introduction to TAS that "We manage to get along without it"). *Atomic Structure* is concerned exclusively with the non-relativistic theory, although, in his preface, Odabaşi tells us that he and Garstang are working on another volume, intended as a sequel, in which the relativistic theory will be discussed. The main new developments in non-relativistic atomic structure physics since TAS was published are the introduction of Racah algebra techniques, the carrying out of much more accurate calculations using computers and the accumulation of a wealth of new experimental data. Of these, a chapter is devoted to the first but the other two are sadly neglected. Much of the book is concerned with the central-field model, in particular the calculation of the algebraic coefficients which occur in the diagonal matrix elements of the Hamiltonian using a single-configuration representation. Having obtained such coefficients, Condon and Shortley in TAS immediately consider whether "the formulas agree with the data in any sense". Their first confrontation is for the configuration p^2, for which the single-configuration theory tells us that there are three terms, ^3P, ^1D and ^1S, and gives us a predicted ratio of separations

$$[E(^1S) - E(^1D)]/[E(^1D) - E(^3P)] = 1.5$$

this ratio being determined entirely by the algebraic coefficients and independent of the choice of orbital functions. The comparison with experimental ratios given in TAS, 1.13 for C I, 1.14 for N II, 1.14 for O III and so on, shows the inherent limitations of the single-configuration theory, which may give useful information on the relative positions of the terms but fails to give precise quantitative information on energy levels and other properties of atoms. While many similar comparisons were given in TAS, only a limited number are given in *Atomic Structure*, and these only in a concluding chapter and in the context of Hartree–Fock theory. The inherent limitations of the single-configuration theory are thus obscured, and a large amount of more recent work, using multi-configuration methods, is neglected completely. (In such work, the entire problem is handled on a computer — the algebra, the calculation of radial functions, the diagonalization of the Hamiltonian matrix and the computation of matrix elements required for the determination of other atomic properties.)

Advances in studies of atomic spectra and atomic structure which have taken place during the past 45 years are such that it becomes increasingly difficult to describe them in a single comprehensive book. A number of specialist works have been published, and doubtless others will appear, but the need for a more comprehensive work remains. Although *Atomic Structure* fails to meet this need satisfactorily, it contains much that is of value. Professor Odabaşi, others who have assisted and Cambridge University Press should be thanked and congratulated for having made it available to us. □

M. J. Seaton is Professor of Physics in the University of London, and Fellow-Adjoint of the Joint Institute for Laboratory Astrophysics (JILA), University of Colorado, and National Bureau of Standards.

Tool use — fundamentals and philosophy

Toshisada Nishida

Animal Tool Behavior: The Use and Manufacture of Tools by Animals. By Benjamin B. Beck. Pp.307. (Garland: New York, 1980.) $24.50.

THE biggest difficulty in studying tool-using behaviour is deciding what constitutes tool use and what does not — no two scientists would completely agree with any definition. Beck illustrates this fundamental problem right at the beginning of his book in providing a test for the reader. He presents 50 animal behaviours from which those representing tool use must be chosen — I only just passed, answering 35 correctly.

The author goes on to catalogue, in considerable detail, observed tool behaviour, and provides a useful classification of tool-manufacture into four components: *detach, subtract, add or combine* and *reshape*. There are a few omissions and some examples with which I would disagree — fishing probes made of the mid-rib of leaves may be an overlooked example of *subtract* and chimpanzees do not "dip" but rather fish for *Camponotus* ants. Beck then reconsiders his catalogue according to the major functions of tool use: *to extend the user's reach, to amplify mechanical force, to augment agonistic display* and *to allow more effective control of fluids*. Again this is a useful categorization, but I would prefer to substitute "augment signal value of display" for "augment agonistic display" as chimpanzees have been seen to use tools even in courtship and other non-aggressive displays.

How do animals begin to use tools? Beck stresses that the discovery of novel tool-using patterns could result fortuitously from exploratory object manipulation and reviews the factors that influence the development of tool use: maturation, and associative and early experience. He then goes on to criticize Alcock's view that tool-users are morphologically ill-adapted to compete for resources and that tool-use compensates for lack of biological equipment. Since all behaviour can be viewed as compensating for lack of morphological structure, the author argues that Alcock's tenet has no special significance for the evolution of tool-using behaviour. Taking chimpanzees as an example, he also persuasively argues against another thesis of Alcock's: that tool-users have invaded niches that are not at all characteristic of their phylogenetic group.

In considering the cognitive aspects of tool use, Beck questions whether the behaviour can be called "intelligent". Pointing out that non-tool behaviour of herring gulls (shell-dropping) and chimpanzees' tool behaviour (termiting) share cognitive similarites, he attacks the notion that tool behaviour necessitates a cognitive sophistication which is unique and more advanced than that subserving non-tool behaviour. He concludes that there is no unique, orderly relationship between tool use and intelligence, and that social and feeding behaviours are probably far more important factors in the evolution of intelligence. Similar arguments are put forward in reviewing the development of human intelligence and tool use.

Finally, he turns to the philosophical implications of his work in remarking that "tool behaviour should not only be stripped of its role as a primary shaper of our own species, but should also be recast as the progenitor of the engine of our destruction". This pessimism represents a trend stemming from the author's opposition to the ethnocentrism of civilizations and the anthropocentrism of our own species, one which has perhaps been greatly influenced by his anxiety about the future of an Earth under threat from a number of human activities. I don't support all of his remarks. I think that the primary shaper of our species is socio-economic behaviour (including subsistence tool use) and that communicative behaviour is secondary. Moreover, the lack of meaningful relationships between tools and intelligence in other species does not necessarily negate its possibility in *Homo*. In this context, I do not understand why he omits Penfield and Rasmussen's famous contribution to cerebral physiology: hand areas of both motor and sensory cortex in human beings are relatively much larger than corresponding areas in apes and monkeys. This can be easily understood by assuming that tools were one of the major selective agencies in human evolution. Indeed, one of the faults of the book is the lack of a systematic review of gripping organs, grasping methods, handedness and skills in primate tool-use.

Yet this is a stimulating book, rich in suggestions, and undoubtedly the best sourcebook available on animal tool behaviour. □

Toshisada Nishida is a Lecturer in the Department of Anthropology at The University of Tokyo.