

I. MACFARLANE SMITH, Ph.D., M.A., B.Sc., Ed.B.

# SPATIAL ABILITY

*Its Educational and Social Significance*



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Dedicated to Joan

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## FOREWORD

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*by Professor P. E. Vernon*

PROFESSOR OF EDUCATIONAL PSYCHOLOGY, INSTITUTE OF EDUCATION  
OF THE UNIVERSITY OF LONDON

THIS is a book which needed writing; and Dr. Macfarlane Smith, who has been closely identified with its subject-matter for over one quarter of a century, is clearly the person to write it. At first sight it would appear to be a highly technical survey of the statistical findings of certain mental tests. But the conclusions which the author draws from his careful weighing of the evidence have very important implications for current educational policy. It is high time, therefore, that educationists should take the trouble to acquaint themselves with this technical evidence, to ponder and act on it. Briefly stated, Dr. Macfarlane Smith's thesis is that British education, particularly that given in grammar schools, while stressing the development of general or all-round intelligence, has over-valued the verbal type of ability at the expense of its psychological opposite—spatial ability. The Crowther Report, Sir Charles Snow and many other public figures have, of course, urged the claims of mathematical, technical and scientific education, together with Britain's need for technologists and scientists. But few of such advocates possess any scientific knowledge of the nature of these abilities they wish to encourage, what is their common essence, nor how this essence is related to other abilities or to temperamental traits and personality qualities. Nor are they, perhaps, sufficiently aware that our current system of selection for secondary and university education actively discriminates against the pupil or student who is most likely to be talented in these directions.

Dr. Macfarlane Smith outlines a large body of work on spatial, performance, mechanical and other non-verbal tests and shows that there is a major underlying factor or type of ability which is

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best defined as the capacity to perceive and hold in mind the structure and proportions of a form or figure, grasped as a whole. This view reconciles the somewhat divergent results of British and American workers, since the latter have often used less appropriate multiple-choice tests involving recognition of details rather than perception and reproduction of complex wholes. There is ample evidence of the usefulness of such tests in selection for technical courses and training, for geometry and art. But in addition a comprehensive survey of work on mathematical aptitude indicates that, apart from general (preferably non-verbal) intelligence tests, the most predictive tests are also those of the spatial factor. In contrast, mechanical arithmetic tests give very little indication of future mathematical or scientific ability (hence Crowther's advocacy of 'numeracy' is psychologically misleading). It would seem that the perception of form is a general characteristic of the abstract thinking involved in mathematics and science, as distinct from the verbal thinking involved in most school subjects.

A good deal of interesting work is surveyed, also, on defects in spatial ability associated with brain injury, cerebral palsy and leucotomy; and a discussion of the relations of this ability to types of attention (analytic vs synthetic) and to EEG brain waves throws further light on the neurological and mental processes involved. Finally the author makes a strong case for some relation between the ability and temperamental qualities akin to introversion, masculinity and initiative. The lack of understanding between the scientist and the humanist probably arises from the fact that their modes of thinking are intimately bound up with their whole personality organization.

The book covers much controversial ground and not all psychologists will endorse all of Dr. Macfarlane Smith's interpretations. I myself wonder, for example, whether some of the correlations and factor loadings he quotes are not too small to justify some of his more novel conclusions; and I would see more virtues in the verbal type of thinking than he seems to allow. But it is all to the good that his evidence and arguments should be

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presented and marshalled logically, since this will stimulate others to undertake further badly needed research. I would, then, particularly commend the book not only to educational policy makers, but also to research students in education and psychology who are searching for fresh ideas to explore.

January, 1963

PHILIP E. VERNON

## ACKNOWLEDGMENTS

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It is not possible to name individually all those who have helped in connection with the researches which form the basis of the present work.

My first introduction to a test of spatial ability occurred when I was a student at the University of Glasgow. Mr. C. A. Oakley, Lecturer in Industrial Psychology, requested volunteers to take a number of aptitude tests and I offered my services as a guinea pig. One of my fellow students who also took the tests and who has since taken a keen interest in my researches on spatial ability was Dr. A. K. Cairncross, the well-known economist. My long-standing interest in the subject seems to date from this incident and from the discussions to which it gave rise.

I received my initial training in psychology in the department directed by Dr. R. H. Thouless, whose classes were a source of lasting inspiration. My interest in the subject had been aroused by the experience of acting as a subject for Dr. Thouless in his first experiments (1931) on phenomenal regression, now called the constancy effect.

Dr. Thouless was then concerned with the problem of demonstrating the existence of a group factor in the abilities underlying the experiments on constancy. Thus, not only did he direct my interest to the field of shape-perception but he also familiarized me with one of the early techniques of factor-analysis. Some years afterwards, it became apparent that Dr. Thouless' researches were more closely related to mine than we realized at the time. We had in fact been studying different aspects of the same factor.

During my first investigation on spatial ability, I was greatly assisted by Dr. W. Stephenson of the University of Oxford, who responded to a postal request by supplying samples of test-materials, some of which were identical with those used by El Koussy in his well-known investigation (1935).

During the second world war, I served as a R.E.M.E. officer,

responsible for servicing radar equipment, and I had little contact with the work of psychologists, but after the war Professor R. A. C. Oliver encouraged me to continue my pre-war investigations. When I joined the staff of the National Foundation for Educational Research as their first officer in charge of Tests Services, Professor P. E. Vernon acted as a supervisor of this research.

My interest in spatial ability has been sustained over the years because of my role as supervisor of the researches of a number of M.Ed. students, many of whom worked in this field and contributed in various ways, notably R. Edwards (now Professor), J. S. Lawes, C. Stewart, C. C. Taylor, F. R. Witty and J. Wrigley (now Professor). I am also indebted for some help to a former colleague, J. J. C. McCabe, and to former students R. Anderson and J. C. Gardener.

In 1959 I was awarded the Research Fellowship of the Institute of Education of the University of Durham and I took the opportunity of carrying out a follow-up study of the validity of secondary school allocation procedures. For help in the collection of data I am indebted particularly to Mr. L. Charnley and Mr. J. Clitheroe, Officers of the City of Carlisle Education Committee, to Mr. T. H. C. Walker, Headmaster of Tynemouth Technical School, and to Mr. T. C. Wonnacott, Headmaster of Higginshaw Secondary Modern School, Oldham.

During my tenure of the Research Fellowship I received valuable assistance from Professor Brian Stanley, Director of the Institute of Education of the University of Durham, and also from the Institute Advisory Committee on Research. It was during this period that the present work took shape.

Subsequently, when I was appointed Director of the Research Unit at Garnett College, Roehampton, Professor P. E. Vernon read the draft of the book and made numerous helpful comments and suggestions. Professor Vernon's influence on the work will be apparent to all who are familiar with his writings.

While the present volume is the direct outcome of my tenure of the Research Fellowship of the Institute of Education of the University of Durham, the views expressed and conclusions

### *Acknowledgments*

reached in it are largely the result of reflections which have taken place from time to time over the last thirty years. For these views I must accept full responsibility, though, of course, they have been fashioned by innumerable circumstances and influences in my educational and family background. In so far as they have merit, much of the credit must go to the teachers who have stimulated and inspired me in the past. It would be ungrateful not to pay tribute to my old University, for it was while I was a student at Glasgow that my interest in the subject was first awakened. Undoubtedly another formative influence was a family tradition which valued technical skill and which fostered a youthful enthusiasm for biography and clan history.

It is scarcely surprising that a student with such a family background and attending a University associated with names such as Watt and Kelvin should become interested in the nature and inheritance of scientific and technical abilities. Thus, it may be deemed not inappropriate if I conclude by quoting an ancient motto of the Clan Macfarlane referring to a traditional interest in the science of astronomy:

*Numen lumen, astra castra.* (The Lord my light, the stars my camp.)

I. M. S.

GARNETT COLLEGE,  
DOWNSHIRE HOUSE,  
ROEHAMPTON LANE,  
ROEHAMPTON, S.W.15



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*Chapter one*

## Spatial Ability and the Selection Problem

### *The shortage of scientific manpower*

It has often been said that, in an age of scientific revolution, a nation's economic progress and survival depend largely upon the quality of its scientific, technological and technical education. Hence, it is widely recognized that the present acute shortage of all grades of scientific and technical personnel is one of the most critical problems affecting the future well-being of Great Britain. While the shortage appears to be world-wide,\* in Britain it approaches the dimensions of a national crisis. Numerous authorities have estimated that in proportion to the population, both the United States of America and Soviet Russia are producing several times the number of scientists and engineers that are being produced in the United Kingdom. C. P. Snow (1959) has estimated that if we compare like with like, putting scientists and engineers together, Britain is training at a professional level one Briton to every one and a half Americans and to every two and a half Russians. He has given the following figures of graduates trained per year (scientists and engineers combined): United Kingdom 13,000; U.S.A. 65,000; U.S.S.R. 130,000.

Snow states that the Russian output of engineers is now much larger than that of the rest of the world put together, approximately, 50 per cent larger. While only slightly more pure

\* C. F. McCrensky (1958) *Scientific Manpower in Europe*. London, Pergamon Press.