Recent philosophy of language has been dominated by a strong naturalistic orientation. In his latest book, Jerrold Katz argues vigorously against this approach and thereby offers "a prolegomenon to a future non-naturalism" [p. x.]. Katz's anti-naturalism is presented in a clear, bold, and unapologetic manner. Virtually every position in this book runs contrary to the current received wisdom: Katz favors an account of semantic theory that appeals to a Platonic notion of meaning capable of underwriting a full-blown analytic-synthetic distinction; semantics is seen as a wholly autonomous discipline to which psychology and the other special sciences have no relevance. Katz is vividly aware that such a view is unlikely to be found initially appealing in the current naturalistic climate. Accordingly, Katz examines the sources of contemporary naturalism in patient detail in an effort to undermine the confidence of those who no longer even question whether naturalistic accounts of meaning are adequate, but rather wonder only which naturalistic account is best. At the same time, the bare beginnings of a Platonistic account of meaning are unveiled and its virtues elaborated with sufficient detail so as to entice the reader to pursue the anti-naturalistic project.

After a brief introductory chapter providing a summary of the main claims to be argued for, Katz launches into a lengthy critique of the arguments in Wittgenstein's *Philosophical Investigations* that are designed to undermine the very idea of a theory of meaning. As Katz rightly points out, many of those who wish to develop a theory of meaning are motivated by the apparent existence of the following linguistic phenomena: synonymy, antonymy, analyticity, redundancy. There can be no doubt that there is a very strong *prima facie* case for the existence of such phenomena, and they cry out for theoretical explanation. Katz provides such an explanation in terms of a Platonic notion of sense, and he looks to Wittgenstein's anti-theoretical arguments to see whether the *prima facie* case for a theory of meaning of the kind he himself favors is defeated. Katz allows that Wittgenstein's arguments are effective against Frege's notion of sense, but because Katz's account of sense is weaker than Frege's - in particular, Katz's senses do not by themselves determine reference - these Wittgensteinian arguments are ineffective against Katz's position. Wittgenstein's general anti-theoretical bias is effectively exposed, and Katz does an impressive job of making the case for a scientific semantic theory designed to explain a wide range of semantic phenomena. This chapter is followed by discussions of Wittgenstein and Kripke.
Katz's discussion of Wittgensteinian themes is interesting and illuminating throughout. Many naturalists, however, will need little persuading on the points that Katz develops so well in these chapters: that there is a strong *prima facie* case to be made for a theory that explains analyticity and so on, and that a semantic theory can and should be developed on the model of scientific explanations in other areas. These naturalists do not reject the scientific model of explanation nor the attempt to bring it to semantic theory; rather, they believe that when serious theory construction begins in semantics, the phenomena of analyticity and so on are explained away rather than explained. Naturalists of this stripe will thus turn eagerly to the chapters on Quine and those who have been influenced by him.

Katz focuses on Quine's argument for the indeterminancy of translation in Chapter 2 of *Word and Object*. He has very interesting things to say here. In the end, Katz argues that the case for indeterminacy rests on the independent argument against meaning and analyticity found in "Two Dogmas of Empiricism". Although I found what Katz has to say on this score persuasive, I was surprised to see that his account of the argument in "Two Dogmas" ignores the last two sections of that paper, in which the argument against analyticity is set in broader epistemological perspective. It is these final sections of "Two Dogmas", I believe, that so many have found so persuasive, and the argument of the rest of the paper does indeed look weak without it. This section of Katz's book would have been far more valuable had it addressed the argument against analyticity that derives from Quine's epistemological holism.

In a chapter entitled, "The Domino Theory", Katz argues that just as Quine's argument in *Word and Object* is undermined by the failure of the argument in "Two Dogmas", work of Davidson, Putnam, and Burge that would threaten his favored account of meaning is similarly undermined. Katz attempts to rescue the analyticity of statements such as 'All cats are animals' from Putnam's twin-earth examples by insisting that the imaginary cases do not show that 'All cats are animals' could have turned out to be false, but rather that there might have been no cats. Here, again, the failure to consider the final sections of "Two Dogmas" seems particularly important, for Quine argues there that although one can consistently hold an analytic/synthetic distinction, the result of doing so is that one is left with a distinction that does no theoretical work. Insulating 'All cats are animals' from refutation by way of the move Katz makes here seems to illustrate Quine's point, as Putnam also suggests (in discussing this very suggestion of Katz's) in "The Meaning of 'Meaning'". Once again, it would have been useful to see Katz address this issue more directly.

Katz directly attacks the pretentions of naturalism in a chapter on the naturalistic fallacy. Naturalism requires both an account of the world that eschews abstract entities and that the only grounds for accepting any account of a set of phenomena be scientific grounds. It is argued here that the best available scientific
explanation of semantic phenomena conflicts with naturalism, for it requires the positing of abstract entities. Those who favor some kind of naturalism must therefore do so for reasons that run contrary to their own thesis: the case for naturalism can only be made on extra-scientific grounds. This kind of argument needs to be taken very seriously by contemporary naturalists, and it requires a sensitive weighing of the competing merits of the Platonistic and naturalistic accounts of semantic phenomena. Katz argues that naturalistic accounts inevitably leave out the normative force of claims about meaning, and he is surely right that, at a minimum, naturalists have a lot of work to do here. How, after all, can facts about the way the world is ground normative claims? Even those who are unpersuaded that naturalists can account for any kind of normativity, however, are unlikely to be convinced that appeal to Platonic entities does a better job of explaining the features of normativity that need explaining. Equally troublesome questions arise, it seems, for the Platonist: how, after all, can facts about Platonic entities ground normative claims? Indeed, this is a worry about Katz’s enterprise generally, for the explanations that involve an appeal to abstract objects inevitably appear quite thin and mysterious. Perhaps it would be better to acknowledge here that we currently have no obviously satisfactory explanation of certain phenomena than to pretend, on the one hand, that we have explained them satisfactorily in naturalistic terms or, on the other, that appeal to objects that lack temporal, spatial, or causal properties does the trick any better. To acknowledge this, as I think we should, is to grant much, though by no means all, that Katz argues for here.

A concluding chapter puts all of the foregoing in broader Kantian perspective. Katz sees philosophy as a body of synthetic a priori knowledge, although he rejects Kant’s transcendental account of how we have such knowledge.

Katz has written a consistently interesting and challenging book. Naturalists and Platonists will continue to fight these battles, and, at least for the foreseeable future, the very substantial gaps in each theory will make attempts to elaborate the other an important and attractive option. Katz would have us draw still more favorable conclusions about Platonism and less favorable conclusions about naturalism, but I do not believe that these conclusions are currently warranted.¹

¹ I have received helpful suggestions on a previous draft of this review from David Christensen and Jerrold J. Katz.

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Malcolm McCullough, William J. Mitchell, and Patrick Purcell (eds.), The Electronic Design Studio: Architectural Knowledge and Media in the Computer Era, Cambridge, MA, MIT Press, 1990, x + 505 pp., $50.00 (cloth), ISBN 0-262-13254-0.

For centuries, architects have been designing the shapes of their buildings using paper and pencils as their tools. Over the last two decades, architects have been making increasingly more sophisticated use of computers for the purpose of conceiving and representing buildings. This development raises challenging questions concerning architectural theory and methods, and the education of new architects. In this volume's 33 extensively illustrated chapters (plus an introduction and an afterword that are really full-fledged chapters in their own right), contributors from universities in the United States, Europe, Japan, Israel, Canada, and Australia articulate current theoretical and practical concerns, provide opinions and case studies, criticize both media and methods, and suggest directions for future developments in Computer Aided Architectural Design (CAAD) and for the future of design education.

The book is, in effect, the published proceedings of the CAAD Futures 89 conference, held in Cambridge, MA, in July 1989. (CAAD Futures is one of the premier international conferences dedicated to computer-aided architectural design. It is held once every two years in a different part of the world.) As such, its chapters form a loosely related assortment of papers concerning a wide range of topics in computer-aided architectural design and architectural education. As can be expected from the proceedings of a conference of this stature, many of the chapters were written by noted experts and are of exceptional quality, while other papers lack this distinction. Some of the papers have been previously published elsewhere, as they well should have been, while others should not have been published at all.

To the first category (exceptional quality) belong, among others, the contributions of William J. Mitchell et al. ("Top-Down Knowledge-Based Design"), George Stiny ("What Designers Do That Computers Should"), and Richard Coyne ("Tools for Exploring Associative Reasoning in Design"). Mitchell's contribution (one of three) describes TOPDOWN—an interactive, knowledge-based design system that assists designers in stepwise refinement of an initially schematic idea into a complete and detailed design. Stiny's contribution focuses on the limitations imposed on the designer's creativity by the unambiguous, structured nature of computer-assisted drawings, which do not permit alternative interpretations of the same drawing as hand-drawn shapes do. Stiny proposes a solution to this problem, based on an alternative topological interpretation of line-drawn images. Coyne's contribution describes the uses of hypermedia and neural networks as means to explore associative reasoning in design. All these contributions are significant in that they depart from the "traditional" uses of computers in design as means of representation, and demonstrate how they can be used for ideation.

Minds and Machines 3: 242, 1993.
It is difficult to capture, in a short review such as this, the breadth and depth of the book. On the one hand, the material covered in the book is very broad indeed. On the other hand, the book lacks structure, despite the editors' valiant attempts to group the contributions into four major categories: (1) theoretical foundations, (2) knowledge-based design tools, (3) information delivery systems for design, and (4) case studies: electronic media in the design studio. The purpose of classifying papers into categories is to help the reader identify those that deal with a common topic. In this case, however, the classification is rather misleading, since the inclusion of papers in any given category seems to be arbitrary. For example, of the four papers in the first category ("theoretical foundations"), only Stiny's paper can be considered a truly "theoretical foundations" paper. The other three deal with different approaches to design education, relying on explicit case studies and the authors' experiences. While interesting and important, these papers are neither theoretical nor foundational treatments of their respective subject matters. Furthermore, if by "theoretical foundations" the editors refer to the theoretical foundations of design education, then Omer Akin's paper, "Computational Design Instruction: Toward a Pedagogy", should have been included in this category, too, rather than in the catch-all "case studies" category. Conversely, most of the papers in the second category ("knowledge-based design tools") actually do deal with theoretical and foundational design issues. For that reason, they should have been included in the first part of the book, particularly since most of them do not actually address knowledge-based design (at least, not from the technical point of view this topic has come to mean). Similar arguments can be made for the inclusion of papers in the other categories.

This confusion could have been easily averted by including a preface or an introduction that would have established the agenda of the book and explained the classification criteria. As it stands, the preface is not helpful in this respect and reads more like a back-cover sales brochure than a well-considered lead-in to the book. It also makes some astonishing statements about the nature of design, which can only be explained as having been taken out of context (e.g., "Design is the computation of shape information that is needed to guide fabrication or construction of artifacts" – surely it is much more than that). Such comments seem rather peculiar, considering the origins of this book.

Regardless of their individual classifications, perhaps twelve or fifteen papers in the book are of outstanding quality, in terms of their knowledgeable treatment of their respective subjects and in terms of the clarity of their presentation. Although several of these papers, as noted earlier, have also been published elsewhere (with some variations), their collection in one volume makes this book a valuable addition to any CAAD library. Unfortunately, these excellent papers are dispersed among as many papers that are far less worthy of the reader's attention: some represent the cutting edge of computer-aided design education six or seven years ago, and some are narrowly focused survey papers. Others are ad-hoc case-study reports that were, no doubt, worthy of presentation at the
conference proper, but lack the rigor, endurance, and longevity of contributions befitting publication in a book.

Finally, the lack of color plates in the book seriously detracts from the effectiveness of some papers, and renders the inclusion of at least one paper an outright mistake: Richard Norman’s poetic paper, “Color Contrast and CAAD: The Seven Color Contrasts of Johannes Itten”, made, no doubt, for a dazzling presentation at the conference (as well as in Norman’s own book, Electronic Color, Van Nostrand Reinhold, New York, 1990). Unfortunately, it loses most, if not all, its effect, and practically all its meaning, when the five figures used for illustrating the text are presented in grayscale rather than in the colors they were meant to convey.

Overall, the book does achieve its editors’ objectives, as stated in the preface: it presents a rich collection of ideas, case studies, and experiences in using computers in design education. Nevertheless, to say that the content of the book “frames the issues” concerning “architectural knowledge and media in the computer era”, as stated in the preface and as suggested by the book’s title, is an exaggeration.

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John R. Anderson, Cognitive Psychology and Its Implications, 3rd edition, New York, W. H. Freeman, 1990, xvi + 519 pp., $32.95 (cloth), ISBN 0-7167-2085-X.

I approached the task of reviewing John R. Anderson’s Cognitive Psychology and Its Implications with some trepidation. After all, earlier editions of this text have achieved somewhat of a classic status in the field of cognitive psychology, and many individuals in that field have already formed opinions regarding it. As a graduate student, I have had earlier editions of the text assigned as required reading in a graduate class (and, previously, in an undergraduate class), and have also taught cognitive psychology courses at the undergraduate level. Thus, I have both a student’s and an instructor’s opinion regarding the text. There is much to recommend the text from both perspectives; yet, for a number of reasons, I chose not to adopt it for my own undergraduate cognitive psychology course.

Cognitive psychology encompasses a rather broad spectrum of topics, ranging from perception, attention, and memory, through reasoning, decision making, and problem solving, as well as language. Training in such a field (as in any field) requires adopting an interest area and focusing one’s attention on the issues of that area. As instructors, we naturally emphasize those topics that we are most informed about, while ensuring that we give sufficient attention to the others. It
happens that my interests fall under the domain of perception and attention, which suggests that I would desire a text that also emphasizes these topics. Unfortunately, the Anderson text is not such a text — it devotes one chapter to the topics of perception and attention combined. Anderson's focus is on the higher cognitive processes (he has dedicated separate chapters to problem solving, expertise, and reasoning) and on mental representations (memory), to which he has devoted four chapters. His chapter on development concerns cognitive development and ignores perceptual development. Anderson argues that "the chapter division in my book reflects the growing emphasis on higher mental processes" (p. 10). This statement should be qualified with the words "by some", for there are still those who regard the study of perception and attention as central, and, for such individuals, the Anderson text would not be satisfactory. However, I would no more want to fault Anderson for his focus than I would want to be faulted for the focus I have chosen for my classes. Thus, while one of the reasons I chose not to adopt the Anderson text revolves around the focus it maintains, others may decide to choose it for this very same reason.

Because cognitive psychology is such an all-encompassing field, its instruction is aided by the adoption of a theme with which to tie the disparate contents together. I have found a functionalist approach to its study useful in this regard. I describe to my classes how the empirical findings we discuss provide cognitive psychologists with a window onto the design of the cognitive system, and ask them to consider why the cognitive evolved the way it has: What adaptive value might these exposed features of cognitive architecture have? While the adoption of an overriding theme (not necessarily a functionalist theme, but some theme) is not a necessary feature of a textbook, it helps a great deal in forming the structure for a course. Such a theme appears absent to me in the Anderson text. Anderson ties contents together via aspects of the architecture (e.g., networks, propositions, and production systems) but does not have a unifying conceptual view such as I described. Again, it could be argued that this is not a necessary feature of a text, that, to the contrary, the absence of such a theme allows an instructor the freedom to impose his or her own. For myself, however, the absence of such a theme leaves the impression of a disjointedness among topics when an underlying coherency could (and does) exist.

Despite the claim just made, Anderson does have a theme of sorts or, perhaps more accurately, an assumption that guides his pedagogical writing. The assumption is this: It is possible to model any aspect of human intelligence (problem solving, reasoning, learning, language processing) on a computer such that the computer behaves indistinguishably from a human (pp. 2–3). Any lack of success in this regard is not because of the impossibility of the quest; rather, it is because we do not yet know enough about the intricacies of human cognition. This assumption is in direct opposition to that of those who would argue that computers and humans are fundamentally different, and it is this qualitative difference that prohibits the realization of "intelligent" computers (cf. Penrose
This is a currently controversial issue in the field, and an instructor may want to evaluate whether he or she agrees with Anderson's beliefs on the issue before adopting his text.

When choosing a text for a course, an important consideration for the instructor is the student population for whom it is targeted. Anderson writes in an exceptionally concise manner, wasting no ink on unnecessary verbiage. For a graduate student, this precision is appreciated and desirable. Undergraduates, however, may have trouble with this style. Further, the text treats the subject matter in a rather formal fashion. Undergraduates in a first course in cognitive psychology need to be made expressly aware of the relevance of the study of cognitive psychology to their lives, and an introductory text at this level needs to capture the excitement of the topic. The Anderson text may be more suitable for graduate or upper-level undergraduate study where these concerns are less of an issue.

The new edition of *Cognitive Psychology and Its Implications* incorporates important new findings and shifts in issues that the field has made since the previous edition of this text (Anderson 1985). For instance, some of the recent advances made in the study of imagery by Farah and her colleagues have been added. Changes from the previous edition include a reorganization and tightening of the chapters on language and the addition of a chapter on intelligence. Restructuring the language chapters involved deleting sections on reading, non-human primate communication, and the entire chapter on language generation. These deletions do not prove harmful; the two remaining chapters form a decent and adequate introduction to psycholinguistics. The addition of a chapter on intelligence is congruent with Anderson's emphasis on higher-level aspects of cognition. But there is one cognitive function that deserves to be more adequately covered in Anderson's text because of its essential role in all cognitive functions and because it is currently a central issue in the field: categorization. If there are future editions of *Cognitive Psychology and Its Implications*, they would benefit from incorporating a chapter devoted to this critical topic. Nonetheless, previous editions of this text have served the field well over the past decade as tools for training a whole generation of cognitive psychologists; it appears that the current edition, as it stands, will continue this tradition.

References

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Researchers in disciplines ranging from AI to education are discovering that intelligent tutoring systems (ITS) provide a fertile ground for testing psychological theory, advancing computational science, and addressing various educational problems. This book, a reprint of the February 1990 special issue of *Artificial Intelligence*, presents excellent in-depth discussions of three state-of-the-art ITSs. Its stated goal of informing the AI community of recent advances, insights, and problems in this sub-field is well achieved, and the book provides interesting and worthwhile reading for anyone interested in this growing and important area of research.

Due to the instructional nature of an ITS, several issues not encountered in other AI systems deserve consideration. For example, the design of an ITS should be consistent with our best psychological understanding of the teaching-learning process. In addition, empirical data from students using the ITS are needed to evaluate the tutor's instructional effectiveness and to guide further refinement of the system. For the most part, the ITSs discussed in this book address these concerns in a highly commendable manner. Two of the systems—John Anderson *et al.* PUPS and White and Frederiksen's QUEST—are based on explicit theories of learning. The third—Lewis Johnson's PROUST—is based on a considerable body of psychological research on programming expertise and the nature of student bugs and misconceptions. All three report empirical trials with students.

The tutoring system described in the chapter “Cognitive Modeling and Intelligent Tutoring”, by John Anderson, Franklin Boyle, Albert Corbett, and Matthew Lewis, is based explicitly on Anderson's well-developed cognitive theory of learning, and the stated purpose for developing an ITS is to test this psychological theory. In this latest version of their tutor, the architecture employed in Anderson's well-known ACT* theory has been revised. Among the changes found in the new architecture, called PUPS (PenUltimate Production System), ACT*'s automatic learning mechanisms have been replaced with a system in which generalizations and discriminations are declarative knowledge structures (rather than productions) produced by problem-solving productions. According to the theory, students solve problems by analogy to annotated examples of solutions.

The model-tracing methodology employed in Anderson *et al.*'s three tutors (LISP, geometry, and algebra) includes an ideal model of how students solve the problems presented and a model of the types of mistakes they are likely to make. The error model recognizes and corrects the student's errors, and the ideal model guides the student along the correct solution path as necessary. Evaluation of the tutor indicates that it can reduce the time spent on a learning task, especially when the task is difficult and considerable search is needed to find a correct solution, and that it can increase achievement.
In contrast to the psychological theory-testing evident in the work of Anderson et al., Lewis Johnson's work on PROUST—described in his chapter on "Understanding and Debugging Novice Programs"—is based on a concern for helping students learn Pascal. PROUST diagnoses errors in 60–100 line Pascal programs on the basis of the programmer's presumed intentions. Johnson argues that diagnosis of students' bugs must be based on these intentions, since only in this context can the appropriateness of a particular statement be determined. In performing this task, the system generates possible goal decompositions based on the problem presented to the programmer and then matches the alternatives against the student's program. The match, of course, is seldom exact, and the system uses plan-difference rules to propose bugs and misconceptions capable of explaining these differences. The system then generates the best interpretation from among the alternatives and presents it to the student.

An evaluation of PROUST's analyses of 270 student programs indicates that when PROUST is able to perform a full analysis of a student's program, it identifies between 91% and 98% of the bugs actually present, as determined by a hand-analysis of the programs. When the program is only partially analyzed (i.e., a substantial part of the program was analyzed, but the interpretation was incomplete or inconsistent), a much lower percentage (approximately 35%) of the bugs are detected. With the present version of the system, between 50% and 80% of the programs (depending on the problem presented) receive a full analysis. Unfortunately, data on the extent to which PROUST improves student learning are not currently available.

The third ITS is Barbara White and John Frederiksen's QUEST (Qualitative Understanding of Electrical System Troubleshooting), a system for teaching electrical circuits that contains features of both a microworld and a tutoring environment, described in their chapter "Causal Model Progressions as a Foundation for Intelligent Learning Environments". The system is based on a theory of learning that involves the evolution of mental models from novice to expert (in this case, a high-school teacher). The authors believe that students learn most effectively when they actively apply their knowledge to solving problems and that the purpose of an intelligent learning environment is to develop in students a progression of increasingly sophisticated mental models for reasoning about circuit behavior. A simple model, for example, might involve whether a bulb will light when a particular switch in the circuit is closed; a more sophisticated model might involve current flow when the circuit contains a resistor or capacitor.

Each model in the sequence simulates circuit behavior for a particular subset of circuit problems and supports the type of problem solving involved in the model that the student is trying to acquire. At each stage of learning, the student works on problems concerned with circuit design and troubleshooting, and students can employ various learning strategies, create and experiment with circuits, and ask for feedback and coaching. Pre-test/post-test comparisons of seven high-school students indicate that five hours of work with QUEST enables students to make
accurate model-based predictions, explain the behavior of a circuit, and troubleshoot for opens and shorts.

All three of these ITSs are excellent examples of state-of-the-art work in this field. Each is based on viable research and theory regarding the way in which students learn, and each chapter includes empirical data from student trials, information not always obtained in ITS research. Nevertheless, one might wish for data more relevant to the theory of learning and teaching that drives the system and on the system's effectiveness relative to other forms of instruction. Most of the data reported are quite superficial in this regard, although the authors appear to be aware of this difficulty, a difficulty due largely to the currently developmental stage of ITS research. In sum, this book is must reading for anyone interested in ITSs.

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Nicholas J. Wade and Michael Swanston, *Visual Perception: An Introduction*, Introductions to Modern Psychology, London: Routledge, 1991, x + 212 pp., $16.95 (paper), ISBN 0-415-01043-8.

This is a very readable little book and should be welcome to those who do not enjoy the weight lifting required by too many recent books with a claim to comprehensiveness. It is a good, elementary introduction for the nonspecialist, and it presents refreshing viewpoints to workers in vision. The authors stress the role of vision in functions like motion and space perception, as opposed to visual performance with respect to brightness, color, shape, etc. They focus on our three-dimensional environment and particularly how we deal with the geometry of space and motion and how we recognize objects. The attempt is made to relate perception to the neural substrate and to provide biological relevance. Not the least merit is the historical perspective in Chapter 2, "The Heritage", as well as at other points in the book, such as in the account of the controversies between Wheatstone and Brewster on who invented the stereoscope.

The authors' thinking is in the line of British empiricism and it is influenced by the work of Gibson's psychology and Marr's AI. Computer-based analogies, are the present vogue, but the authors also caution that analogies are not "true" descriptions of "real" phenomena.

Does perception inform us of physical reality? Only to the extent of the physical capabilities of our senses. But within that range our survival is proof that the information is adequate, so that we can continue to function in our physical
environment. Wade and Swanston take a somewhat stronger position than this on "physical reality". But, of course, this is a perennial argument.

Chapter 1 lays out the conditions for understanding visual perception, and Chapter 2 contains some accounts of how we have arrived at our present stage of understanding. Chapter 3, "Light and the Eye", might more appropriately have been named "Light and Vision". The first half describes the structures of the eye and its optical performance, including some elementary ophthalmology. The second half concerns itself with the neurophysiology of the visual pathway and some psychophysical phenomena with a neural interpretation. This is all standard stuff. It is explained in simple language and is generally accurate except for a few glitches and omissions. For example, it is stated that the direct stimulus from photoreceptors hyperpolarizes the bipolar cells when, in fact, there are two classes, the ON and OFF bipolars, one hyperpolarizing and the other depolarizing in response to direct photoreceptor input. The ON and OFF pathways, which originate in the retina, remain identifiable deep into the visual projections and have generated much recent interest.

Chapters 1 to 3 set the stage for the remainder of the book: the psychophysics of space and motion perception and of object recognition. Chapter 4, "Location", which deals with space perception, has some nice touches. It stresses the importance of reference frames—retinocentric, egocentric, and pattern-centric—how the information from each differs, and the need to integrate it. It discusses the variety of cues on which our space perception depends. It describes a nice set of demonstrations—which the reader can implement—for visual direction, binocular rivalry, and stereopsis.

If there is a weakness in this chapter, it is due to the traditional misconception of "corresponding points", which is common to most texts on binocular vision. According to the traditional view, corresponding points in the two retinæ have the same coordinates relative to the foveae, and they have zero disparity. Those points in physical space that are imaged on corresponding points are supposed to be the loci of single vision—which is inaccurate. The supposedly central role of corresponding points in stereo-vision rests on geometrical miscalculations. In fact, the most important cue for binocular stereo-vision is disparity, and the neurophysiological substrate for this is the cells in visual cortex that are tuned to disparity. Their retinal receptive fields are not located at "corresponding points". Much of the confusion could be avoided if the meaning of "corresponding points" was changed to denote those retinal points that project to cortical cells tuned to their disparity.

The Vieth–Müller circles, the apparent loci of equidistance from the observer, have long been given attention, as they are in this book, in connection with "corresponding points". While their importance in this regard is doubtful, they do belong to an interesting class of curves. Generally, as the fixation point changes, the image of an object on the retina is displaced. But there is a class of curves—and the Vieth–Müller circles belong to it—whose images on the retinae remain
fixed as the fixation point moves over such a curve. To my knowledge, the perceptual significance of these curves has never been explored.

In the next chapter, motion, like space perception, is treated with respect to frames of reference: retinocentric, egocentric, and geocentric. Several illusions, like induced motion and the waterfall illusion, are related to these frames of reference. Discussions are presented of the different stimuli to motion perception, of the need to compensate for movements of eyes, head, and observer in computing geocentric motion, and of mistakes (illusions) that occur through misjudgments of parameters like distance from the observer.

"Recognition" is the title of Chapter 6, which contains some further interesting observations on how our vision works. But it does not have much to say about recognition, which occurs when something familiar registers. How does something become familiar, and how is it recognized? Unfortunately, we know little about this, and so Wade and Swanston instead discuss some preconditions for recognition such as perceived size and shape constancy. The neurophysiologists' "tuned" cells and the psychophysicists' channels have raised intriguing questions on how the nervous system may register some features of the visual environment. But how such features might be combined into the Gestalt remains a mystery.

In summary, this is a well-written, up-to-date little book by two very competent authors. Unlike some others, it is not concerned only with the exciting results of yesterday, which may or may not outlast a printing. It shows how much we have learned about visual perception and how much we still have to learn.

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David Levy and Monty Newborn, How Computers Play Chess, New York, Computer Science Press, 1991, $23.95 (cloth), ISBN 0-7167-8239-1, $11.95 (paper), ISBN 0-7167-8121-2.

This is a nice, readable book. It does not cover everything, and sometimes I feel it emphasizes certain things to excess. However, it covers a lot, and for someone who wishes to obtain an education in what has happened over the years in computer chess and what is likely to happen in the next few years, this book is to be recommended.

The description of the Kasparov–Deep Thought match in 1989 starts the book and is done in Newborn's best style. It is perceptive and witty and an excellent chronicle of an event that will certainly be remembered a long time (somewhat as Minds and Machines 3: 251, 1993.
when a child prodigy first appears on a tennis court and is duly drubbed by the champion). However, this will be looked at quite differently a few years from now.

After that, we are treated to a history of computer chess. For real devotees to computer chess, this will be somewhat repetitive, but it is a good, crisp summary of the high points. The coverage of search algorithms used in the main programs and of the relatively new technique of solving simple endgames by data-base analysis is also very fine.

If I have any problem with this book, it is with Levy setting himself up as a yardstick for measuring progress. There are all sorts of rating scales that have measured progress in computer chess, and these are used in the parts of the book done by Newborn. However, Levy chooses to interpret the world in terms of how it revolves around him. While he gives a number of his games against computers, it is interesting to note that he only briefly acknowledges his 4–0 defeat by Deep Thought in 1989, and gives not a single one of the games. Tsk, tsk, David. Science before ego, you know.

However, as I said earlier, this is a book that most readers will enjoy and well worth the soft-cover price.

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