

2000 Presidential Address

Elaborating the Differential in Differential Psychology

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The methods of differential psychology have contributed importantly to the current state of behavioral science, but their limitations continue to be well — publicized in the “experimental versus correlational” literature. The argument developed here is that the value of these methods has been constrained as much by the phenomena to which they are applied as by underlying flaws that render them inferior to classical experimental methods. Some applications of differential methods to alternative phenomena are examined that promise to broaden significantly the contribution that differential methods can make to our understanding of behavior and behavior change.

A general sentiment running through my presentation today is that as SMEP nears its 40th birthday, it needs to have a mid-life crisis. In an age of “positive” psychology, including “positive” development, the overt promotion of a mid-life crisis may appear unseemly but I would like to tell you why I think such a crisis should occur and the direction I would like to see its resolution take.

My contention is that much of the promise of pushing the boundaries of psychological and behavioral research that was envisioned at the founding of SMEP and in the inaugural editorial in the introductory issue of *Multivariate Behavioral Research* (Cattell, 1966a) has yet to be realized;

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Presidential address given to the Society of Multivariate Experimental Psychology, Saratoga Springs, NY, October 2000. For that presentation, I subtitled my talk *Wishing SMEP a Mid-Life Crisis — And the Sooner the Better!* I gratefully acknowledge the suggestion of my colleague, Jack McArdle, to use the mid-life crisis as a metaphor helping to organize these comments. I am especially indebted to Bill Meredith for a thorough reading and critique of the penultimate version of the manuscript. I also received many valuable comments and suggestions from Paul Baltes, Steve Boker, Michael Browne, Don Ford, and Tim Salthouse.

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that although we are running ahead of the pack in many respects, there are ways, and it is time, to “pick up the pace.”

Some Features of Mid-life Crises

To portray why I believe a mid-life crisis for multivariate experimental psychology would be a worthwhile event, let me first summarize briefly some of the more popular conceptions of the concomitants of a mid-life crisis and the efforts often made to resolve it. The concomitants of a mid-life crisis include: (a) dissatisfaction with one’s current situation, (b) a sense of having failed to achieve some important goals, and (c) an increased awareness of the threat of younger competitors. Efforts to resolve a mid-life crisis include: (a) maximizing one’s remaining assets, and (b) building liaisons with the novel and attractive .

Evoking a Mid-life Crisis

To help SMEP along the path to a mid-life crisis, I would like to point out what I see as some sufficient, if not necessary, precipitating factors.

Dissatisfaction With One’s Current Situation

Long have the methods of differential psychology co-existed with those of classical experimental psychology (Cattell, 1966a; Cronbach, 1957). In a century of systematic application and many important findings concerning *structural* aspects of behavior, the differential approach has not provided us with much direct information regarding the nature of *process*. The labels *psychometric* versus *information processing* models, for example, so prominent in the cognitive research literature, bluntly exemplify the difference in orientations. The latter is intimately tied to process; the former not.

To be blunt, the essential focus of differential psychology is *differences*. Differences are identified by three fundamental kinds of comparisons:¹ (a) comparisons among kinds of entities (e.g., qualitative differences), (b) comparisons among entities of the same kind (interindividual differences), and (c) comparisons within the same entity over different occasions (intraindividual differences).

Differential psychology emphasizes the second kind of comparisons — among entities of the same kind. Further analysis of these kinds of differences yield information about typical outcomes of developmental processes for sets of similar entities (i.e., similarity of states among the same

¹ I am indebted to Don Ford for suggesting this to-the-point classification.

kind of entities), but not direct information about the change (developmental) process itself.

A change is inferred to have occurred when a difference is sustained across a series of comparisons of the same entity with itself and only comparisons within the same entity over different occasions (intraindividual differences) contain information about change processes. Thus, intraindividual differences must be studied if differential psychologists are focused on change (or developmental processes). Fortunately, many of the data analytic methods created by differential psychologists are designed to analyze patterns of differences, not just one kind of difference. Therefore, those same methods can be applied to the study of differences containing information about change (i.e., intraindividual differences). Moreover, as will be emphasized later, those methods can be (and are being) elaborated to focus more precisely on identifying change processes (e.g., rates of change and changes in rates of change).

I will illustrate a basic point with a homely example. Some time ago, while working a crossword puzzle (an activity now considered by some to be a promising weapon in the war against cognitive aging), I was confronted by the following clue for a four-letter word: "A sign of healing." I found that three of the four letters were already determined from words running in the other direction. My target was S C A __. My first thought for exhausting my remaining degree of freedom was R. A SCAR is a sign of healing. Before writing the R, it occurred to me that the answer could also be SCAB. A SCAB is a sign of healing. Here was an everyday example of what I have come to see as a key difference in orientation among users of the methods of differential psychology. A SCAR is something visible (measurable) but it signifies healing begun and essentially completed in the past. SCAB is an indicator of an ongoing healing process.

Consider further the "different" implied by the term differential psychology. Typically, it is amounts or levels of attributes; the SCARS, as it were, of processes that have already played out to that point in time. For example, at the time they are measured, our primary mental abilities scores are the SCARS remaining from the *current* resolution of genetic and environmental forces. It is true that those scores do not have to remain fixed; they might be different the next time they are measured. If they are different, they are simply new SCARS that (a) are something of a surprise in the case of human abilities and personality traits, and (b) evoke the "awkward" business of change measurement.

From a differential perspective, inferences regarding the nature of process tend to rest on the products rather than on the operations that produced those products. I argue that we should not be satisfied with this situation: The

methods of differential psychology are (or at least can be) more directly applicable to the study of process.² In another context, Newell, Liu, and Meyer-Kress (2001) noted “The global regularities of change over time at the different time scales are to be found at the level of the changing pattern of the dynamics rather than in the performance outcome of task space.” In relation to the example above, both SCARS and SCABS are performance outcomes, but SCABS are “closer” to the process of healing than SCARS. As was noted above, SCABS are currently changing indicators of ongoing action, rather than of action more or less completed in the past.

Additional evidence of a general dissatisfaction with the status quo is the growing interest in random effects modeling, mixed modeling, hierarchical modeling, et cetera. These methods take into account patterns of intraindividual change explicitly and then capitalize on interindividual differences in that intraindividual variability.

A Sense of Having Failed to Achieve Important Goals

Despite the life-time of investment in applying multivariate correlational methods to developing a better understanding of behavior and behavior change that many of us have made, there seems little compelling reason for sitting back and rejoicing over what has been accomplished thus far. So much obviously remains to be done. The fires of discovery that SMEP’s and MBR’s founders ignited have resulted in a better understanding of many phenomena, but by no means have they succeeded in truly revolutionizing our understanding of the complexities of behavior. In many respects, the majority of current multivariate experimental psychology has settled into what Kuhn (1962) has labeled “normal science.” I don’t believe that the current level of accomplishment is satisfying when it is weighed against the aspirations upon which the society and its journal were founded — aspirations which included “redeeming the scientific situation” (Cattell, 1966a, p. 4).

An Increased Awareness of the Threat of Younger Competitors

Two generations of researchers have come of age since the founding of SMEP in the early 1960s. During that time, multivariate, correlational methods have become more sophisticated and more widely deployed. There is now an entire journal devoted to structural equation modeling, for example.

² Meredith (personal communication, October, 2001) put it well — “Growth and development are lawful. All individuals obey the same laws of development. Every individual develops differently from every other. So we need mathematical laws whose parameters can account for individual differences.”

Nevertheless, many behavioral scientists have looked enviously at the green grass of other disciplines and are exploring, for example, the promise of linear and non-linear dynamical systems modeling (Vallacher & Nowak, 1994). Envy of, and efforts to explore the promise of such alternatives must be encouraged. Indeed, serious self-scrutiny regarding the limitations of our old and steadfast, mainly linear and additive modeling procedures is not a bad move at this point in our history, especially if it makes us more sensitive to their deficits and more aware of worthy and promising competitors.

To summarize, the faithfulness and dedication of multivariate correlational research is not to be belittled. Nevertheless, after 40 years of devotion to that most demanding of “significant others” — the study of behavior and behavior change — there seems to me to be ample reason not to be satisfied with the current state of the relationship. To ask “Can this be all there is?” “Isn’t there something else that can be done?” “Aren’t there other directions that need to be explored?” seems appropriate behavior at this stage of our development.

To feel with some degree of passion a dissatisfaction and a need to explore alternative possibilities at this point in SMEP’s life is, in popular terms, to be experiencing a mid-life crisis. For my money, it is a useful and productive way to think about where multivariate experimental psychology is today in its relationship to our discipline and to plan where we would like it to be tomorrow. To the extent that one accepts the diagnosis of a mid-life crisis, it is fitting to examine how it might be resolved. As the outgoing president of SMEP, it is my prerogative now to offer my resolution to the very sense of crisis that I have been trying to induce.

Resolving the Mid-life Crisis

In the opening section, two kinds of activities were identified that, at least at the popular level, are invoked to resolve a mid-life crisis. They were: (a) maximizing one’s remaining assets; and (b) building liaisons with the novel and attractive. I will examine each of these lines of activity in turn.

Maximizing One’s Remaining Assets

Baltes and Baltes (1990; see also Baltes & Dickson, 2001) modeled adaptation to changing circumstances as one ages in terms of “selective optimization with compensation.” One maintains high levels of performance by focusing on fewer activities at which to excel and working harder (and more cleverly) at them. This may be the point at which my example begins to strain. One doesn’t exhort a group of independent scientists to focus on fewer topics.

One can, however, argue for the salience of some lines of research over others. There is always a risk involved in characterizing some research activities as more promising than others, but today it seems a risk worth taking.

I want to take the risk and argue as forcefully as I can for some selective optimizing by refocusing the targets to which the methods of differential psychology are applied. The targets I wish to promote are selected indicators of change. This implies paying less attention to applying the methods to single occasion scores.

A century of developing and improving methods for designing studies, measuring attributes, and modeling data has resulted in a tremendous bank of assets — our methods for defining variables and analyzing relationships among them. As powerful as these methods are, it also matters a great deal just how they are used. I believe that there is ample evidence of significant value to be gained by strengthening and extending differential psychology's methods in the direction of applying them to change indicators. Multivariate experimental psychologists are in a position to have a great impact in this regard because, except for the most narrow definition, changes are patterns and inherently multivariate. If resolving a mid-life crisis is the mechanism by which such a change of emphasis and direction can be accomplished then I say, "Bring on the crisis and the sooner, the better."

Building Liaisons with the Novel and Attractive

Historically, the methods of differential psychology and the study of human abilities have been very closely intertwined. What has been measured, retested, and analyzed by a variety of techniques has been conceived of largely as estimates of true scores — endowments of individuals on important ability characteristics. Multivariate experimental psychology has helped to develop and refine an impressive set of tools by which to derive further meaning from these scores, including canonical correlation, factor analysis, and linear structural equation models, to name a few. I am not proposing that any of these tools be surrendered. Rather, I want to see their use extended, I hope to far greater effect. In the process, I believe the methods will be further strengthened and new ones will come into existence as new problems and new ways of looking at old problems elicit the need for them.

The liaison which I want to promote — between the methods of differential psychology and indicators of change — already exists; but it is something of a tenuous existence. I want to see it refined, strengthened, and extended. Let me examine some of the pertinent aspects of rationale for fostering this liaison as well as some features of application, in more detail.

Interindividual Differences in Intraindividual Change

Some years ago, my colleagues and I (Baltes, Reese, & Nesselroade, 1977) in describing what we believed should be the focus of developmental research proposed that “developmental psychology deals with behavioral changes within persons across the life span, and with differences (and similarities) among persons in the nature of these changes.” The first emphasis was placed on behavioral changes *within persons* and then on differences (and similarities) *among persons*. The key distinction drawn was between the traditionally dominant focus of differential psychology — differences among persons — versus an alternative — differences in changes among persons. Said another way, the key contrast is between interindividual differences in intraindividual changes in some variables versus interindividual differences in the initial, final, or average level of those variables.

Paul Baltes and I explored these ideas more fully in a subsequent discussion of the rationales for conducting longitudinal research (Baltes & Nesselroade, 1979). We argued that there were five such primary rationales: (a) direct identification of intraindividual change, (b) direct identification of interindividual differences (and similarities) in intraindividual change, (c) analysis of interrelationships in behavioral change, (d) analysis of causes (determinants) of intraindividual change, and (e) analysis of causes (determinants) of interindividual differences in intraindividual change. All five rationales, as was the focus of developmental inquiry given above, are inextricably bound to the idea that changes (intraindividual variability) are an elemental focus of inquiry.

Intraindividual Change and Variability in Behavior

Stepping back from developmental psychology, there is more generally a substantial history of investigating intraindividual change and intraindividual variability in behavior (e.g., Cattell, 1963, Fiske & Maddi, 1961, Fiske & Rice, 1955, Harris, 1963, Horn, 1972, Horn & Little, 1966). Following an extensive period of graduate training in the laboratory of Raymond B. Cattell at the University of Illinois³, much of my own research career has been concerned with some of these topics. Over the past 10 years or so, it has been my privilege to work on models for the representation of change with a large number of innovative colleagues including Steve Boker, Michael Browne, Dara Eizenman, Paolo Ghisletta, Jungmeen Kim, Shu-

³ My graduate training was primarily in Cattell’s laboratory, but it was greatly enriched by contact with the likes of Lloyd Humphreys, Henry Kaiser, Maurice Tatsuoka, Ledyard Tucker, and Jerry Wiggins.

Chen Li, Jack McArdle, Peter Molenaar, Alex von Eye, and Xinzi Wu. One of the principal themes in these collaborations has been to strengthen the representation of intraindividual changes and interindividual differences and similarities in those change patterns. In large measure, the work has involved applying the methods of differential psychology to the study of change. As this work is illustrative of the direction of my proposed resolution of SMEP's mid-life crisis, I would like to say some more about it.

Often, when intraindividual variability in behavior is recognized as an interesting phenomenon, what is emphasized is the more traditional differential nature of the attributes. For instance, Murray (1938) said, "The sometimes marked inconsistencies that occur are put down to the subject's characteristic range of variability, itself an attribute of personality." Cattell (1973) asserted, "A general tendency to fluctuate...exists as a personality trait."

However, the "stability" of intraindividual change and variability is not the topic on which I am focusing today. Instead, consider the emphasis in the following biological perspective on the matter, "All real, active, thermodynamic machines (including all living forms), capable of sustained performance, manifest a dynamic stability characterized by nonlinear, cyclic processes. The primitive function is periodic; the basic element of temporal organization is the cycle" (Yates, Iberall, & March, 1972). In a "negative" way, one can see a related perspective in the comment by Gulliksen (1950) who wrote, "...the major difficulty with reliability obtained by the successive administration of parallel forms is that it is too high. This is because there is no possibility for the variation due to normal daily variability to lower the correlation between forms." In one case, intraindividual variability is sought as a basic element of organization; in the other it is regarded as something of a nuisance. In both cases, it is something with which to be reckoned.

Some of the many content domains in which intraindividual variability has been studied include mood, self-concept, temperament, locus of control, memory, creativity, work values, teacher performance, human abilities, and socio-economic status. Several of these are domains in which there is a general expectation of stability of individual differences and similarities. Nevertheless, when studied from an intraindividual variation perspective persons have been shown to exhibit considerable, systematic change across time in such variables.

Several decades of research on intraindividual variability concepts have contributed to our understanding of behavior in a number of ways (see e.g., Nesselroade & Featherman, 1997; Nesselroade & Ghisletta, 2000, for reviews). The contributions include: (a) enriching descriptions and theories of personality and ability by introducing dimensions and emphasizing features largely neglected in the past, (b) formalizing the state-trait distinction, (c)

providing a spring board for integrating idiographic and nomothetic emphases, (d) providing a means for re-defining personality consistency, and (e) offering an avenue from traditional interindividual differences modeling into dynamical systems modeling.

Intraindividual variability concepts have also: (a) captured important sources of variance including erroneously interpreted individual differences as when asynchronous intraindividual variability is confounded with interindividual differences at a given time point, (b) formalized the identification of occasion-specific sources of variance among persons, (c) provided one possible explanation for such phenomena as increasing interindividual variability with increasing age to the extent that it is observed, and (d) provided a source of “predictors” of other behaviors.

In this discussion, however, I want to emphasize more some methodological aspects of the work on intraindividual change and variability rather than substantive findings. The aspect to which I want to call primary attention has a great deal to do with the locus of changes imposed by the modeling procedures.

*Applying the Methods of Differential Psychology
to Repeated Measurements*

What are some key methodological alternatives when one has repeated measurements on individuals? One can concatenate the scores for each individual, forming individual pathways and examine interindividual differences in these pathways. Consider, for example, generalized learning curve analysis — the innovative proposal by Tucker (1958, 1966; see also Rao, 1958). This methodology has played an important role in the last two or three decades of the struggle to represent change. It was a progenitor of what is now termed Latent Growth Curve Modeling (see e.g., McArdel & Epstein, 1987; Meredith & Tisak, 1984, 1990) — a set of methods being widely applied to the study of developmental pathways.

Tucker, (1966) wrote the generalized learning curve model as:

$$x_{ji} = b_{j1}y_{1i} + b_{j2}y_{2i} + \dots$$

where x_{ji} is the score on trial j ($j = 1, 2, \dots, n$) for individual i ($i = 1, 2, \dots, N$); b_{j1} , b_{j2} , ..., are coefficients dependent on the trials, and y_{1i} , y_{2i} , ..., are individual parameters.

This is a valuable extension of the traditional modeling of interindividual differences in level because it defines a structure for the patterns of changes that are observed across a series of occasions of measurement. Cronbach

(1975) hailed it as an example of rapprochement between the differential and classical experimental approaches. Nevertheless, it is limited in the modeling of interindividual differences in intraindividual changes. The reason is that the values that define the individual are fixed with respect to time. The individual's parameter values do not change across trials. Thus, there is ample representation of interindividual differences but no direct representation of intraindividual changes.

Another attempt to apply the methods of differential psychology to repeated measurements is represented by *P*-technique factor analysis (Cattell, 1963; Cattell, Cattell, & Rhymer, 1947). For reasons that will be clear, that topic is discussed in the next section.

Applying the Methods of Differential Psychology to Change, Rates of Change and Changes in Rates of Change

Observers of science and the development of scientific disciplines point out that progress in science has rather invariably followed the pathway from static (often linear) relations among concepts to dynamic (often nonlinear) ones. West (1985), for example, argued that in the natural development of a scientific discipline there comes at some point sufficient dissatisfaction with static representations that they are replaced with dynamic ones. For nearly 40 years the call for more dynamical representations of important phenomena has been made in the social sciences (Arminger, 1986; Coleman, 1968; Tuma & Hannan, 1984).

The history of psychology, including the way we train graduate students in research methods, indicates that any movement in the direction of innovative mathematical and statistical modeling will tend to be enthusiastically resisted. Innovation in the area of quantitative methods seems to take the form of gradualism more so than punctuated equilibrium. Still, one does see some evidence of shifts in the application of methods to data that reflect a growing sensitivity to the need for improvements in the way we represent process and change.

Common Factor Model Applications

Early efforts to apply multivariate models to rates of change included differential-*R* technique factor analysis (Cattell, 1963) which involved fitting the common factor model to the intercorrelations of difference scores. Some of the features of this effort to apply differential methods to change scores have been examined elsewhere (e.g., Nesselroade & Bartsch, 1977; Nesselroade & Cable, 1974) and will not be dwelt on here. Somewhat

coincident with the development of differential-*R* technique factor analysis was the innovation labeled *P*-technique factor analysis by Cattell et al. (1947) and Cattell(1963). The nature of the *P*-technique model is portrayed in Figure 1.

The factors exert their influence on the variables, but only concurrently rather than in a time-lagged manner. Thus, the model can represent only concurrent aspects of intraindividual change and variability. Cattell (1963) recognized the need for improvements in this basic application of the factor model and challenged his colleagues to provide them. Although several years passed before this occurred, eventually a number of time series-based applications of the factor model surfaced (e.g., Engle & Watson, 1981; Geweke & Singleton, 1981; McArdle, 1982; Molenaar, 1985) that represented much stronger ways to model the repeated measurements data of *P*-technique studies. Michael Browne and I are currently working on some extensions of auto-regressive, moving average (ARMA) time series models for modeling psychological processes (Browne & Nesselroade, 2002).

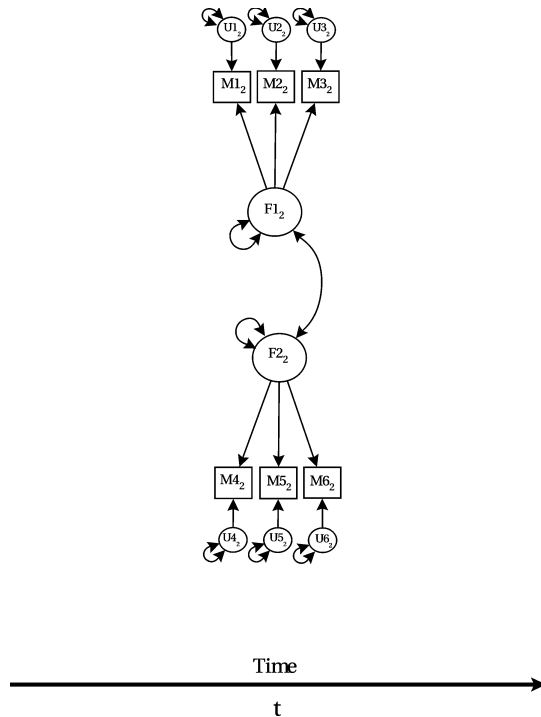


Figure 1
P-technique Factor Model (Nesselroade, McArdle, Aggen, & Meyers, 2002)

In reviewing these and other contributions, Nesselroade, McArdle, Aggen, and Meyers (2002) identified two alternative dynamic factor model specifications as the Direct Autoregressive Factor Scores (DAFS) model and the White Noise Factor Scores (WNFS) model. The DAFS model was articulated by McArdle (1982) and the WNFS model by Molenaar, (1985). These models represent different conceptualizations of how variables change and their application gets us closer to a genuinely multivariate study of process.

The nature of the DAFS specification is portrayed in Figure 2.

The DAFS model incorporates lagged effects of factors on variables by allowing the factor scores to manifest time-related dependencies in the form of auto-correlations (cross-correlations can also be introduced). For example, *yesterday's* factor scores can directly influence *today's* factor scores. In so doing, *yesterday's* factor scores help determine *today's* observed variable scores. Notice that earlier factor scores only indirectly influence later manifest variable scores.

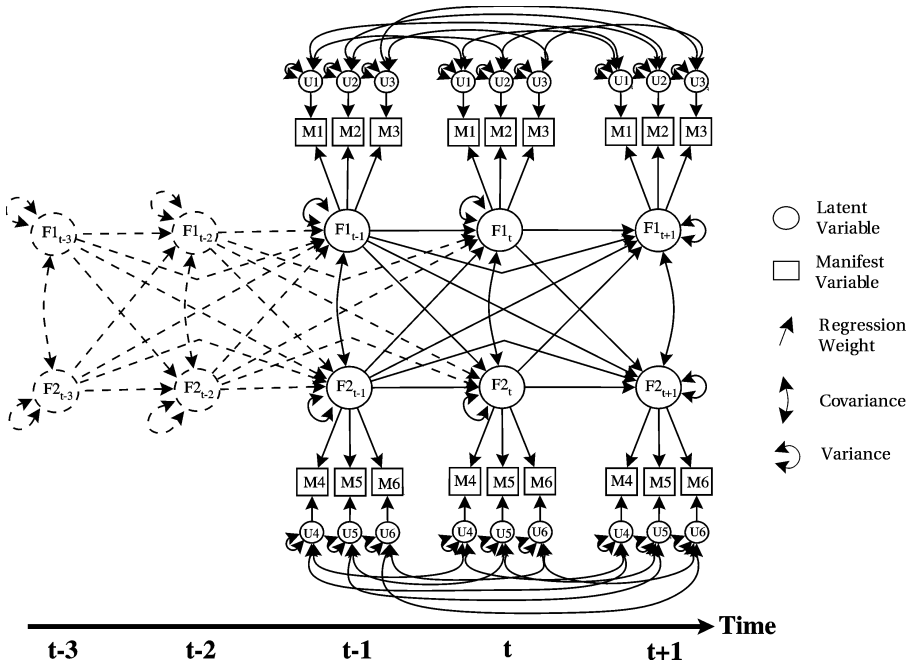


Figure 2

Direct Autoregressive Factor Score (DAFS) Model (adapted from Nesselroade, McArdle, Aggen, & Meyers, 2002)

The nature of the WNFS specification is portrayed in Figure 3. To identify the time series of factor scores within the estimation framework he was using, Molenaar (1985) specified them as a “white noise” time series. In the WNFS specification, earlier factor scores directly influence later values of the manifest variables. *Today’s* observed scores are influenced both by *today’s* factor scores and by *yesterday’s* factor scores.

In this context of applications that further strengthened the modeling of interindividual differences (and similarities) in intraindividual changes, Nesselroade and Molenaar (1999) presented a rationale and an algorithm for evaluating groups of time series to identify subsets of individuals whose lagged covariance matrices did not differ significantly and thus offered some justification for a pooling of the information for further analysis by, for example, the WNFS and DAFS models mentioned above. The emphasis was on explicitly recognizing when time series information was sufficiently different among individuals that pooling the information would only confound relationships. Conversely, the approach served efficient design by providing

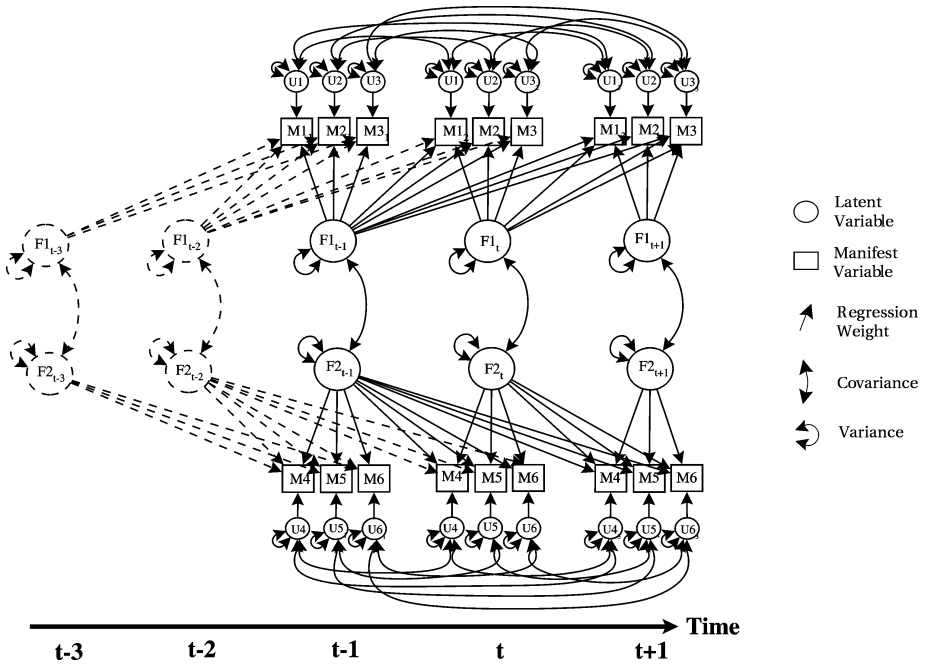


Figure 3
White Noise Factor Score (WNFS) Model (adapted from Nesselroade, McArdle, Aggen, & Meyers, 2002)

a rationale for collecting shorter time series on more persons, rather than longer time series on fewer persons in situations where long-term commitments by individuals were tenuous.

Differential Equation Applications

Boker and his colleagues (e.g., Boker & Graham, 1998; Boker, Postolache, Naim, & Lebenluft, 1998) have been exploring the use of differential equations representing dynamical systems models for representing emotional and other kinds of variability occurring over short time frames. These models can be easily adapted to representing other kinds of variability such as that involved in the trait-state distinction (e.g., Boker & Nesselroade, 2002; Nesselroade & Boker, 1994). One of the very promising features of these modeling techniques is that they can be fitted using panel data containing as few as three waves of measurement. Moreover, the model parameters can be estimated using easily available linear structural equations modeling software.

The model on which Boker and Nesselroade (2002) focused is the dampened linear oscillator, one example of which is a pendulum with friction. The heart of the procedure involves converting each individual's times series into estimates of first and second derivatives (velocity and acceleration, respectively) that describe his or her trajectory over time. One procedure for securing these estimates (local linear approximations of derivatives) uses a function of the difference scores as estimates of first derivatives and a function of the differences between successive differences to estimate the second derivatives. These estimates of first and second derivatives become the input data for fitting the differential equation model:

$$(1) \quad \frac{d^2x_{(t)}}{dt^2} + \zeta \frac{dx_{(t)}}{dt} + \eta x_{(t)} = 0$$

where $x(t)$ represents the value of a variable x at time t , η is related to the frequency of oscillation and ζ represents the damping effect. This second order differential equation can be expressed as a system of two first order equations (Boker & Nesselroade, 2002) by defining

$$(2) \quad x_{(t)}^* = \frac{dx_{(t)}}{dt}$$

and

$$(3) \quad \frac{dx_{(t)}^*}{dt} = -(\zeta x_{(t)}^* - \eta \dot{x}_{(t)}).$$

An analogy to multiple regression is readily manifest in the second equation if one views

$$\frac{dx_{(t)}^*}{dt}$$

(the rate of change in the rate of change in x) as the criterion variable and x^* (the rate of change in x) and x as the predictor variables. Indeed, this model can be specified as a structural equation model as shown in Figure 4 and its parameters can be estimated using familiar structural equation modeling techniques and programs.

Thus, the basic model represents intraindividual change and variability directly in velocity and acceleration but the procedure depends on interindividual differences in those intraindividual change values to develop estimates of the model parameters. If one assumes that one model fits all persons (as in ordinary regression, for instance) then the variation among people's scores (rates of change) enable one to estimate parameters. In the case of the linear oscillator, the differences in scores are presumed to occur because people are at different locations in the oscillatory cycle at the time they are measured. Someone whose velocity is high and whose acceleration is zero is sailing through the nadir of the arc whereas someone whose

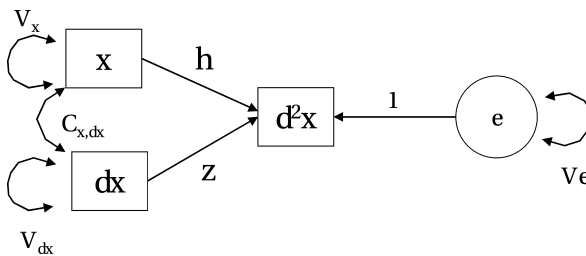


Figure 4
Damped Linear Oscillator (Boker & Nesselroade, 2002)

velocity is zero but whose acceleration is high is in the process of reversing directions. Without such interindividual variation among people, this approach would not work.

The domain of affect is a promising area of application for such dynamical model fitting. Counterparts to rates of change and changes in rates of change are found in concepts such as lability and volatility of affect. The notion of damping inheres in concepts such as self-control, peer pressure and support, emotional “burn out,” et cetera.

Obviously, the dampened linear oscillator is only one of many possible models that can be fitted to this most common kind of behavior and social science information — panel data. Other kinds of oscillators as well as quite different models are also candidates for representing process and change to the extent that the investigators are able to render their ideas operational in these terms. My colleague Jack McArdle is currently developing the specification of a set of dynamical models using difference equations as his starting point (McArdle & Hamagami, 2001).

Conclusions

As the examples given above show, a number of multivariate, analytical tools are currently available for applying the essential philosophy and methodologies of differential psychology to various indicators of change, including first and second derivatives of dynamical systems models. Application of these very powerful tools extends the concept of structure to where it overarches patterns of change as well as the more traditional “stable” scores with which we are familiar. This, I believe is the multivariate experimental psychologist’s key, at this point in our history, to coming to grips in a meaningful way with the concept of process.

The strengths of “the Galton-Thurstone movement,” according to Cattell (1966b) are that it is (a) multivariate rather than bivariate, and (b) freely observing rather than manipulative. Bringing this orientation to bear on detecting the nature of changes instead of focusing it only on the nature of putative stability is a set of steps worth taking. Such a path can, I believe, lead multivariate experimental psychology into a happy resolution of its midlife crisis — a vital new relationship with its one true love — the study of behavior.

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