daily schedules from 35 years ago.

Attending: A dynamic systems perspective

John M. Flach
Wright State University
Ohio, USA

Complex socio-technical systems create problems due to both "too much data" and "too little information". The problem of "too much data" has been the focus of much of the traditional work on attention that has been inspired by such metaphors as bottlenecks, spot lights, and resources. However, these metaphors have not adequately addressed the problem of "too little information". That is, the problem of extracting meaning from the dynamic flow of data that is available at the interface. This paper presents an alternative framework for addressing the problem of attention. This framework treats attention as a dynamic process of tuning to the constraints that bound performance of the socio-technical system. Within the dynamic systems framework, this problem has been identified as the problem of adaptive control or the dual control problem. That is, the control system (e.g., the human operator) must discover the adjust appropriately to the task constraints while simultaneously controlling the system and meeting performance objectives. In principle, a well designed adaptive control will gradually evolve toward greater degrees of coordination and toward greater effectiveness in meeting task demands. However, by their nature adaptive control systems are nonlinear and prone to instability. This paper explores the theory of dynamic systems and adaptive control as a framework for studying attention and human performance. Within this framework, attention is not simply a question of the capacity for processing data, but the capacity for processing meaning. That is, the adaptive control system must solve the problem of correspondence between the data, the state of the world, the task objectives, and the alternative courses of action. That is a coordination problem that cannot be addressed as a piecemeal summation of attention, pattern recognition, decision making, and motor control. A more global perspective is needed. The implication of this global perspective for the design of interfaces will be considered. The interface is the medium of coordination in socio-technical systems. The structure of this medium can determine the difference between increasing effectiveness or instability; between being lost or being situationally aware; between insight or befuddlement.

The strategic regulation of memory reporting: Mechanisms and performance consequences

Morris Goldsmith and Asher Koriat
University of Haifa
Haifa, Israel

Unlike in much traditional laboratory research, in most real-life memory situations people have a great deal of freedom to control their memory reporting in accordance with personal and situational goals. For instance, they may choose to report only information that they feel sure about, or they may choose to answer at a level of generality at which they are unlikely to be wrong. In the present paper we focus on these two types of metamnemonic control, examining both their underlying mechanisms and their consequences for memory performance.

We first put forward a theoretical model that delineates the monitoring and control processes underlying the decision to volunteer or withhold particular items of information in free-report situations. Simulation and empirical results demonstrate the critical role that these processes play in allowing rememberers to strategically regulate the amount and accuracy of reported information. We then extend this framework to address how people control the level of generality or "grain size" of the information that they report. Here too people are shown to utilize their monitoring and control processes in a strategically effective manner, taking into account competing demands for both accuracy and informativeness. Finally, we discuss the more general implications of our work and how it may be applied to the study, assessment, and enhancement of memory performance.

Retroactive bias in memory

Larry L. Jacoby
New York University
New York, USA

Automatic processes can operate to increase the availability of a particular response. A series of experiments using the process-dissociation procedure will be reported to show that the effects of such availability bias are independent of those of more algorithmic (consciously-controlled) bases for responding. For example, habit originating from training in the experimental setting can produce an availability bias whose effects are independent of recollection. Habit serves to increase the probability of a particular response regardless of whether doing so opposes or acts in concert with the effects of recollection, the intended basis for responding.

The process-dissociation procedure combines results from opposition (interference) and in-concert (facilitation) conditions to separate the contributions of automatic and consciously-controlled processes. Use of the procedure is based on the assumption that automatic and controlled processes are independent bases for responding. This independence assumption can be instantiated in a model similar to a recent "counter model" advanced by Ratcliff and McKoon to provide an account of process dissociations that is more detailed, but consistent with, our original model. We have developed a variant of the counter model that accounts for effects on both speed and accuracy in Stroop-like tasks.

Metacognitive processes related to the fluency heuristic

Colleen Kelley
Macalester College
Minessota, USA

Studies of metacognition are studies of subjective experience and the utility of subjective experience for the control of behavior. One important metacognitive task is assessment of the objective difficulty of problems or comprehensibility of text. Such judgments are often based on one's subjective experience with the problem or text. However, subjective experience can be altered by specific prior experiences. A series of experiments explored the effect of reading or paraphrasing sentences on later estimates of the objective difficulty of those sentences and new sentences. Participants interpreted the increased familiarity of sentences as due to the qualities of the sentences themselves and rated old sentences as less difficult. Such cognitive illusions are difficult to dispel.

The haptic glance: A route to rapid object identification and manipulation

Roberta L. Klatzky
Carnegie-Mellon University
Pittsburgh, PA, USA

Susan J. Lederman
Queen's University
Kingston, ONT, Canada

Skilled performance often requires that the performer reach for an object that is not in the visual field. The object may be a control knob on an instrument panel or a free-standing entity that has an uncertain position and orientation relative to workspace coordinates. Successful manipulation without vision requires that the person contact an object in the workspace; identify whether it is the desired object; if so, determine its orientation (relative to any manipulatory constraints); orient the arm and shape the hand in order to contact the object with the appropriate manipulatory posture; and perform the requisite movement.

This sequence of operations is guided by a combination of (a) features extracted from haptic input, and (b) prior knowledge about the workspace and objects within it -- top-down and bottom-up processing, respectively. For manipulation without visual intervention to be feasible, the combination of bottom-up and top-down processing must quickly yield cues to object identity and orientation.

The work to be reported here addresses what we know about objects from early contact, on the order of 200 ms. We call such contact a "haptic glance."

Two studies will be described. These studies deal with the first stages of haptically guided manipulation that occur post-contact: extracting haptic features and identifying objects. The first study is concerned with the nature of early perceptual features within the haptic system, defined as features that can be processed in parallel across the fingers. The second study asks whether, and how well, object identification can be achieved after brief contact, given various levels of prior hypotheses to guide top-down processing. These studies establish that within the first quarter-second of processing, the haptic system yields sufficient information for object identification to occur, thus forming the basis for non-visually guided manipulation by skilled performers.

Attentional flexibility and aging

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Robust age-related decrements in multi-task performance have been frequently reported in the literature. Unfortunately, however, there has been a conspicuous absence of research directed to the question of whether older adults have the capability to improve their multi-task performance through practice or training and whether such improvements might parallel those exhibited by younger adults or instead narrow or eliminate the age-related gap in multi-task performance. We will report the results of a series of studies in which we have investigated the issue of training for mutli-task performance of young and older adults. Initial studies have suggested that training strategies which emphasize flexible coordination of multiple tasks lead to improvements of learning and performance for both young and old adults. Most interestingly, the skills learned with these training strategies appear to be transferable across different tasks. Ongoing research, which will be described at the conference, is examining the mechanisms which underlie these training benefits for young and elderly adults.

Preserved semantic access in neglect patients

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The aim of this study is to investigate the preservation of semantic access in patients with severe neglect dyslexia for words and non-words. Patients were given the following tasks: 1) reading aloud letter strings (first basic reading task), 2) making semantic decisions (categorical and inferential judgments), 3) making semantic decisions and reading the letter strings immediately afterwards (semantic-reading tasks), 4) reading letter strings again (final basic reading tasks, and 5) auditory control tasks. The results showed that performance in the semantic tasks was as good as in the auditory condition. Moreover, the reading of the patients improved dramatically in the semantic-reading tasks but this was not maintained in the final basic reading task. Non-words showed only a minor improvement.

One possibility that needs to be considered is that semantic tasks lead to the subjects scanning further to the left: i.e., a better scanning of the letter string may be considered to be the cause of the better performance obtained in the semantic tasks and in the semantic-reading tasks. This possibility was tested in another experiment in which each letter forming a word and a non-word was underlined with different colors. Patients were given the following tasks: 1) naming the color printed under each letter (first basic color naming task), 2) making semantic decisions (categorical and inferential judgments), and naming the colors immediately afterwards (semantic-color naming tasks), 3) naming the colors again (final basic color naming tasks).

The results of this experiment showed that the performance on the basic color naming task was very poor and not significantly different from the performance obtained in the semantic-color naming tasks. Therefore, the basic phenomenon found in the previous experiment cannot be explained with a general improvement in the processing of lexical strings, due to better scanning of the left. In contrast, it can be interpreted as an interaction between the attentional system and the different reading routes, with the semantic routes being less affected by neglect. It seems plausible that the use of the semantic route requires, but also leads to, a broadening of attentional focus, while the use of non-lexical phonological correspondences involves a more narrow attentional focus.

Specifying relations between research and the desi - machine interactions: An illustration from the planning and control of multiple task work in medical reception

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Cognitive Psychology has well specified relations between its research and practices. Research acquires knowledge by explanation and prediction to provide understanding of cognitive phenomena. Applied Cognitive Psychology has less well specified relations. Research acquires knowledge by its application to solve problems. It has been argued that Applied Cognitive Psychology has grown, but not progressed. First, there are failures to solve such problems. Second, the literature shows little evidence of the validation of such applications. This paper argues the need for better specified relations to enhance the validation of Applied Cognitive Psychology, and so its progress. Research should acquire knowledge by diagnosis and prescription to solve cognitive design problems of humans interacting with machines to perform effective work. Validation should conceptualize; operationalize; test; and generalize knowledge with respect to the solution of such design problems (Long, in press). This paper offers an illustration of such relations, by means of a model of the planning and control of multiple task work in medical reception (Hill, Long, Smith and Whitefield, 1995). The model is based on a framework for the planning and control of office administration (Smith, Hill, Long and Whitefield, in press), and a conception for human-machine interaction (Dowell and Long, 1989). A study collected data concerning medical reception, its domain of work and its performance, which were used to construct the model. The latter includes structures and behaviors of medical reception; and objects of its domain of work. The model differentiates: task plans; procedure plans; and activity plans. A simulation, in MODSIM II, is used to illustrate the specified relations between research and practices. The model supports the diagnosis of a (hypothetical) design problem and the prescription of a design solution, as required for validation. Similar research from other domains is also cited, including amphibious landings and airtraffic management. Finally, it is suggested that the research and practices, as specified here, might be more clearly designated as Cognitive Engineering (in contrast to Cognitive (Psychology) Science), than as Applied Cognitive Psychology (Long and Dowell, in press).

Human multiple-task performance

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Experimental psychology and cognitive science have progressed sufficiently far that there are now encouraging prospects for a general unified theory of human performance. Such a theory may ultimately enable useful predictions and applications to be made in a variety of -traffic control, flight-cockpit operation, and human-computer interaction). Toward this end, our recent research has endeavored to formulate an EPIC (Executive-Process/Interactive-Control) information-processing architecture. EPIC is a theoretical framework that has modules for processing symbolic information at perceptual, cognitive, and motor levels. On the basis of this framework, detailed computational models that use a production-system formalism may be constructed to characterize single-task and multiple-task performance in a variety of contexts, including both laboratory and real-world situations. For example, we have developed and tested models that provide good quantitative accounts of reaction-time and accuracy data from various versions of the psychological refractory-period (PRP) procedure, continuous visual-manual tracking and tactical decision making, and on-line interactions between telephone operators and long-distance call customers. Together, these models reveal striking similarities in human performance across several domains. From our research, some instructive lessons may be learned: (1) Computational models of multiple-task performance yield insights that would be harder to reach by other avenues. (2) Available empirical data strongly shape the properties that such models should have. (3) For many purposes, a symbolic rather than neural-network representation is appropriate to construct models that aptly describe both rapid overt behavior and covert brain processes. (4) People have surprisingly high capacity for executing cognitive procedures. (5) There is no immutable "central" response-selection or decision bottleneck. (6) People's capacity to process information and take action at peripheral perceptual-motor levels is significantly limited. (7) To cope with the latter limitations and to satisfy task priorities, flexible strategies are used for scheduling concurrent tasks. (8) These strategies are implemented by efficient executive cognitive processes. (9) New man-machine interfaces may be designed to accommodate people's perceptual-motor limitations. (10) New personnel-training techniques may be crafted to facilitate the acquisition of efficient executive strategies. The present Association Lecture will summarize the work through which these lessons have been learned.

Mental models in theory and practice

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This paper will review and compare the way in which the notion of "mental models" has been used in theoretical applied psychology. In particular we will examine some cases where operators control very complex dynamic variables and degrees of freedom. We will define a model as an homomorphic mapping of the properties of physical systems into the mind, and consider why it is necessary to invoke the notion of a "model" when looking at ways in which operators of real systems behave. We will discuss some approaches to mental model identification and representation in such cases, and will discuss how attention and performance are related to model properties, and how such considerations can lead to the useful application of basic psychological research.

An integrative system of metacognitive components involved in retrieval from human memory

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A theoretical system of metacognitive components for self-directed memory retrieval is described and empirically evaluated. These components consist of: (1) a preliminary feeling of knowing for an answer, (2) a confidence judgment in a retrieved answer after a search of memory, (3) a decision of whether to output a retrieved answer, (4) a subsequent feeling of knowing for an unretrieved answer, and (5) a decision of whether to continue or terminate searching memory for the unretrieved answer. Some of these components have been investigated previously but only in isolation. Here we integrate them into a theoretical system for directing one's own retrieval. The system provides a good account of relevant older findings and of several new findings. Some of the new findings demonstrate how people trade off the costs and benefits of continued searching of memory and how the criterion for the decision to continue searching varies in a predictable way. The theoretical system also accounts for several newly reported findings from earlier research (and related findings in the literature) by postulating two separable subdivisions in the system: One major subdivision gives rise to guesses (including commission errors and correct responses) whereas the other major subdivision gives rise to omission errors; different metacognitive mechanisms are proposed to mediate the activity of each of those subdivisions.

Examining individual differences in the adaptive use of strategies in an air traffic controller's task

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There are two types of factors that influence strategy selection: those that are intrinsic to the current problem or task at hand, and those that are outside the local problem, but are part of the general problem environment. For example, one intrinsic factor that has been shown to influence strategy choice is manipulated familiarity with subcomponents of the problem. By contrast, an example of an extrinsic factor that has been shown to influence strategy choice is how often a particular strategy has been successful in the recent past. The first part of this talk reviews some of the evidence that supports this intrinsic/extrinsic conception of strategy choice. The latter part of the talk applies this framework to the following questions: (a) are people sensitive to the environmental characteristics of the task environment in a dynamic task such as a simulated air traffic controller's task?; (b) if they are sensitive and adaptive, do people differ in their sensitivity as measured by differences in their adaptation profiles?; and (c) can we predict differences in sensitivity and adaptivity based on other individual difference measures?

Theory-driven neuropsychological rehabilitation: The role of attention and competition in recovery of function after brain damage

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Why do patients who suffer brain damage recover partially or completely in most cases? While neurophysiological mechanisms play a part in the acute recovery phase, it is necessary to invoke neuropsychological mechanisms also, particularly to explain the gradual post-acute recovery. There is however no theoretical framework within which to explore such mechanisms of recovery, other than that of Luria, who argued that recovery is based on compensatory functional reorganisation of residual undamaged circuits.

This paper presents examples of compensatory mechanisms underlying recovery of function, but argues that these have their limitations. Under certain circumstances, it is argued, intrinsic recovery of the impaired circuits - restitution of function - may be possible. This is particularly plausible in the light of recent evidence of a much greater plasticity in the adult central nervous system than has previously been recognized.

Learning underlies much recovery of function - both compensatory and restitutive - and intact attention is a prerequisite for many types of learning. Data are presented showing that attentional function shortly after stroke predicts motor recovery two years later. This finding is related to Posner and Peterson's view that there exist functionally and anatomically distinct supramodal attentional control systems in the brain, and evidence from a factor analytic study of a everyday attentional performance in a sample of normal subjects is presented to support this view of attention.

Posner proposed that a system responsible for spatial orientation of attention may be modulated by a right-hemisphere dominant alertness/sustained attention system. A number of experiments are described which support this notion, including a rehabilitation study showing that left spatial inattention can specifically be improved by manipulating alertness.

Attention and action are intimately linked, as Rizzolatti and many others have shown. Rizzolatti has also suggested that space may be separable into personal, near extrapersonal and far extrapersonal regions respectively. Studies are reported showing that irrelevant movements of a left limb in left hemispace reduce unilateral neglect, which is not the case for movements of the left limb in right hemispace or the right limb in left hemispace. Furthermore, simultaneous moves of both left and right limbs together abolish this effect. This is explained in terms of competitive inhibition and facilitation between distinct but linked spatial attention circuits for personal and extrapersonal space. A simple connectionist implementation of these results is presented, and their effective clinical implementation is demonstrated.

The possibility that some visual information about objects is uniquely available for control of motor actions with respect to these objects, as suggested by Goodale and

others, led to experiments showing that unilateral neglect could be reduced by changing the nature of the response to long metal rods from one of pointing to one of reaching-to-grip. A further experiment demonstrates short-term improvements in neglect using a variant of this procedure where patients are permitted to experience the discrepancy between their phenomenal visual environment and their proprioceptive experience.

In summary, theoretically-based cognitive and neuro-psychology is essential for the development of effective rehabilitation strategies in order to facilitate recovery after brain damage.

The development of metacognitive knowledge in children

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In this paper, the literature on the acquisition of metamemory in children is reviewed. First, relevant conceptualizations of metamemory are discussed. A major distinction derived from these conceptualizations concerns the components of declarative and procedural metamemory. Whereas the former is assessed via interviews or questionnaires in absence of any memory task, the latter is derived from individuals' judgments or estimates given during an ongoing memory task. Measures of declarative and procedural metamemory are critically discussed. In a next step, developmental trends in the acquisition of declarative and procedural metamemory are described. The overview starts with the discussion of studies investigating the development of knowledge about person variables, task variables, and strategy variables (i.e., aspects of declarative metamemory) that determine memory performance.

Developmental trends in components of procedural metamemory such as memory monitoring (e.g., performance prediction, feeling-of-knowing, judgments of learning) and self-regulation/control (e.g., allocation of study time, termination of study) are discussed next. The subsequent section describes the major findings concerning interrelationships among metamemory, memory behavior (i.e., strategy use), and memory performance, focusing on developmental trends in these relationships. The last part of the presentation concerns applied issues. In particular, training studies addressing both declarative and procedural metamemory are summarized, and implementations of metamemory training programs in school and university settings are described in more detail.

Individual and group protocols for training complex skills in laboratory and applied settings

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Within the context of the Training Research for Automated Instruction (TRAIN) laboratory, which is dedicated to developing and validating pedagogical principles of automated instruction for diverse curriculum goals, we established a synergy between research and practice in designing individual and group protocols for training complex skills. Guided by theories of complex skill acquisition and by needs of trainers, we designed protocols, tested them in experiments utilizing complex video game-like laboratory tasks, and motivated their employment in aviation and other applications. An Active Interlocked Modeling (AIM) dyadic protocol increased training efficiency 100% without reducing effectiveness in experiments and inspired the pursuit of innovative dyadic protocols for training Israeli Air Force pilots and United States Air Force navigators. A tetradic protocol increased efficiency further without reducing effectiveness and led to the development of new protocols for training pilots at the Irish National Airline, Aer Lingus. In turn, their unique training program raised questions that we addressed in experiments on discussions among trainees and on spacing of practice. Another experiment combined a highly effective training protocol, Multiple Emphasis on Components, with the AIM dyadic protocol. The combination increased effectiveness without decreasing efficiency and became central in original training recommendations for fencers. Similarly, recommended changes in professional football training emerged from backward transfer analyses of task structures, retrospective subject reports, and individual difference patterns across experiments (e.g. increasing correlations between general intelligence and performance over practice). Our research tasks share with football increasing intellectual challenges throughout skill development due to a rich interplay between declarative and procedural processes from beginning to end. Furthermore, instructional design in both settings improve or impair the dynamics of this interplay. Our current efforts are aimed at developing a theoretical framework that will encompass our empirical research and extend the foundation for principled design of complex skill training.

Attention to location and objects affects reaction time and motion perception

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Related presentations of a target at the same location lead to longer reaction times (Inhibition Of Return) in spatial orienting tasks, such as saccadic eye movement or detection, and to shorter reaction times (Facilitation of Return) in feature discrimination tasks. Our latest studies suggested that the underlying mechanisms for the inhibition and facilitation seem to be very much different in terms of spatio-temporal properties, and accumulative learning effects. Motion perception is also known to be influenced by attention, but it showed its own spatio-temporal properties. We compare the variety of psychophysical measures of attention to sort out different modulations at different levels and loci of visual information processing.

Frame of reference for navigation

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Human navigation, whether through real space, or electronic space requires two distinct cognitive subsystems. A perceptual motor control loop is necessary to support actual guidance. A more global visual spatial cognitive map is necessary to represent destinations to approach and hazards to avoid, both of which are necessary for long range planning. These subsystems differ in a number of respects. The former is ego-referenced, 3d (forward looking), close representation of space, defined in terms of the "language of action". The latter tends to be more world referenced, 2d (top down planar), and global in scope.

Designing display systems to support these two cognitive systems represents a challenge because the navigator not only needs both kinds of information, but also knowledge of how one relates to the other, in order to perform the necessary cognitive transformations to determine whether "what I see" (the perceptual motor loop), corresponds to "where I should be" (the cognitive map). We will discuss a program of research on the development of such displays for navigation in guidance in both the airspace and in electronic space. Our focus will be on how different philosophies of display integration support both guidance and global hazard awareness.

Prospective time judgments and workload

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If participants know in advance that they will be asked to judge the duration of a task (the definition of prospective time judgment), they must divide attention between the stimulus information processing task and the temporal task. Assuming that attentional resources are limited, prospective duration judgments are related to the amount of attentional resources allocated to an information processing task. In other words, prospective duration judgments reflect the workload demands of a task. Coverging evidence, both theoretical and empirical, suggests that performance on a duration production task is indeed a sensitive, practical, and non-obstructive index of workload.

Because people make prospective time judgments in many real life situations, these judgments may be used to asses the workload involved in performing various everyday tasks. We discuss several of these situations and illustrate how prospective time judgments can be used to understand task-related attentional processes. Two examples involve making decisions under stress and waiting in lines. The use of time production as a workload measure in applied settings is also described. The benefits and shortcomings of the utilization of prospective duration judgment in everyday situations is discussed from theoretical and practical perspectives.

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