Modeling Positive Human Health: From Covariance Structures to Dynamic Systems

Anthony D. Ong and Alex J. Zautra

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Abstract and Keywords

In this chapter, we illustrate how recent advances in longitudinal methodology can be applied to diverse issues of interest to positive psychologists. The aim of the chapter is to describe how contemporary theories of well-being may be empirically evaluated using a variety of research designs and analytic techniques that can fully capture the complexity and dynamics of positive human health. Throughout, we identify unresolved methodological challenges associated with the measurement and analysis between- and of within-person phenomena and elaborate on the implications of these challenges for process research in positive psychology.

Keywords: dynamic systems, growth curves, longitudinal

> The life, the fortune and the happiness of every one of us depend on our knowing something about the rules of a game infinitely more difficult than chess. The chessboard is the universe, the pieces are the phenomena of the universe. The player on the other side is hidden from us. We know that his play is always fair, just and patient. But we also know, to our cost, that he never overlooks a mistake, or makes the smallest allowance for ignorance. To the man who plays well, the highest stakes are paid, with the sort of flowering generosity with which the strong show delight in strength. And he who plays ill is check-mated—without haste and without remorse. What I mean by education is learning the rules of this mighty game.
>
> —*Thomas H. Huxley* (1948), *A Liberal Education*

The rules for doing research that can net the highest stakes in understanding are, to a considerable extent, the rules of design and measurement. Many forms of data analysis can lead to the same conclusion when a study is well designed, but even the most intricate and powerful data analysis methods cannot extract a dependable basis for understanding when a study is poorly designed. Design is critical. At the core of good design is good measurement. If the variables of an otherwise adequate design are not measured well, if they are not reliable and reliably independent, the results from analysis, however intricate and powerful these may be, can be of little value and may be quite misleading. It is therefore important to know the design properties of measurements, for these (p. 98) properties indicate what the results from analyses can and cannot reveal.

In this chapter, we illustrate how recent advances in longitudinal methodology can be applied to diverse issues of interest to positive psychologists. Although we do not intend to provide an in-depth review, we do strive to critically evaluate and address conceptual and methodological issues surrounding the need for (a) reliable and theory-driven measures of positive health and well-being, (b) study designs that link information at different levels of analysis, and (c) innovative methodological approaches that are sensitive to complex dynamic relationships. Progress on these issues requires a greater understanding of process. The aim of this chapter is to help build such understanding by describing how contemporary theories of well-being (i.e., subjective well-being and psychological well-being) may be empirically evaluated using a variety of research designs (e.g., longitudinal panel designs, intensive bursts designs) and analytic techniques (e.g., growth curve analysis and dynamic systems analysis) that can fully capture the complexity and dynamics of positive human health. We conclude with a brief discussion of methodological issues that might profitably be considered in future research.

Elaborating the “Positive” in Positive Psychology

Any theory that purports to be scientific should account for the extant evidence—ideally all of the evidence. It should also give indications of where new evidence should be sought that can test the theory and lead to modifications. A clear and detailed theoretical model thus is a necessary foundation for all empirical research. In an everyday sense of things, positive psychology is a theory of human strengths and potentials to which there are individual differences within the human species. Among the strengths and potentials that characterize humans in contrast to other species are some that allow for description of one individual as different from another. In all languages of the world there are words used to describe positive aspects of human functioning in which people differ. These positive aspects of human health have been referred to with the term “well-being.” Positive psychology is thus a theory of human well-being.

There is a problem in describing theory in this way, however. Well-being is a singular word. But the accumulated evidence indicates that there is more than one kind of quality that is said to be characteristic of human well-being. These qualities appear to be positively correlated, but no unifying principle (such as the principle that unites different forms of energy—kinetic, heat, chemical, etc.) has been established that unites different forms of well-being. Thus, the problem is that use of the singular word "well-being" fosters belief that different positive human experiences are all forms of one thing, well-being, when the empirical evidence points to many more. It is possible that there is one organizing principle pervading all human well-being. It is reasonable that there should be. It would be valuable to have a measure of it. But the evidence adduced thus far does not indicate that principle. Studies that can lead to such discovery therefore need to be based on good understanding of empirical measurement evidence.

Measuring Dimensions of Positive Health and Well-Being

The theories of subjective well-being (SWB; Diener, 1984) and psychological well-being (PWB; Ryff, 1989) were developed in response to simple structure evidence of covariation among measures of human well-being. The theories are largely descriptive—and account of what are the dimensions that characterize the human capacity for generating and coping with complexities. But the theories are also a description of variables with which measures of human well-being correlate, and an account of how and why such relationships come about. The theories are thus also explanatory. Although both theories aim to describe how people evaluate their lives, each gives emphasis to different aspects of this evaluation.

SWB defines evaluations in terms of three elements: reports of positive and negative affect and judgments of overall life satisfaction (Diener, 1994). A key assertion of this model is that positive emotion defines a dimension of well-being that cannot be accounted for through the assessment of subjective distress, depressed affects, or other negative emotions (Watson, Clark, & Tellegen, 1988). Overall life satisfaction then is thought to depend on the promotion of positive states, the diminution of negative affects, and the cognitive structures that support judgments that weigh the positive in life more heavily than the negative.

In contrast, PWB parses well-being into six elements: judgments of self-acceptance, personal growth, purpose in life, positive relations with others, environmental mastery, and autonomy (Ryff & Keyes, 1995, chap. 9). The authors of this approach distinguish their model as one that (p. 99) focuses on stable, "stick-to-the-ribs," qualities of the person in comparison to models of happiness that rely on subjective reports of positive states that are more transitory. Indeed, measures of the positive differ dramatically in the proportion of variance in their scores that constitute a stable trait (see Kenny & Zautra, 2001) versus a state, which varies within a person over time. Seen in this light, the two

approaches, SWB and PWB, may be thought of as more complementary, tackling different temporal aspects of the assessment of well-being.

Considerable progress has been made in identifying and measuring the separate elements of SWB and PWB. Reliable measures of these elements have been developed—the Positive and Negative Affect Schedule (PANAS; Watson et al., 1988), the Satisfaction With Life Scale (SWLS; Diener, Emmons, Larsen, & Griffin, 1985), and the PWB scales (Ryff, 1989). Different forms of evidence have been put forth to indicate the validity of these elements. Evidence of discriminant validity of SWB elements has been supported with multi-trait, multi-method analyses (Lucas, Diener, & Suh, 1996). Evidence of convergent validity of PWB elements has been indicated with common factor analyses (Ryff & Keyes, 1995). And evidence for the convergent and discriminant validity of all nine SWB and PWB elements has been supported with confirmatory factor analyses (Keyes, Shmotkin, & Ryff, 2002). Thus it has become clear that the phenomenon referred to as “well-being” is a mosaic of many component parts. This mosaic, such as it is, can be partitioned into a parsimonious set of dimensions, representing measurements that imperfectly account for individual differences among a large number of these components.

The Need for Idiographic Evidence

Although the foundational evidence has provided a basis for understanding the phenomenon of well-being, other basic information is needed to establish the nature of the phenomenon. That is, individuals are believed to exhibit coherent patterns of experience that cannot be fully described or explained merely by locating individuals within a fixed system of trait dimensions (Allport, 1966). Although nomothetic (between-person) analyses have yielded converging evidence for the construct validity of measures of SWB and PWB, very little attention has been given to investigating idiographic (within-person) relations among these elements (Ong, Horn, & Walsh, 2006).

Perhaps, nowhere more than in positive psychology is the importance of repeated measurement and analysis so essential (Ong & van Dulmen, 2006). Studies that include only one occasion of measurement provide a good example of ambiguities that arise when an assumption of stability is made. These ambiguities have been described in detail by Nesselroade (1991a). When participants are measured on only one occasion, the “interindividual” variability in the measurements can reflect three different sources: (a) stable differences among people (traits), (b) “intraindividual” variability (states), and (c) temporal measurement error. These three possible sources of variation are inextricably confounded when data are obtained on only one occasion, and it is impossible to separate them (Nesselroade, 1991b).

Because phenomena also may vary reliably and lawfully within individuals, conclusions based on nomothetic research are premature without idiographic information (Nesselroade, 1991b). With few exceptions (e.g., Wessman & Ricks, 1966; Zevon &

Tellegen, 1982), however, construct validation of SWB and PWB measures has been based largely on nomothetic rather than idiographic research. Little is known about whether the separate elements of SWB and PWB can be reliably and independently observed within individuals studied across time. To our knowledge, no study has provided evidence indicating that the reliability and independence of measurements that have been indicated in between-person analyses of both SWB and PWB (i.e., Keyes et al., 2002) also obtain for within-person observations of these phenomena. Evidence of this possibility is needed if SWB and PWB theories are to move beyond being simple descriptive empirical generalization of research findings to provide some indications of how positive health and well-being is organized within individuals, how such experience develops across the life span, or how individual differences in well-being come about.

The Need for Evidence of Measurement Invariance

Implicit in the comparison of groups and individuals is the assumption of equivalence of measurement. This assumption, however, is rarely tested directly in research in positive psychology. Yet the interpretation of either “interindividual” or “intraindividual” results, based on nonequivalent measurements, is riddled with ambiguity (Horn & McArdle, 1992). Evidence of measurement invariance is fundamentally important for evaluating both nomothetic and idiographic evidence. For in each case, before any construct validation results can be sensibly (p. 100) interpreted, there must be assurances that the scales measure the same attributes in the same way in different groups and circumstances. If scales do not measure the same factors (a) in the same way in different groupings of people or (b) in the same people measured in different places and times, there is no logical basis for interpreting the results of analyses of differences between means or variances or correlations (Meredith & Horn, 2001).

Do people interpret the items of SWB and PWB scales in comparable ways? A consistent finding in the literature is that women score slightly lower than men on measures of SWB (Lucas & Gohm, 2000), but significantly higher than men on PWB measures of Positive Relations with Others and Personal Growth (Ryff & Keyes, 1995). Although these observed differences may reflect valid psychological differences between men and women, it is also possible that the item content of certain SWB and PWB measures may differentially capture aspects of well-being that women are more likely to endorse, whereas the item content of other measures may summarize aspects of well-being that men are more likely to endorse (Ong et al., 2006). Establishing that an instrument is factorially invariant, therefore, provides evidence not only that respondents from different groups can be legitimately compared on the same scale, but also that observed group mean differences in raw scores reflect valid and meaningful group differences at the level of the latent variable assumed to underlie those scores. Evidence of measurement invariance across time, thus, is a necessary prerequisite for understanding all other evidence pertaining to the temporal validity of such constructs (Horn & McArdle, 1992; Meredith & Horn, 2001).

In essence, these concerns are all related to the larger issue of establishing the validity of measures of processes that are going on inside the person's head. Behavioral scientists rarely have been comfortable with the assumption that avowals of happiness and other states of well- and ill-being bear a one-to-one correspondence with actual states of well-being of the organism, and are even less comfortable with the assumption that the degree of accuracy of these accounts of subjective states is equivalent across people differing in personality, intelligence, and social situation. Recent advances in brain imaging have taken this question to a new level, pairing self-reports of emotive states with neural activation in regions of the brain known to be associated with those states. The evidence accumulated thus far suggests that there is considerable correspondence between self-reports of emotion and activation of brain regions, but also that people can differ substantially in the degree of excitation in response to stimuli that provoke an emotional state (Craig, 2005).

Designing Studies of Change

Because the process of change represents a main, central issue for the study of positive psychology, needed are research designs that can capture ongoing processes of growth and adaptation. In this section, we highlight the utility of longitudinal panel and intensive bursts designs. Arguments are presented that bear on the value of these designs as underutilized approaches that appear particularly appropriate to the investigation of intraindividual change and variability in SWB and PWB. Throughout, we argue that the strength of the process approach is an essential shift away from cross-sectional, single-variable explanations toward person-centered accounts of positive health.

Longitudinal Panel Designs

Many of the most interesting research questions addressed in positive psychology relate to how individuals change over time and what factors influence the development of adaptive change. Longitudinal panel designs are particularly well suited for evaluating models of “long-term” change or development. In the typical longitudinal panel design, (a) data are collected at two or more points in time, (b) the same sample of people is interviewed at distinct points in time, and (c) data from the respondents are compared across these time points to monitor patterns of change. Although longitudinal panel designs vary with respect to the composition of the sample, the number of follow-up assessments, and the intervals between assessments, such designs share two defining characteristics. First, the same research participants, who constitute the “panel,” are measured for two or more points in time (the measurement periods or “waves”). Second, at least one variable is measured for two or more waves. This is the “longitudinal” aspect of the data, which allows the measurement of qualitative or quantitative change within

individuals from one wave to the next. In contrast to the longitudinal panel design, “cross-sectional” designs involve the assessment of research participants at only one measurement point (for a review, see Raudenbush, 2000).

Intensive Bursts Designs

There are times when the investigator is interested in closely observing change while it is occurring. In comparison with longitudinal panel designs, (p. 101) intensive bursts designs allow researchers to observe processes of “short-term” change within a rapidly changing window of time. The use of electronic diaries (e.g., palm pilots) allows for the study of the determinants and consequences of changes in well-being within people's everyday lives. The short time intervals between events and self-reports improve accuracy and reduce bias. In addition to these improvements in measurement precision, repeated assessments of the same person over time solves a serious problem in inference that plagues research in this area. Variables that predict differences between people on an outcome like happiness may have no effect or even the opposite effect on the same outcome when measured as a change within the person observed over time (Tennen & Affleck, 1996). Only careful studies that evaluate changes over time in both the independent and dependent variable can safely make such assertions. Finally, electronic diaries have methodological advantages that are connected to the use of intensive bursts designs. First, electronic diaries allow individuals to report their behavior and experiences over the range of situational circumstances experienced in everyday life. Second, they allow for statistical modeling of behavior over time. Third and most important, such procedures can test, rather than assume, the validity of the nomothetic approach.

Methodologies That Are Sensitive to Dynamic Relationships

In addition to designing studies of change, one critical aspect of testing theories of change is fitting models of change to empirical data. In this section, we describe analytic possibilities that are available for longitudinal panel designs and for intensive bursts designs. We focus our comments on two general data analysis strategies, namely those associated with growth curve modeling and dynamic systems analysis, respectively. For a more thorough discussion of other statistical approaches for modeling change, the interested reader is referred to Collins and Horn (1991), Collins and Sayer (2000), Kenny and Zautra (2001), McArdle and Hamagami (2001), and Raudenbush (2001).

Growth Curve Modeling

One of the major goals of positive psychology is to determine factors that influence normal and optimal development. These factors may be fixed at a particular level (e.g., gender, ethnicity) or variable (e.g., physical health, emotions). Traditional statistical methods such as repeated measures analysis of variance cannot take into account the time-varying nature of covariates. The most commonly used approach to modeling change in continuous variables that allow for time-varying covariates is “growth curve models.” Growth curve models, such as hierarchical linear models (Raudenbush, 2000), fit growth trajectories for individuals and relate characteristics of these individual growth trajectories (e.g., slope) to covariates. Because these models typically involve relatively few occasions of measurements, longitudinal panel designs are generally the temporal design of choice when fitting growth curve models. The individual growth trajectory can be expressed as

$$Y_{ti} = \beta_{0i} + \beta_{1i}x_{ti} + e_{ti}$$

for a linear model of growth. Y_{ti} represents individual i's outcome score at time t, where $t = 1, \ldots T$; x_{ti} represents the measure of time for individual i; and β_{0i} and β_{1i} represent the intercept and slope, respectively, of linear growth for individual i. This is often referred to as the level 1 equation. The intercept and slope parameters are random effects; in other words, they may vary across individuals, as reflected in the need for the i subscript denoting individual. This leads directly to the level 2 equations:

$$\beta_{0i} = \gamma_{00} + u_{0i}$$

$$\beta_{1i} = \gamma_{10} + u_{1i}$$

Growth curve modeling is an appropriate technique for studying individual change because repeated measures can be considered as nested within individuals and can be represented as a two-level hierarchical model. At the within-person level, each individual's development is modeled as a unique growth trajectory. At between-person level, the growth parameters of these trajectories become the outcome variables, which are then modeled as a function of person-level characteristics. Consider a growth trajectory of SWB for individual A with intercept β_{0A} and slope β_{1A}. The level 2 equations state that individual A's intercept β_{0A} can be decomposed into two components: the grand mean of all the β_{0i}'s for all individuals, γ_{00}, and β_{0A}'s deviation from this grand mean, u_{0A}. Likewise, individual A's slope β_{1A} can be decomposed into two components: the grand mean of all the β_{1i}'s for all individuals, γ_{10}, and β_{1A}'s deviation from this grand mean, u_{1A}. Interindividual variability in intercepts is expressed in the variance of the u_{0i}'s, and interindividual variability in slope is expressed in the variance of the u_{1i}'s. (p. 102) It is possible to include predictors in addition to time (or even instead of time) in the level 1 equation, and to include time-invariant predictors in the level 2 equation. For excellent overviews of growth curve and hierarchical linear models for longitudinal panel studies, the reader is referred to Raudenbush (2000), McArdle and Nesselroade (2003), and Maxwell and Tiberio (2007).

Dynamic Systems Analysis

A recent implementation of intensive bursts designs is dynamic systems analysis. Fundamentally, a dynamical systems approach offers a way to formalize concepts of self-regulation. The focus is on modeling or representing the relationships between the current state of a variable or an ensemble of variables and the subsequent state of such variables (Boker & Nesselroade, 2002). One key advantage of the dynamic systems approach over other approaches to modeling dynamic processes is the capacity to represent “shocks” or other inputs from outside the individual.

For example, consider a model of self-regulation that reflects a “pendulum with friction,” which is hypothesized to best exemplify the intraindividual disregulation that may result from exposure to daily stress. This model is referred to as a “damped linear oscillator.” The equation for the damped linear oscillator can be expressed as a linear regression formula in which the acceleration of the pendulum is the outcome variable and the position and velocity of the pendulum are the predictor variables (Boker, 2001). From a developmental perspective, “velocity” may refer to the linear change in the system (e.g., change in mood), and “acceleration” may pertain to the curvature (e.g., the speed with which the mood change occurs). Differential equation models express effects within a system in terms of their derivatives (i.e., the instantaneous rates of change of the variables), as well as in terms of the values of the variables themselves. For example, a differential equation model of emotion regulation following stress might relate daily affect to its slope, or first derivative (i.e., how rapidly an individual's mood was changing). A more complete model might include effects related to its curvature, or second derivative (i.e., how rapidly mood was accelerating and decelerating in its change). These three parameters—initial position (emotion/affect), velocity (change), and acceleration (speed of change)—represent a dynamical system in which the relationships between them define a central tendency of a family of trajectories that any one individual might have (Boker & Nesselroade, 2002). The regression coefficients from this structural equation model, in turn, define order parameters (e.g., frequency and decay rate) of the system that best represents the interrelations between variability in affect and stress over time. The dynamic systems approach is both efficient and powerful, since it can identify intraindividual fluctuations in dynamics using relatively sparse data.

Summary and Conclusions

We have strived to demonstrate in this chapter that positive psychology is a theory with many facets. But to recognize that positive psychology has many facets is merely to start to understand it. Just what are the facets? How do they emerge in culture and in individuals? What are their functions? How do they change and evolve over time? We offer no definitive answers to these questions. Rather, we have attempted to provide a general orienting framework that can guide the thinking of researchers about positive psychological phenomena, sensitize them to the kinds of data that are needed to study these phenomena, and suggest fruitful lines of analyses and interpretation of their effects.

In particular, we have suggested that scientific understanding has moved away from the idea that human well-being can be well represented by a single dimension. Evidence accumulated over the course of this century has made it clear that the phenomenon of human well-being is multidimensional. Therein lies a problem in identifying particularly happy individuals; therein lies a problem of determining where to look for particularly happy individuals; therein lies a difficulty of examining a hypothesis stipulating that, on average, happy people will display more wisdom and character than unhappy people. Jahoda (1958) brought attention to this problem 50 years ago and it still does not have a ready solution. The use of eudaemonic indicators solves one problem but introduces another: In what sense is one better off with a higher “purpose in life,” to take one example, if unhappiness accompanies it? A reliance on measures of physical health as outcomes has been a steadying influence, but it is important to identify the implicit model that underlies the use of health as an outcome for studies in positive psychology.

We also have suggested that one major limitation of current theorizing in positive psychology is inherent in the very properties of extant measurement tools. That is, most theories of well-being (SWB and PWB) are described in terms of Cartesian coordinates or factors. These factors may be rotated into an infinity of different positions, each (p. 103) equally adequate for describing the relationships among dimensions of well-being, but each calling for different concepts and different languages for describing human well-being. A metatheory of simple structure has guided the rotation that has been accepted as the basic structure of SWB and PWB theory. This metatheory requires that manifest dimensions of well-being relate to a finite number of factors. This is a reasonable requirement for studies designed to indicate it—and many studies have been so designed—but it is not an indication of how well-being *must* be organized to account for relationships that are observed within and across individuals.

Finally, we have underscored the importance of taking a process approach to understanding the complexity of positive human health and well-being. Extant theories of

SWB and PWB provide few details about how well-being develops or about how positive psychological states interact and work together to produce optimal human functioning.

These theories thus do little to indicate the dynamics of human adaptation. The kind of system that ultimately will best describe such adaptation and its development, contend will be functional and will map on to the human brain. Over time, such a system might be more nearly of the form of a spiral of Archimedes, out of which evolves a repetitive building on what is known (induction), which leads to deductions that generate empirical studies and more induction, which leads to further deductions, which spawn further induction, and so on. In the long run, knowing that science is a never-ending search for better explanations and that no theory is ever complete we can be confident that SWB and PWB theories will be replaced by a better theory.

Future Questions

1. How is positive health and well-being organized across individuals?
2. How does positive health and well-being develop across the lifespan?
3. How do individual differences in positive health and well-being come about?

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Anthony D. Ong

Anthony D. Ong Department of Human Development Cornell University Ithaca, NY, USA

Alex J. Zautra

Alex J. Zautra, Department of Psychology, Arizona State University.