SELECTED ISSUES AND PROBLEMS IN LONGITUDINAL DATA ANALYSIS

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I would like to talk about the experiences of the Organizational Behavior Research Group within the American Institutes for Research with a longitudinal study of Army enlistee socialization. The emphasis will be on general applications rather than theoretical development. I will review the various eclectic approaches we took in our data analysis, especially multivariate techniques such as factor analysis. Finally, I will talk about additional possible approaches that could have been taken in order to more succintly capture the dynamic process of organizational socialization over time.

Problems in univariate analysis. Before going on to the elegant environs of multivariate analysis, let us pause to very quickly review some still existing problems in longitudinal analysis on the "lowly" univariate level. A major interest in any longitudinal analysis is the detection of true change and the valid attribution of the "causes" or "precursors" of change, once detected. Even the "simple" process of tracking one variable over time leads to many problems and approaches in trying to validly detect true change.

As pointed out in a review article by Hummel-Rossi and Weinberg (1975), there have been at least five different approaches to measuring change in the univariate case:

1) raw gain score
2) an estimate of the true gain score
3) a base free measure of gain
4) a true residual gain score, and
5) a multiple regression (or partial correlation) approach where the prescore and other assumed determinants of the post score are entered into a step down (or stepwise) analysis

The raw gain score, especially, has serious problems in terms of reliability, regression artifacts, etc. It is not my intent to review all these approaches here. Suffice it to say that Hummel-Rossi and Weinberg conclude that in virtually all cases, the true residual gain score or partial correlation are the preferred methods.

Problems in multivariate analysis. In most longitudinal studies, of course, the investigator is using not one, but several sets of variables. This raises additional questions as to which multivariate techniques are the most appropriate for one's particular purposes.

For the matter of detecting change, Frederiksen (1974) has considered certain problems involving multivariate time series.

1) the question of changes (or growth) over time in one variable (or set of variables) being related to changes (or growth) over time in another variable (or set of variables)
2) Detecting change over time in:
   a) trends on individual variables or on derived composites
   b) the structural relationships of sets of multiple variables

Frederiksen then presented several structural models which were special cases of Jöreskog's (1970, 1973) general model for the analysis of covariance structures. These models considered such things as whether two stochastic variables had common or independent components, whether the components were stochastic or fixed, whether their residual components were common or independent, and whether the common components were lagged.

For detection of change, Frederiksen suggested comparative model-fitting, but he did not go into specifics.

Model of organizational socialization. With the above in mind, at this point, I will briefly sketch out the overall model and design of our own longitudinal study of Army enlistee socialization. Then I will discuss the various analytic approaches we took to test the model.

Our model of the socialization process consisted of three major stages (cf. Van Maanan, 1972):

1) anticipatory socialization
2) entry, and
3) metamorphosis

Anticipatory socialization is the set of influences that impinges on an individual prior to his formal entry into an organization.

Entry deals with events characterizing the individual's first encounters with the actuality of the new organization where the veracity of initial expectations is tested.

Metamorphosis represents the process by which the individual must adjust and accommodate his life and work style to that imposed by the organization.

Under our conceptualization, each stage included one or more sets of variables.

Anticipatory socialization included recruits' demographic background, expectations, career goals and anticipated adjustment.

The entry stage began in basic combat training. In this stage there were a number of sets of independent (or predictor variables) and sets of criteria. Among the predictors were perceptions of leadershipclimate, perceptions of

primary group climate, and, of course, basic demographic background. The main and interactive effects of the above led to confirmation or disconfirmation of the recruits' expectations which in turn lead to positive or negative adjustment to the Army in behavior and/or attitude. This posited set of relationships (in the model, at least) then continued through Advanced Infantry Training and on to the first duty assignment. The first duty assignment was considered to be the metamorphosis stage.

Our data was gathered using self-report questionnaires. Thus, at all times we were dealing with the Army enlistees' self-reported perceptions.

There were four waves of data collection.

Phase I - At Army base Reception Centers

This was before the recruit started basic combat training. Thus, this is pre-service expectations.

Phase II - End of Basic Combat Training

This is, of course, the first major milestone in the Army enlistee socialization process.

Phase III - End of Advanced Individual Training

This is the transition area between anticipatory socialization and metamorphosis.

Phase IV - First Permanent Assignment

Most people were surveyed 2-3 months after starting their assignment. This was considered the metamorphosis stage.

Our global objective, of course, was to track and describe the military socialization process with particular attention to the criteria of self-reported behavioral and attitudinal adjustment over time.

Model Testing

We attempted to test our socialization model in a number of ways:

1) Static descriptions of model relationships at the four fixed points in time (cross-sectional analysis).

2) Longitudinal analysis across the four points in time, often using hypotheses and variable composites developed in the cross-sectional analyses.

Cross-sectional analyses. Just a very brief description of the cross-sectional analyses, mentioning only those aspects necessary for understanding the longitudinal analyses, will be presented here.

Each of the four phases was analyzed separately. The various independent and criterion variables were operationalized as multivariate sets of items. Each one of these sets was subjected to principal components orthogonal varimax factor analysis. Intuitive comparisons of factor loadings were then made between the four phases. Although this approach has many problems (Nunnally, 1973), it is very helpful for heuristic purposes. For example, perceptions of leadership climate and primary group climate (i.e., "people" factors) seemed to remain stable over time. However, the number of organizational perception factors increased and seemed to become more sharply focused over time. From a theoretical perspective this is entirely reasonable.

The enlistees have had lifelong experience with people but had to experience the Army environment before their perceptions of the Army become stable and focused dimensions.

A crossed, incomplete factorial design was set up using several demographic characteristics (age, educational level, race, income, etc.). Key single items (e.g., reenlistment intention) and the factor scores were used as the dependent variables. Multivariate analysis of variance was then conducted to ascertain demographic differences at each of the four points in time and to help decide which characteristics needed to be retained for the longitudinal analysis.

Canonical correlation was used to relate the set of independent variables to the set of criterion variables. The factor scores previously derived from these domains were entered into the analysis rather than individual items. This was done in order to make the results more generalizable and parsimonious. That is, we used more reliable composites which reflected the basic dimensions of the enlistees' perceptions.

All the main and interactive effects of the previously mentioned factorial design were partialled out before the canonical correlation was computed. That is, our model could be thought of as proceeding in stages. First were entered the demographic characteristics to account for criterion variance. Then, the independent variables were entered to assess their contribution above and beyond that of the demographic characteristics.

Longitudinal analysis. Several issues were raised which could be addressed only with longitudinal analysis:

1) Non-response bias over time

- Are the people who do not respond in all four phases different in characteristics from those who do not? If they are, the validity of many of the longitudinal analyses is threatened.

2) "Practice" effects

- Do the enlistees change their responses over time simply as a function of repeated measurement?

3) Changes in factor structure over time
   - Is the factor structure of the variable sets stable over time?
4) Trends on single criterion items
   - Are there changes in level over time on the major criteria?
5) Model testing over time
   - Do the independent variables assessed in the early phases predict the criteria assessed in the last phase?

In order to test for non-response bias over time, an extension of the previously mentioned factorial design was used. Those who responded to all four phases had to be compared with those who did not so respond. Response/no response was added to the factorial design. Also, cross-tabulations of the demographics with response/no response were made. There seemed to be no serious biasing effect. The only factor ever mildly related to no response was educational background. Less educated enlistees dropped out of the sample at a slightly higher rate than the others.

The possibility of practice effects was assessed with control groups. For the second and third phases it was possible to arrange for administration to enlistees who had not ever seen the questionnaire. The control group responses were compared with the longitudinal cohort responses. No meaningful differences were found.

The issue of changes in factor structure is a particularly thorny one. As pointed out by Nunnally (1973), comparison of factor loadings can be quite misleading. A relevant classification scheme is proposed by Baltes and Nesselroade (1973). They posit a 2x2 matrix to account for possible changes in factor patterns and/or factor scores. The factor pattern can be invariant (i.e., stay the same) or non-invariant. The factor scores can be stable (i.e., the individuals' positions on the distribution stay the same) or fluctuant.

After due consideration, we decided to use a technique suggested by Nunnally (1973). We tested for "factor emergence." That is, the factor score coefficients from the last phase were applied multiplicatively to the earlier phases item scores. These forced composites were then correlated with the factor scores from the last phase. The main interest was to ascertain if the magnitude of the correlations increased over time.

The tests for trends on the single criterion items was straightforward. Orthogonal polynomial contrast weights were applied to the item scores obtained over time. These "trend" scores were then analyzed to determine if there were changes in level over time.

The model testing over time was done sequentially. First, the Phase I independent variables were related to the Phase IV criteria using canonical correlation. Then the Phase II independent variables were added to assess their contribution above and beyond the criterion variance accounted for by the Phase I independent variables.

Time and space do not permit detailed discussion of the substantive results of all the above analyses. Instead, I will mention some implications for analytic strategies in longitudinal analysis which we observed.

Bivariate correlations of predictors with criteria (cross-sectional and longitudinal) often failed to reveal significant relationships. Typically, multiple regression and canonical correlation were needed to detect relationships and to derive meaningful predictor and criterion dimensions to explain the relationships.

There must be a meaningful time-sequential model to guide the longitudinal analysis. Arbitrary relating of data from time X to time Y often shows transient dimensions which can be misleading without an overall model.

The effects of certain predictors often have considerable lag. Concurrent analyses would never detect these lag effects.

Additional longitudinal analysis techniques. There are other anlaysis techniques which I will only mention as seeming to have potential for meaningful longitudinal analysis.

Rummel (1970) mentions a techique called transformation analysis. Using this method, a transformation matrix is obtained which rotates the factors from one point in time to a least squares fit to the factors of a later point in time. The normalized elements of this matrix measure the relationship between the factors of the two time periods in the same space. A number of other matrices are also obtained to quantitatively assess the similarities and differences in factor structure between the two time periods.

The technique of three-mode factor analysis (Levin, 1965) could also be used for longitudinal data. In this approach, time would be the third mode. Factors would be obtained which reflect changes over time.

Still another possibility (and the last one I will mention), is to use canonical correlation. That is, within a given factorial domain, the items measured at time 1 would be related to the same items measured at time 2. The factor structure of the canonical composites can then be compared to the factor structure obtained at the individual points in time. The size of the canonical R would indicate the overall degree of relationship between the two times, of course.

It is obvious that there are many unanswered issues and problems in longitudinal analysis. However, a number of the above approaches seem to be steps in the right direction. The potential

rewards of well planned longitudinal and mixed (i.e., a combination of longitudinal and cross-sectional) designs are so great that I fervently hope the leading statisticians will continue to develop new and better analytic techniques.

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