SOME THEORETICAL STUDIES OF INTELLIGENCE:

EXTENSIONS AND TESTS OF ASPECTS OF PIAGET'S MODEL

A THESIS PRESENTED IN PARTIAL FULFILMENT
OF THE REQUIREMENTS FOR THE DEGREE
OF MASTER OF ARTS
IN PSYCHOLOGY AT
MASSEY UNIVERSITY

K.E. VOGES

1979

To

Heather

ABSTRACT

This study attempts to integrate two particular aspects of Piaget's theory, seriation of weight behavior and the equilibration model, with the recently developed information processing approaches to psychology, derived from the development and proliferation of the computer. It is felt that computer based technologies will be more widely used in the future in psychology, to help solve a variety of common problems. A major contemporary problem that the computer may help to overcome, is that of trying to integrate the great mass of experimental data that has been collected over the years of psychological investigation.

The paper has a number of major sections, a preliminary section discussing methodology, a section concerned with single subject performance on a weight seriation task, and a section concerned with Piaget's theoretical model, equilibration. A review is given of a range of modern approaches to psychology, including computer-based approaches and systems science. As well, the details of the methodologies of computer simulation, systems science, and single subject performance models are considered.

The actual experimental work deals with the development of a production system based on a study by Baylor and Gascon (1974), which deals with the seriation of a number of weights. Computer programs were written, in PASCAL to facilitate portability, to simulate the weight seriation

behavior of children in the age ranges of approximately 6 to 9 (Stages 1, 2 and 3). As well as validating the findings of Baylor and Gascon, a further approach to weight seriation problems was discovered for the Stage 1 child (this approach has been termed "Opposite placement of couples" to complement Baylor and Gascon's "Juxtaposition of opposites". These programs are presented in the paper, along with examples of the print out obtained, and a comparison between these and the children's protocols were made. Only children exhibiting Stage 1 and Stage 3 behavior were considered in detail, as it was felt that the Stage 2 behavior was too complex and required more extensive observation before actual modelling of the behavior should be attempted.

Piaget's equilibration model is reviewed and discussed, with emphasis being placed on its relationship to cybernetics. As well, other mechanisms of the transition from one stage to another are considered, specifically the models of Klahr and Wallace (1976) and Pascual-Leone (1970).

It was concluded that the models embedded in the programs give an accurate simulation of the various types of behavior observed through the age range discussed. Various extensions of the work are also considered, relating to the integration of other aspects of cognitive and motivational aspects into the model. It is felt finally that it is important to extend work in the area of representation of the environment to enable the program to have something to manipulate. Piaget's work already has an information processing flavour, through his development of the concept of operations, but there is hardly any work based on the processing of representations of the environment. This helps give a direction to future research.

PREFACE

This study stems from an interest in Piagetian theory associated with operations, equilibration and cybernetics, and the challenge to relate some of these concepts with aspects of computer simulation. I believe the computer has an important, indeed vital role to play in the future of theoretical psychology. After reading many authors who are convinced of the truth of this belief, I feel that my attempt to acquire some knowledge in this area has been worthwhile. Psychology can make from the transition from a qualitative descriptive science to a quantitative, analytical one. If the models produced are to serve any useful purpose they must yield predictions that can be tested against experimental data. Because psychological systems are generally very complex, realistic models capable of solution could not have been formulated in the precomputer era. Now computational difficulties should no longer be a limiting factor in the development of a quantitative theoretical psychology. The only limitation now lies in our ability to formulate hypotheses about the operation of psychological systems, and to develop new mathematical and experimental techniques to test them.

I would like to take this opportunity to thank Dr. Don McAlpine for his understanding and help during his supervision of this work. Conversations with Don are always (for me) an intellectually stimulating experience, and I thank him for those experiences. I would also like to thank Lindsay Groves from the Computer Science department for putting up with my abysmal ignorance concerning the workings of computer programs, and for giving me a considerable amount of his time and knowledge to increase my understanding of the process. Finally, I would like to thank my wife, for her patience, and for her support, without which this thesis would not have been completed.

K.E. Voges
November, 1979

CONTENTS

LIST OF FIGURES

PART I

PRELIMINARIES

CHAPTER 1

A STATEMENT OF THE PROBLEM

In many respects this thesis has as its main concern a methodological problem, outlined at different times by different theorists. It represents a growing dissatisfaction with a science that seems to be becoming an encyclopedia of known facts rather than an interpreter and organizer of these facts. This dissatisfaction was crystallized in an article by Newell (1973), in which he considers a very real problem emerging in psychological research, or rather two interrelated problems. The first concerns a lack of direction in research. Newell lists 59 different phenomena (by no means a final or exhaustive list) with which experimental psychology deals, and is pessimistic about any finality being reached in any study. 'Matters simply become mudier and mudier as we go down through time. Thus, far from providing the rungs of a ladder by which psychology gradually climbs to clarity, this form of conceptual structure leads rather to an ever increasing pile of issues, which we weary of or become diverted from, but never really settle' (Newell, 1973, pp.288 - 289). We seem to consider research as another consumable commodity. The research is performed with little consideration for extension or integration with current theory. This is Newell's second problem. 'We never seem in the experimental literature to put the results of all the experiments together.... We do...relate sets of experiments. But the linkage is extraordinarily loose. One picks and chooses among the qualitative summaries of a given set of experiments what to bring forward and juxtapose with the concerns of a present treatment' (Newell, 1973, p.298). The problem concerns an integration of the great mass of data that has been gathered over the last hundred years since psychology has been considered an experimental science.

Other theorists, such as Deutsch (1960) have commented on the same problem. In his book, Deutsch suggests that there are too many facts in psychology, and the task is now to interpret them. Lewin was also aware of this problem. In a far-ranging paper (Lewin, 1965, p.201) he states: 'The need for a closer fusion of the various branches of psychology demands tools which permit better integration.' He was also aware of the problems with such an approach. 'We will produce but an empty formalism, if we forget that mathematization and formalization should only be done to the degree that the maturity of the material under investigation permits at a given time' (Lewin, 1965, p.201). One of his major concerns in the presentation of his theory was to bring together the total field of psychology in a logically consistent manner. He believed such a goal would be impossible without adequate mathematization. If a theory could combine into one logical system of known facts which previously could be tested only by separate theories, this particular theory would have great value as an organizational device. Lewin was of the opinion that concepts of topology would prove 'fruitful for representation in every field of psychology' (Lewin, 1965, p.215).

In many scientific fields, the concentration over the past several decades has been on analytical fact-finding, and experimental approaches in highly specific areas. This has been useful in helping to develop knowledge and to understand the details of specific but limited subjects. At some time however, there should be a period of synthesis, reconciliation and integration, so that the analytical and fact-finding elements are unified into broader, multidimensional theories. 'There is evidence that every field of human knowledge passes alternatively through phases of analysis and fact finding to periods of synthesis and integration. Recently systems theory has provided this framework in many fields - physical, biological and social' (Beishon & Peters, 1972, p.16).

In the remainder of this section I shall consider some attempted solutions to the problems I have outlined, as well as the general methodological approach to be followed in this study. As will be seen, my main emphasis is towards what may be loosely termed a systems approach to the conceptualization of human cognitive activity. This new approach, following on from the theoretical work of Von Bertalanffy (1951), is being considered more and more in various physical and social sciences, and it is time that such an approach was investigated for its application to psychological issues. Coupled to this is the invention and proliferation of the high speed general purpose digital computer. This is I feel a significant step towards a very necessary tool designed to "put it all together", and make use of the immense wealth of data that has been gathered. A number of writers (Reitman, 1965; Apter, 1970) have considered the invention of the computer to be as important an event for psychology as the invention of the microscope was for biology. The exciting implications of this comparison have yet to be fully realized.