THINKING

by Sir Frederic Bartlett

THE MIND AT WORK AND PLAY

Its illustrations are clear and its language throughout has the simplicity which follows only upon mastery. . . . It is also commended for pure delight to any reader who is prepared to explore the mysteries of the mind at work and play. THE SCHOOLMASTER

(George Allen & Unwin)

REMEMBERING

An Experimental and Social Study

(Cambridge University Press)

THINKING

An Experimental and Social Study

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PREFACE

As I have indicated in Chapter 8 of this book, it was my purpose, as far back as in 1932, to develop an experimental study of the large variety of processes which people call "thinking." A beginning was made then, but it had not proceeded very far before the second Great War came, and for sufficient reasons my interests, and those of most of my colleagues, were diverted to experiments and reflexions about bodily skill, its basic characters, and the conditions of its acquisition and practice. All the time the possibility of developing experiments upon thinking which would differ from the traditional approaches remained more or less active at the back of my mind.

If I had attempted to write this book in the 1930's it must have included some detailed and critical account of earlier psychological work. Fortunately Professor George Humphrey published his splendid study of the classical experimental psychology of thinking in 1951,[1] and there is now no need for me to try to repeat what he has already done with complete authority.

Recently a great revival of interest in problems of thinking has occurred and much has been published. But here also there is available plenty of readily accessible and reliable information. Extensive references, and much discussion, for example, may be found in the brilliant and original book by Professor Jerome Bruner and others entitled *A Study of Thinking*.[2]

It will be noticed that the present volume contains comparatively few specific references to the work of other psychologists, earlier or contemporary, about thinking. In writing it, in fact, I was not concerned to produce anything

[1] *Thinking: An Introduction to its Experimental Psychology*. London: Methuen 1951.

[2] New York: John Wiley & Sons, London: Chapman & Hall 1956.

like a systematic treatise. I had three principal aims in mind. First to try to put thinking into its place as a natural development from earlier established forms of bodily skilled behaviour. Secondly, on the basis of this approach, to design some more or less novel experiments of a predominantly objective type, and such that, I hoped, anybody with sufficient interest could carry further for himself. Thirdly, to illustrate a few of these experiments, and to embark upon some discussion of their results. The book is in no sense final. If it should succeed in starting more and better explorations in the spacious field of its study, it will have served its purpose.

No author, writing a book of this kind, can possibly acknowledge all his debts to other people and to varied sources of information. Many of them he may not even himself know. I owe probably most of all to generations of Cambridge students who have taken part in discussion classes, and to colleagues in the University of Cambridge Psychological Laboratory, and the Medical Research Council Unit for Research in Applied Psychology established at Cambridge since 1944. To the Medical Research Council itself and to St. John's College in the University of Cambridge, I am deeply indebted for long-continued support and encouragement. Dr. E. F. Gale, F.R.S., and Dr. J. S. Mitchell, F.R.S., both read and criticised the chapters on Experimental Thinking, though naturally any views that these chapters express are my own responsibility. I particularly wish to express my thanks to Mrs. V. Simmonds for preparing the various drawings that have been included in the text, and to Miss Pauline Dyson for much valuable editorial work.

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CHAPTER ONE

Thinking as a Form of Skill

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One thing, at least, about thinking is absolutely certain. All the various ways in which it is practised by human beings have become possible only as a result of prolonged processes of biological development. For many centuries thinking was regarded as a sort of gift, specially presented to man, and the most important and decisive of all the differences which distinguish man from the other animals. No serious and informed person can any longer accept this as the correct view.

It follows that if we want to find out something definite about the nature and conditions of thinking processes, our best chance is to make use of clues that may be available from the study of simpler but related behaviour. In fact, if we do not do this, it seems as if the only alternative is to construct some general theory or other, and then to use observation and experiment to justify this theory. The result is bound to appear both tautologous and to some degree arbitrary; and in any case it is not what the scientist wants.

2. THINKING AS HIGH-LEVEL SKILL

It seems reasonable to try to begin by treating thinking provisionally as a complex and high-level kind of skill. Thinking has its acknowledged experts, like every other known form of skill, and in both cases much of the expertness, though never, perhaps, all of it, has to be acquired by well-informed practice.

Every kind of bodily skill is based upon evidence picked up directly or indirectly from the environment, and used for the attempted achievement of whatever issue may be required at the time of the performance. Every kind of thinking also claims that it is based upon information or evidence which, again,

must be picked up directly or indirectly from the environment and which is used in an attempt to satisfy some requirement of the occasion upon which the thinking takes place.

It would be easy enough to go on pointing out a number of other likenesses, of a similar general character, between bodily skill and thinking. But it is extremely important to realize that the case for beginning a study of the thought processes by using as clues what is already known and established about the measurement and nature of bodily skill, does not, in any important sense, rest upon these.

Everybody who has ever attempted to study thinking has had to admit that it is a very complicated affair, with many different modes, with varying objectives that may seem to have little or nothing in common one with another, and with a wealth of circumstances which can influence its direction and its efficiency. Particularly if an experimental approach is tried there is so much to observe that unless we have some clues to give an initial direction to our observations we are almost certain to get bogged down in an unmanageable mass of detail. The case for building upon what is known about bodily skills is essentially methodological and pragmatic. We must have some definite points of departure, but points of departure do not normally, and certainly need not, themselves dictate either the direction of travel or the end of the journey. In this instance we are in no way committed to an attempt to establish an elaborate analogy between bodily skills and thinking processes. In fact we know that whenever any biological process is built up upon functions simpler than itself it is almost sure to acquire its own peculiar characteristics and to have its own special conditions. We can, and indeed we must, use what has been established about the simpler functions, to provide us with a line of approach, but we are not to suppose that exploration will reveal nothing that is radically new.

The last fifteen years or so have produced a marked advance in our knowledge of how to set about the measurement of bodily skills, and of their leading, critical features. It seems not unreasonable to hope that a brief review of the present position may indicate workable methods and definable problems for an experimental approach to thinking.

3. PROPERTIES OF SKILLED PERFORMANCE

Nobody normally uses the term "skill" of the very simplest kind of behaviour, where what can without violence be treated as a single stimulus gives rise to what can be treated, equally without violence, as a single, and isolated, response. We do not consider experiments to determine an absolute threshold—for example, the smallest amount of light, or sound, that can be seen, or heard—as experiments on the measurement of skill. In the same way a determination of reaction-time is not, in itself, a measure of skill; or, in fact, is any quantity which expresses the character of a single item in, say, a repetitive task when that item is taken out of its setting and produced under exactly determined and constant conditions. These are all highly abstract items, or constituents of behaviour, made possible and measurable only by carefully controlled experiment, and although their study is enormously important for many reasons it can contribute nothing of real moment to an understanding of skill. It is perfectly true that thresholds, reaction times, items of behaviour taken out of their setting, can all be shown to be capable of modification as a result of repetition. And this can be taken to indicate that they are, in fact, more dependent upon what precedes and follows them in the experiments than is usually recognized. But they are not ordinarily studied from this point of view, and they are not very good cases to take, partly because the range of possible modification is small, and partly because the experimental situations in which they can be investigated are already so simplified that it is difficult to find out anything definite about the modifications, except that they take place and what they are.

Even these very simple cases obviously demand a working combination of receptor and effector functions; but we begin to use the term "skill" only when a good many receptor and effector functions are interlinked and related within an order of significant succession which possesses an inherent character of direction and moves towards an issue regarded as its natural terminus.

This essential requirement of any performance that can be called skilled becomes much more plain if we look at a few actual instances. The player in a quick ball game; the operator,

engaged at his work bench, directing his machine, and using his tools; the surgeon conducting an operation; the physician arriving at a clinical decision—in all these instances and in innumerable other ones that could just as well be used, there is the continuing flow from signals occurring outside the performer and interpreted by him to actions carried out; then on to further signals and more action, up to the culminating point of the achievement of the task, or of whatever part of the task is the immediate objective. From beginning to end the signals and their related actions form a series, not simply a succession. Skilled performance must all the time submit to receptor control, and be initiated and directed by the signals which the performer must pick up from his environment, in combination with the other signals, internal to his own body, which tell him something about his own movements as he makes them. These are the main reasons why all forms of skill, expertly carried out, possess an outstanding character of rapid adaptation. For the items in the series have, within wide limits, a fluid order of occurrence and varying qualities. So what is called the same operation is done now in one way and now in another, but each way is, as we say, "fitted to the occasion."

4. EXPERIMENTS ABOUT BODILY SKILLS

It is of interest that none of the increased understanding of the psychology of skill which has been won was started from a formal analysis of laboratory situations. The initial impetus came from direct and, as far as possible, unprejudiced observation of practices and activities that everybody would agree to call skilled. It is equally true and equally interesting that once the working ideas had been suggested by direct observation, further definite progress was achieved only as it became possible to put these working ideas into operations that could be built for the laboratory and tested under reasonably well-controlled conditions.

(*a*) *"Timing"*

The situation in which signals and responses to signals can be set into an order of significant sequence is not a difficult one

to study experimentally.[1] When this is done it becomes readily demonstrable that by far the most important characteristic of expert bodily skill is "timing," and also that timing has little or nothing to do with the absolute speed at which any component response in the skill sequence is performed. Efficiency depends, more than upon anything else, upon the regulation of the flow from component to component in such a way that nowhere in the whole series is there any appearance of hurry, and nowhere unnecessarily prolonged delay. R. Conrad, particularly, in a number of most elegant and penetrating experimental studies, has shown that bodily skills inevitably have a temporal structure and also that this can become defined and smoothed through exercise, so that the initially long intervals between components are shortened, and the short intervals become lengthened. The whole performance then takes on that character which is perhaps more often than any other used by the critic as the leading criterion of expertness in any form of bodily skill: that the operator has "all the time in the world to do what he wants."

If we look into this more closely we find that it means that no single component in skilled behaviour is a function merely of that signal which immediately starts the response going. Within limits that can be experimentally determined and measured, surrounding signals and responses in both directions are contributing their shares. In the actual performance of most, and perhaps all, forms of bodily skill the temporal limits of this kind are rather narrow. It is only the near past and the near future that count. Moreover, it seems as if it is the near future—"anticipation of what is coming next" if a psychological description is required—that plays the principal part in producing that objective smoothness of performance which is the hall-mark of a high quality of skill.

Another way of putting all this, and perhaps the most interesting of all if we are looking for clues about how to

[1] Excellent illustrations of fairly simple and readily constructed arrangements that can be used for this sort of experiment may be found in Conrad, R.: *Speed and Load Stress in a Sensori Motor Skill*, Brit. J. Industr. Med., 1951, 8, pp. 1–7 *Timing*, M.R.C. Appl. Res. Unit, 1953, Rep. No. 188; Leonard, J. A.: *Advance Information in Sensori Motor Skills*, Quart. J. Exp. Psychol., 1953, 5, pp. 141–9; Singleton, W. T.: *The Change of Movement Timing with Age*, Brit. J. Psychol. 1954, 3, pp. 166–72. Many others could be given.

design experiments on thinking, is to say that the immediate evidence, at any moment of skill behaviour, is incomplete. It leaves gaps on both sides. On the side of the near past the gap has already been filled, but to make use of it may require a mechanism of short-term storage, or, to use the psychological expression, of immediate memory. On the side of the near future the gap still remains partially unfilled; the operator must be accepting evidence which has not yet reached the stage for action, at the same moment at which he is already acting upon other evidence.[1]

When any bodily movement is performed as a component in a skill sequence, three time measures relating to that movement are always possible. These are: the reaction-time, the time which elapses between the immediate signal and the beginning of the movement; the movement time itself, and the interval between this movement and the next succeeding movement. It is possible, and indeed usual, for all of these to vary while any measure of whatever it is that the movement achieves remains constant. Hence it is that measures of the overall achievement in the case of skill behaviour very rarely throw any light upon the processes involved in the achievement itself.

(*b*) *Stationary Phases of Bodily Skill Performance*

Of the three measures far the most unstable, and also the one that contributes most to an understanding of the skill processes, is the third. A considerable number of investigators, studying manipulative skill from many different points of view, have agreed that the variable elements in most psycho-motor skills are not the travel components but the "halts" or intervals from one direction of travel to another.

It is, for example, a leading feature of many bodily skills that when a moving object reaches a certain position relative to an operator, the latter must take appropriate steps to despatch it, or transport it, with considerable accuracy, to another position which may either be decided by him (as in most ball

[1] I have attempted to work out the variety of functions of "Anticipation in Human Performance" in an article with this title published in *Essays Presented to Professor David Katz*. See also N. H. & J. F. Mackworth: *Remembering Advance Cues during Searching*, M.R.C. Appl. Res. Unit, 1957, Rep. No. 258.