1 Introduction

The goal of this book is to explore the origins of individual differences in behavioral development during infancy and early childhood. A key phrase is "individual differences." When developmentalists look at infancy and early childhood, they are usually absorbed by the dramatic changes that members of our species undergo during this fast-moving period of development. For example, Jean Piaget, the most influential figure in developmental psychology since the 1960s, described cognitive changes in terms of the transition from the sensorimotor actions of infancy to the representational abilities of early childhood, seen most clearly in the blossoming of language. However, Piaget was concerned only with average developmental trends, not with differences among children.

In contrast, when we look at children, we see children, not the child. That is, our interest centers on the development of individual differences among children rather than universal or normative (average) aspects of our species' development. A powerful theory of development must be able to explain individual differences, if for no other reason than that such differences exist – individual differences represent a major part of the phenomenon to be explained. There are, however, other reasons for studying individual differences: Descriptions and explanations of normative aspects of development bear no necessary relationship to those of individual differences; questions concerning the origins of individual differences are more easily answered than questions concerning the etiology of normative aspects of development; and the developmental issues of greatest relevance to society are issues of individual differences. A discussion of these topics can be found in Chapter 2.

A second key word is "origins." Because our perspective is quantitative genetics, the word "origins" implies an interest in understanding the role played by genetic as well as environmental factors in the development of individual differences. As explained in Chapter 3, quantitative genetics provides a general theory of the development of individual differences that

leads to novel concepts, methods, and research. Emphatically, it is more than the study of nature versus nurture. For example, a current research focus is the "nature of nurture," the developmental interface between genetic and environmental influences. Relevant research addresses such topics as genotype–environment interaction, genotype–environment correlation, and genetic mediation of "environmental" influences, discussed in Chapters 9, 10, and 11, respectively.

Another important example of the extension of quantitative genetics beyond the nature–nurture question is the study of the role of genetics in developmental change as well as continuity. The realization that genetic influences contribute to change has broad implications for the study of development, beginning with a conceptual reorientation away from the old notion of genes as static, unchanging influences and leading to new methods and research that address genetic etiologies of developmental transitions and changes, the topic of Chapters 5 and 6 and the focus of a new subdiscipline, developmental behavioral genetics (Plomin, 1986a).

The lifeblood of research on developmental change and continuity is the longitudinal study, and research on genetic transitions and changes in development requires longitudinal quantitative genetic designs. The difficulties of conducting longitudinal studies are legion, and these difficulties are magnified many times in developmental behavioral genetic research by the need for special samples such as twins and adoptees. For this reason, in addition to Skodak and Skeels's (1949) classic longitudinal adoption study of IQ, there are only two long-term longitudinal quantitative genetic studies of behavioral development. One is the Louisville Twin Study, a 20-year study of twins from infancy through adolescence (Wilson, 1983). The focus of this work has been IQ, although during the past decade, temperament has become central to the study.

The other major study is the Colorado Adoption Project (CAP). One of the aims of this book is to present new data from the CAP that address the origins of individual differences during infancy and early childhood, especially changes and continuities. The CAP history, design, measures, and basic results in infancy were described in an earlier book (Plomin & DeFries, 1985a); these infancy analyses were based on data from a sample of 182 adopted infants and 165 nonadopted infants who were studied at both 12 and 24 months of age. The background of the CAP is briefly described in Chapter 4, and in later chapters we update the infancy results for the complete CAP sample of 245 adoptive and 245 nonadoptive families. However, we focus primarily on issues of change and continuity during infancy and early childhood; in addition to the infancy data for the complete CAP sample, we present data for 186 adopted and 151 nonadopted CAP

children at 3 years and 162 adopted and 134 nonadopted children at 4 years.

Until now, CAP analyses have relied on parent–offspring comparisons – the biological and adoptive parents of the adopted children and the parents of the nonadopted children were also tested as part of the CAP. Parent–offspring comparisons are especially interesting when offspring are studied in childhood because genetic sources of change during development lead to differences between parents and their young offspring. In this genetic sense, the CAP design can be seen as an "instant" longitudinal study from childhood to adulthood. Viewed from this perspective, the CAP parent–offspring data have yielded some surprising results, as described in Chapters 6 and 8. An important complement to the parent–offspring data is the sibling adoption design, which compares adoptive and nonadoptive siblings. The contemporaneous relationship of siblings as compared with the developmentally distant relationship of parents and young offspring adds a new dimension to the CAP results. The present book describes this first longitudinal study of adoptive and nonadoptive siblings for the following sample of adoptive and nonadoptive siblings: 67 and 82 pairs, respectively, at 1 year of age; 61 and 70 pairs at 2 years; 50 and 54 pairs at 3 years; and 42 and 43 pairs at 4 years.

One of the major advances in quantitative genetic techniques during the past decade has been the development of model fitting, in which family resemblance is expressed in terms of an underlying model consisting of several unobserved genetic and environmental parameters and this model is compared with, or "fit" to, the observed correlations. The CAP design is sufficiently powerful that simple correlations for the various genetically related and unrelated family members can be meaningfully compared – and these simple data are presented throughout the book. The advantages of model fitting include the following. It makes assumptions explicit; it tests the fit of a specific model and compares different models; it provides standard errors of estimates; and it can incorporate into a single analysis different types of data – such as data from nonadoptive as well as adoptive families and parent–offspring data as well as sibling data – rather than considering each type of data separately. The main disadvantage of model fitting is the relative inaccessibility of models to people who have not learned the model's special language and the accompanying feeling that models are black hats from which estimates magically appear. For this reason, in Chapter 7 we introduce model fitting and develop simple parent–offspring models for CAP.

In Chapter 8, these simple models are applied cross sectionally to the basic CAP data for adopted and nonadopted children at 1, 2, 3, and 4

years of age. The parent–offspring model and a combined parent–offspring and sibling model are also extended to the analysis of longitudinal data. All of these models are univariate, although longitudinal analysis is conceptually similar to multivariate analysis (Plomin, 1986b). A new development in model fitting is multivariate analysis (DeFries & Fulker, 1986); multivariate extensions of the CAP sibling and parent–offspring models are also presented in Chapter 8 and applied to the analysis of interrelationships among temperament and cognitive measures at 2 and 3 years of age and to the developmental differentiation of specific cognitive abilities in early childhood.

In summary, the purpose of this book is to consider the development of individual differences in behavioral development during infancy and early childhood as illuminated by quantitative genetic theory and research, emphasizing developmental change as well as continuity. We begin in the next chapter by contrasting individual-differences and group-differences approaches to the study of development and discuss the advantages and disadvantages of the two approaches. In Chapter 3, we suggest that quantitative genetics provides the basis for a general theory of the etiology of individual differences, a theory of a scope and power rarely seen in the behavioral sciences. Chapter 4 describes the design and measures of the Colorado Adoption Project, the data of which provide the foundation for much of what we know about the origins of individual differences from infancy to childhood.

We then discuss issues and evidence concerning developmental transitions and changes, specifically in relation to infancy and early childhood. The focus of Chapter 5 is the description and prediction of developmental change from the perspective of individual differences, not from the usual normative perspective. In Chapter 6, we turn to an explanation of these changes, considering both genetic and environmental etiologies.

The next two chapters form a section on model fitting. Chapter 7 is a didactic chapter that provides an elementary introduction to model-fitting approaches used in quantitative genetics. The chapter builds toward the basic univariate sibling and parent–offspring models employed in CAP. In Chapter 8, these models are used to analyze the major CAP sibling and parent–offspring data at each year. Chapter 8 also presents a longitudinal parent–offspring and twin model that considers genetic correlations from childhood to adulthood. The final topic of Chapter 8 is the extension of the parent–offspring models to the multivariate case; the multivariate sibling model is applied to the relationship between temperament and cognition at 2 and 3 years of age, and the multivariate parent–offspring model is applied to data on specific cognitive abilities at 3 and 4.

The next three chapters address the developmental interface between nature and nurture. Interaction is the focus of Chapter 9. We emphasize genotype–environment interaction because adoption data alone permit an exploration of this type of interaction. In addition, however, we examine three other types of interactions: interactions involving parent–offspring resemblance, longitudinal interactions (specifically, longitudinal changes in IQ), and temperament–environment interactions. Developmentalists' concerns with genotype–environment interaction are often better represented by the concept of genotype–environment correlation, which refers to the correlation rather than interaction between environmental influences and genetic propensities. In Chapter 10, three types of genotype–environment correlation are discussed and attempts to assess each type are presented. Finally, the issue of genetic mediation of "environmental" influences is the focus of Chapter 11. In other words, heredity can contribute to the variance of measures of family environment and to the covariation between environmental measures and measures of development; these issues are addressed using sibling and parent–offspring comparisons in the adoptive and nonadoptive families of the CAP.

The purpose of the final chapter is to summarize what we know as well as what we need to learn about the origins of individual differences during infancy and early childhood. It will come as no surprise that the ratio of what we know to what we do not know is small indeed. Nonetheless, the ratio is more impressive when we consider how few studies have addressed these issues. Moreover, the numerator of the ratio contains some exciting findings, and we hope that these will fuel further research on the origins of individual differences.

2 Individual differences and group differences

Interest in as well as understanding and acceptance of behavioral genetics are often hindered by a single issue: confusion between individual differences and group differences. That is, behavioral genetic theory and research address individual differences (variance), whereas most psychological research involves group comparisons (means). In this chapter, we contrast these two approaches and then discuss the advantages and disadvantages of an individual-differences perspective. In part, the relative neglect of an individual-differences approach is due to its apparent atheoretical orientation. For this reason, the next chapter considers quantitative genetics as the basis for a general theory of the origins of individual differences.

The group-differences approach focuses on average differences, such as gender, age, cultural, or species differences, among groups of individuals within a population. In contrast, the etiology of differences among individuals in a population is the focus of individual-differences research. The point of this chapter is not that the individual-differences approach is better than the group-differences approach. The two approaches are perspectives, and perspectives are neither right nor wrong, only more or less useful for a particular purpose. However, we do argue that the two approaches differ in important ways that affect theories and research. In the following section, the basic distinction between the two approaches is examined more closely.

Individuals and groups

The term "individual differences" usually refers to continuous variation among individuals in a population. Variance, an index of individual differences, is the average squared deviation from the mean. Group differences such as differences between the means of boys and girls or groups of children of different ages are clearly not individual differences. Therefore, at first glance, it seems straightforward to distinguish between

individual-differences and group-differences approaches. However, the distinction requires closer examination.

Experiments

The mere mention of these two approaches in psychology will no doubt trigger associations with the distinction drawn 30 years ago between the experimental and correlational "disciplines of scientific psychology" (Cronbach, 1957):

> While the experimenter is interested only in the variation he himself creates, the correlator finds his interest in the already existing variation between individuals, social groups, and species. (p. 671)

> Individual differences have been an annoyance rather than a challenge to the experimenter. His goal is to control behavior, and variation within treatments is proof that he has not succeeded. Individual variation is cast into that outer darkness known as "error variance." . . . whatever your device, your goal in the experimental tradition is to get those embarrassing differential variables out of sight. (p. 674)

In terms of the present issue, experimenters usually focus on group differences. However, experiments are only a small subset of studies of group differences. As indicated in the first quotation, Cronbach compares experiments with all other research on group differences as well as individual differences. Further complicating the relationship between the experimental–correlational distinction and the distinction between group differences and individual differences is the fact that the experimental method is not limited to the study of group differences. It can be applied to the study of individual differences, as in analyses of aptitude-by-treatment interactions, which was the thrust of Cronbach's prescription for the integration of experimental and correlational approaches.

Nonetheless, the primary focus of experimental research is usually on group differences, the group membership being considered an independent variable. Experiments are discussed again later in this chapter when we consider analyses of the etiology of group differences and individual differences.

Dichotomies

Another problem of classifying research in terms of the distinction between individual differences and group differences occurs when a trait is defined and measured as a dichotomy. In psychopathology, the disease model borrowed from medical pathology leads to dichotomous diagnoses – for example, children are diagnosed as autistic or not. Is this a group difference or an individual difference? We suggest that when individuals can be as-

sessed only dichotomously, as in the presence or absence of a disorder, the dichotomy can be viewed as either a group difference or an individual difference.

The problem is further complicated because psychopathology rarely involves true dichotomies; continuously distributed differences among individuals are the rule (e.g., Rutter & Garmezy, 1983). For example, children's attentional problems and conduct problems are not distributed as dichotomies. In such cases, when the normal distribution for problem behavior is divided at some threshold, information is lost because we pretend that every individual above the threshold has the disorder and everyone below does not. The assignment of dichotomous scores in such cases is analogous to having an extremely crude measure of height in which we diagnose individuals as either "normal" or "tall." However, until we are able to measure the individual variability that exists in nature, these cases, for all practical purposes, must be treated as dichotomous individual differences, like autism. For the same reason, nonclinical studies that divide their samples at some point such as the mean are best considered crude studies of individual differences.

Extremes

A second problematic category leads to a different conclusion: mean comparisons involving the high or low extremes of a distribution. Analysis of extremes cannot lead to generalizations concerning the normal distribution of individual differences for the simple fact that only the extremes of the distribution are studied. This is not merely a semantic argument: Descriptions and explanations of extreme groups bear no necessary relation to the description and explanation of the normal continuum of individual differences.

Within the analysis of extreme groups, an individual-differences approach can be taken. For example, the genetic and environmental etiologies of individual differences at the low or high ends of the IQ distribution – mental retardation and genius – could be explored. More often, however, membership in extreme groups is considered an independent variable. For example, children selected to be shy are brought to the laboratory and compared with a group of children selected for their lack of shyness (Kagan, Reznick, & Snidman, 1986). Another category of examples comes from "at-risk" studies: Children are selected whose parents are extreme for some problem behavior; the mean performance of the children at risk is compared with the mean performance of a control group of children (Watt, Anthony, Wynne, & Rolf, 1984). Results of such studies are limited to the

extreme groups studied and cannot be generalized to the distribution of differences among individuals within the normal range.

Naturally occurring groups

A third possible confusion involves naturally occurring categories such as gender, age, and ethnic group. Given that children are either girls or boys, is gender an individual-differences variable? The answer is no. Psychologists may assess a dependent behavioral measure, one that is nearly always continuously distributed, and then compare girls and boys for that measure. For example, the average verbal abilities of boys and girls have often been compared. As argued later, such group differences are usually trivial compared with individual differences within the groups and, again, description and explanation of differences between groups are not necessarily related to those within groups. For example, if the average difference in verbal ability between girls and boys were found to be due to hormonal differences, it could not be assumed that individual differences among boys' or girls' verbal ability are also due to hormonal differences.

As in the case of extreme groups, individual differences can be studied within groups. In this book, for example, parent–offspring resemblance and associations between environmental and behavioral measures are compared for infants and children in order to detect possible differences in the etiology of individual differences during the transition from infancy to early childhood.

Universals

Another complication in distinguishing between individual-differences and group-differences approaches concerns "universal" theories, such as theories of why the human species talks or walks. Clearly, these are not studies of individual differences. The focus is on the average behavior of a group – the group in this case is the human species. Because the behavior of a single group is studied, such research does not literally involve group differences; nonetheless, all of the issues relevant to the study of group differences are relevant to the study of a single group.

Within-individual differences

Finally, we reserve the term "individual differences" to refer to differences between individuals, not to ipsative approaches that study within-individual variability. Unless ipsative approaches are meant to be strictly idiographic,

their generalizability depends on studying within-individual variables in a between-individual context. In this book, we analyze longitudinal change and continuity within individuals; however, these issues are considered in a between-individuals framework.

The neglect of individual differences

Despite the exceptions just described, it is generally not difficult to make the distinction between group-differences and individual-differences research. When research is seen from this perspective, a surprising imbalance emerges: Far more contemporary research in psychology, and in developmental psychology in particular, focuses on group differences than on individual differences.

For example, the *Handbook of Child Psychology* (Mussen, 1983) presents a recent and representative sampling of theory and research in the field of developmental psychology. Of the 2,926 pages of text (excluding references, outlines, and notes), 78% are devoted predominantly (i.e., more than half the page) to group differences. Of the 48 chapters, 41 include more pages on group differences than on individual differences. Moreover, 19 chapters include not a single page on individual differences, and 4 other chapters consider individual differences on 2% or fewer of their pages. The topics of these 23 chapters are instructive because they point to areas most likely to profit conceptually and empirically from an individual-differences approach. The 23 chapters fall into two major categories and two minor ones. Six chapters involve the oldest fields of psychology: perception and learning. Nine chapters consider cognition and language. In addition, there are two chapters on brain development and three chapters on intervention. The three remaining chapters involve history, systems theory, and cross-cultural research.

Only eight chapters in the *Handbook* devote more than 50% of their pages to individual differences. A list of these chapters follows:

"The Evolution of Environmental Models in Developmental Research"

"Design and Analysis in Developmental Psychology"

"Assessment of Children"

"Developmental Behavioral Genetics"

"Morality"

"Stylistic Variation in Childhood and Adolescence"

"Socialization in the Context of the Family"

"Developmental Psychopathology"