PROSPECTUS: *THE COGNITIVE SCIENCES*

Dr. Michael R.W. Dawson,
Professor, Department of Psychology,
The University of Alberta,
Edmonton, AB
CANADA T6G 2P9

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Phone: 780-492-5175
E-mail: mdawson@ualberta.ca
Website: http://www.bcp.psych.ualberta.ca/~mike/
Online CV: http://www.bcp.psych.ualberta.ca/~mike/CVStuff/index.html

Overview of *The Cognitive Sciences*

Purpose and Audience

The Cognitive Sciences is a book-in-progress that has the primary goal of introducing graduate and senior undergraduate students to the foundations of cognitive science. The main premise of the book is that there are currently three schools of cognitive science: classical cognitive science, connectionist cognitive science, and embodied cognitive science. The purpose of the book is to describe the foundational ideas of each of these schools of thought, to provide examples of research that characterizes each school, and to explore relationships among the three approaches. Is there three different kinds of cognitive science, or are there concepts that provide unifying links between the three different schools?

Organization

The Cognitive Sciences is divided into two main parts. Part I considers each flavor of cognitive science separately, and thus will provide students a solid grounding in each approach.

Chapter 1 compares experimental psychology to cognitive science, noting that cognitive science once was more unified than psychology, but that this may no longer be true. It raises the question is there one cognitive science or many cognitive sciences?

Chapter 2 provides an account of the multiple levels of investigation employed by cognitive scientists, explaining why cognitive science is interdisciplinary. It provides an updated version of the tri-level hypothesis, a perspective that I used as a uniting theme throughout my 1998 book *Understanding Cognitive Science*.

Chapter 3 introduces the core ideas of the classical approach to cognitive science, including rationalism and logicism; recursion; underdetermination and innateness; physical symbol systems, universal machines and production systems; weak and strong equivalence; mental imagery; and modularity.

Chapter 4 introduces the core ideas of connectionist cognitive science in a fashion that compares them to the classical properties that were introduced in Chapter 3. Topics that are treated in Chapter 4 include empiricism; associationism; architectural properties of artificial neural networks; models of animal learning using simple networks; interpreting the internal structure of more complex networks (using musical cognition as an example); distributed representations; and a comparison of connectionism to classical cognitive science using the multiple levels of investigation that were described in Chapter 2.

Chapter 5 introduces the core ideas of embodied cognitive science, and relates these ideas to the foundations of classical and connectionist cognitive science that were presented in Chapters 3 and 4. These include the embodied mind as a reaction to methodological solipsism; stigmergy and environmental control; situatedness and feedback; behavior-based robotics and the subsumption architecture; the extended mind; synthetic psychology; social robotics and social simulation theory; and a comparison of the embodied approach to the other two approaches using the multiple levels of investigation that were described in Chapter 2.

Part II of *The Cognitive Sciences* explores similarities and differences between the different approaches to cognitive science. The basic issue that readers are now in a position to consider in more detail, given the material covered in Part I, is the extent to which the different schools of thought in cognitive science can be unified or at the very least can be exploited cooperatively in a research program.

Chapter 6 takes some of the defining characteristics of classical cognitive science, properties that are frequently used to distinguish it from other approaches, and shows how these characteristics are not as distinctive as is often presumed. For instance, many key ideas – central control, serial processing, local representations, internal models – were a matter of technical conven-

ience. The distinctions between the three approaches in cognitive science are shown to be blurred, raising the possibility for hybrid theories in which ideas from all three different schools of thought can be applied at the same time.

Chapter 7 provides a detailed example of such a hybrid theory by providing an account of the problems studied in the field of visual cognition, and by examining the properties of Pylyshyn's ambitious theory of seeing and visualizing. This theory uses mechanisms from all three different approaches in cognitive science to provide accounts of perception, mental imagery, and the coordination of vision with action.

Chapter 8 provides a second example of the utility of the hybrid approach by showing how musical cognition has been approached by the three different schools of thought. It explores the theoretical relationship between musical cognition and each school of cognitive science, and reviews research on musical cognition that has emerged from each school. It ends by arguing how a complete account of musical cognition requires cooperative interactions from all three perspectives.

Chapter 9 revisits the main theme of Chapter 1 – one cognitive science or many? – in the context of all of the intervening material. It argues that cognitive science is a unified discipline if one focuses on its foundational ideas, and if one does not characterize cognitive science in terms of its different disciplines or its different content areas. However, it leaves room for the reader to disagree with this conclusion.

Distinctive Features

The most distinctive feature of this book is that it introduces cognitive science by giving equal and fair treatment to the three schools of thought in cognitive science: classical, connectionist, and embodied. The first wave of cognitive science texts (Osherson & Lasnik, 1990; Osherson & Smith, 1990; Stillings et al., 1987) emphasized classical cognitive science; later editions of these books (Scarborough & Sternberg, 1998; Stillings, 1995) were revised to include some treatment of connectionism. However, the embodied approach – which is of growing importance (Clark, 2008; Robbins & Aydede, 2009) – is not introduced. Other works introduce the embodied approach (Clark, 1997; Shapiro, 2011), but provide only enough information about classical and connectionist cognitive science to establish a context.re are two distinctive features of the book. The discipline of cognitive science has evolved to the point that a balanced treatment of all major schools of thought is required to provide students a proper introduction.

A second distinctive feature of this book is its modular design. Though the book develops ideas cumulatively, each chapter has been designed to stand on its own. Furthermore, each chapter has been developed in a modular fashion as well, as a series of short essays, each of which can also stand alone. I am excited about this modular approach; it is slightly less restrictive than previous work of mine that basically wrote a mini-chapter with each page (Dawson, 2008; Dawson, Dupuis, & Wilson, 2010), but is still easy to write and to read because it is so focused. It also permits a great deal of flexibility in instruction. For instance, I'm aware that several instructors used only a couple of chapters of my 1998 book to introduce classical or connectionist cognitive science to their classes. The modular approach to the current book may facilitate such usage.

A third distinctive feature of this book is that it will be embedded in a great deal of web support that is currently available from my own web page (http://www.bcp.psych.ualberta.ca/~mike/). From this page, one can access my web support for my PSYCO 354 "Foundations of Cognitive Science" course, which – by the end of the fall term – will have all of its material revised in accordance with *The Cognitive Sciences*. Currently this site includes lecture slides and handouts and sample exams (structured on my 1998 book). The site also provides the University of Alberta Dictionary of Cognitive Science (http://www.bcp.psych.ualberta.ca/~mike/Pearl_Street/Dictionary/). This resource has about 450 visits to its home page a month; over the past year I have added many new definitions to it that are terms covered in *The Cognitive Sciences*. New definitions have

been regularly announced on my Twitter account (http://twitter.com/mrwdawson).

Relationship To Other Texts

Because of the interdisciplinary nature of cognitive science, and because it is such a broad discipline to master, cognitive science courses are themselves interdisciplinary and fragmented. This too is reflected in the structure of the books used in these courses.

Many cognitive science textbooks emphasize content areas (instead of theoretical foundations), and are written by a variety of authors, each a specialist in a particular content area (Gleitman & Liberman, 1995; Green, 1996; Kosslyn & Osherson, 1995; Osherson, 1995; Posner, 1991; Smith & Osherson, 1995; Stillings et al., 1987; Stillings, 1995). The advantage of this approach is that books that have this structure provide a good introduction to the breadth of content areas and methodologies of cognitive science. The disadvantage is that it is difficult to find a unifying theme – why are all of these content areas viewed as illustrating cognitive science? Furthermore, to my knowledge no existing book of this nature provides balanced treatment of the three major schools of thought in the discipline.

A second approach to a cognitive science book is to focus more on example ideas or themes that are relevant to cognitive science. For instance, the first part of one such book (Thagard, 2005) has chapters with titles such as 'logic', 'rules', 'concepts', 'analogies', 'images', and 'connections'. Another popular book (Friedenberg & Silverman, 2012) has so many such topics listed that its table of contents is confusing! Of course, the advantage of such books is that again the variety of topics covered reflects the breadth of the discipline. The disadvantage is that this approach neglects a thematic account of schools of thought in cognitive science; for instance, many of the topics in such books can be found in other disciplines: what specifically is it about them that makes them examples of cognitive science?

The Cognitive Sciences is an example of a rarer book that uses a single author who attempts to introduce the core ideas of the discipline in a systematic fashion. This approach was taken in my earlier work "Understanding Cognitive Science" (Dawson, 1998). That book, though, only explored the relationships between classical and connectionist cognitive science. The evolution of cognitive science as a discipline calls for a similar styled book, but one that is modernized to reflect new approaches in cognitive science.

Relationship To My Previous Books

I have written four books, one of which covers classical cognitive science and relates it to connectionism (Dawson, 1998), two of which focus on connectionist cognitive science (Dawson, 2004, 2005), and one which introduces embodied cognitive science (Dawson et al., 2010). I have used these books as texts in courses offered to third or fourth year psychology students, but know that these books have been used at other institutions (for programs other than psychology, such as the cognitive science program at Carleton, and at both undergraduate and graduate levels). *The Cognitive Sciences* is my first attempt to cover all three approaches to cognitive science in a single volume, and it takes advantage of the extensive experience acquired when I wrote my previous books. For my own foundations of cognitive science course, *The Cognitive Sciences* will be used to replace my 1998 book.

Relation To A Course Syllabus

The organization of *The Cognitive Sciences* has reflected my very long experience in teaching cognitive science at the undergraduate and graduate levels. My courses are generally offered during a single semester composed of 13 weeks. Chapters 1 and 2 would be presented as an introduction to the discipline in the first two weeks of such a course. The next six weeks of the course would present the material in Chapters 3 through 5, spending two weeks apiece on each school of thought. The remaining chapters, which explore relationships amongst the three schools of thought, would be covered in the remaining weeks of the term, with each chapter covered in its own week of classes.

Current Status Of The Manuscript

At the time this prospectus is being written, I have completed a complete draft of the entire book. This first draft is 222,973 words, 45 figures, and 17 tables. A detailed table of contents, with information about the current status of each chapter, is provided in the pages that follow.

Chapter Descriptions Including Tables of Contents

1. Part I: The Cognitive Sciences
    - The purpose of Part I of the book is to provide the theoretical foundations of the core ideas in cognitive science. In the current status of the discipline, these core ideas have to be presented in the context of three general schools of thought: classical cognitive science, connectionist cognitive science, and embodied cognitive science. Part I, which consists of the first 5 chapters, has the primary goal of introducing the core ideas as well as the basics of these schools of thought. At the end of Part I, the reader should have an excellent sense about the foundations of modern cognitive science.

Chapter 1: The Cognitive Sciences: One or Many?
Earlier work argues that psychology is fractured, but cognitive science is not. I'm going to challenge this view by citing some debates between different approaches to cognitive science. This will raise the key theme of the book: is there unity in cognitive science, or is it fractured too?
Current status: Completed, 12,198 words, 4 figures
Table of Contents For Chapter 1 (Titles with page numbers):

Chapter 2: Multiple Levels of Investigation
The purpose of this chapter is to introduce some basic notions of how information processing systems are to be explained, and to relate these to cognitive science. Basically I argue for the need for 4 different levels of investigation. This chapter also has a nice historical tone. It will be used as the glue to hold the different approaches to cognitive science together, particularly in Part II.
Current status: Completed, 17,124 words, 2 figures, 2 tables
Table of Contents For Chapter 2:

Chapter 3: Elements of Classical Cognitive Science
The purpose of this chapter is to introduce the basic ideas of the classical approach to cognitive

science. It also provides examples of studying cognition at the various levels of analysis introduced in Chapter 2. In my view, this chapter is a very excellent introduction to the foundations of the classical approach.

Current status: Completed, 34,960 words, 13 figures, 1 tables

Table of Contents For Chapter 3:

Chapter 4: Elements of Connectionist Cognitive Science

The purpose of this chapter is to present the foundations of connectionist cognitive science, and to contrast its foundational ideas with those of classical cognitive science introduced in Chapter 3. The structure of this chapter roughly (but not perfectly) mirrors the structure of Chapter 3. The latter part of the chapter emphasizes the need for interpreting the internal structure of networks, and illustrates this with some interesting and novel work involving networks trained to deal with musical chords.

Current status: Completed, 43,492 words, 15 figures, 13 tables

Table of Contents For Chapter 4:

Chapter 5: Elements of Embodied Cognitive Science

The purpose of this chapter is to present the foundations of embodied cognitive science, and to contrast its foundational ideas primarily with those of classical cognitive science introduced in

Chapter 3 and (to a lesser extent) with connectionist cognitive science introduced in Chapter 4. This chapter introduces some key ideas, like stigmergy, the subsumption architecture, robotics, and simulation theories of mindreading. This material on embodied cognitive science is material that usually wouldn't be found in a book discussing the classical and connectionist approaches, which are more established.

Current status: Completed, 31,533 words, no figures or tables

Table of Contents For Chapter 5:

2. Part II: Unifying Approaches In Cognitive Science
    - The purpose of Part II of the book is to explore possible unification of the three approaches to cognitive science introduced in Part I. Each chapter will focus on a topic, a content area, or an idea, and will explore the theme of the chapter from all of the different perspectives. I haven't made any final plans for this part of the book, but here are some ideas that are likely to be treated; this list is very rough, and is likely not complete:

Chapter 6: Marks Of The Classical

This chapter begins with Vera and Simon's (1993) claim that all three approaches to cognitive science are intrinsically classical, as well as criticisms of this claim, not to mention more radical positions that argue for the adoption of one approach to cognitive science and the abandoning of others. The chapter then asks whether there exist "marks of the classical" – features that reliably distinguish a classical model from competitors consistent with different schools of thought. A detailed examination of many possible marks of the classical, drawing heavily on the history of digital computers, follows. It is concluded that no reliable marks of the classical exist. This conclusion is then used to propose that there is room for all three positions to be contributors to cognitive science, and that there is even the likelihood that all three positions can be included together in a single account of a cognitive phenomenon. The chapter ends with a brief overview of one such theory, McNeill's (2005) account of gesture and thought. (A more detailed example of a hybrid theory, Pylyshyn's account of visual indexing, is presented in more detail in the next chapter.)

Current status: Completed; 23,448 words; no figures or tables

Table of Contents For Chapter 6:

Chapter 7: Seeing and Visualizing

The purpose of this chapter is to present an overview of Pylyshyn's theory of visual indexing. This is because this theory is an excellent example of a hybrid theory that has classical, connectionist, and embodied characteristics. This is also because Pylyshyn is well known as a champion of classical cognitive science, and a critic of the other two approaches. In addition to providing an example hybrid theory, this chapter provides an interesting introduction to the various problems facing cognitive scientists who are concerned with explaining vision or spatial reasoning.

Current status: Completed, 20,400 words, 8 figures, no tables

Table of Contents For Chapter 7:

Chapter 8: Classical Music and the Cognitive Sciences

The purpose of this chapter is to take a more speculative approach to integrating the three schools of thought in cognitive science by proposing how they might contribute to an account of music. This chapter is be a revision and extension of a chapter in my "From Bricks To Brains" book; this previous chapter looked at the cognition of classical music from the perspectives of classical cognitive science and embodied cognitive science. The chapter begins by establishing the analogy that cognitive science is classical music, and then examines three different kinds of classical music, relating each to one of the schools of thought in cognitive science. The kind of research conducted on musical cognition by each school of thought is reviewed, emphasizing the differences between each approach. The chapter ends, though, by considering possible links between the approaches as would be expected in a unified cognitive science

Current status: Completed, 28,072 words, no figures, no tables

Table of Contents For Chapter 8:

Chapter 9: From The Cognitive Sciences To Cognitive Science

This chapter provides a recap of the main issue of the book – one cognitive science or many? – and explores some ideas about how cognitive science may be unified. It argues that the main problem with the classical approach is its continued focus on what Norman called "the pure cogni-

tive system". It suggests that one approach to dealing with this situation is recognizing that cognitive science is pre-paradigmatic, and that elements of all three schools of thought are required to provide a complete account of cognition. Two general approaches for fostering such cooperation, natural computation and synthetic psychology, are briefly discussed.

Current status: Completed; 11,746 words, 3 figures, 1 table

Table of Contents For Chapter 9:

References

Clark, A. (1997). *Being There: Putting Brain, Body, and World Together Again*. Cambridge, Mass.: MIT Press.

Clark, A. (2008). *Supersizing The Mind: Embodiment, Action, And Cognitive Extension*. Oxford ; New York: Oxford University Press.

Dawson, M. R. W. (1998). *Understanding Cognitive Science*. Oxford, UK: Blackwell.

Dawson, M. R. W. (2004). *Minds And Machines : Connectionism And Psychological Modeling*. Malden, MA: Blackwell Pub.

Dawson, M. R. W. (2005). *Connectionism : A Hands-on Approach* (1st ed.). Oxford, UK ; Malden, MA: Blackwell Pub.

Dawson, M. R. W. (2008). Connectionism and classical conditioning. *Comparative Cognition and Behavior Reviews, 3 (Monograph)*, 1-115.

Dawson, M. R. W., Dupuis, B., & Wilson, M. (2010). *From Bricks To Brains: The Embodied Cognitive Science Of LEGO Robots*. Edmonton, AB: Athabasca University Press.

Friedenberg, J., & Silverman, G. (2012). *Cognitive Science: An Introduction To The Study Of Mind* (2nd ed.). Thousand Oaks: SAGE.

Gleitman, L. R., & Liberman, M. (1995). *An Invitation To Cognitive Science, Second Edition: Language* (Vol. 1). Cambridge, MA: MIT Press.

Green, D. W. (1996). *Cognitive Science: An Introduction*. Oxford: Basil Blackwell.

Kosslyn, S. M., & Osherson, D. N. (1995). *An Invitation To Cognitive Science, Second Edition: Visual Cognition* (Vol. 2). Cambridge, MA: MIT Press.

Osherson, D. N. (1995). *An Invitation To Cognitive Science, Second Edition*. Cambridge, MA: MIT Press (3 volume set).

Osherson, D. N., & Lasnik, H. (1990). *An Invitation To Cognitive Science: Language* (Vol. 1). Cambridge, MA: MIT Press.

Osherson, D. N., & Smith, E. E. (1990). *An Invitation To Cognitive Science: Thinking* (Vol. 3). Cambridge, MA: MIT Press.

Posner, M. (1991). *Foundations of cognitive science*. Cambridge, MA: MIT Press.

Robbins, P., & Aydede, M. (2009). *The Cambridge Handbook of Situated Cognition*. Cambridge ; New York: Cambridge University Press.

Scarborough, D., & Sternberg, S. (1998). *An Invitation To Cognitive Science: Methods, Models, And Conceptual Issues* (2nd ed. Vol. 4). Cambridge, Mass.: MIT Press.

Shapiro, L. A. (2011). *Embodied Cognition*. New York: Routledge.

Smith, E. E., & Osherson, D. N. (1995). *An Invitation To Cognitive Science, Second Edition: Thinking* (Vol. 3). Cambridge, MA: MIT Press.

Stillings, N., Feinstein, M. H., Garfield, J. L., Rissland, E. L., Rosenbaum, D. A., Weisler, S. E., et al. (1987). *Cognitive Science: An Introduction*. Cambridge, MA: MIT Press.

Stillings, N. A. (1995). *Cognitive Science: An Introduction* (2nd ed.). Cambridge, Mass.: MIT Press.

Thagard, P. (2005). *Mind: Introduction to Cognitive Science* (2nd ed.). Cambridge, Mass.: MIT Press.