SOME EXPERIMENTS ON STRUCTURED LEARNING

INTRODUCTION

When an experimental psychologist accepts an invitation to share in a conference of distinguished mathematicians and mathematical educators it is most important that when he speaks he makes clear his standpoint and presuppositions and the limitations of what he has to say. With the widespread interest in and enthusiasm for 'new mathematics' of one sort or another, it is inevitable, and indeed highly desirable, that educational psychologists should be closely involved in attempts to evaluate the efforts and results of the different innovators in this field. In general, the educational psychologists' concern tends to be with the gross or overall effects of what the different materials and methods achieve. They therefore tend to be concerned with things like success and failure rates, and rates of progress in developing various mathematical skills. To put it another way, they tend to be more concerned with what is achieved than with how and why it is achieved. By comparison, and from the standpoint of an experimental psychologist interested in understanding more about complex learning and thinking, my primary interest is in understanding the processes whereby the end products are achieved and only secondarily in success or failure rates. To put it another way I want to know what factors are responsible for success or failure not just how many subjects succeed or fail. Perhaps by way of illustration I may compare an approach used extensively by the late Sir Frederic Bartlett and his students. He repeatedly pointed out that in studying perceptual-motor skills it was more important to know how the various component parts of a complex skill were built up and integrated into a whole, than to know whether the skill was successful or not. Though of course, this latter is also very important. What I am suggesting is that an approach which has been tried and clearly demonstrated to be successful in twenty five years of intensive study of perceptual-motor skills should at least be given a fair trial in the study of mental skills. That then is the framework and starting point of the studies I shall be reporting in a moment. As will soon become evident, the other main formative influence on the work I shall be reporting arises from the early studies of human thinking by Bruner and his colleagues.

One further introductory word is called for as regards the psychological theoretical standpoint of the work reported here. As you know there are
still two strong but very different theoretical traditions in psychology, usually labelled stimulus-response type and cognitive type. The stimulus-response theorists, or perhaps better called associationist theorists, speak in terms of associations between discrete events in the environment (the stimuli) and discrete events associated with the organism (the responses). The cognitive theorists are more likely to talk about formal categories of behaviour, giving relatively less attention to the topographic aspects of behaviour classed within those categories. As Mandler (1962) sees it “The important questions” as regards this theoretical controversy “are: Do organisms learn generalizable, but discrete, responses in specific situations or are rules of behaviour, maps or schemata laid down which connect various behaviours and environmental inputs? Do organisms learn what to “do”, or do they learn “what leads to what”? And commenting on the cognitive theories Mandler adds “... they belong to a much larger class of theories which have claimed to be “structural”; including not only the gestalt school and its heirs but also the speculations of Piaget, Bartlett and Hebb among others. What these positions have in common is a postulation of the organization of behaviour not derivable from any combination or association of stimulus-response links.”

My own view, about which I shall say more at the end of this paper, is that to assert that we must be either stimulus-response type theorists or cognitive type theorists is to pose a false dichotomy. I shall argue that there is now enough evidence to suggest that cognitive processes may in fact use as building blocks smaller chunks of behaviour built upon stimulus-response type principles.

These opening remarks are, I suppose, more by way of an apology, for whilst you mathematics educators are making leaps and bounds in the development of new and existing approaches to the teaching of mathematics, we are slowly plodding along behind trying to find out why this or that method is more successful than another. In justification of our approach we should argue that as scientists interested in behaviour we are not only concerned to be able to predict accurately but also to understand why we are able to predict accurately. Of course, there is more to it than this, because we also believe that when we understand the processes involved in accelerated learning of one part of mathematics we may then be in a better position to generalize effectively to other areas.

SOME PRESUPPOSITIONS

I said earlier that I must lay bare my presuppositions. Here are some of them. First, that structural learning is a complex activity and that we are not likely to understand it by studying the performances of subjects on tasks which last