

have been included. That innovation in a book of this nature is a welcome addition and, as pointed out in the preface, should lead to better national planning as well as to international cooperation.

This is a book of international status in every sense and there seems little doubt that it should go a long way in promoting a better and wider understanding of this important area of low temperature technology. It should prove to be an invaluable aid to the decision makers in the assessment of future large scale technologies. □

## Starting with an open mind

*Development in Infancy.* (A series of Books in Psychology.) By T. G. R. Bower. Pp. viii+258. (W. H. Freeman: San Francisco and Reading, July 1974.) £5.20 cloth; £2.90 paper.

It was the style of 18th Century philosophers of mind to premise their arguments upon speculative assumptions concerning the original nature and subsequent development of human perception. Bower's splendid little book is in that tradition—but with one hugely crucial difference. In place of speculative assumptions about the original nature of perception the pages of this volume provide a stunning array of experimental research, much of it by the author and his collaborators, designed to explicate how in fact the infant during the opening years of life comes to perceive space, objects, locus and trajectory, and how he develops appropriate concepts and behaviours to cope with what he comes to know. Bower has given us not only a compendium of empirical findings, but a speculatively (sometimes too speculatively) argued treatise on the starting nature of human knowledge and the course of its early transformation in response to encounters with the environment.

It may well be the most important work on early human development since the launching of Piaget's magisterial research a quarter of a century ago, and although it brings that work into question both broadly and in detail, it builds upon it as a starting point. For it is not the work of the Geneva group that is brought most deeply into doubt by this book, but rather the empiricist view of knowledge—the assertion that knowledge is acquired by the gradual accretion of associations or stimulus—response connections that mirror the state of the environment. Indeed, Bower's conclusions point instead to the early importance of man's inherent structure, to the array of

species-typical readinesses to register upon and organise knowledge by highly ordered rules reflecting man's evolution.

Development goes forward by stages of organisation, each stage supplanted by a later stage when usable conflict occurs in the attempted application of earlier rules. It is the concept of usable conflict that distinguishes the author's view from that of conventional learning theory, for encounters with the environment are shown to be effective in producing change only when the infant is able to code the disparity between his expectancies and what actually transpires as a result of his responding. The codability of such mismatches depends upon the development of rule structures for interpretation—the result of maturation shaped by experience.

For Bower, the initial structure of space for the infant is supramodal, a space into which the special senses are mapped. Sufficient experimental evidence is presented to raise sharp questions about both Berkeley's and Piaget's accounts of the associative or conceptual welding of the disparate spaces of eye, ear, and hand. New and searching techniques of research are now available—many of them invented by the author—that suggest that the hand knows what the eye knows before it has had its own experience of reaching under visual control. "It is highly improbable", he argues, "that any organism evolved a visual system or an auditory system that was not an outgrowth of the supramodal perceptual system . . . the system that responds to those properties of objects that can be specified via any sensory modality." In like vein, primitive visual objects, although they are elaborated by 'experience' simultaneously to encompass more properties, begin as inherently organised representations including more than a single modality. Witness the distressed surprise of the infant at the beginning of his manipulatory career who reaches out for a virtual object produced by polarised light and polarising spectacles, and finds no tactual feedback on grasping the target. An older child is less surprised, having come to differentiate palpability from visual object qualities.

Bower then argues that at the earliest stage, as indicated by studies of eye-movement and reaching, the infant has two disparate systems for identifying and conserving the identity of objects. One is for objects in motion and is based on a smooth pursuit system; the other is for static objects and is based on the saccadic system. Only with maturation and with appropriate experience, Bower argues, do infants develop rules for dealing simultaneously with the two systems.

As far as cognitive development is concerned, it is conceived of as the development of rules and regulatory processes that serve to organise different features of input and to sequence classes of behaviour rather than specific behaviours. Bower argues that no specific single behaviour is ever found to be crucial to development; adequate 'manipulatory' behaviour seems to develop even in limbless thalidomide children who carry out reaching and prehensive tasks with their mouths and teeth. "It is more parsimonious to assume change in an underlying concept which generates all of the behaviours, than to assume separate independent changes in each behaviour." Cognitive development, then, is seen as the progressive growth of increasingly comprehensive and differentiated control systems for constructing and sequencing behaviour. Bower presents a brilliant series of experiments to illustrate his point, centred upon the development of the concept of an object; how it is recognised as the same object though undergoing transformations in appearance, locus, and even singleness of identity.

But for all its virtues and power, this book is flawed in a way that destines it to criticism and challenge. It is flawed, ironically, by an overextension of its virtues; its very clarity of premise and argument, capped by uncompromising conclusions, makes it vulnerable. It will serve for years as a source of ideas for doctoral theses that will prove it inconclusive theoretically and wrong or partially wrong experimentally. For, in fact, there are not yet enough findings in the field of infant cognitive research to justify the inferential depth of Bower's arguments or the boldness of his conclusions. And though the experiments—perhaps too closely focused on work at Edinburgh, Harvard, and Geneva—are highly ingenious, and often brilliant, many of them are neither easily reproducible nor yet as conclusive as the author believes. (Witness his reliance on a doubtful study by Wertheimer indicating that newborns can orient visually to a voice source in space; or the still questionable reproducibility of some of his own results.) Indeed, because of the clarity and depth of the premises, the crisply unqualified statement of the findings, and the forthrightness (at times recklessness) of conclusions, the book will provide both a paradigm for next stages of research—and a whipping boy.

Yet, however much it will be attacked as 'premature', it is a major synthesis of work on the "original nature of mind" and will rank as one of the major books on human development to be written during the last decade. **Jerome Bruner**