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*Achim Stephan, Sven Walter (Eds.),
Handbuch Kognitionswissenschaft*

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Achim Stephan, Sven Walter (Eds.), Handbuch Kognitionswissenschaft

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Introduction

The defining aim of a handbook is to provide a concise and comprehensive overview of the existing knowledge on a particular topic. For a handbook of cognitive science, this must thus be what we know about cognition.

A handbook for cognitive science is a formidable challenge on at least three accounts. First, cognition is a field wider than many: it ranges from explaining the behavior of a single organism to humans' musings in the formal language of logic. A handbook must thus cover a wide swath of territory and describe connections between seemingly disparate phenomena. Second, cognitive science is a young and rapidly developing science, its state defined not (or not anymore) by agreed-upon foundations, but rather on selecting from among several *prima facie* equivalently probable alternative explanatory schemes. Thus, a handbook of cognitive science cannot be a simple enumeration of current truth nuggets; rather, it must draw the scene where current ideas compete. Finally, cognitive science is a new and independent discipline created at the melting point of a handful of disciplines. A handbook of cognitive science must thus tackle the problem of proving a perspective that is unifying and pluralist at the same time.

The *Handbuch Kognitionswissenschaft* takes on this at least tripartite challenge and solves it with bravura. It covers a very broad range of topics in cognitive science. It is up-to-date on all major positions, conceptualizations, views and research programs. Finally, its structure offers a treatment that keeps the connection to its original science while making room for truly new and original transdisciplinary research. The resulting conceptual tensions in the book thus reflect the tensions in the field, the openness of questions, and the contributions of competing approaches. The *Handbuch Kognitionswissenschaft* forms an invaluable source of information for any cognitive scientist or student with a basic familiarity with cognitive science.

The book consists of 5 sections, often subdivided into subsections, of which these are again subdivided into chapters, most of which have a unique set of authors. It begins with 1) a short introductory section on the history and origins of cognitive science, followed by 2) 6 sub-sections introducing the six sub-disciplines that make

up cognitive science (anthropology, computer science, linguistics, neuroscience, psychology and philosophy). The following sections, 3 and 4, are the core of the book and carry its thrust. Section 3 comprises 10 chapters introducing major current overall conceptions of cognition, and section 4 consists of 25 chapters discussing current topics in cognitive science, mostly in the form of cognitive abilities ranging from perception and attention to reasoning and solution finding. The book closes with a fifth section consisting of 10 chapters on most recent developments in cognitive science.

In the following I will discuss each section of the book, starting with section 2, followed by 3 and 4, before discussing the framing of the book in section 1 and 5. The review closes with a comparison to similar volumes.

The sub-disciplines of cognitive science: section 2

Section 2 of the handbook presents the subdisciplines of cognitive science. It follows the seminal paper by Keyser, Miller and Walker (1978) in what disciplines make up cognitive science: anthropology, computer science, linguistics, neuroscience, psychology and philosophy. These disciplines could hardly be a more diverse mix. Consisting of both human and natural sciences, they differ not only in primary approach and topic, but also culture and vocabulary. If cognitive science is to be a truly transdisciplinary science, as the editors explicitly purport, cognitive science will lie in between the disciplines, i.e. in their interrelations. Given that there are 6 sub-disciplines, there are 30 possible connections through which any one discipline might influence another.

How, then, does one concisely set so much information down into a handbook? The *Handbuch Kognitionswissenschaft* follows several ordering principles. First, each discipline is portrayed in several chapters with separate authors who are experts in their field. Second, each section consists of an introduction summarizing the content of the upcoming chapters, which are labeled by subdivisions of the discipline. Psychology, for example, is subdivided into cognitive psychology, cognitive modeling, neuropsychology, developmental psychology, personality psychology and evolutionary psychology. The subdivision orders the findings by the approach taken, but also by the relation between disciplines: e.g. neuropsychology combines neuroscience and psychology, cognitive modeling psychology and computer science, etc. Third, to guide the reader, each subdivision has roughly a common structure: a description of central questions and methods is followed by an exposition of the relation to other (sub-) disciplines of cognitive sciences, examples of specific findings or positions, some current directions and a short enumeration of further literature.

While laying the foundation for the rest of the book, however, any attempt to harmonize and display each discipline on equal footing has by nature to be partial: each discipline is described not without its idiosyncratic style and vocabulary.

Further, while some chapters offer an introductory treatment, others are rather advanced technical synopses of the state of the respective field. Last, while some sub-chapters describe a very broad and established field of study (e.g. cognitive psychology), others rather describe a single research program or perspective (e.g. evolutionary psychology).

In sum, the second part of the book convincingly summarizes the sub-disciplines of cognitive science and the wealth of their interrelations, thereby laying the groundwork for the truly transdisciplinary perspective on human cognition in sections 3 and 4.

Structures of cognition and cognitive functions: sections 3 and 4

Sections 3 and 4 are the core of the book, consisting of chapters that summarize the different major conceptualizations of cognition over the last 50 years and ensuing research rationales (section 3), and a comprehensive collection of essays on the different cognitive functions (section 4).

Part 3 begins with an excellently clear, brilliantly written 3-chapter introduction by Tarek R. Besold and Kai-Uwe Kühnberger to developments in historical order: the computer model of the mind, i.e. cognition as symbol processing, a response to its shortcomings by connectionism and neural network models, and a consensus view that a full description of human thinking is likely impossible without integrating elements from both a symbolic and sub-symbolic account. The subsequent 7 chapters address more recent approaches to conceptualizing cognition, partly as a response to the failures of previous approaches to provide applied solutions to real-world problems as encountered in robotics and the ensuing lack of credibility in explaining human cognition. Those include all major current positions from dynamical systems theory, to embodied, embedded, situated and social cognition and enactivism.

This section of the book is particularly vivid in portraying the rapid development of cognitive science in the past few decades and its current state as a plethora of competing approaches. Not only has the computational theory of mind lost its explanatory primacy, but what counts as cognition has shifted, branching and widening considerably. The current concept of cognition is not limited to deliberate problem solving and reasoning anymore, but includes perception and navigation. Cognition is also no longer confined to the inside of the head: it is now believed to depend crucially on the world, on culture, artifacts and social norms. Particularly noteworthy are several extremely clearly written chapters by Holger Lyre and Sven Walter, delineating and demarcating approaches describing cognition as 'depending on stuff outside the head' under the labels of embodied, embedded and situated cognition on philosophical grounds. In addition, a short and succinct chapter on evolutionary robotics by Marieke Rohde provides a great example for a current

research project that conceptualizes cognition very broadly, and as fundamentally embodied, embedded and situated.

In general, the handbook does an excellent job of presenting the wide variety of emerging approaches and conceptualizations in an evenhanded manner. This balanced view has much virtue. While progress has undoubtedly been made in understanding the mind, it is unlikely that hitherto any part of cognition has beyond doubt been explained by any one approach, while all others have been disproved. A good example for this is the volatile history of neural networks. Introduced as an alternative to the symbol system hypothesis, neural networks were dismissed early in their development as interesting. The finding that one-layer perceptrons could only solve linearly separable patterns (Minski & Papert 1969) was erroneously generalized to the criticism that neural networks are powerless and limited algorithms, stalling progress for decades. In recent years however, neural networks have taken computer science by storm as models of vision (Krizhevsky et al., 2012; Mnih et al., 2015), spurred by novel development in GPU architecture and the availability of large-scale data sets for training. While any one approach may seem more promising than another, the question of which approach will finally explain any part of human cognition remains wide open. The *Handbuch Kognitionswissenschaft* does full justice to this openness by giving an excellent account of all the current competing theories that are likely to shape the future of cognitive science.

Part 4 of the book then offers 25 chapters in which concrete topics of human cognition are discussed, from perception, to attention, problem solving, volition and communication. Each of the chapters aims to provide a unifying, transdisciplinary perspective of a topic in cognitive science. To address the challenges of transdisciplinary writing, many chapters have more multiple authors, often from different disciplines. Those chapters make particularly fascinating reads, showcasing tension between conceptualizations of fundamental concepts through different disciplines, and proposing a tentative resolution.

A particular example is the article on the concept of 'representation' by Gottfried Vosgerau, Alois Knoll, Tobias Meilinger and Kai Vogeley. The authors trace the story of the concept 'representation' from an intentional state (Brentano), through its development into the central and thus heavily theory-laden term of the representational theory of mind and the subsequent diversification into the multiple meanings 'representation' takes in the contexts of the different disciplines constituting cognitive science today. To return to a unified concept for all of cognitive science, the authors propose a liberal definition of representation, as internal states necessary to assume in a theory to explain flexible behavior. While lacking the specificity of a more theory-laden concept, it is a promising starting point for a re-unification of the different existing conceptualizations.

Treatment of origins and future directions: sections 1 and 5

Where does cognitive science come from, and where is it going? The *Handbuch* only briefly addresses the first question. While short summaries of the developments of concepts, or the presentation of one approach as a reaction to the failures or shortcomings of a previous approach are commonly discussed in many chapters throughout the book, only the single chapter constituting section 1 critically discusses the received view of how cognitive science came into existence. While the primary aim of the handbook cannot be self-reflection, more diachronic treatment of cognitive science might have helped to understand the origins of current developments, and allowed the reader to better evaluate current critical movements such as 'Critical Neuroscience'.

In contrast, with respect to the most recent developments of cognitive science the *Handbuch Kognitionswissenschaft* offers considerable material. Many chapters in sections 3 and 4 (structures of cognitive systems, cognitive capacities) address most recent developments. In addition, the fifth section of the book, entitled *Newer developments*, provides a varied collection on recently emerging topics such as affective science, cognitive anthropology as well as ethics, and situated affectivity. One topic discussed here is of particular interest: affective science, i.e. the scientific study of affective phenomena. Colombetti and Stephan report in the chapter 'affective science' that whereas cognition in the sense of rational thought has historically often been construed as opposed to emotion and affect, more recent approaches focus on the interaction and interpenetration of affect and cognition in its wider definition. This view has potential to inform treatment options for emotional disturbances and computational approaches that aim to model emotional understanding and performance. As a particular example of on-going research a chapter by Wendy Wilutzky, Achim Stephan and Sven Walter further addresses situated affectivity as a counterpart to situated cognition: to which degree are affective states constituted or influenced by the context of the agent? It is to be expected that in the years to come, affective phenomena will come into closer focus in all fields of cognitive science, and the treatment of affective science (both in this and other parts of the book) is an excellent primer.

Comparison to similar volumes

Compared to other handbooks of cognitive science The *Handbuch Kognitionswissenschaft* is unique in many aspects. It is written in German, and constitutes the only handbook of cognitive science in this language. Its importance for German-speaking scientists in the field of cognitive science is thus profound. Unfortunately, however, the choice of language may also limit its impact considerably.

Most other comparable volumes in English are narrower in focus or considerably less recent. The *Handbook on Phenomenology and Cognitive Science* (2010), and the *Handbook of Cognitive Science: An Embodied Approach* (2008) focus on specific

research programs, i.e. the phenomenological account and the embodied account of mind respectively. The *Handbuch Kognitionswissenschaft* is similar in structure and spirit to *A Companion to Cognitive Science* (1998), while being considerably more up to date on recent developments and findings, and also to *The Cambridge Handbook of Cognitive Science* (2012), while being nearly twice as long. The *Handbuch Kognitionswissenschaft* cashes out this additional space in a comparably more fine-grained, in depth discussion of single topics. Thus, while readers looking for an introductory and overview treatment of the general concepts of cognitive science may be better served with *The Cambridge Handbook of Cognitive Science*, readers that seek detailed information on particular perspectives, current developments and in-depth discussion may want to consult the *Handbuch Kognitionswissenschaft*.

In sum, compared to other volumes the *Handbuch Kognitionswissenschaft* offers a up-to-date, comprehensive view of the state of cognitive science that currently no other handbook can offer in this form. It is thus an essential volume for any student and practitioner of cognitive science, as well as to any scientist interested in cognition.

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