

Dynamic Cognitive Processes in Broad Perspective

Colin M. MacLeod¹, Bob Uttl², and Nobuo Ohta²

¹University of Waterloo, Canada

²University of Tsukuba, Japan

Summary. This brief chapter provides an overview of the book. A sketch is provided of the sharp contrast between the popular view that cognition is relatively static and the view in the discipline that cognition is highly dynamic. This provides the high-level theme of the entire book. Weaving throughout the book are several other more specific themes, notably the roles of consciousness and of inhibition in cognition, and the complementary behavioural and neuroscience approaches. Linkages across chapters are described, and a brief synopsis of each chapter is provided.

Keywords. Dynamic cognition, static cognition, perception, attention, memory.

Introduction

In the “real world”—which cognitive psychologists resolutely insist on thinking they are part of—it is widely believed that the apparatus of cognition is static. This has been true for millennia, perhaps the result of (or at least a reflection of) Plato’s powerful “wax tablet” metaphor conjuring an image of a fixed memory. Eyewitness reports in the courtroom serve as the quintessential example. Eyewitnesses have seen the episode with their “own eyes,” so police, jurors, and judges place heavy reliance on their “first hand” descriptions and recountings of the event. Perception is seen as literal, as if done by an audio/video recording device: What happened is precisely what the eyewitness saw and heard at that moment in time. Attention is seen as automatic, captured in a thoroughly consistent way by the event: What happened was the focus of the eyewitness’s experience, shared with other eyewitnesses. Memory is seen as composed of faithful records of the event as if captured on videotape; they may fade but they do not change over time: What the eyewitness reports from memory later is

exactly what they experienced at the time of the original event, which in turn is exactly what happened.

Cognitive psychologists know that this perspective is wrong. Indeed, it would be considerably closer to the truth to say that this perspective is wholly wrong than wholly right. We have known this for a long time, perhaps since the very beginnings of psychology in the late 1800s, and we continue to reinforce and elaborate on just how wrong this view is, as our understanding of cognition broadens and deepens.

The cognitive revolution that began a half century ago has, in fact, been very much about the realization of how sweepingly non-static cognition really is. This is strikingly clear in the book that became the “manifesto” of cognitive psychology: Ulric Neisser’s *Cognitive Psychology* (1967). On the first page of the introduction, Neisser emphasizes that thought always influences cognition, saying that “Whatever we know about reality has been *mediated*, not only by the organs of sense but by complex systems which interpret and reinterpret sensory information” (p. 3). A few pages later, he brings forth the key idea, saying that “The central assertion is that seeing, hearing, and remembering are all acts of *construction*, which may make more or less use of stimulus information depending on circumstances” (p. 10).

The highly dynamic framework set out by Neisser continues to be the guiding perspective of cognitive psychologists, and explains why we stand apart from everyone else in how we understand the world around us. Dynamic cognition permits flexible interaction with our environment, allowing us to exert “cognitive control” over our experience. We are not passive recipients of information but active manipulators of it.

It might reasonably be said that, after a half century, it is a little discouraging that our dynamic perspective has not overcome the dominant static perspective “out there.”¹ But change of this grand scope is rarely rapid, and inroads have been made. Indeed, the best illustration of a change in everyday thinking about cognition is with respect to the very example described above: eyewitness testimony. The pioneering research of Elizabeth Loftus (1979; Loftus & Ketcham, 1991) and the continuing work of many other cognitive researchers have fostered recognition in the legal community of the fallibility of eyewitness testimony because of the dynamic, reconstructive nature of the cognition upon which that testimony rests. As another illustration, the burgeoning literature on false memories (see, e.g., Schacter, 1995; 2001), where we create in our minds episodes

¹ In fact, this fundamental idea of cognition being constructive goes back much earlier, at least to the work of Bartlett (1932) on memory, amazingly done at the height of behaviorism, which itself took a decidedly more static perspective.

that did not actually happen yet we confidently believe them to have happened, attests further to the pervasive dynamics of cognition.

A Survey of the Book

The chapters in this book provide evidence of how very dynamic cognition is. They represent “state of the art” descriptions of research programs covering the range from perception to memory. They also illustrate the breadth of the approaches and methodologies being used to reveal cognitive processes, from behavioral studies to brain imaging. Our goal in this first chapter is to guide the reader through the organization of the book, to give a sense of the emphasis of each chapter, and to highlight some of the principal themes that cut across the chapters.

Beginning our travels at the beginning, in the domain of perception, Behrmann, Geng, and Baker pose a question that has been recognized as fundamental since the earliest philosophers began to think about the mind: How do we develop a usable percept, given the overwhelming complexity of the world around us? In showing that there are a great many processes involved, they make abundantly clear the degree to which multiple stages of interpretation are always ongoing. Yet out of this comes a powerful form of learning, one of which we are ordinarily not even aware. This issue of awareness or consciousness also becomes one of the principal themes of the book, foreshadowing chapters by Merikle and Smith; Rajaram and Travers; Otani, Kato, and Widner, and others. The elegance of the converging approach that Behrmann, Geng, and Baker use—examining normal and patient populations as well as non-human animals, and delving into the behavioral and the neural levels of analysis—provides a kind of “case study” of what is best about cognitive neuroscience. Coming full circle, the book also closes with a chapter by Moscovitch and his colleagues also focusing on the brain-cognition linkage. Not only is cognition dynamic, but so are the neural processes upon which cognition operates.

Continuing to focus on perception, but more at the level of experience, Toppino and Long take what might seem to be a very simple—and hence simply explained—perceptual phenomenon and show its cognitive complexity. They examine one of the best known of all visual illusions—the Necker cube—and in a series of simple yet powerful experiments demonstrate that the resonance between the two ways to see the figure is due neither to bottom up nor to top down processes, but to both operating in concert. The interplay between the two types of processing is fundamentally dynamic: We are constructing our perceptions, not simply having them

wash over us. That this is true for a simple line drawing should immediately make clear that cognition is vastly more complex and malleable than a static view could ever hope to explain. Cognitive processes “talk to each other” and through this conversation we develop an understanding of our world in all its complex interaction.

Moving to the realm of attention, Humphreys, Braithwaite, Olivers, and Watson describe a clever technique for investigating the nature of search processes involved in visual attention. What happens to our processing of a visual scene when part of the display that we must search through is “previewed”? What if the previewed part does not contain what we are looking for? The clear answer at the gross level is that we benefit, sometimes as if that previewed portion can be entirely set aside and consequently not interfere with searching the rest. The preview is very brief in these studies, yet we can rapidly avail ourselves of this information and change the way we deal with the entire display. This flexibility is the hallmark of dynamic information processing. Like Behrmann et al. and also Moscovitch et al., Humphreys et al. relate their findings to the neural underpinnings of perception and attention, reflecting the ever-increasing merging of cognitive and neurophysiological approaches. Moreover, their account of how we disregard the previewed information rests on our inhibiting that information; clearly, this inhibition is viewed as an important part of our ability to attend selectively, a fundamental element of cognitive control. By introducing the concept of inhibition here, Humphreys et al. also establish one of the major themes of this conference, as will become evident when we consider some of the chapters on memory by Whittlesea and Hughes; Anderson; Rajaram and Travers; and Sheard and MacLeod.

Merikle and Smith provide a bridge from the perception and attention chapters to those on memory. They tackle a problem that was long neglected in the study of cognition, and even seen as impossible to study—consciousness. Over the past quarter century, though, there has been a dramatic change in this view, both in attention and memory, and indeed elsewhere in psychology. Consciousness research, in one form or another, now abounds. This is certainly in keeping with the dynamic perspective, and even broadens it to include dramatic processing below awareness. Again, a simple question becomes the basis for an elegant series of studies: How long does information acquired beneath the level of consciousness persist in memory and influence our behavior? Their answer is that such information may last a very long time, and again the beauty of a converging approach is ably demonstrated. They show this via their own careful experiments, via a meta-analysis of relevant literature, and via research on anaesthetized patients, finding all of these kinds of research to point to the same conclusion: that unconsciously perceived information leaves a quite

deep and lasting footprint in memory. In so doing, they amplify one of the central themes of the conference—the role of consciousness in cognition. There would definitely appear to be dynamic processes operating not only above but also beneath the surface of consciousness.

Like Merikle and Smith, Whittlesea and Hughes write about research at the interface between perception/attention and memory. The phenomenon they study is itself evidence that we do not simply see precisely what is “out there.” *Repetition blindness* refers to our failure to detect the reoccurrence of a stimulus in a rapid, but quite brief, stream of stimuli. Why would we fail to detect such a repetition? There are theories that ascribe this failure to inhibition of the repeated item’s representation, again raising the inhibition theme that began here with Humphreys et al. Whittlesea and Hughes, however, present evidence that calls such an inhibitory explanation into question. Indeed, they argue strongly against such an activation/inhibition account more broadly in the realm of memory. They characterize such an explanation as far too static and opt instead for an account in terms of construction and attribution, which they argue to be optimally dynamic. The world around us is uncertain, and we must rapidly resolve that uncertainty to know how to function. To do so, we construct plausible interpretations on line from the information available in the world and in memory, and then we attribute our experience to the stimulus (or its facsimile in memory) rather than to our interpretation. Under this view, perception and memory are highly dynamic, piecing together “on the fly” a believable story about experience.

Starting from a very different perspective, Terasawa nevertheless arrives at a similar conclusion. He introduces a model of perception and memory that effectively adds what he refers to as *cross-inhibition* to existing large-scale memory models such as Hintzman’s MINERVA2. He asks whether memory is retrieved or created, and suggests based on his model that “created” provides a better answer. Memories are in essence created on line as an outcome of multiple related retrievals. Of course, this answer is consistent with a more dynamic overall perspective on perception and memory. He maintains that remembering derives from activation of multiple non-symbolic representations and simultaneous “inter-restraint” (inhibition) of other representations. Out of this a coherent picture emerges, echoing in a more formal model the construct-and-attribute view that Whittlesea and Hughes put forward in the preceding chapter. Attempting to capture the dynamic nature of cognition in a structured, formal model is indeed an important challenge.

The inhibition theme moves front and center in the work of Anderson, as the book shifts its focus to memory. For a decade, Anderson has built the strongest case yet made for an important role of inhibition in memory.

He maintains that to control memory we must inhibit certain information to highlight other information. This permits behavior, and especially responding, to be flexible to the shifting constraints imposed by the environment. The proposed interplay between inhibition and activation is inherently a dynamic one, but the core of his argument is that inhibition is necessary for executive control—of memory, and indeed of behavior more generally. His experiments are clever and compelling. Most notable is his demonstration that a piece of information inhibited for one purpose may well carry that inhibition with it when it must be used for other, apparently unrelated purposes. In closing his chapter, Anderson makes contact with a number of the other memory situations where inhibition has been seen as playing a crucial role, leading nicely into the two chapters that follow his. And he also reports tantalizing new results suggestive of the localization of inhibitory processing using functional magnetic resonance imaging (fMRI), emphasizing again the cognitive neuroscience theme that runs throughout the chapters of this book.

The inhibition theme is further expanded on by Rajaram and Travers, in discussing what they refer to as “deselection”—a type of negative priming or inhibition that serves the purpose of de-emphasizing certain information in the environment so that other information may be accentuated. They investigate the relative effects of deselection on explicit and implicit tests of memory, where divided attention at encoding has been shown to reduce performance. In putting the emphasis on implicit memory, they return indirectly to the theme of consciousness discussed earlier by Merikle and Smith, given that implicit memory constitutes the use of memory without awareness. They then provide evidence that they see as warranting a long-lasting inhibitory influence. Like Anderson—but in sharp contrast to Whittlesea and Hughes—their overall perspective is that facilitation and inhibition work in tandem to handle the attentional and memorial demands of everyday information processing. Indeed, long-term memory is seen as resulting from the dynamic interaction of these two types of processes.

Sheard and MacLeod take a position much more akin to that of Whittlesea and Hughes than to those of Anderson and of Rajaram and Travers. The issue addressed by Sheard and MacLeod is how we update memory, and they use intentional forgetting—as realized in the *directed forgetting* paradigm—to address this issue. Of course, the very fact that we can update memory—that we can replace an old address with a new one or substitute a revised plan for its predecessor—is evidence of the malleability of learning and memory, and hence of the dynamic nature of processing. In directed forgetting, people are asked to forget specified information on cue, and do so with some success. One account of this has been that we inhibit what we want to forget; another has been that we selectively re-

harse what we want to remember. Interestingly, the evidence for these two accounts comes from different instantiations of the directed forgetting paradigm. Sheard and MacLeod present data in support of the rehearsal explanation, and argue strongly that inhibition is not necessary to explain any instance of directed forgetting, again piquing the debate on inhibition.

Staying in the domain of memory, Otani, Kato, and Widner examine in detail a phenomenon that most people would probably think could never happen—improved memory over time without further opportunity to learn. This is called *hypermnnesia*, which occurs when *intertest forgetting*, the loss of information that occurs quite intuitively with the passage of time, is outweighed by *reminiscence*, the additional recovery of information that can occur due to repeated testing. Their central question is whether reminiscence is conscious or unconscious, again returning to another of the central themes of the conference, discussed already by Merikle and Smith and by Rajaram and Travers. Covering a careful series of studies, they conclude that indeed reminiscence can be implicit, corresponding to the “real world” experience of information just “popping into mind.” Something is happening in memory without further learning or even awareness, that leads to improved remembering, clear evidence of the fluctuating and dynamic nature of memory.

For much of the history of memory research, emphasis has been placed almost exclusively on memory for the past—*retrospective* memory. This bias makes sense: When we talk about remembering, this is what we ordinarily mean. But we also need to remember the future—*prospective* memory, and often find this type of remembering to be especially error-prone. The dentist appointment to go to, the medication to be taken—these intentions must also be encoded and retrieved. But until quite recently this form of remembering had received scant attention in the memory literature. [This may explain why retrograde amnesia seems so much more “intuitive” to people despite the fact that anterograde amnesia is the more common type—again, the natural bias is to associate memory with the past rather than the future.] Unlike the preceding chapters which were concerned with retrospective remembering, the next two chapters, by Uttl and by Graf, place prospective remembering front and center.

The issue of awareness—consciousness—is relevant here again, as prospective remembering requires awareness of our prior intention(s). Uttl considers how prospective and retrospective memory relate to each other, and examines the changes in these abilities with age. As well, he offers a cogent criticism of methods used to evaluate and measure prospective remembering. He also introduces a new paradigm for examining prospective memory, with the research using this paradigm leading him to conclude that decline with age is a function of reductions in both sensory abilities

and processing resources. Graf puts forward an incongruity search hypothesis, which maintains that the initial processing done with respect to a prospective memory cue means that when retrieval occurs later, this cue generates a mismatch between anticipated and experienced fluency which leads in turn to a more concerted search. This kind of fluency and attribution idea harks back to the type of processing proposed by Whittlesea and Hughes in their chapter. Once again, we see on-line evaluation operating in remembering in very dynamic fashion. Indeed, to use prospective memory, we must dynamically recover our intentions while we are engaged in the ongoing flow of information processing.

In the final chapter, Moscovitch and his colleagues examine memory retrieval and consolidation from a broad and converging perspective, similar to that taken by Behrmann, Geng, and Baker at the beginning of the book, and thereby bringing us full circle. Moscovitch et al. explore the retrieval of autobiographical and other types of memories as a way to evaluate the process of consolidation. In the standard consolidation theory, hippocampal activity for a memory is held to decline over time, eventually “dropping out” as the memory is consolidated neocortically. Moscovitch et al. outline an alternative theory that they call *multiple trace theory* under which hippocampal activity does not disappear over time for autobiographical memories. They then describe tantalizing evidence from their own work and that of others to support this novel perspective. These fascinating ideas derive from converging work with normal individuals and amnesic individuals. This chapter is a wonderful place to end the book, illustrating as it does the richly dynamic interconnections in behavior and in brain that permit the successful functioning of cognition despite involving so many kinds of environmental (and mental) stimulation.

Conclusion

We hope that this brief sketch will serve to encourage the reader to delve into the many experimental and especially theoretical ideas brought forth by the authors, and to consider the new perspectives that they raise with respect to inhibition, consciousness, cognitive neuroscience, and the other themes that we have noted in this introduction. Taken as a collection, these chapters provide irrefutable evidence of the dynamic nature of cognition from perception to memory.

Author Notes

Correspondence may be sent to Colin M. MacLeod, Department of Psychology, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada (e-mail: cmacleod@uwaterloo.ca); to Bob Uttl, Institute of Psychology, University of Tsukuba, Ibaraki 305-8572, Japan (e-mail: bob.uttl@alfalab.com) or to Nobuo Ohta, Institute of Psychology, University of Tsukuba, Ibaraki 305-8572, Japan (e-mail: nobohta@human.tsukuba.ac.jp).

References

- Bartlett, F. C. (1932). *Remembering: A study in experimental and social psychology*. New York: Macmillan.
- Loftus, E. F. (1979). *Eyewitness testimony*. Cambridge, MA: Harvard University Press.
- Loftus, E. F., & Ketcham, K. (1991). *Witness for the defense: The accused, the eyewitness, and the expert who puts memory on trial*. New York: St. Martin's Press.
- Neisser, U. (1967). *Cognitive psychology*. New York: Appleton-Century-Crofts.
- Schacter, D. L. (Ed.) (1995). *Memory distortions: How minds, brains, and societies reconstruct the past*. Cambridge, MA: Harvard University Press.
- Schacter, D. L. (2001). *The seven sins of memory: How the mind forgets and remembers*. Boston: Houghton Mifflin.

