Abstract
The long-standing topic of how to represent and measure change in behavioral sciences is examined. We contend that focusing on change processes such as growth and development intrinsically requires one to operationalize three fundamental and intimately connected concepts—measurement, design, and analysis. In the measurement section, we discuss some historical developments such as initial attempts to obtain “ostensive” characteristics of behavioral abstractions, some controversies surrounding difference scores and regression toward the mean, and the various factor analytic approaches offered by Cattell’s (1952) data box. We also examine more recent measurement schemes, such as multivariate representations of change and latent difference scores. In the design section, we stress the importance of a proper selection of occasions of measurement, and we discuss recent advances, such as planned incompleteness of data and the use of minilongitudinal studies to overcome practical difficulties. Finally, in the modeling section, we discuss newer modeling approaches, such as dynamic factor models and dampened linear oscillator models. While not settling any of the historical controversies, we contend that the more recent and promising methodological innovations for studying change discussed here, although not a solution, represent a much needed step toward the fundamental goal of more adequately representing and measuring change.

How to represent and measure quantitative change is a long-standing topic, rich in both history and controversy, in behavioral science (see, e.g., Bohmstedt, 1969; Burr & Nesselroade, 1990). Oddly, for decades investigators in subdisciplines such as developmental psychology have blithely proceeded with studying their content relatively undeterred by the fact that there was precious little agreement among even the experts on such seemingly fundamental matters as how to measure, represent, and construe quantitative change (e.g., Cronbach & Furby, 1970; Harris, 1963). Proposed solutions
to the most basic concerns (such as calculating change scores on psychological and behavioral attributes) have been among the most controversial. A significant amount of the explicit effort to improve the situation has been generated within the lifespan development research and theory tradition. Succeeding generations of methodologically sensitive individuals have revisited the old problems, recognized some new ones, and have both invented their own procedures and adapted those of other fields to improve the representation of measured changes in interesting psychological and behavioral variables (e.g., Boker & Nesselroade, 2000, 2001; Goulet & Baltes, 1970; Meredith & Tisak, 1982; McArdle & Hamagami, 2001; Nesselroade & Reese, 1973; Nesselroade & Baltes, 1979).

We examine some of the relevant historical issues and approaches to the measurement of change to set the stage for a discussion of more recent, promising efforts to better represent and measure quantitative change. Indeed, we believe that some major and fundamental shifts are occurring in the way developmentalists think about change and process. Some currently available methods for measuring and representing changes in quantitative variables will be described and summarized, and some projections will be made concerning future directions of methodological innovation for studying developmental change (see also Molenaar, Huizenga, & Nesselroade, this volume).

The Context for Change Measurement

Without clear and unambiguous concepts of process and change, there cannot be much in the way of a developmental science. For concepts of change to have scientific viability, there must be available practical and valid ways to render change concepts operational. The latter rests heavily on the capacity to represent and measure change. This simple chain of reasoning rather tersely defines the content domain of this chapter.

We believe that to facilitate the study of growth, development, and other kinds of change processes, change measurement has to be defined and made operational simultaneously across three major domains—measurement, design, and modeling or analysis (see Nesselroade, 1991a, 1991b). We examine each of these domains in turn, exploring their particular interfaces with efforts to resolve some of the very old problems in change measurement.

Much of the work reviewed here stems from the classical test-theory tradition (Gulliksen, 1950) and relies on assumptions of interval or ratio scales of measurement. Item Response Theory (IRT) modelers are also attentive to the problems of measuring change (Embretson, 1991; Nesselroade & Schmidt McCollam, 2000). Moreover, a considerable body of work has focused on methods for the analysis of categorical and ordinal measurements, which in turn has lead to nonparametric statistical methods for representing change concepts (Cliff, 1991). We focus on the first set of methodologies and literature. Readers interested in the latter measurement strategies are referred