

**GENETIC BASIS OF
MORPHOLOGICAL
VARIATION**

**RICHARD H. OSBORNE
FRANCES V. DE GEORGE**

Foreword by Theodosius Dobzhansky

Genetic Basis of Morphological Variation

AN EVALUATION AND APPLICATION
OF THE TWIN STUDY METHOD

By Richard H. Osborne and
Frances V. De George

Published for THE COMMONWEALTH FUND
by HARVARD UNIVERSITY PRESS
Cambridge, Massachusetts, 1959

© 1959 BY THE COMMONWEALTH FUND

*Published for The Commonwealth Fund
By Harvard University Press, Cambridge, Massachusetts*

For approximately a quarter of a century THE COMMONWEALTH FUND, through its Division of Publications, sponsored, edited, produced, and distributed books and pamphlets germane to its purposes and operations as a philanthropic foundation. On July 1, 1951, the Fund entered into an arrangement by which HARVARD UNIVERSITY PRESS became the publisher of Commonwealth Fund books, assuming responsibility for their production and distribution. The Fund continues to sponsor and edit its books, and cooperates with the Press in all phases of manufacture and distribution.

Distributed in Great Britain by Oxford University Press, London

LIBRARY OF CONGRESS CATALOG CARD NO. 59-15743

MANUFACTURED IN THE UNITED STATES OF AMERICA

*To the Twins and Other Subjects
Who Made This Study Possible*

Foreword

Nature-nurture polemics are no longer quite as rife as they used to be during the period between the two world wars. Nevertheless, the question of the relative contributions of heredity and environment to the causation of the differences between persons remains one of the outstanding unsettled problems of the Science of Man. The diversity of opinion continues to be as great and irreconcilable as ever. Only a few years ago Darlington was able to write: "Man is immensely adaptable, not through the plasticity of the individual but through the variability of the species. . . . Individual adaptability is indeed one of the great illusions of common sense observation." At the opposite extreme, Alfred Adler wrote: "But the concept that character and

personality are inherited from one's parents is universally harmful because it hinders the educator in his task and cramps his confidence." And yet, is this so intractable an issue that it must remain outside the framework of scientific analysis? Obviously it need not be; but the only hope of arriving at an universally satisfactory settlement lies in acquisition of well authenticated evidence, not in declarations of personal opinions, however uncompromisingly or persuasively stated. Careful gathering of reliable data was the goal which Osborne and De George set for themselves, and their book reports the results so far obtained.

The naive hope that some day we shall know which human "traits" or "characters" are hereditary and

FOREWORD

which are environmental is no longer entertained by any informed student of the problem. More sophisticated approaches had to be adapted. All traits and all characters are hereditary and all are environmental; there is no organism without heredity, and no heredity can produce an organism except by transforming a part of the environment into a living body; the path which the development of the body takes is necessarily within the norm of reaction of the organism, set by its genotype but realized within a given succession of environments. The nature-nurture problem takes, then, a different form. We must ask what portion of the variance in a given trait observable in a given population is ascribable to the existing diversity of genotypes and what part can be accounted for by the diversity of environments. This statistical approach is adopted by Osborne and De George. The critical value is everywhere the ratio of the variances observed between members of monozygotic twin pairs and between those of dizygotic twin pairs. These "intrapair" variances are, in turn, compared with the "interpair" variances, which measure the diversity of the forms which a given trait takes in the population from which the twins studied are a sample.

Some of the results obtained by Osborne and De George can be understood properly only in the light of the principle that what is inherited is the norm of reaction to the environ-

ment, and not this or that "character." Thus, Osborne and De George have found no appreciable genetic components in the variability of such traits as the body weight, the head length, and some measurements taken transversally to the long axis of the body. Other studies on twins, particularly the classic work of Newman, Freeman, and Holzinger, have found a strong genetic component in the same characters. And yet, there is no contradiction between these studies. It turns out that a considerable proportion of the twins studied by Newman, Freeman, and Holzinger were young people still in the process of growth, while Osborne and De George have dealt with adult twins. The most reasonable explanation is, consequently, that the genetic components in the determination of the growth rates and growth patterns are relatively greater than those in the conformation of the fully developed traits in the adult.

The work of Osborne and De George represents a great step forward in the studies on the nature-nurture problem. Surely, much further work is needed; the data which they have collected will however remain a part of the store of factual evidence, as well as an example of how such evidence should be gathered and analyzed.

Theodosius Dobzhansky
Columbia University, New York

Preface

The study reported here explores the possibilities of investigating the important question of genetic and environmental interaction by genetic methods utilizing the techniques of morphological description and measurement.

The complex nature of man's genetic variation and some of the problems which are unique to human studies are reviewed. The twin method is then evaluated, within the context of our understanding of the phenomenon of human twinning, for its usefulness in detecting genetic variability and analyzing genetic and environmental interaction. With this background, the twin method is then applied to the study of different descriptions and measurements of morphological variation.

Because this is a preliminary study, emphasis has been placed upon the methods of investigation and upon providing an empirical basis for the application of genetic and morphological studies to different human problems. It is hoped that the methods presented here and the results of this analysis will suggest further twin research and morphological studies in genetics, anthropology, and the medical sciences.

While the present study was designed for the analysis of genetic and environmental effects on what may be termed "normal" morphological variation, selection of the subjects on the basis of medical histories and examinations has made it possible to extend considerably the scope of the investigation. Most of the data relat-

PREFACE

ing to medical information have been reported elsewhere. Those aspects which have a bearing on the evaluation of the twin method or the analysis of morphological variables are reported here. Extensive data available from the records of the Columbia-Presbyterian Medical Center also have been incorporated.

The Twin Study Project was carried out under the auspices of the

Institute for the Study of Human Variation in Columbia University, and was conducted within the facilities of the Columbia-Presbyterian Medical Center. The collection of the data was started in September 1952 with a poll of all new admissions to Vanderbilt Clinic, for twins; it was completed in March 1956.

June, 1959

R. H. O.
F. V. De G.

Acknowledgements

Throughout the course of this study, Drs. Theodosius Dobzhansky, L. C. Dunn, and Howard Levene at Columbia University, and Dr. Robert Loeb at the Columbia-Presbyterian Medical Center gave generously of their time and counsel, and all of them read the manuscript. Particular gratitude is due to Dr. Levene for his statistical guidance, and to Dr. Dobzhansky for writing the Foreword.

We are grateful to Dr. Harry L. Shapiro of the American Museum of Natural History for advising on anthropological aspects, for making available anthropometric instruments, and for reading the manuscript.

Dr. John Scudder and Miss Mary Sargent of the Presbyterian Hospital Blood Bank, together with their staff, were of the greatest assistance through-

out the course of the study not only in performing blood grouping determinations, but also in providing laboratory equipment and facilities. Dr. Amos Cahan and Mr. James Jack of the Knickerbocker Foundation, Inc., and Dr. Phillip Levine of the Ortho Research Foundation also gave advice and assistance in obtaining the blood determinations so vital to the zygosity diagnosis.

The subjects were examined in the Constitution Laboratory in the Department of Medicine, College of Physicians and Surgeons, Columbia University. Dr. William Sheldon and his staff were helpful in executing procedures pertinent to this phase of the study. Dr. Sheldon assigned the somatotype ratings and made valuable control data available for the

ACKNOWLEDGMENTS

analysis of body build. Dr. Sylvia Traube was particularly helpful in expediting various study procedures and in making arrangements for the study subjects. Miss Edith Seabury gave generously of her time in obtaining questionnaire information.

The medical aspects of this study profited greatly from the advice and assistance of Dr. Sylvia Traube, Dr. Albert Damon, and Dr. Warner Nash, who, in addition to other staff residents, conducted the medical examinations of all of the subjects studied. Clinical laboratory determinations were performed primarily by Miss Ellen Mikkelsen and Miss Betty Nielson.

The juvenile series was obtained from the Fetal Life Study conducted in the Department of Pediatrics, Columbia University, College of Physicians and Surgeons, and Babies Hospital. This study was aided by grants from the Rockefeller Foundation, the Life Insurance Medical Research Fund, the New York State

Department of Health, the New York Foundation, The Association for the Aid of Crippled Children, and the U.S. Public Health Service (Grant G-4194).

We thank Mrs. Janet Nichols for giving us access to her excellent records and to the Sloane Hospital statistics. To Mr. Robert Demarest we are indebted for illustrating the Masculinity-Femininity Ratings.

Acknowledgements are gratefully extended to the hospital registrars, record room personnel, x-ray technicians and aides, and to friends and colleagues who contributed so generously throughout the course of this study.

All aspects of this study—the collection of data, the analysis, and the preparation of the manuscript for publication—were supported by the Commonwealth Fund. We wish to express our deepest appreciation for this help and for the understanding and cooperation of the staff throughout this period.

Contents

Foreword, by Theodosius Dobzhansky	vii
Preface	ix
Acknowledgements	xi

PART ONE

Introduction

I. Genetic Study of Morphological Variation	3
The Methods of Human Genetics	9

PART TWO

An Evaluation of the Twin Study Method

II. Methods of Analysis	15
III. Obtaining a Twin Sample	25
IV. The Diagnosis of Twin Zygosity	31

PART THREE

The Design of the Study of Normal Morphological Variation

V. General Considerations	41
VI. The Source and an Evaluation of the Study Sample	44

CONTENTS

VII. The Frequency of Twin Pairs in Relation to Sex and Zygosity . . .	50
VIII. The Method of Analysis	59

PART FOUR

The Analysis of Morphological Variation

IX. Stature, Weight, and Ponderal Index	69
Stature	69
Weight	71
Ponderal Index	73
Conclusions Drawn from Stature, Weight, and Ponderal Index Studies	74
X. Anthropometry	77
Arm and Hand Measurements	78
Length	78
Total arm length	78
Upper arm length	78
Forearm length	79
Hand length	79
Middle finger length	79
Breadth	82
Wrist breadth	82
Hand breadth	82
Circumference	83
Upper arm circumference	83
Forearm circumference	83
Minimal wrist circumference	83
Summary of findings on arm and hand	84
Trunk Measurements	87
Length	87
Sitting height	87
Suprasternal height	87
Breadth and depth	87
Bideltoïd breadth	87
Bi-acromial breadth	87
Chest breadth	90

CONTENTS

Chest depth	90
Waist width	90
Hip breadth	90
Bi-iliac breadth	91
Bitrochanteric breadth	91
Circumference	91
Chest circumference	91
Chest circumference at xiphoid process	91
Waist circumference	94
Hip circumference	94
Summary of findings on trunk	95
Leg and Foot Measurements	98
Length	98
Total leg length	98
Thigh length	98
Lower leg length	98
Foot length	98
Breadth	99
Ankle breadth	99
Heel breadth	99
Foot breadth	99
Circumference	103
Thigh circumference	103
Knee minimal proximal circumference	103
Knee minimal distal circumference	103
Calf maximal circumference	104
Ankle minimal circumference	104
Summary of findings on leg and foot	105
Head and Neck Measurements	108
Length	108
Head length	108
Head height	108
Total face height	109
Upper face height	109
Nose height	109

CONTENTS

Ear height.....	112
Breadth.....	112
Head breadth.....	112
Minimal frontal breadth.....	113
Bizygomatic breadth.....	113
Bi-ocular width.....	113
Interocular width.....	115
Nose breadth.....	115
Bigonial breadth.....	115
Mouth width.....	115
Neck width.....	115
Circumference.....	119
Head circumference.....	119
Neck circumference.....	119
Summary of findings on head and neck.....	120
Conclusions Drawn from Anthropometry.....	121
XI. Fat, Bone, and Muscle.....	128
Fat Measurements.....	128
Upper arm skinfold thickness.....	129
Chest skinfold thickness.....	129
Scapular skinfold thickness.....	129
Abdominal skinfold thickness.....	131
Thigh skinfold thickness.....	131
Summary of findings on body fat measurements.....	133
Bone Measurements.....	133
Muscle Measurements.....	134
Upper arm diameter.....	134
Conclusions Drawn from Fat, Bone, and Muscle Studies.....	135
XII. The Analysis of a Body-Build Taxonomy.....	136
Endomorphy.....	139
Mesomorphy.....	140
Ectomorphy.....	140
Total somatotype.....	140
Conclusions Drawn from Somatotype Studies.....	142

CONTENTS

XIII. A Masculinity and Femininity Rating.....	145
Development of a Masculinity-Femininity Rating Scale.....	146
Upper body.....	146
Upper extremity.....	146
Trunk.....	147
Waist.....	147
Abdomen.....	147
Lower body.....	148
Buttocks.....	148
Trochanteric fat pad and hip line.....	148
Thigh.....	149
Lower leg.....	149
Method of Quantification.....	149
Application of the Masculinity-Femininity Rating Scale.....	153
Conclusions Drawn from Masculinity-Femininity Rating.....	154

PART FIVE

Summary and Conclusions

XIV. Summary and Conclusions.....	157
-----------------------------------	-----

APPENDICES

I-A The Study Procedure.....	165
I-B Reasons for Exclusion of Twin Pairs from Analysis.....	176
II Zygosity Diagnosis.....	178
III-A Sample Somatotyping Card.....	181
III-B Data on Unrelated Controls.....	182
IV Masculinity and Femininity Rating Method.....	184
References.....	193
Index.....	203

Tables

TABLE	PAGE
1 Mean ages of twins studied	47
2 Concordance-discordance in education level	48
3 Sex composition of twin study samples	51
4 Sex and zygoty composition of twin samples	52
5 Viable twin pairs born in Sloane Hospital 1945 to 1954 inclusive, by race and by hospital service	53
6 Sex distribution in single abortions, by hospital service and race	55
7 Sex distribution in twin abortions, by hospital service and race	56
8 Sex of individuals in juvenile twin birth series	56
9 Health status of surviving juvenile series twin pairs	57
10 Stature	70
11 Weight	72
12 Ponderal index	74
13 Correlation between height and weight	74
14 Total arm length	79
15 Upper arm length	80
16 Forearm length	80
17 Hand length	81

TABLES

TABLE	PAGE
18 Middle finger length	81
19 Wrist breadth	82
20 Hand breadth	83
21 Upper arm circumference	84
22 Forearm circumference	85
23 Minimal wrist circumference	85
24 Correlation between upper arm length and forearm length	86
25 Correlation between forearm length and wrist breadth	86
26 Sitting height	88
27 Suprasternal height	88
28 Bideloid breadth	89
29 Bi-acromial breadth	89
30 Chest breadth	90
31 Chest depth	91
32 Waist width	92
33 Hip breadth	92
34 Bi-iliac breadth	93
35 Bitrochanteric breadth	93
36 Chest circumference (at nipples)	94
37 Chest circumference (at xiphoid process)	95
38 Waist circumference	96
39 Hip circumference	96
40 Correlation between chest breadth and bitrochanteric breadth	97
41 Correlation between chest breadth and suprasternal height	97
42 Total leg length	99
43 Thigh length	100
44 Lower leg length	100
45 Foot length	101
46 Ankle breadth	101
47 Heel breadth	102
48 Foot breadth	102
49 Thigh circumference	103