a few interesting lines of research, while many others are omitted, and there is no general account of theory or of the wider research literature. I suggest that a format more like *Advances in Experimental Social Psychology* and *Progress in Experimental Personality Research* would be more useful.

Topics within the terms of reference of the title, or of my amended title, which are omitted are: the evolution of nonverbal signals—gaze, facial, vocal, and others—for aggression; the meaning of those signals in different social contexts (discussed by Ellsworth for gaze); the combination of elements simultaneously or in sequence to make up larger signals, and whether there are "syntactical" principles involved; the similarities of nonverbal communication and language, the combination of verbal and nonverbal signals, and what happens when they conflict; and why nonverbal communication is used by humans at all.

There is almost no discussion of research methods in this volume, although there are at the moment sharp disagreements between research workers about whether or not we should use laboratory experiments, role-playing, or field studies of different kinds. Within animal studies there is disagreement about how far animal social systems should be interfered with—how far provisioning primates affects group behavior, for example. Some research workers use behavior only—frame-by-frame analysis of film or ethological statistical methods—whereas others emphasize the importance of subjective meaning. Some think that there is a sharp separation between the causal laws that govern animal and simpler human behavior on the one hand and human behavior governed by plans, rules, and reasons on the other.

To turn to some of the contents of this book, there is an excellent chapter by Exline, Ellyson, and Long; this reports the Exline experiment showing that low-power members of human hierarchies look more. Ellyson found later that subjects given high power in an experimental situation or rated as having a control orientation according to the FIRO (Fundamental Interpersonal Relations Orientation) scheme looked more when talking, whereas low-power subjects looked more while listening. This makes an important contribution to our knowledge of the tricky relationship between power and gaze. Phoebe Ellsworth reports her well-known experiments showing that the stare can act as a threat; new experiments show that in other social settings a stare can lead to the giving of help, and can inhibit aggression. It is concluded that the stare is an arousing stimulus, but that it can have a wide variety of meanings.

Carroll Izard reports a number of excellent experiments on the expression of emotion—showing that adopting a facial expression results in experiencing the emotion, that fewer shocks were given to an apparently angry victim, and that cutting the facial nerves of rhesus monkey mothers and their infants led to more agonistic and less prosocial behavior.

Several chapters are about animal communication. E. W. Menzel reports a number of studies of a group of young chimpanzees, where there was very little aggression because the animals observed each other very closely and achieved a high degree of coordination of behavior. For example, a less dominant animal gave way to a more dominant one before any aggressive signals were needed. Robert Miller also reports observing very few fights when two monkeys were competing to avoid electric shocks; he was able to reverse dominance relations by conditioning a dominant animal to fear a submissive one, and found that social isolates were poor senders of nonverbal signals and that good senders were poor responders and were of lower status; those at the top of the hierarchy were intermediate senders and receivers. The full implications of these fascinating results have yet to be worked out.

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The Early History of Optics

Theories of Vision from al-Kindi to Kepler. DAVID C. LINDBERG. University of Chicago Press, Chicago, 1976. xii, 324 pp., illus. $20. University of Chicago History of Science and Medicine.

The early history of optics has all too often seemed to be either a recital of one damn thing after another or a tangled mass of esoteric threads. Lindberg's excellent new book brings much intelligibility to the subject. And it is a particularly welcome intelligibility for being open-ended and suggesting further problems for investigation. For instance, what if any difficulties arose from the use of discrete rays to represent essentially continuous radiation?

As the title indicates, the book ranges from the 9th to the early 17th century; there is also a fine, succinct chapter devoted to the essential ancient background. Those whose interest lies in major theoretical turning points may feel that too much space is devoted to the Latin Middle Ages and the Renaissance, and those with more contextualist concerns will wish for greater attention to how optics fitted into the Arabic cultural ambit. But perfect balance is not a high virtue for a work of this kind. Lindberg cuts a (by no means narrow) swath that excludes psychology and epistemology, but this limitation is tempered by his awareness of the perils of Whiggery: virtually never did I get a feeling of historical distortion. Although ample attention is given to optical anatomy and its meager development during the period, the book deals mainly with views of what was happening between the visible object and the optic nerve. Kepler himself did no optical anatomy, but relied on the work of others. By a happy choice one of these was Felix Platter, who had asserted the sensitivity of the retina and denied that of the crystalline humor. This could give justification for calling the crystalline humor by the theory-laden term "lens."

In the development of Lindberg's theme the pivotal figures are Ibn al-Haitham (the Alhazen of the Latins) and Kepler. Alhazen's work is characterized by his taking seriously all three of the dominant approaches to optics—philosophical, mathematical, and medical. He argued for the position (maintained by Aristotelianism but rejected by Stoicism) that vision was a passive process, but this did not square well with the established mathematical treatments, according to which visual rays were emitted from the eye. At a first approximation we may think of Alhazen's solution as reversing the direction of the rays. "Forms" of light and color proceeded from the object to the eye, where they were "fixed" in the crystalline humor and then transmitted, by a process that Lindberg calls quasi-optical, to the brain. But this scheme had serious difficulties. Alhazen asserted that to avoid perceptual chaos there had to be a one-one correspondence between the points of the surface of the object and the points of the anterior surface of the crystalline humor. But he also conceived there to be radiation from all superficial points of visible objects in all directions. (This conception, which Lindberg regards as representing an important step, had been maintained by al-Kindi, but he held an extramission theory of vision.) The result was that each superficial point of the

crystalline humor was bombarded with forms from all points of the object, and confusion seemed inevitable. Alhazen made an apparently ad hoc escape by according a privileged position to rays that fell perpendicularly on the surface of the crystalline humor and were thus, according to his view of ocular structure, directed toward the center of the eye. These determined how the object was to be grasped. But even this was not the end of the story, for Alhazen later allowed an important role to rays that fell obliquely on the eye and were refracted by its outer parts. He rather proudly said that none of the older writers had used refraction in this way, but if Lindberg's interpretation of the difficult passage expounding the matter is right he was falling into a fairly elementary error. I am not yet convinced that Lindberg has given the whole picture, but if Alhazen could be made more consistent he may also appear far less "modern."

In the West, Lindberg establishes for Roger Bacon a position of central scientific importance as the first person to assimilate the work of Alhazen with any thoroughness, although Bacon still managed to add to Alhazen's scheme a visual power emitted from the eye. Grosseteste, who was ignorant of Alhazen's work, is accorded less importance than in many accounts. Lindberg makes a good case for Bacon's influence on John Pecham, and a rather more tenuous one for his influence on Witelo. Printed editions of Pecham's short textbook and Witelo's long one had considerable influence in the 16th century, and it was against Witelo that Kepler reacted in his major optical work. The later Middle Ages saw less positive work in the tradition of geometrical optics. We may best see this as resulting from a paradoxical combination of skeptical tendencies and a more rigid adherence to Aristotelian texts. Lindberg discusses a variety of Renaissance writers, but manages to show their limited role in preparing the way for the Keplerian achievement.

The central feature of that achievement was the treatment of the crystalline humor as a lens which focused the incoming rays to form a picture on the retina, although Kepler was able to give no more than a qualitative account. The essential one-one correspondence was now between points of the object and points of the retina, and many difficulties in Alhazen's model were averted. There is the obvious analogy of the camera obscura, to the theory of which Kepler had made some important contributions, but Lindberg is at pains to minimize its significance. A difficulty which Kepler strongly felt was that the retinal image was inverted and reversed, and this contributed to his demand for a strict separation between the "optical" and "physical" aspects of vision: the former ended at the retina. Lindberg is much concerned to maintain Kepler's continuity with preceding work. "I am arguing that Kepler was the culminating figure in the perspectivist tradition, and I must strenuously object to Crombie's and Straker's attempt to view him as a revolutionary figure who transformed visual theory by 'mechanizing' it" (p. 207). Lindberg's approach brings out many important aspects of Kepler's thought that might otherwise be lost, but, I think, gives less than full weight to the significance of Kepler's pushing a *single* optical theory as far as it would go, rather than letting the geometrical propagation of light and color slowly merge into something else inside the eye. Crombie's striking image of the eye in Kepler's treatment as a dead eye can still direct our attention to what may be greater elements of novelty than Lindberg would allow.

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The Sun's Atmosphere

The Solar Chromosphere and Corona. Quiet Sun. R. GRANT ATHAY. Reidel, Boston, 1976. xii, 506 pp., illus. $59. Astrophysics and Space Science Library, vol. 53.

The outer atmosphere of the sun is a wonderfully complex tangle of magnetic field, streaming gas, wave motions, and nonthermal particles. A generation of solar physicists have struggled to understand it, and despite their heroic efforts, aided during the last decade by detailed measurements from space experiments, the sun preserves most of its mysteries intact.

According to current ideas, the two-million-degree solar corona is heated by the dissipation of mechanical energy propagated from the top of the convection zone. Heat flows back to the surface by conduction, there to be radiated into black space. Heat flows outward as well and, where the magnetic field lines open to interplanetary space, drives the solar wind. R. Grant Athay's new book surveys the physical processes that underlie this broad conception and the empirical evidence that supports (and contradicts) it.

The monograph is intended for a wide audience. Comprehensive and current, the book is remarkably self-contained and clearly written. Second-year graduate students with a background in stellar atmosphere theory, as well as solar or stellar specialists, can profit from reading it. In the first half of the book, Athay reviews recent observations of structure, motions, magnetic fields, and spectral characteristics. Two excellent chapters summarize the essential elements of non–local-thermodynamic-equilibrium line formation and the inference of chromospheric structure. In chapter 9, Athay assesses the energy and momentum balance of the solar atmosphere. The final chapter reviews, rather hastily, some elements of wave generation and heating.

Considering its great scope, I found the book well balanced between theory and observation. Athay has contributed heavily to the field he summarizes (particularly in the analysis of line spectra), and his authoritative, physical approach to the subject sustains the reader throughout. Many blunt, provocative statements appear—the field is by no means a closed subject, and the specialist will find many points with which to argue. But this, after all, is the mark of a good monograph.

The book is strongest when Athay is discussing chromospheric observations and their interpretation. I found his discussion of chromospheric and coronal heating in the last chapter too short and too isolated from the rest of the book to be satisfactory. In fact, the book's main fault is that it lacks a sustained, coherent point of view. Each chapter is complete and well written, but the book does not have a dominant theme, despite the author's intention, expressed in the preface, to treat the atmosphere from the viewpoint of energy transformations in a magnetized gas. Moreover, too little distinction is made between the energy flow in open as opposed to closed magnetic regions in the corona.

Athay's review of the literature stops at about 1974; the pace of research has overtaken him at several points. The index is hopelessly inadequate—for example, not a single reference to the coronal temperature distribution is included.

Despite these minor faults, this monograph will serve solar and stellar astronomers as a guide and challenge for many years to come. Athay has reviewed a vast, untidy, and fascinating subject with authority and insight.

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