INFORMATION TO USERS

This reproduction was made from a copy of a document sent to us for microfilming. While the most advanced technology has been used to photograph and reproduce this document, the quality of the reproduction is heavily dependent upon the quality of the material submitted.

The following explanation of techniques is provided to help clarify markings or notations which may appear on this reproduction.

1. The sign or “target” for pages apparently lacking from the document photographed is “Missing Page(s)”. If it was possible to obtain the missing page(s) or section, they are spliced into the film along with adjacent pages. This may have necessitated cutting through an image and duplicating adjacent pages to assure complete continuity.

2. When an image on the film is obliterated with a round black mark, it is an indication of either blurred copy because of movement during exposure, duplicate copy, or copyrighted materials that should not have been filmed. For blurred pages, a good image of the page can be found in the adjacent frame. If copyrighted materials were deleted, a target note will appear listing the pages in the adjacent frame.

3. When a map, drawing or chart, etc., is part of the material being photographed, a definite method of “sectioning” the material has been followed. It is customary to begin filming at the upper left hand corner of a large sheet and to continue from left to right in equal sections with small overlaps. If necessary, sectioning is continued again—beginning below the first row and continuing on until complete.

4. For illustrations that cannot be satisfactorily reproduced by xerographic means, photographic prints can be purchased at additional cost and inserted into your xerographic copy. These prints are available upon request from the Dissertations Customer Services Department.

5. Some pages in any document may have indistinct print. In all cases the best available copy has been filmed.
Confirmatory factor analysis of the job element inventory

Hayes, Theodore Laurance, M.A.

Rice University, 1987
PLEASE NOTE:

In all cases this material has been filmed in the best possible way from the available copy. Problems encountered with this document have been identified here with a check mark √.

1. Glossy photographs or pages ______
2. Colored illustrations, paper or print ______
3. Photographs with dark background ______
4. Illustrations are poor copy ______
5. Pages with black marks, not original copy ______
6. Print shows through as there is text on both sides of page ______
7. Indistinct, broken or small print on several pages √
8. Print exceeds margin requirements ______
9. Tightly bound copy with print lost in spine ______
10. Computer printout pages with indistinct print ______
11. Page(s) _________ lacking when material received, and not available from school or author.
12. Page(s) _________ seem to be missing in numbering only as text follows.
13. Two pages numbered _______. Text follows.
14. Curling and wrinkled pages ______
15. Dissertation contains pages with print at a slant, filmed as received _______
16. Other ____________________________
    ______________________________________
    ______________________________________
    ______________________________________

University
Microfilms
International
RICE UNIVERSITY

CONFIRMATORY FACTOR ANALYSIS OF
THE JOB ELEMENT INVENTORY

by

THEODORE L. HAYES

A THESIS SUBMITTED
IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE

MASTER OF ARTS

APPROVED, THESIS COMMITTEE:

Robert J. Harvey, Director
Assistant Professor

William C. Howell
Department Chairman

Kenneth R. Laughery
Henry R. Luce Professor of
Psychology

Houston, TX

April, 1987
ABSTRACT

Structured methods of job analysis have traditionally been based upon theories of job performance that describe work in terms of discrete dimensions of behaviors, such as work output, relations with others, etc. Recent job analysis research has sought to reduce the effort of a traditional structured job analysis by reducing the demands placed upon the rater providing job analysis information. The Job Element Inventory (JEI) is one such structured job analysis inventory which seeks to reduce the effort in the job analysis process while assessing jobs through a priori theories of work activities. Early research has shown that the JEI has many desirable properties, though the replicability of its putative structure has not been addressed. This research employed confirmatory factor analysis methods designed to assess the replicability of the structure of the JEI in many different samples of data. Results indicate that the JEI's structure was recoverable, with minor modifications, across several disparate jobs. These results were consonant with popular theories of work behavior. Implications for future applications of the JEI are discussed.
ACKNOWLEDGEMENTS

I would like to thank my advisor, Dr. R. J. Harvey, for his guidance throughout this project and many others. I would also like to thank Dr. W. C. Howell and Dr. K. R. Laughery for their invaluable comments and assistance. In addition, my eternal gratitude must be extended to Ms Doris Malone, who is probably most responsible for my progress at Rice.

Finally, I would like to thank everyone who has put up with my less than friendly behavior during the past few months. I hope to return to normal soon.
TABLE OF CONTENTS

I. Introduction .................................................................1
   A. Purposes of the current investigation .........................9
   B. A brief introduction to confirmatory factor analysis ......12
   C. An example of LISREL ...............................................14
   D. Model identification ...............................................17

II. Method .............................................................................21
    A. Respondents ............................................................21
    B. Instrument ..............................................................22
    C. Datasets ....................................................................23
    D. Procedures ..............................................................24
    E. Measurement model descriptive statistics ....................27

III. Results ...........................................................................30
     A. Application of the Coast Guard patterns to CFA1 data ....30
     B. Application of Validation1 patterns to Validation2 data ..33

IV. Discussion .........................................................................36
     A. LISREL analyses .......................................................36
     B. Implications of the analyses ........................................39
     C. Postscript: A refactoring of the JEI ............................40

V. References .........................................................................43
TABLES

1. Different datasets used in JEI analyses ..........................24

2. Results from the confirmatory factor analyses for each
division using CFA1 data and Coast Guard patterns ..........31

3. Results from the confirmatory factor analyses for each
division using Validation2 data and Validation1 patterns .....34

4. Coefficient alphas for each division using different data
sources .................................................................35
FIGURES

1. An example of a confirmatory factor analysis measurement

model .................................................. 16
CONFIRMATORY FACTOR ANALYSIS OF
THE JOB ELEMENT INVENTORY

INTRODUCTION

Theories of job performance have led to the development of several well-researched job analysis methods, such as the critical incident technique (Flanagan, 1954), Functional Job Analysis (Fine and Wiley, 1971), the Position Analysis Questionnaire (PAQ; McCormick, Jeanneret, and Mecham, 1972), and the Occupational Analysis Inventory (Cunningham, Boese, Neeb, and Pass, 1983). These four methods (though to a lesser extent the critical incident technique) are structured job analysis techniques. They reflect the logic of McCormick, Cunningham, and Gordon (1967, pp. 417-419), who postulated that: 1) human work activity could be described in quantitative terms or elements; 2) sets of these elements tended to "go together" or occur in combination through (or in) the behaviors necessary to perform various jobs; 3) elements or behaviors that occur together could be thought of as dimensions of work activity and circumstances; and 4) that these dimensions are directly indicative of an underlying behavioral structure to the domain of human work.

Without such theoretical underpinnings much of Industrial/Organizational psychology would be enslaved by a task inventory perspective (e.g., Christal, 1974), unable to "move off the dead-center of empiricism" (McCormick et al., 1967, p. 417) and create generalizations of human work behavior. Structured job analysis methods have addressed these issues well in general, but in describing the relevant general behaviors of work these instruments have engendered
problems of their own.

Two problems inherent to structured methods of job analysis are the rigorousness of the job analysis process (i.e., how much information is desired, who should provide ratings) and the lengthiness of the process. These issues may be labeled the information problem and the exertion problem, respectively. For instance, the PAQ has 187 items and six response scales, while the OAI has between 230 and 617 items and several response scales (these can vary; Cunningham, 1986, personal communication). In these structured inventories, each item and scale has its own special meaning, requiring a professional job analyst's interpretation. Also, the reading level of the PAQ (Ash and Edgell, 1975) is beyond that of a college graduate, and there is every reason to believe that the OAI's reading level is similar. FJA requires that a task inventory be developed first and then someone familiar with the task inventory and the FJA scales must rate each job, a time consuming process. However, the results of a professionally conducted job analysis are regarded as legally defensible (Uniform Guidelines, 1978; Thompson and Thompson, 1982) and are valid representations of the job's activities, providing great value to an organization (McCormick, 1976, 1979).

Recent job analysis research has attempted to address the information and exertion issues, though the extent to which they have succeeded is debatable. Wilson and Harvey (1987) have labeled these endeavors reduced-effort job analysis (REJA). Research addressing the information issue has been performed largely by those interested in validity generalization (e.g., Pearlman, 1980; Schmidt, Hunter, and
Pearlman, 1981; Cornelius, Schmidt, and Carron, 1984). Research into the exertion issue has sought to retain the informativeness of traditional structured job analysis methods while reducing the response demands made upon the rater (e.g., Harvey, Friedman, Hakel, and Cornelius, 1985a; Wilson and Harvey, 1985).

Research into the information issue has been prompted by concerns that traditional structured job analysis methods provide a "quantitative overkill" (Cornelius et al., 1984, p. 256) of information, that too much of a company's resources are tied up in a traditional job analysis, and that simple holistic ratings of either the similarity of various jobs or of levels of a few broadly defined dimensions (Pearlman, 1980) can suffice for personnel functions such as compensation, job grouping, promotion, etc.

Several articles investigating reduced information have reported successful efforts in this area of REJA research. Cornelius et al. (1984) had incumbents sort jobs into one of several preestablished categories, and then had them make ratings of these jobs on several loosely defined atttribute and worker-oriented scales. They found high correlations between the sorted results and the rating results, and claimed that this constituted evidence of the feasibility of the holistic rating approach for job classification purposes. In a similar vein, Sackett, Cornelius, and Carron (1981) had each member of a panel of job experts compare jobs and make similarity ratings. They found that when these ratings were submitted to a cluster analysis, results indicated a similar structure as that produced by more detailed ratings.

A different tack has been taken by Jones, Main, Butler, and Johnson
(1982) and Smith and Hakel (1979). These researchers had students make
ratings of several jobs, with which they were unfamiliar, using the PAQ.
They found that the convergent validity between raters for PAQ
dimensions was very high (lowest validity was .89), and suggested that
by using relatively job naive raters the process of job analysis could
be simplified and made less expensive and intrusive.

In response to these studies, Harvey and his colleagues (e.g.,
Friedman and Harvey, 1987; Butler and Harvey, 1987; Blunt, 1986; Harvey
and Hayes, 1986) have provided ample evidence to challenge many of the
conclusions made in studies mentioned above through research using the
PAQ. Briefly, these more recent studies have shown: 1) even by
increasing the level of job descriptive information to job-naive student
subjects, PAQ convergent validities with experts are still markedly low
(r = .64 with experts when students were given extensive task information;
Friedman and Harvey, 1986); 2) ratings made on the basis of holistic
ratings, when correlated with other holisitic ratings or ratings from
actual PAQ and task dimensions, have low reliabilities and convergent
validities, even for job or instrument experts (Blunt, 1986; Butler and
Harvey, 1987); and 3) reliabilities obtained from reduced information
studies are unacceptable, as they are below those which would be
expected by chance alone (Harvey and Hayes, 1986). In summary, these
PAQ studies have strongly indicated that there is not much utility in
reducing the information demands in a structured job analysis.

There are two more criteria that have not been assessed in the
reduced information REJA literature. The first is legal viability. As
Sackett et al. (1981, p. 803) noted, the legal defensibility of REJA
ratings under the reduced information paradigm is questionable, since it must be the case that "judges (raters) have no personal stake in the outcome, i.e., they have no reason for wanting any job to be viewed as similar or dissimilar to any other job." The extent to which this condition may be met in practice is dubious and must be evaluated on a case-by-case basis, thereby making the rating and review process about as expensive as a traditional structured job analysis.

Another criterion is in the prediction of compensation. One of the strongest arguments for the use of the PAQ is that it predicts the compensation of job incumbents very well. The PAQ generates compensation "points" that can be applied to any job analyzed by the PAQ, a valuable personnel administration function. McCormick et al. (1972) found that the multiple Rs for prediction of civilian job compensation was between .80 and .90, while the R for prediction of Naval jobs was .77 (Harris and McCormick, 1973).

In contrast to efforts to reduce the information available to the rater, research into reducing the exertion in job analysis has sought to retain the detail and information of the structured techniques while lessening the number of items or the number of response scales. Wilson and Harvey (1985) obtained responses to a task inventory from almost 3600 incumbents based on two scales, time spent and importance. They dichotomized the time spent ratings (0= did not spend any time on the task, 1= did spend some amount of time on the task) and found that correlations between the dichotomous ratings and the continuous ratings had a high median correlation (.80; range of .49 to .91). These results indicated that dichotomous scales may provide equivalent job information
while reducing the response demands on the rater.

A final avenue taken by REJA researchers has been the development of the Job Element Inventory (JEI; Harvey et al., 1985a). The JEI was adapted from the PAQ by Cornelius and Hakel (1979) to serve as a low reading demand, high job information structured job analysis inventory which would be completed by job incumbents, in that case Coast Guard fleet personnel. The JEI was written to parallel the content of the PAQ with fewer items (153) and only one relative time spent scale (as opposed to six PAQ scales). As such, it is a worker-oriented inventory (i.e., it assesses general worker behaviors across many disparate jobs). In the only comparison of the PAQ and JEI so far, Harvey, Friedman, Hakel, and Cornelius (1986, pp. 38–40) found that the multiple Rs from predicting PAQ dimension scores from JEI dimension scores ranged from .71 to .94, a high level of agreement.

Only one study examining the ability of a REJA technique to predict compensation rates has been reported in the literature so far. Harvey et al. (1986) found that the R for prediction of compensation rates for the Coast Guard, using JEI factor scores, was .73. In addition, the R from predicting PAQ compensation points from the JEI ranged from .73 to .86 depending on how many factors were used as predictors, indicating that the information assessed by these instruments was of near comparable utility.

Research reported thus far with the JEI seems to indicate that it has more promise as a viable job analysis technique than do other REJA techniques. Given that the predictiveness of the JEI puts it in competition with other structured job analysis methods such as the PAQ,
the stability of the JEI's internal structure needs to be assessed. One would expect that the factors based sample-specific variance in the Coast Guard data might change over different samples as the instrument assesses more of the "world of work" (see Gorsuch, 1982, p. 342 ff). Also, various exploratory factor analysis models cannot be compared with each other to see how well they explain the covariation amongst the items. Therefore, the present research has been designed to assess the structure of the JEI, over several different sources of data, using a confirmatory factor analysis approach through the method of linear structural relations (LISREL; Joreskog and Sorbom, 1986).

The use of LISREL to examine or confirm theories concerning the latent structure of factors in I/O psychology has been extremely limited. This technique is relatively new and not generally accessible to the average researcher. Specialists in the field of factor analysis have advised that LISREL be employed instead of repeated exploratory analyses to test theory (e.g., Ford, MacCallum, and Tait, 1986). One example of this usefulness of LISREL analysis in the resolution of conflicting exploratory results has been in the study of the structure of the Job Diagnostic Survey (JDS; Hackman and Oldham, 1975, 1976).

The JDS seeks to assess several core dimensions of the work environment: task identity, skill variety, feedback from the work, feedback from agents, dealing with others, task significance, and autonomy. These dimensions are not supposed to be correlated (1975, p.166). In one study, Dunham (1976) found that all of these dimensions loaded on only one factor. In a different study, Green, Armenakis, Marber, and Bedeian (1979) found factorial evidence for a negatively
worded item method factor. Another study found that two of the dimensions (feedback from agents and dealing with others) were extraneous (Evans, Kiggundu, and House, 1979). Finally, two studies presented results to show that the seven core dimensions plus the age, educational achievement, level in the organization of the respondent, and a item wording method factor could account for the variance in JDS ratings (Fried and Ferris, 1986; Idaszak and Drasgow, 1987). Other studies have shown different numbers of factors.

In advocating the use of LISREL in a confirmatory factor analysis of the JDS, Harvey, Billings, and Nilan (1985b) pointed out that in performing repeated exploratory analyses earlier researchers had overlooked three important assumptions inherent in exploratory factor analysis. First, the initial estimates of the amount of common variance in each item (the communalities) must be estimated. Second, the researcher must choose the number of factors to be rotated. Finally, the researcher is faced with a large number of rotation methods, each producing somewhat different results depending on the researcher's preconceived notions of the "proper" rotation. Also, exploratory analyses give no information as to the extent to which the chosen exploratory factor is a good summary of, or "fits", the data, and no information on how the factor model could be improved to explain more information (Harvey et al., 1985b, p. 462).

Harvey et al. (1985b) used a confirmatory factor analysis approach to show that the original seven dimensions, plus two method factors, could account for the variance in a large set of JDS responses better than other models. In a response to an exploratory analysis claiming
the superiority of the seven JDS factors plus one method factor (Idaszak and Drasgow, 1987), Hayes and Harvey (1987) tested the Idaszak and Drasgow (1987) model and the Harvey et al. (1985b) model and showed that the seven factor solution plus two method factors was again the best representation of the data in a separate dataset.

**Purposes of the Current Investigation**

The purpose of this investigation was to test the theoretical structure of the JEI's six a priori divisions—Information Input (24 items), Mental Processes (30 items), Work Output (33), Relationships with Others (36), Job Context (17), and Other Job Characteristics (13). These divisions are based on theoretical groupings of the JEI's items, and mirror the divisions of the PAQ. LISREL is not capable of testing whether or not the items belong in one division more than another; that is the role of the researcher. However, LISREL can test how well an item contributes to the variance of that division, and how well it is caused by the latent factors constituting that theoretical division, while assuming that the item belongs in that division.

The LISREL analyses will determine how well a measurement model (see below) of the proposed divisional structure estimates the population covariance matrix for the items in each division. This would provide information on the validity and internal cohesiveness of that dimension, as well as information on the meaningfulness of the intradivisional factors. If the measurement model could reliably explain a set of items that have coherent semantic meaning in terms of those intradivisional factors, then there would be psychometrically rigorous evidence to facilitate interpretation and prediction based on the job analysis.
results for each division.

It is important to know the structure of the divisions for several reasons. A utilitarian reason is that the intradivisional factors are used as predictors in a compensation equation. Since items within intradivisional factors generate scores for those homogeneous item composites, and since better prediction comes from more predictors, it is important to have well-defined and replicable item composites.

Also, if the divisions are poorly defined, their reliability may be suspect. This point is extremely important, as the demonstrated lack of psychometric rigor of many REJA techniques may limit their applicability.

Another reason for investigating the divisional structures is to find if the JEI's divisions are assessing the same worker behaviors as the PAQ. While it should given that it is a low reading level transcription of the PAQ, this still needs to be assessed.

Yet another reason is taxonomic. As described above, McCormick and his colleagues (1967, 1972) have postulated that the structure of work was describable and predictable through some number of worker-oriented elements. If the JEI's structure is indicative of reasonable work behavior dimensions, then not only will this structure be readily amenable to explanation, but the applicability of the JEI for determining necessary human attributes, training needs, etc., for various jobs will be increased substantially.

In order to test the putative structure of the JEI's divisions as reported in Harvey et al. (1985a), two methods were followed. The first, which could be thought of as the "worst case scenario", was an
attempt to assess the fit of the original factor patterns from the Coast Guard to all other JEI responses (N=1565). This would be the worst case since the non-Coast Guard data included widely disparate jobs (e.g., accountants, fire fighters, prison dog trainers), and so it was expected that the original patterns would not fit the new data well. Next, a "best case scenario" was developed wherein two large representative samples of JEI responses were formed. New factor patterns were developed exploratorily through one dataset, and those patterns were fitted to the second dataset. Since the respondents in the two datasets were roughly equivalent, it was expected that very good fit would result from this procedure.

This research addresses the construct and external validity of each division (Cook and Campbell, 1979, pp. 38-85). Construct validity refers to the extent to which generalizations to higher-order constructs can be made from current research, and external validity refers to the extent to which results are replicable across samples or populations. The construct issue is interpretational, and shall be addressed in the Results section of this report. The current research project examines the external validity of each division through testing the goodness of fit of factor patterns based on one sample as compared to widely disparate data from three other samples (the "worst case scenario" below).

The internal validity of each division, or the extent to which items influence each other, is not addressed quantitatively in a LISREL analysis. However, through the nonstatistical fit measures described below, the current research can address issues concerning the internal
cohesiveness of the divisions (see Nunnally, 1978, pp. 212-213, 256-270). Internal cohesiveness will be assessed both by comparing the relative fit of one model to the relative fit of another model with a different number of factors, and by computing coefficient alphas (Nunnally, pp. 213ff) for each division. The model with better internal cohesiveness would have fewer modifications and better fit than a model with less cohesiveness, and will make better theoretical sense. Also, the model coefficient alpha is a direct linear index of internal cohesiveness.

A Brief Introduction to Confirmatory Factor Analysis

LISREL provides a strong measurement link between theory and the operationalization of the theory's constructs. Confirmatory factor analysis, in a very crude manner, can be thought of as exploratory factor analysis in reverse; it is factor analysis by deduction using an hypothesis testing paradigm. A brief review of the assumptions underlying both exploratory and confirmatory factor analyses points out the differences between these two approaches.

When an investigator performs an exploratory factor analysis, he or she makes several implicit assumptions (see Ford et al., 1986; Long, 1983; Rummei, 1970) probably unknowingly. First, all common factors are correlated, or as in principal components analysis, all components are orthogonal. Second, all observed variables are directly affected by all common factors (or components). Unique factors, which contribute variance to only one observed variable each, are uncorrelated with one another and they are uncorrelated with the common factors. Finally, all observed variables have an associated unique factor, sometimes referred
to as error variance (adapted from Long, 1983, p.12).

In an exploratory factor analysis the researcher can control the variables entered into the analysis, the type of analysis desired (e.g., common factors or principal components), and the parameters of the research analysis techniques (such as communalities and the types and degree of rotations). In a confirmatory analysis the researcher controls not only these facets of the analysis, but also a number of others. First, there is a formal specification made by the researcher as to which measured variables are affected by which common factors. Also, the researcher must specify which of the common factors are correlated. There must be a specification of the variables affected by unique factors, and a specification of which unique factors are correlated with each other (unique factors cannot correlate with common factors). Also, in confirmatory analysis, the parameter values are assumed to be estimated without measurement error, which is why there are latent constructs to account for the unique variance (adapted from Long, 1983, p 12).

It is possible through a LISREL analysis that several possible covariance structures may account for equivalent amounts of fit (Bentler, 1980). It is incumbent upon the researcher to determine which of the models with equivalent fit provide the best explanation of the data. Also, LISREL assumes that unmeasured latent variables cause measured manifest variables. "Cause" is meant to imply that, given the model and constrictions on parameters specified by the researcher, only certain values for parameters can be observed for the model's variances and covariances (Bentler, 1980, pp. 425-426). Just as Simon (1985, p.
13) identified causation from correlation in the cases where there was temporal precedence and error terms were uncorrelated, McCormick et al. (1972, p. 348) have stated that items describing worker behaviors "take on the coloration" of the divisions with which they are logically associated. Hence, one may speak of causation in LISREL analyses. 

An Example of LISREL

Figure 1 presents a diagram of a possible confirmatory factor analysis model for scholastic achievement, including unique factors ($\Theta_6$, "theta delta"), measured variables or 'items' ("x", referred to as manifest variables), common factors ( $\xi$, "zi", or "ksi" as LISREL spells it), the interfactor correlation variable ( $\Phi$, "phi"), and the factor loading paths ( $\Lambda$, "lambda") relating manifest variables to common factors. While this model is only fanciful, it should serve as an adequate example of the confirmatory factor analysis process.

In the language of confirmatory factor analysis, Figure 1 displays a measurement model. Put plainly, the measurement model produces an estimate of the population item covariance matrix $\Sigma$ using the sample covariance matrix $S$, itself an estimate of $\Sigma$. The goal of the measurement model is to provide an estimate of $\Sigma$ through specifying the effects and interrelations of the latent constructs lambda, ksi, phi, and theta delta to account for the covariances between the manifest variables in $S$ (Herten, 1985; Herten and Costner, 1985; Joreskog and Sorbom, 1986; Long, 1983). The sample covariance matrix $S$ itself does not overtly indicate the direct and indirect effects of any unobserved processes such as common or unique factors, and so in terms of model or theory building $S$ does not provide enough information. However, $S$ is
the best sampling estimate of \( \Sigma \). Hence by examining the potential latent structure that could account for \( S \) through use of the measurement model, the researcher can attempt to explain the processes creating by estimating the information in \( \Sigma \).

The mathematical formula for the measurement model is

\[
\mathbf{X} = \mathbf{A}_x \xi + \mathbf{G} \delta \tag{Eq. 1}
\]

where \( \mathbf{X} \) is the \((q \times 1)\) vector of manifest variables \( x_1 \ldots x_q \), \( \mathbf{A}_x \) is the \((q \times s)\) matrix of the loadings (expressed in beta weights, as in regression) for each of the \( q \) xs to the appropriate \( s \) ksis, \( \xi \) is the \((s \times 1)\) ksi vector, and \( \mathbf{G} \delta \) is the \((q \times 1)\) vector theta delta, containing the unique factors for each manifest variable that contribute variance only to that variable.

Suppose that Figure 1 is a model of a scholastic achievement test with three items \((x_1, x_2, x_3)\). Item 1 is a reading comprehension question, item 2 is a word problem requiring algebra, and item 3 is a multiplication problem. The researcher might hypothesize that two factors account for the variance in these three items, a Verbal factor and a Quantitative factor (the ksis); in addition, the researcher might hypothesize that these factors are oblique, and so in this figure phi has a nonzero value (phi would equal zero if the ksis were orthogonal, as in a principal components analysis).

In LISREL notation the rows of matrices denote "results", or here test items, and the columns are "causes", or here ksis (Herting, 1985, p. 274). Note in Figure 1 that there are freed path loadings, or lambdas, relating \( \text{item1} \) to \( \text{ksi 1} \), \( \text{item2} \) to \( \text{ksi1} \) and \( \text{ksi2} \), and \( \text{item3} \) to \( \text{ksi2} \); other possible loadings (e.g., \( \text{item1} \) to \( \text{ksi2} \)) are constrained to
FIGURE 1
An example of a confirmatory factor analysis measurement model

\[ X = \Lambda_\xi \xi + \Theta \delta \]

Here, \[ \Lambda_\xi = \begin{bmatrix} \lambda_1 & 0 \\ \lambda_2 & \lambda_3 \end{bmatrix}, \quad \bar{\Lambda} = \begin{bmatrix} \text{item1} \\ \text{item2} \end{bmatrix}, \quad \bar{\Theta} = \begin{bmatrix} \bar{\delta}_1 \\ \bar{\delta}_2 \end{bmatrix} \]

\[ \xi = (\xi_1 \xi_2), \quad \text{and} \quad \Theta = \begin{bmatrix} \delta_1 & 0 & 0 \\ 0 & \delta_2 & 0 \\ 0 & 0 & \delta_3 \end{bmatrix} \]
remain zero. The lambda matrix shows that the researcher believes that the Verbal factor (ksi1) has a direct causal effect on items 1 and 2, and so LISREL will estimate beta weights for these loadings. The researcher has decided that item3 (the multiplication problem) is not affected by the Verbal factor, and so the loading is constrained to zero. Also, the phi matrix--which is symmetric--shows that there is a correlation between ksi1 and ksi2, and that the variance of each ksi has been constrained to 1, standardizing these variables. Finally, the unique factors are uncorrelated.

In the measurement model of Figure 1, the researcher decided that the math word problem had both Verbal and Quantitative components, and so there are two lambdas freed for item2. If the researcher thought that the word problem did not have either a Verbal or Quantitative component, then one loading would be constrained to zero. The increase in information gained by freeing both lambdas can be gauged through various indices of information accounted for (see below). However, the statistical solution is inferior to the theory-based assumptions the researcher makes.

**Model Identification**

One essential property of the measurement model is that it must be identified (Long, 1983; Joreskog and Sorbom, 1986). Identification refers to the unique determination of the model's parameters. In a model that is not identified the estimations arrived at by LISREL and the subsequent interpretations made by the investigator may be specious, especially in the case where more than one pattern of ksi, lambda, and/or phi matrices produces equivalent estimation for the values
of \( \Sigma \).

Absolute determination of whether or not a model is identified is impossible, since it requires an examination of each population covariance parameter equation. Joreskog and Sorbom (1986, pp. I.20-24) and Long (1983, p.42) provided two alternative necessary conditions for identification. The first is that there must be at least \((qs+(s(s+1)/2))\) parameters constrained in the model, where \(q\) and \(s\) are defined as above. The second is the condition that \(\phi\) be positive definite (i.e., if by pre- and post-multiplying any \((r \times r)\) matrix of values by any \((r \times 1)\) vector the resultant product is greater than one, the matrix is positive definite) with diagonal elements equal to one.

An equally unfavorable condition exists when there are no constraints placed on the possible values assumable by any parameters. This special case creates a just-identified, or saturated, model (Bentler and Bonett, 1980; Long, 1983). These models have as many equations to estimate parameter values as they have parameters. The chi-squares of saturated models are equal to zero (see below). With a lack of constraints placed upon a model's parameters, more than one set of parameters may provide adequate estimation of the population covariance matrix (Long, 1983, p. 40). Therefore, the constraints imposed on the model's parameters, which are based on theoretical considerations, not only allow for tests of the theory but also help identify the model.

Identified models are desirable. Generally though, a model will be overidentified; that is, it will have more constraints than are necessary to provide a good estimation. These models are testable and
interpretable. One of the goals of LISREL is to provide for a statistical test of the reasonableness of the constraints imposed on a model by estimating chi-square values to compare overidentified models for the same data source with differing constraints.

LISREL reports chi-square values and degrees of freedom for all covariance structures estimated through a maximum likelihood factor analysis procedure, along with a root mean square residual value. Without going into detail (which can be found in Bentler and Bonett, 1980; Bentler and Weeks, 1981; Joreskog and Sorbom, 1986), the maximum likelihood analysis seeks to minimize various functions of traces of the determinants of $\Sigma$ and $\mathbf{S}$ through the measurement model, producing a function $F$. When $F$ is multiplied by the number of respondents in the sample, the resulting value is distributed as a chi-square. The chi-square's degrees of freedom are equal to the number of unconstrained sample variances and covariances ($p$) less the number of estimated parameters in the measurement model ($q$), or $(p(p+1)/2)-q$.

The chi-square, then, is a direct statistical test of the amount of fit provided by its associated measurement model: the better the fit, the lower the $F$, and so the lower the chi-square. The null hypothesis assumed by the chi-square is that the model is a plausible representation of the latent processes producing the population covariance matrix $\Sigma$. To the extent that the chi-square is larger than its degrees of freedom, the null hypothesis will be rejected in favor of the assumption that the model does not constitute an adequate representation of the causal processes.

One factor which will influence the chi-square is the number of
respondents. The larger the number of respondents, the higher the chi-square. Large chi-squares can be achieved even if the true fit to the population covariance matrix is very good (Bentler and Bonett, 1980, p. 591), which would result in leading the researcher to the erroneous conclusion that the model was not providing very good fit to $\Sigma$.

Given this problem of the influence of large sample sizes, Bentler and Bonett (1980) and MacCallum (1986) recommended that the chi-square value be evaluated with caution, and that instead researchers examine fit indices which are based upon chi-squares (see p. 27ff below).
METHOD

Respondents

Survey responses from four independent sets of job incumbents were included for analysis. The first set of responses to the JEI was obtained through its initial administration (see Harvey et al., 1985a); there were 2,029 Coast Guard respondents in this sample (job titles for all samples are listed in Appendix B).

Respondents in the second set were 594 Correctional Officers, Level III (CO IIIs), in a southwestern state’s Department of Corrections. CO IIIs are prison guards who have been employed by the Department of Corrections beyond the initial six month training and probationary period. They have no supervisory responsibilities for other employees, though they do supervise inmates. Respondents were selected through stratified random sampling of the CO IIIs of all Correctional Units throughout the state; approximately eight percent of the Department’s CO IIIs participated in this analysis.

Respondents in the third set were 852 correctional supervisory personnel at all ranks (sergeants through majors) in the aforementioned state’s Department of Corrections. All Supervisors system-wide were required to participate in the job analysis project, though some did not for various undisclosed reasons. The Supervisory sample includes ninety-five percent of the population of Correctional Supervisors in the state.

The fourth sample included 119 employees of a small southwestern municipality. All municipal employees were required to participate in the job analysis project. These respondents represented a wide range of
municipal occupations, such as police officers and accountants.

In each of the four samples respondents were participants in projects designed to improve human resource management practices, from selection to performance appraisal development to compensation determination. The job analysis data were collected as a necessary first step in these projects, and respondents were designated to participate in the data collection process. Though those with strong objections were allowed to refuse to participate, none expressed such reservations.

Instrument

The complete JEI and instructions to respondents are reproduced in Appendix A (the version printed there was used in the study of Correctional personnel). Participants provided responses to the 153 survey items of the JEI on specially prepared marked-sense forms. Where missing item responses were detected, the arithmetic mean for that item in that dataset was inserted through a standard computer procedure. This practice is routine (Cohen and Cohen, 1975) and, if there appears to be no pattern to the missing items, should not distort statistical results. No such pattern was evident.

Though the JEI is designed to assess universal work dimensions, some of the instrument's items need to be reworded for various employment situations. For example, in the original (Coast Guard) version of the JEI, item 71 read "Contact Chief Petty Officers", item 29 read "Responsible for safety of USCG members", and item 151 read "Serve as an air crewman". For the CO IIIs and Supervisors, item 71 was rewritten to "Contact immediate supervisors as part of the job", item 29 became
"Accept responsibility for the safety of other employees", and item 151 was rewritten to "Work in hazardous job situations". Items were rewritten to maintain the meaning of the original instrument. The extent to which that intent was realized will be reflected in the logical sense to be drawn from the results of the exploratory and confirmatory factor analyses presented later in this report.

Datasets

As reported above, there are four independent sets of respondents to the JEI. Table 1 lists each of these datasets according to the predominant employment source of the respondents. The original exploratory factor analyses presented in Harvey et al. (1985a) were performed using the data from the Coast Guard respondents only. In order to complete the goals of the present study three different combinations of the datasets were used, and these are also presented in Table 1.

All datasets contained covariance matrices of the 153 items as required for input to LISREL. The first four datasets in Table 1 have been described above in this section. "Validation1" and "Validation2" were drawn independently and at random from each of the four original datasets. Both datasets are large, independent, and heterogeneous in order to reflect the broadest variability in JEI responses. Analyses of these heterogeneous dataset should indicate the "world of work" detectable by the JEI beyond information available through more homogeneous samples alone (Gorsuch, 1982, p. 342ff). Validation1 served as a dataset for a refactoring of the JEI, and Validation2 served as a confirmatory factor analysis data source for the exploratory
<table>
<thead>
<tr>
<th>Dataset name</th>
<th>N</th>
<th>Description of respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coast Guard</td>
<td>2029</td>
<td>As above.</td>
</tr>
<tr>
<td>CO III</td>
<td>594</td>
<td>As above.</td>
</tr>
<tr>
<td>Supervisory</td>
<td>852</td>
<td>As above.</td>
</tr>
<tr>
<td>Municipality</td>
<td>119</td>
<td>As above.</td>
</tr>
<tr>
<td>Validation1</td>
<td>967</td>
<td>A randomly selected sample of respondents from each of the four original datasets above, including 301 from the Coast Guard, 303 from CO III, 304 from Supervisory, and 59 from Municipality.</td>
</tr>
<tr>
<td>Validation2</td>
<td>967</td>
<td>A randomly selected sample of the remaining respondents from each of the four original datasets above, including 383 from Coast Guard, 167 from CO III, 357 from Supervisory, and 60 from Municipality. None of these respondents are included in Validation1 above.</td>
</tr>
<tr>
<td>CFA1</td>
<td>1565</td>
<td>All respondents from CO III, Supervisory, and Municipality.</td>
</tr>
</tbody>
</table>

factor analysis patterns from Validation1 in the manner described below in Procedures. "CFA1" was created to serve as the confirmatory factor analysis data source for the original exploratory factor analysis patterns from the Coast Guard data.

**Procedures**

The major goal of the current research was a confirmatory factor analysis of the JEI through development of measurement models for the factor structures of the JEI's six divisions. The purpose of the research was not to carry out a cross-validation of the JEI divisions
per se as in Cudeck and Browne (1983). Such an endeavor would require the use of the same measurement models using independent samples of data (Guilford, 1954; Pedhazur, 1982) in order to estimate the goodness of fit across the samples. Currently the database of JEI responses does not include enough respondents for this process.

A very important aspect of the analyses required the determination of the most appropriate lambda and ksi matrices. These two matrices contain information on the strength of the effects of each ksi on each item in that division, and the pattern of items that would be allowed to load on the ksis. A confirmatory factor analysis of a "worst case" scenario required the application of the rotated factor patterns (showing significant loadings of items onto the intradivisional factors) derived from the Coast Guard exploratory factor analyses for each JEI division to an independent set of data, CFA1. Since these two data sources contained such disparate jobs, the fit of Coast Guard patterns to all other JEI responses would be expected to be poor. The rotated factor pattern of significant item loadings for each division was used to create the pattern of free and constrained loadings for an initial ksi matrix. LISREL models using the initial ksi matrix without modification (see below) will be referred to as original models.

In addition, a null model was estimated for each division (Bentler and Bonett, 1980, p. 595ff; Herting, 1985). A null model specifies that no common factor variance can account for variance in the population covariance matrix, and that the covariances are simply a function of the unique factors. Therefore, the estimation of $\Sigma$ would be based on unique factor variance alone, producing a baseline estimate of fit. By
comparing the fit provided by the various measurement models to the fit suggested by the null model, indices of relative fit (the incremental fit index rho, and the normed fit index delta) can be computed (Bentler and Bonett, 1980; see below). Rotated factor patterns for each division as based on the Coast Guard analyses are reproduced in Appendix D. A reproduction of a LISREL program used to analyze the data for one division is presented in Appendix C.

After the LISREL program gave estimates for the free parameters it then estimated modification indices. A modification index is a value equal to the minimum expected decrease in the overall chi-square if a single constrained parameter is allowed to vary (Joreskog and Sorbom, 1986; Long, 1983). Since freeing one parameter to vary causes a loss of one degree of freedom, the expected minimum decrease should be statistically significant. Long (1983, p. 69) suggested that this value should exceed 3.84, while Joreskog and Sorbom (1986, p. III.19) suggested 5.00 as a cutoff value. Since this procedure is very exploratory in nature and should only be used when theory would not restrict such modifications, this researcher decided on a minimum modification index of 50.00 as an arbitrary, though very conservative, cutoff value. In other words, the modification would have to produce a reduction in the overall chi-square which would be significant beyond the $p < 0.001$ level. These modifications are noted in Appendix D, and are hereafter referred to as the "best" models.

After estimation of the parameters for the original models using the data from CFA1, and the subsequent reestimations to produce the best models, the next phase of the analyses required the use of Validation!
and Validation2. The items comprising each of the six JEI divisions were factor analyzed to develop new original models based on the more representative data in Validation1. Measurement models were then developed using data from Validation2, as were new best models. This would allow for an assessment of the fit of the "best case" scenario models in that both Validation1 and 2 contained very similar respondents. The fit of Validation1 factor patterns to Validation2 data, therefore, should be very good. Rotated factor patterns for each division, along with the modifications made, are presented in Appendix E.

**Measurement Model Descriptive Statistics**

Chi-square values for significance testing can be compared from model to model to show the decrease in chi-square provided by freeing or constraining certain parameters. However, note that a chi-square provides only a statistical test of the null hypothesis, as opposed to the nonstatistical fit indices described below. Just as in univariate and less complicated multivariate techniques, a comparison of statistical tests across experiments is problematic. Generally the researcher will want to know the increase in goodness of the estimations made through various models in comparison to the estimation made by using the null model alone, a more absolute comparison. Therefore the chi-squares can be translated into measures describing the gain in population covariance matrix estimation fit by the model over the null model. Several fit indices are appropriate for this investigation.

Rho is one incremental fit measure (Bentler and Bonett, 1980, p. 599). It is the ratio of the amount of information gained through the
inclusion of common factor variance as specified in a measurement model relative to the information explained by the null model, which expresses population item covariance as only due to unique variance. The formula for rho can be explained as the null model's chi-square divided by its degrees of freedom, minus the model's chi-square divided by its degrees of freedom, that whole quantity divided by the ratio (minus one) of the null model's chi-square divided by its degrees of freedom. However, as Bentler and Bonett noted (1980, p. 599), rho does not necessarily lie between zero and one, and so it is not completely analogous to a regression squared multiple correlation. Bentler and Bonett (1980, p. 599) suggested that a model with a rho or delta of at least .90 was well specified, which would mean that little extra information for the estimation of $\xi$ was remaining unexplained.

Delta is another incremental fit index. Its formula is the same as rho's, except that the chi-squares are not divided by their degrees of freedom, and one is not subtracted from the denominator ratio. Delta does fall between zero and one, though it too is not interpretable as a squared multiple correlation. However, the logic of rho and delta is directly analogous to that of the strength of association measure omega squared (Hays, 1981, p. 290ff). As Hays pointed out, this index is a measure of the reduction in the uncertainty of estimates of a variable $y$ given knowledge about the variability of $y$ in relation to a variable $x$. Similarly, rho and delta may be indicative of the relative decrease in uncertainty of estimation of the population covariance matrix values given the joint effects of the common factors and the unique factors. These indices will be more indicative of the quality of the models,
especially when the chi-square is almost destined to reject the models
due to large sample sizes.

Another fit measure is the parsimonious fit index (PFI: James,
Mulaik, and Brett, 1982, pp. 155ff). The PFI is equal to \( \rho \) multiplied
by the ratio of the degrees of freedom of the model under investigation
to the degrees of freedom of the null model. This index is included
because it penalizes a researcher by reducing the model's fit for \( \Sigma \) due to
including too many ks in the confirmatory model, since an increase in
the number of estimated parameters decreases the degrees of freedom of
the model.

A final fit measure is the root mean square residual value (RMSR).
This is a measure of the closeness of LISREL covariance matrix estimates
to the sample covariance matrix values. It is calculated by calculating
the sum of squared deviations of the the LISREL estimates from the
sample values, dividing by the total number of estimates, and taking the
square root of that quantity. The desired value of this measure should
be as close to zero as possible, though Joreskog and Sorbom (1986, p.
I.41) note that the RMSR is relative to the values of \( \Sigma \).

The final measurement taken from each division is the coefficient
alpha. This measure assesses the correlation of the division's
constituent items with possible (as yet unwritten) alternate items
describing the same content, and this is an index of reliability. This
value will fall between zero and one. All coefficient alphas are
presented in Table 4 (p. 35).
RESULTS

Application of the Coast Guard Patterns to CFA

Several measurement models were generated for each JEI division based on the Coast Guard patterns. Table 2 lists these models with their associated chi-squares, degrees of freedom, rho, delta, PFI, and RMSR. First, descriptions of the null model are reported (null models do not have an incremental fit value). The original models are then presented for each division, followed by the best models for that division (refer to Appendix D for listings of the original and modified patterns of variables). Listed finally are the models based on alternative factor patterns as described in Harvey et al. (1985a, Appendix A). These were potential alternative factor solutions considered by those researchers, but rejected for being less interpretable than the factor solution chosen for that division. However, they are presented to provide some basis of comparison for the confirmatory factor analytic results for the division models under consideration.

The results presented in Table 2 are only from oblique models, both because Harvey et al. (1985a) specified that the factors were oblique and because in all cases the orthogonal common factors models provided very poor fit to the population covariance matrices. Comparisons of the predictiveness of models with different numbers of ksis within the same division are acceptable, since the population covariance matrix will not change through altering the number of common factors. Note that the chi-square values for all models presented in Table 2 are significant beyond the p<.0001 level, a function of the sample sizes. Also, all
TABLE 2

Results from the confirmatory factor analyses

for each division using CFA1 data and Coast Guard patterns

<table>
<thead>
<tr>
<th>Division</th>
<th>Chi-square</th>
<th>DF</th>
<th>rho</th>
<th>delta</th>
<th>PFI</th>
<th>RMSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: null (0) ** (Information Input)</td>
<td>13399.8</td>
<td>276</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.56</td>
</tr>
<tr>
<td>1: original model (4)</td>
<td>2272.8</td>
<td>242</td>
<td>.82</td>
<td>.83</td>
<td>.72</td>
<td>.11</td>
</tr>
<tr>
<td>1: best alternative (6)</td>
<td>1817.9</td>
<td>226</td>
<td>.85</td>
<td>.86</td>
<td>.70</td>
<td>.10</td>
</tr>
<tr>
<td>2: null (0) (Mental Processes)</td>
<td>23597.8</td>
<td>435</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.96</td>
</tr>
<tr>
<td>2: original (4)</td>
<td>4860.8</td>
<td>395</td>
<td>.80</td>
<td>.81</td>
<td>.73</td>
<td>.22</td>
</tr>
<tr>
<td>2: best (4)</td>
<td>4273.9</td>
<td>393</td>
<td>.83</td>
<td>.83</td>
<td>.75</td>
<td>.17</td>
</tr>
<tr>
<td>2: best alternative (7)</td>
<td>2496.4</td>
<td>376</td>
<td>.90</td>
<td>.90</td>
<td>.78</td>
<td>.10</td>
</tr>
<tr>
<td>3: null (0) (Work Output)</td>
<td>23442.9</td>
<td>496</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.47</td>
</tr>
<tr>
<td>3: model (5)</td>
<td>4931.8</td>
<td>447</td>
<td>.78</td>
<td>.80</td>
<td>.71</td>
<td>.14</td>
</tr>
<tr>
<td>3: best (5)</td>
<td>3975.2</td>
<td>442</td>
<td>.83</td>
<td>.83</td>
<td>.82</td>
<td>.09</td>
</tr>
<tr>
<td>3: best alternative (3)</td>
<td>5451.0</td>
<td>453</td>
<td>.76</td>
<td>.77</td>
<td>.70</td>
<td>.16</td>
</tr>
<tr>
<td>4: null (0) (Relationships with Others)</td>
<td>28917.6</td>
<td>561</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.85</td>
</tr>
<tr>
<td>4: model (5)</td>
<td>6837.0</td>
<td>505</td>
<td>.75</td>
<td>.76</td>
<td>.68</td>
<td>.18</td>
</tr>
<tr>
<td>4: best (5)</td>
<td>4299.5</td>
<td>494</td>
<td>.85</td>
<td>.85</td>
<td>.75</td>
<td>.10</td>
</tr>
<tr>
<td>4: best alternative (8)</td>
<td>4473.2</td>
<td>483</td>
<td>.84</td>
<td>.85</td>
<td>.72</td>
<td>.12</td>
</tr>
</tbody>
</table>

(Table 2 continues)
(Table 2 continued)

<table>
<thead>
<tr>
<th>Division</th>
<th>Chi-square</th>
<th>DF</th>
<th>rho</th>
<th>delta</th>
<th>PFI</th>
<th>RMSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>5: null (0) (Job Context)</td>
<td>8896.3</td>
<td>136</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.76</td>
</tr>
<tr>
<td>5: model (3)</td>
<td>1887.5</td>
<td>113</td>
<td>.76</td>
<td>.79</td>
<td>.63</td>
<td>.24</td>
</tr>
<tr>
<td>5: best (3)</td>
<td>1806.3</td>
<td>112</td>
<td>.77</td>
<td>.80</td>
<td>.63</td>
<td>.22</td>
</tr>
<tr>
<td>6: null (0) (Other Job Characteristics)</td>
<td>5281.2</td>
<td>91</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.69</td>
</tr>
<tr>
<td>6: model (5)</td>
<td>387.1</td>
<td>53</td>
<td>.89</td>
<td>.93</td>
<td>.52</td>
<td>.12</td>
</tr>
<tr>
<td>6: best alternative (2)</td>
<td>1020.7</td>
<td>64</td>
<td>.74</td>
<td>.81</td>
<td>.52</td>
<td>.22</td>
</tr>
</tbody>
</table>

** NB: numbers enclosed in parentheses are the number of ksis (common factors) in that analysis. Where no best model or best alternative model is presented, none was available or suggested by the modification index values. The names of the divisions are included by the null models.

models meet the necessary conditions for identification as outlined above. In four of the six divisional analyses presented above, the best model (or original, when no best model was indicated) was superior to any other within that division. The alternative models, which as mentioned above had been considered but rejected as not clearly interpretable by Harvey et al. (1985a), provided better fit in divisions 1 and 2. Inspection of the fit indices and RMSR for division 1, though, indicates that the differences between the original model and the alternative model are practically trivial; in fact, the PFI for the alternative model is less than the original model's PFI due to more factors explaining about the same level of fit.

Differences in the fit indices and RMSR for division 2 models are more pronounced than in division 1. However, these differences may
reflect the fact that any given measurement model having more estimated
parameters than another measurement model for the same variables will
provide a better statistical fit simply because fewer constraints are
imposed and more information is estimated. However, as pointed out
above in the discussion of saturated models, a lack of constraints not
only makes questionable statistical sense, but the lack of substantial
theoretical constraints makes this particular measurement model suspect.
Indeed, an examination of the seven-factor division 2 model showed that
this alternative was conceptually uninterpretable. Therefore the best
division 2 model represents a better measurement model.

Application of the Validation1 Patterns to Validation2 Data

Several measurement models were generated for each JEI division
based on the Validation1 patterns. The patterns are based on results
from the exploratory factor analyses for each division. Table 3 lists
these models with their associated chi-squares, degrees of freedom, rho,
delta, PFI, and RMSRs. Once again, fit measures are not presented for
the null models. The original models are then presented for each
division, followed by the best models for that division (refer to
Appendix E for a listing of the original and modified patterns of
variables). Unlike Table 2, comparative values for alternative models
are not presented in Table 3. This is both to improve readability of
the table and because comparisons of results between tabled results in 2
and 3 can be made, since the information contained in the divisional
covariance matrix—the worker activities that division seeks to
assess—will remain the same. Reasons for differences across data
sources in the predictiveness of the particular models tested will be
TABLE 3

Results from the confirmatory factor analyses for each division using Validation2 data and Validation1 patterns.

<table>
<thead>
<tr>
<th>Division</th>
<th>Chi-square</th>
<th>DF</th>
<th>rho</th>
<th>delta</th>
<th>PFI</th>
<th>RMSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>1: null (0) **</td>
<td>9832.1</td>
<td>276</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.79</td>
</tr>
<tr>
<td>1: model (5)</td>
<td>1415.3</td>
<td>234</td>
<td>.85</td>
<td>.86</td>
<td>.72</td>
<td>.14</td>
</tr>
<tr>
<td>2: null (0)</td>
<td>16114.1</td>
<td>435</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.98</td>
</tr>
<tr>
<td>2: model (4)</td>
<td>2656.3</td>
<td>392</td>
<td>.84</td>
<td>.84</td>
<td>.76</td>
<td>.17</td>
</tr>
<tr>
<td>2: best (4)</td>
<td>2584.2</td>
<td>391</td>
<td>.84</td>
<td>.84</td>
<td>.76</td>
<td>.15</td>
</tr>
<tr>
<td>3: null (0)</td>
<td>17123.7</td>
<td>496</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.79</td>
</tr>
<tr>
<td>3: model (5)</td>
<td>2761.9</td>
<td>448</td>
<td>.85</td>
<td>.84</td>
<td>.76</td>
<td>.14</td>
</tr>
<tr>
<td>4: null (0)</td>
<td>16641.2</td>
<td>561</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.85</td>
</tr>
<tr>
<td>4: model (4)</td>
<td>3609.2</td>
<td>515</td>
<td>.79</td>
<td>.78</td>
<td>.73</td>
<td>.19</td>
</tr>
<tr>
<td>4: best (4)</td>
<td>3529.3</td>
<td>514</td>
<td>.80</td>
<td>.79</td>
<td>.73</td>
<td>.17</td>
</tr>
<tr>
<td>5: null (0)</td>
<td>5975.3</td>
<td>136</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.81</td>
</tr>
<tr>
<td>5: model (4)</td>
<td>727.6</td>
<td>110</td>
<td>.87</td>
<td>.88</td>
<td>.70</td>
<td>.18</td>
</tr>
<tr>
<td>6: null (0)</td>
<td>3425.2</td>
<td>78</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>.88</td>
</tr>
<tr>
<td>6: model (5)</td>
<td>234.3</td>
<td>52</td>
<td>.92</td>
<td>.93</td>
<td>.61</td>
<td>.11</td>
</tr>
</tbody>
</table>

** NB: numbers enclosed in parentheses are the number of ksis (common factors) in that analysis. Where no best model is presented, none was available or suggested by the modification index values.

discussed below.

As in Table 2, all models in Table 3 have chi-squares significant beyond the p<0.001 level, probably a function of the large sample size.

Also, the models meet the necessary conditions outlined above for identification. Note that only divisions 2 and 4 have modified models, and for these two the drop in chi-square of approximately 80 is
practically imperceptible in terms of model fit indices or RMSRs. Given the inconsequential or null gain through the modification indices for these divisions, the original models seem to give very good relative estimations to $\xi$. This conclusion should be compared to results in Table 2, where the best modified original models for each division seemed to give a noticeably better fit than the original models.

Table 4 shows the coefficient alphas for each division. Results are presented first for CFA1 data, then Validation2 data, then finally for all JEI responses combined ($N=3,594$). Note that they are all over .806; Nunnally (1978, p. 245) suggested that for basic research this level of reliability is adequate.

**TABLE 4**  

<table>
<thead>
<tr>
<th>DIVISION</th>
<th>CFA1</th>
<th>Validation2</th>
<th>ALL ($N=3,594$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.8989</td>
<td>.9089</td>
<td>.9005</td>
</tr>
<tr>
<td>2</td>
<td>.9410</td>
<td>.9393</td>
<td>.9370</td>
</tr>
<tr>
<td>3</td>
<td>.9328</td>
<td>.9373</td>
<td>.9328</td>
</tr>
<tr>
<td>4</td>
<td>.9343</td>
<td>.9269</td>
<td>.9276</td>
</tr>
<tr>
<td>5</td>
<td>.8061</td>
<td>.8173</td>
<td>.8189</td>
</tr>
<tr>
<td>6</td>
<td>.8120</td>
<td>.8266</td>
<td>.8172</td>
</tr>
</tbody>
</table>
DISCUSSION

LISREL Analyses

A glance at the results presented in Tables 2 and 3 shows that the models provided very good fit overall, with a close correspondence between fit indices as estimated on the same divisions across different datasets. In sum, the worst case was not too bad while the best case gave good results as expected. The incremental fit indices did not (with one exception) meet Beniter and Bonett's (1980) suggested .90 threshold for adequate specification. However, inspection of the intradivisional factor structures and content contained in Appendices D and E, and the high coefficient alphas for each division across data sources, argues against a quick dismissal of these analyses based on a somewhat arbitrary cutoff value. While it would have been desirable to have found incremental fit values above .90, results from these divisional analyses are consonant with the theory underlying both the PAQ and the JEI.

The confirmatory factor analysis of Validation\textsuperscript{1} using Validation\textsuperscript{2} data showed better overall fit to the models than did the results presented in Table 2, which showed results from using Coast Guard patterns on CFA\textsuperscript{1} data. This is due to the nature of the datasets. The patterns created from the exploratory analysis of the Coast Guard data were applied to a much broader range of variance in CFA\textsuperscript{1}, which contained responses from prison guards, their supervisors, and municipal employees. As Gorsuch (1982, p. 342 ff) pointed out, such differing sources of variance will almost necessarily create different factor patterns, loadings, scoring coefficients, etc. Of course, such varying
results are inherent in exploratory factor analysis (see Harvey et al., 1985b, for a discussion of these hazards). Indeed, it is more surprising to find that the Coast Guard patterns fit the other data so well than it is disappointing that they did not do so better.

Similarly, since Validation1 and Validation2 were random samples drawn from the same data sources, it is not surprising that they fit each other so well. This fit is reflected in the lack of modifications made to the original models for each division (see Appendix E) and the high coefficient alphas.

An important related issue in confirmatory factor analysis is cross-validation of results (MaaCallum, 1986; Cudeck and Browne, 1983; Schmitt and Stults, 1986). The familiar method to show the stability of results over different samples is cross-validation (e.g., Pedhazur, 1982). To use this strategy (almost exclusively in regression), the researcher develops an ordinary least squares model relating the dependent variables to the independent variables in one sample, and then applies the original item weights to variables measured in a new, independent sample.

Cudeck and Browne (1983) developed a metric to assess the cross-validation of a model which followed the same logic as the procedure in regression cross-validation. Cudeck and Browne's method required that the chi-square value be multiplied by the ratio of two over the number of subjects. Competing models attempting to explain data drawn from two independent samples of respondents would then be evaluated on this metric; the model with the lowest cross-validation metric across samples would be the better model.
There was a good reason why the current study did not adopt this strategy. Alternative models with differing numbers of items were tested and found to provide minimal (if any) improvement over the modified original models. However, it was clear from an inspection of the item content of the factors for those alternate solutions that they simply did not make much sense in comparison to the original models. Also, since the data from CFA1 were included in Validation1 and Validation2, those latter two datasets would not have independent sources of information for a proper cross-validation.

The use of modification indices has its consequences. MacCallum (1986) and Cliff (1983) have both warned that alterations to models should be made either in accordance with substantive theoretical demands or when the modifications do not have serious consequences for some aspect of the theory. In either event, however, both MacCallum and Cliff cautioned that the use of modification indices was tantamount to an exploratory analysis in that it may capitalize on sample-specific variation.

In the current project modification indices were used sparingly, especially in light of the recommended use by Joreskog and Sorbom (1986) and Long (1983). The increased fit through these alterations was not large in most cases, though some gain was realized. Only factors in division 4 of the Coast Guard/CFA1 analyses required many modifications. However, the differences in interpretations due to these modifications were minimal, indicating that for this sample the exploratory use of modification indices was not detrimental to the results gleaned from the purely confirmatory approach. Finally, in the Validation1/2 analyses,
modifications were infrequent, and once again insubstantial.

The measures of goodness of fit suggest that even with widely disparate data sources, the content of the items within each division assesses the equivalent worker activity information. Results can be compared from the two different data sources for the same division, indicating that these divisions are well conceived and empirically robust. Also, results obtained from these analyses strongly indicate that once the JEI response database grows larger, and thereby includes more representative jobs, a future confirmatory analysis should provide even stronger evidence for the integrity of the six a priori divisions.

**Implications of the Analyses**

The revised divisional factor structures presented in Appendix E show a close correspondence to the Coast Guard factors. Where change was apparent it could be attributed to the splitting of one Coast Guard factor into a few more representative factors. This was the case with Coast Guard factor 2 (split into Validation1 factors 1 and 5) and Coast Guard factor 20 (split into Validation1 factors 21 and 22).

There is no criterion, such as the prediction of compensation points, by which to measure the utility of these revised factors. A comparison of the revised JEI intradivisional factors to the PAQ intradivisional factors in Appendix F shows that the JEI's factors match the PAQ factors fairly well, especially when one considers that the PAQ factors are based upon assessments of thousands of jobs while the JEI's are based upon a handful. Therefore, the convergence between the factors of the JEI and PAQ is very encouraging.

Once the validity and internal cohesiveness of these divisions is
refined through a broader database, the predictive and heuristic value of the JEI should be greatly enhanced. Given the results from these confirmatory analyses, with small variability in the range of jobs and a small number of respondents, future results from research using the JEI should provide exciting new directions for job analysis technology and theory.

There are several avenues for research using the JEI to take from this point. First, the JEI should be rewritten so that it is applicable "off the shelf". The current version uses illustrative examples for items that vary from site to site. Although analyses of the data did not indicate that slightly different item wording was producing method variance, this issue should be addressed. In addition, future analyses should determine how well a dichotomous response format recreates the structure of the JEI, and what effect such a scale would have on results and applications of the JEI. Another interesting possibility is the use of the JEI in "knowledge engineering/elicitation" applications. The basic knowledge engineering concepts would seem to dovetail with the goals of job analysis very well, especially for training needs. Finally, by determining the content of the incumbent's activities, measures of the worker's productivity through carrying out those activities may be gathered.

Postscript: A Refactoring of the JEI

Now that the divisions have been analyzed thoroughly with the available data through confirmatory means, an exploratory factoring of the divisions and overall dimensions is possible. These exploratory patterns will serve as the template for present and future research into
the properties of the JEI until more samples of data are available of adequate size.

One present research need is for factor scoring coefficients. These weights will be used to interpret results from job analysis studies using the JEI, so that sample fluctuations will not lead to spurious interpretations of the job analysis data. Also, new jobs can be compared to the current database of jobs to give a better idea of the relative level of worker activities required in the newly analyzed jobs.

To analyze all of the existing JEIs, a correlation matrix of all 3,594 responses was developed and submitted to a principal factors analysis for both the overall dimensions and the six divisions. In all factor analyses, the initial factor solution was rotated to an oblique (correlated factors) solution. The prior communality estimates for the diagonals were the squared multiple correlations obtained from predicting that item from all other items in the analysis.

Using the scree plot method, the eigenvalues of the overall dimensions (through including all 153 items in one analysis) indicated breaks at 5, 6, 8, 9, 10, 12, and 13 factors. The original analysis of the JEI by Harvey et al. (1985a) had suggested breaks after fewer factors, and those researchers settled on a five factor solution. In order to aid in the interpretation of the current results, factor scores developed from two equal datasets, developed by splitting the original dataset of 3,594 respondents in half, were applied to the original larger dataset. The correlation of the factor scores from the split halves should indicate the concordance of factor structures in the data (Everett, 1983). Everett (1983) suggested that the correlation between
corresponding factor scores based on independent sets of data should correlate at least .90, since the squared correlation then would indicate a shared variance of 81% between estimates from different sources. The correlation will not equal one due to sampling variability and the fact that, with principal factors, factor scores are only estimates. This procedure was applied for all indicated factor solutions listed above.

The results of this procedure indicated that only a five or six factor solution would meet the criterion for correlations of .90 for all factors, since correlations for higher numbers of factors tended to show extremely poor correlations (between .03 and .40). Upon visual inspection of factor solutions, the six factor solution was the better of these two. Not only was the simple structure more pronounced in the six factor solution, but eight items did not load on any factors in the five factor solution (three of those items also did not load on any factors in the six factor solution). The results of the six factor solution are presented in Appendix G.

In addition, separate factor analyses were carried out for each division. These results are contained in Appendix H. In general, these analyses reproduced the factor structures of Validation1. These results argue further for the validity, replicability, and cohesiveness of these factors.
REFERENCES


Harvey, R. J., Friedman, L., Hakel, M. D., and Cornelius, E. T. 
(1985a). *Dimensionality of the Job Element Inventory (JEI), an easily administered worker-oriented job analysis questionnaire.* Unpublished manuscript.

Harvey, R. J., Friedman, L., Hakel, M. D., and Cornelius, E. T. 
(1986). *Dimensionality of the Job Element Inventory (JEI), a simplified worker-oriented job analysis questionnaire.* Unpublished manuscript.


Applied Psychology, 72, 69-74.


U. S. Equal Employment Opportunity Commission, U. S. Civil Service

APPENDIX A

Complete Job Element Inventory as used for the Department of Corrections job analysis survey
TEXAS DEPARTMENT OF CORRECTIONS

JOB ANALYSIS SURVEY

MAY, 1986
GENERAL INSTRUCTIONS

1. You are being asked to describe your present job in terms of job elements and tasks. Do not report duties performed by other employees who work with you unless you also do them as part of your regular job. Remember only rate those tasks that you perform as part of your job.

2. **Do not rate work activities that are not part of your present job,** no matter how often you may have done them in the past. Rate only the work that you perform now.

3. In describing your present job, go back as far in time as is necessary to present a true picture. You will probably need to go back several weeks, but not more than 3 months.

4. Remember, describe only the work that you actually perform. **Do not describe the job you wish you could have. Do not describe jobs you held previously. Do not describe the duties of other employees you work with if you do not also perform these duties.**

5. Do not consult with other employees as you fill out the survey. We are interested in your views only. If you have any questions please feel free to ask the survey administrators.

6. Your individual responses will not be shown to any T.D.C. officials. Please answer as truthfully and accurately as possible.

7. Before you begin filling out your answer sheet please do the following:

   1. In the space that reads "NAME OF INCUMBENT" please write your full name.

   2. In the space that reads "BRIEF JOB DESCRIPTION" please write in the area in which you work right now. Choose one of the following:

   - Maintenance
   - Agriculture
   - Construction
   - Food Services
   - Industry
   - Laundry
   - Health Services
   - Building Security
   - Recreation
   - Field Security
   - Legal Services
   - Transportation
INSTRUCTIONS FOR COMPLETING THE ANSWER SHEETS

1. When using the answer sheets, please remember the following points:

   A. Use only a #2 pencil; erase any changes completely.

   B. Completely blacken the square covering the number you choose for each item. Do not make any marks outside the square.

   EXAMPLE: To make a rating of "3" you should mark as follows:

   N 1 2 X 4 5

   C. Do not fold or otherwise mutilate the answer sheets. To score properly the answer sheets must be clean and flat.

   D. You have been given 2 answer sheets. The survey is in two parts. Please use one answer sheet to answer the first 139 questions. Following these questions will be a new set of instructions for the remaining questions. At this point please write your name on the second answer sheet in the place where you wrote your name on the first answer sheet. Use this second answer sheet to answer the remaining 153 questions.
INSTRUCTIONS FOR RATING JOB ELEMENTS

On the following pages you will find a list of job elements that may be a part of your work. Read each job element and decide if your job involves the element. If your job does not involve the element mark N on your answer sheet. If the element does apply to your job, choose a number from the rating scale at the top of each page to fill in on your answer sheet. Because this survey is designed to describe a wide variety of jobs, you may find that many of the job elements do not apply to your job. Do not worry if you find that many of the elements receive ratings of N; this is normal. For our job analysis we need to know which elements are not a part of your job as well as which ones are.

For the elements that DO apply to your job, you are to select a number between 1 and 5 that best describes the amount of time you spend on each element, in comparison to all of the other elements you do on the job. Elements that take relatively little time, as compared to all other elements, should be rated low on the scale, and elements that you spend a relatively long time on should be rated high on the scale. The scale you will use looks like this:

\[
\begin{array}{cccccc}
\text{Compared to ALL other tasks I spend} & \underline{\text{on this task.}} \\
N & 1 & 2 & 3 & 4 & 5 \\
\text{No time} & \text{much less} & \text{less} & \text{about} & \text{more} & \text{much more} \\
\text{time} & \text{time} & \text{the same time} & \text{time} & \text{more time} & \text{time}
\end{array}
\]

Choose only one response for each elements. It is important that you respond only to the job elements that are a part of your work, and that you respond accurately to all of the job elements that are a part of your work.

MAKE SURE THAT YOU ANSWER EVERY QUESTION. Check frequently to make sure that the number on the answer sheet matches the number printed next to the element.

If you have any questions while you are completing the survey feel free to ask one of the survey administrators about it.
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No time</td>
<td>Much time</td>
<td>Less time</td>
<td>About time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

1. Use written materials (examples: manuals, memos, notices).
2. Use quantitative materials (graphs, tables of numbers).
3. Use pictures or picture-like materials (blueprints, maps).
4. Use pattern devices (templates, stencils).
5. Use visual displays (examples: gauges, computer terminals).
6. Use physical measurement devices (rulers, pressure gauges).
7. Use features of nature (examples: weather conditions, cloud formations).
8. Use man-made features (examples: bridges, roads, buildings).
9. Use verbal communications.
10. Use sounds (examples: engine noises, alarms).
11. Use touch to get information (examples: judge temperature or texture).
12. Use odors (applies to any odor you need to smell in order to do your job).
13. Use taste (examples: food or beverage preparation).
14. Perform tasks that require you to see extreme detail of objects (reading very small print, setting ignition points).
15. Perform tasks that require you to see moderate detail of objects (hammering nails, reading gauges).
16. Perform tasks involving the care or treatment of sick or injured.
17. Work outdoors.
18. Work in an enclosed area that is hot.
Compared to ALL other tasks I spend ____ on this task.

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No time</td>
<td>Much less time</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

19. Work in an enclosed area that is cold.
20. Work in polluted air (dust, toxic fumes).
21. Work in areas that subject you to vibration.
22. Work under improper lighting conditions (too dark, too much glare).
23. Work where you become dirty easily.
24. Work in a cramped or uncomfortable space.
25. Work in a quiet area.
26. Work in an area of moderate noise (e.g., office with typewriters).
27. Work in an area with loud noises.
28. Accept responsibility for the safety of the general public.
29. Accept responsibility for the safety of other employees.
30. Judge distances.
31. Tell differences between colors.
32. Notice different patterns in sound (Morse code, engines not running right).
33. Notice differences or changes in sound through loudness, pitch, or tone quality.
34. Sense bodily position and balance (walking on I-beams, walking in unstable areas).
35. Judge speed of moving objects.
36. Judge speed of some process (cooking time, developing pictures).
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No time</td>
<td>Much less time</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

37. Inspect products, objects, materials, or equipment.
38. Judge size or weight of objects without direct measurement.
39. Gather or arrange information into a meaningful order.
40. Code and decode (radio codes, computer languages, Morse code).
41. Maintain logs.
42. Add, subtract, multiply, or divide numbers.
43. Work with percentages, fractions, or decimals.
44. Use algebraic, geometric, trigonometric, or statistical methods.
45. Use tools that perform precise operations (example: micrometers).
46. Use tools with long handles (brooms, shovels).
47. Use tools or devices for the purpose of handling other objects (examples: tongs, ladles).
48. Use hand-held power devices that perform very precise or accurate operations (soldering irons, welding equipment).
49. Use hand-held power tools (saws, drills).
50. Use devices that you draw or write with.
51. Use devices that apply something (paint brushes, rollers).
52. Use miscellaneous equipment or devices (examples: tractors, road graders, fork lifts, bicycles, rowboats, air/space vehicles).
53. Use stationary machines or equipment that you control (examples: drill press, air compressor).
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>No</td>
<td>Much less time</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
</tr>
</tbody>
</table>

54. Use devices that have fixed or variable settings (TV selector switch, room thermostat).

55. Use keyboard devices (typewriters, calculators, computers).

56. Use powered water vehicles (boats, ships).

57. Drive cars or trucks.

58. Use man-moved mobile equipment (wheelbarrows, hand trucks, floor polishers, lawn mowers).

59. Use remote-controlled equipment (conveyors, cranes, ladders).

60. Set up or adjust machines or equipment.

61. Use hands directly to form or change materials.

62. Take equipment apart or put it back together.

63. Arrange or pack objects or materials.

64. Perform tasks that require highly skilled bodily coordination.

65. Present information to public groups.

66. Perform to entertain other people (play in a band, act in a play).

67. Attend to other's needs (attend to sick or injured people, waiting on tables, cutting hair).

68. Contact senior officers or senior officials as part of the job (majors, assistant wardens, wardens, government officials).

69. Contact middle-level officers or staff personnel as part of the job (captains, TDC staff).
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No time</td>
<td>Much less time</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

70. Contact immediate supervisors as part of the job (sergeants, lieutenants).

71. Contact specialists within the organization as part of the job (technicians, photographers, law enforcement agents).

72. Contact outside professionals as part of the job (doctors, lawyers, professors, engineers, consultants).

73. Contact outside specialists as part of the job (draftsmen, designers, photographers, law enforcement agents, meteorologists).

74. Contact clerical personnel as part of the job (secretaries, book keepers, receptionists).

75. Contact public customers (as in stores or restaurants).

76. Contact salesmen and suppliers.

77. Contact buyers and purchasing agents.

78. Contact the public (example: providing professional services).

79. Contact trainees, apprentices, or students.

80. Contact special interest groups (examples: government inspectors or regulators, property owners, clubs).

81. Supervise people who are not employees.

82. Operate in emergency situations.

83. Deal with people in difficult situations (EEO or drug problems, law enforcement).

84. Take risks while serving others.

85. Perform in dangerous situations.
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No time</td>
<td>Much time</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

86. Perform the same physical task over and over.

87. Perform the same mental task over and over.

88. Work according to a schedule that allows you some freedom as long as you finish your job.

89. Follow certain set procedures on your job (follow a check-list while inspecting equipment).

90. Perform under time pressures.

91. Continually watch out for events that happen rarely on your job but that are important or critical.

92. Continually watch for frequent changes in your job situation (monitor inmate traffic, constantly watch gauges that change often).

93. Work in distracting conditions.

94. Move light objects on occasion.

95. Make efforts equal to lifting about 20 to 50 pounds.

96. Make efforts equal to lifting about 50 to 100 pounds.

97. Use finger movements (as with drawing instruments, keyboard devices).

98. Perform tasks that require a steady hand or arm.

99. Coordinate hand and/or foot movement with what you see (driving a car, steering a boat).

100. Coordinate your hand movements with what you hear.

101. Advise people in resolving their problems.

102. Persuade others to agree with some action or procedure.
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No time</td>
<td>Much less time</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

103. Instruct others, either formally or informally, in some skill or knowledge.

104. Analyze problems.

105. Answer questions from others.

106. Anticipate the need for materials to accomplish work.

107. Anticipate the need for manpower to accomplish work.

108. Approve requests and/or proposals from others.

109. Settle disputes among others.

110. Schedule meetings with other people.

111. Assess the quality of other people's work.

112. Assign priorities to tasks.

113. Assign people to tasks.

114. Give formal briefings to others.

115. Clarify goals and tasks for others.

116. Compile data for decisions.

117. Demonstrate techniques and procedures.

118. Modify equipment.

119. Modify ideas, decisions, or procedures.

120. Monitor equipment.

121. Move equipment and supplies.

122. Predict future events.
Compared to ALL other tasks I spend ____ on this task.

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Much</td>
<td>Less</td>
<td>About</td>
<td>More</td>
<td>Much</td>
</tr>
<tr>
<td>time</td>
<td>less</td>
<td>time</td>
<td>the same</td>
<td>time</td>
<td>more</td>
</tr>
</tbody>
</table>

123. Prepare plans and schedules.
124. Preside over meetings.
125. Recommend procedures and courses of action.
126. Resolve conflicting findings.
127. Repair equipment.
128. Requisition equipment.
129. Select appropriate equipment and materials.
130. Supervise others.
131. Discuss issues and problems with others.
132. Disseminate or provide information to others.
133. Distribute equipment and supplies.
134. Draft written materials.
135. Draw up plans of action.
136. Encourage the efforts of others.
137. Enforce directives.
138. Estimate time, cost, and other needs for projections.
139. Formulate policies.
140. Identify causes of equipment problems.
141. Identify causes of personnel problems.
142. Accept responsibility for decisions and actions of others.
143. Supervise the operation of equipment.
Compared to ALL other tasks I spend _____ on this task.

<table>
<thead>
<tr>
<th>N</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No time</td>
<td>Much less</td>
<td>Less time</td>
<td>About the same time</td>
<td>More time</td>
<td>Much more time</td>
</tr>
</tbody>
</table>

144. Test equipment.
145. Provide first aid.
146. Dispense medication.
147. Stand watches.
148. Consider ideas and suggestions of subordinates.
149. Adjust to new situations.
150. Keep supervisor informed.
151. Work in hazardous job situations.
152. Carry firearms.
153. Maintain records.
APPENDIX B

A list of all job titles of respondents to
the Job Element Inventory
<table>
<thead>
<tr>
<th>DATA SOURCE</th>
<th>JOB TITLE</th>
<th># OF INCUMBENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coast Guard</td>
<td>Airman</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Aviation Electronics Mate</td>
<td>153</td>
</tr>
<tr>
<td></td>
<td>Aviation Machinists Mate</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Aviation Structural Machinist</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>Aviation Survival Specialist</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>Boatswains Mate</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td>Damage Controlman</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Dental Technician</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>Electronics Mate</td>
<td>79</td>
</tr>
<tr>
<td></td>
<td>Electronics Technician</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Fire Control Technician</td>
<td>44</td>
</tr>
<tr>
<td></td>
<td>Fireman</td>
<td>62</td>
</tr>
<tr>
<td></td>
<td>Gunners Mate</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Hospital Corpsman</td>
<td>68</td>
</tr>
<tr>
<td></td>
<td>Machinery Technician</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td>Marine Science Technician</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Musician</td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Photo Journalist</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td>Quartermaster</td>
<td>87</td>
</tr>
<tr>
<td></td>
<td>Radarman</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Radioman</td>
<td>92</td>
</tr>
<tr>
<td></td>
<td>Seaman</td>
<td>86</td>
</tr>
<tr>
<td></td>
<td>Sonar Technician</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Storekeeper</td>
<td>94</td>
</tr>
<tr>
<td></td>
<td>Subsistence Specialist</td>
<td>86</td>
</tr>
<tr>
<td>DATA SOURCE</td>
<td>JOB DUTY AREA</td>
<td># OF INCUMBENTS</td>
</tr>
<tr>
<td>------------</td>
<td>-----------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>CO III</td>
<td>Health Services</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Recreation</td>
<td>13</td>
</tr>
<tr>
<td></td>
<td>Legal</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Building Security/Ad. Seg.</td>
<td>386</td>
</tr>
<tr>
<td></td>
<td>Pickets/Gates</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Clerical/Records</td>
<td>47</td>
</tr>
<tr>
<td></td>
<td>Special Operations</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Field Security</td>
<td>28</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td>Maintenance</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Industry</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Agriculture</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Food Services</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Laundry</td>
<td>10</td>
</tr>
<tr>
<td>Supervisors</td>
<td>Maintenance</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Construction</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Industry</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Health Services</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Legal Services</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>Special Operations</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Pickets/Gates</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Building Security</td>
<td>403</td>
</tr>
<tr>
<td>DATA SOURCE</td>
<td>JOB DUTY AREA</td>
<td># OF INCUMBENTS</td>
</tr>
<tr>
<td>--------------</td>
<td>---------------------------</td>
<td>----------------</td>
</tr>
<tr>
<td>Supervisors</td>
<td>Office/Clerical</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Internal Affairs/Discip.</td>
<td>105</td>
</tr>
<tr>
<td></td>
<td>Administrative Segregation</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td>Field Security</td>
<td>72</td>
</tr>
<tr>
<td></td>
<td>Dog Sergeant</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Transportation</td>
<td>3</td>
</tr>
</tbody>
</table>
APPENDIX C

A sample program to run a LISREL analysis. The columns and rows after "PA LX" is the pattern of free and constrained loadings specified by the researcher (0=constrained, 1=free to vary). The MA columns and rows correspond to the starting values of parameters in the PA matrices (there are no PA matrices for phi or delta, as these are implied elsewhere in the program). This program will estimate the fit of a measurement model for division 2, Mental Processes, from fitting Validation1 patterns of items to Validation2. For the results of this program, see Table 3 and Appendix E.
CFA FOR DIVISION 2: FOUR FACTORS

DATAPARM NG=1 NI=153 NOBS=967 MA=CM
CM FULL UNIT=8
LABELS

* 'J1' 'J2' 'J3' 'J4' 'J5' 'J6' 'J7' 'J8' 'J9' 'J10' 'J11' 'J12'
'J13' 'J14' 'J15' 'J16' 'J17' 'J18' 'J19' 'J20' 'J21' 'J22' 'J23'
'J24' 'J25' 'J26' 'J27' 'J28' 'J29' 'J30' 'J31' 'J32' 'J33' 'J34'
'J35' 'J36' 'J37' 'J38' 'J39' 'J40' 'J41' 'J42' 'J43' 'J44' 'J45'
'J46' 'J47' 'J48' 'J49' 'J50' 'J51' 'J52' 'J53' 'J54' 'J55' 'J56'
'J57' 'J58' 'J59' 'J60' 'J61' 'J62' 'J63' 'J64' 'J65' 'J66' 'J67'
'J68' 'J69' 'J70' 'J71' 'J72' 'J73' 'J74' 'J75' 'J76' 'J77' 'J78'
'J79' 'J80' 'J81' 'J82' 'J83' 'J84' 'J85' 'J86' 'J87' 'J88' 'J89'
'J90' 'J91' 'J92' 'J93' 'J94' 'J95' 'J96' 'J97' 'J98' 'J99' 'J100'
'J101' 'J102' 'J103' 'J104' 'J105' 'J106' 'J107' 'J108' 'J109' 'J110'
'J111' 'J112' 'J113' 'J114' 'J115' 'J116' 'J117' 'J118' 'J119' 'J120'
'J121' 'J122' 'J123' 'J124' 'J125' 'J126' 'J127' 'J128' 'J129' 'J130'
'J131' 'J132' 'J133' 'J134' 'J135' 'J136' 'J137' 'J138' 'J139' 'J140'
'J141' 'J142' 'J143' 'J144' 'J145' 'J146' 'J147' 'J148' 'J149' 'J150'
'J151' 'J152' 'J153'

SE
110 141 139 123 135 111 112 108 116 148 113 119 122 138 39 153
104 129 128 107 106 140 133 43 44 42 40 41 146 145/

MO NX=30 Nksi=4 LX=FU FR PH=ST ID=DI FR
PA LX

* 1 0 0 0
  1 0 0 0
  1 0 0 0
  1 0 1 0
  1 0 0 0
  1 0 0 0
  1 0 0 0
  1 0 1 0
  1 0 0 0
  1 0 0 0
  1 0 0 0
  1 1 0 0
  1 0 0 1
  0 0 0 1
  1 0 0 0
  0 1 0 0
  0 1 0 0
  1 1 0 0
  1 1 0 0
  0 1 0 0
  0 1 0 0
  0 0 1 0
  0 0 1 1
0 0 0 1
0 0 0 1
0 0 1 1
0 1 0 0
MA LX
*
1 0 0 0
1 0 0 0
1 0 0 0
1 0 0 0
1 0 1 0
1 0 0 0
1 0 0 0
1 0 0 0
1 0 1 0
1 0 0 0
1 0 0 0
1 0 0 0
1 1 0 0
1 1 0 1
0 0 0 1
1 0 0 0
0 1 0 0
0 1 0 0
0 0 1 0
0 1 0 0
0 0 0 1
0 0 0 1
0 0 1 1
0 1 0 0
MA PH
*
1
0 1
0 0 1
0 0 0 1
MA TD
*
2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2
OUTPUT MI NS TM=420
APPENDIX D

Patterns of factors within each division. These patterns are reported in Harvey et al. (1985a). Numbers in parentheses indicate which other factor number that item loads on. Modifications made for best models are noted at the end of the description of each division.
DIVISION 1: INFORMATION INPUT

Number   | Item
---------|-------------------------------------------------
Factor 1: Interpreting what is sensed
32.      | Notice different patterns in sound.
33.      | Notice differences or changes in sound through loudness, pitch, or tonal quality.
10.      | Use sounds.
15 (2).  | Perform tasks that require you to see moderate detail of objects.
5 (2).   | Use visual displays.
34 (3).  | Sense bodily position and balance.
11 (4).  | Use touch.

Factor 2: Using various sources of information
1.      | Use written materials.
2.      | Use quantitative materials.
3.      | Use picture-like materials.
14.     | Perform tasks that require you to see extreme detail of objects.
6.      | Use physical measurement devices.
4.      | Use pattern devices.
9.      | Use verbal communication.

Factor 3: Being aware of environmental conditions
30.      | Judge distances.
35.      | Judge speed of moving objects.
7.       | Use features of nature.
8.       | Use man-made features.
31.      | Tell differences between colors.
Factor 4: Using various senses.

13. Use taste.
12. Use odor.
36. Judge speed of some processes.
38. Judge size or weight of objects without direct measurement.
37. Inspect products, objects, or equipment.

Modifications: none.

DIVISION 2: MENTAL PROCESSES

Factor 5: Decision making/people

110. Schedule meetings with other people.
141. Identify causes of personnel problems.
139. Formulate policies.
123. Prepare plans and schedules.
135. Draw up plans of action.
111 (6). Assess the quality of other people's work.
112. Assign priorities to tasks.
108. Approve requests and/or proposals.
116. Compile data for decisions.
148. Consider ideas and suggestions of subordinates.
113 (6). Assign people to tasks.
119. Modify ideas, decisions, or procedures.
122. Predict future events.
138 (6). Estimate time, costs, and needs for projections.
39 (7). Arrange information into a meaningful order.
153. Maintain records.
104. Analyze problems.

Factor 6: Decision making/things.

129. Select appropriate equipment.
128. Requisition equipment.
107. Anticipate manpower needs.
106. Anticipate the need for materials.
140. Identify the causes of equipment problems.
133. Distribute equipment.

Factor 7: Decision making/quantitative.

43. Use percents, fractions, decimals.
44. Use algebraic or statistical methods.
42. Subtract, multiply, or divide numbers.
40. Code and decode.
41. Maintain logs.

Factor 8: Decision making/medical.

146. Dispense medication.
145. Provide first aid.

Modifications: free item 41 to load on factor 1;
free item 107 to load on factor 1.

DIVISION 3: WORK OUTPUT

Factor 9: Performing skilled/technical activities.

144. Test equipment.
127. Repair equipment.
48. Use precise hand-held powered devices.
62. Take equipment apart or assemble it.
60. Set up or adjust machines.
118. Modify equipment.
45. Use tools that perform precise operations.
143. Supervise operation of equipment.
54 (12). Use devices that have fixed settings.
49 (11). Use hand-powered saws or drills.
59. Use remote-controlled equipment.
98 (10). Perform tasks that require a steady hand or arm.
53 (12). Use stationary machines or equipment that you control.
61 (10). Use hands directly to form materials.

Factor 10: Performing materials handling/related manual tasks.
95. Make efforts equal to lifting 25-50 lbs.
96. Make efforts equal to lifting 50-100 lbs.
94. Move light objects on occasion.
121. Move equipment and supplies.
63. Arrange or pack objects or materials.
46 (11). Use long-handed tools.
47. Use tools or devices for the purpose of handling other objects.
51 (11). Use devices that apply something.
64. Perform tasks that require highly skilled bodily coordination.

Factor 11: Using miscellaneous equipment/devices
52. Use miscellaneous equipment or devices.
56. Use small boats.
58. Use man-moved mobile equipment.

Factor 12: General physical coordination
97. Use finger movements.
55. Use keyboard devices.

50. Use devices that you draw with.

100. Coordinate hand movements with what you hear.

Factor 13: Controlling machines/processes.

99. Coordinate hand and/or foot movement with what you see.

57. Drive cars or trucks.

Modifications: free item 46 to load on factor 12; free item 47 to load on factor 11; free item 95 to load on factor 11; free item 98 to load on factor 12; free item 100 to load on factor 13.

DIVISION 4: RELATIONSHIPS WITH OTHERS.

Factor 14: Supervision/coaching and related activities.

130. Supervise others.

103. Instruct others in skill or knowledge.

117. Demonstrate techniques and procedures.

136 (16). Encourage the efforts of others.

142 (16). Accept responsibility for the decisions and actions of others.

105 (17). Answer questions from others.

137 (16). Enforce directives.

150. Keep supervisor informed.

131 (16). Discuss issues and problems with others.

101 (16). Advise people in resolving their problems.

132 (16). Disseminate or provide information to others.

102 (16). Persuade others to agree with some action or procedure.

76. Contact salesmen and suppliers.
Factor 15: Public/related personal contacts.

78. Contact the public.
80. Contact special interest groups.
74. Contact clerical personnel as part of the job.
77. Contact buyers and purchasing agents.
65. Present information to public groups.
73 (17). Contact outside specialists as part of the job.
79 (18). Contact trainees, apprentices, or students.
72 (17). Contact outside professionals as part of the job.
81. Supervise people who are not employees.
68 (17). Contact senior officers or senior officials as part of the job.

Factor 16: Supervision/judgment/coordination.

126. Resolve conflicting findings.
124. Preside over meetings.
125. Recommend procedures and actions.
134. Draft written materials.

Factor 17: Exchanging job-related information.

70. Contact immediate supervisors as part of the job.
69. Contact middle-level officers or staff personnel as part of the job.
71. Contact specialists within the organization as part of the job.
75. Contact public customers.

Factor 18: Engaging in general personal contacts.

67. Attending to the needs of others.
16. Treat the sick or injured.
66. Perform to entertain others.
Modifications: free item 65 to load on factor 14;
free item 66 to load on factor 15;
free item 71 to load on factor 15;
free item 74 to load on factors 14 and 17;
free item 75 to load on factor 15;
free item 76 to load on factor 15;
free item 79 to load on factor 14;
free item 81 to load on factor 14;
free item 130 to load on factor 15;
free item 134 to load on factor 15.

DIVISION 5: JOB CONTEXT

Factor 19: Being in a stressful/unpleasant environment.

24. Working in a cramped space.
23. Work were you become dirty.
18. Work in an enclosed area that is hot.
22. Work under improper lighting conditions.
27. Work in an area with loud noises.
19. Work in an enclosed area that is cold.
20. Work in polluted air.
21 (20). Work in areas that subject you to vibration.
17 (20). Work outdoors.

Factor 20: Being in hazardous job situations.

84. Take risks while serving others.
85. Perform in dangerous situations.
151. Work in hazardous job circumstances.
82 (21). Operate in emergency situations.

Factor 21: Engaging in personally demanding situations.

83. Deal with people in difficult situations.
109. Settle disputes among others.
25. Work in a quiet area.

   Modifications: free item 25 to load on factor 19.

DIVISION 6: OTHER JOB CHARACTERISTICS

Factor 22: Being alert to changing situations.

92. Continually watch for frequent changes in your job situation.

120. Monitor equipment.

147. Stand watches.

89 (26). Follow certain set procedures.

91 (25). Continually watch out for events that happen rarely on your job but that are important or critical.

   Factor 23: Performing repetitive activities.

86. Perform the same physical task over and over.

87. Perform the same mental task over and over.

   Factor 24: Interpersonal responsibility.

29. Accept responsibility for the safety of other employees.

28. Accept responsibility for the safety of the general public.

   Factor 25: Work under demanding job situations.

93. Work in distracting situations.

90. Perform under time pressures.

149. Adjust to new situations.

   Factor 26: Performing unstructured vs. structured work.

88. Work according to a schedule that allows you some freedom as long as you finish your job.

   Modifications: none.
APPENDIX E

Patterns of factors within each division. These patterns are derived from analyses on the randomly selected samples of all datasets (Validation†; see above). Numbers in parentheses indicate which other factor number that item loads on. Modifications made for best models are noted at the end of the description of each division.
DIVISION 1: INFORMATION INPUT

<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Factor 1: Using senses to gather information.</td>
</tr>
<tr>
<td></td>
<td>Perform tasks that require you to see <strong>moderate</strong> detail of objects.</td>
</tr>
<tr>
<td>15.</td>
<td>Use visual displays.</td>
</tr>
<tr>
<td>5 (5).</td>
<td>Sense bodily position and balance.</td>
</tr>
<tr>
<td>34 (2).</td>
<td>Use touch.</td>
</tr>
<tr>
<td>2 (5).</td>
<td>Use picture-like materials.</td>
</tr>
<tr>
<td>14.</td>
<td>Perform tasks that require you to see <strong>extreme</strong> detail of objects.</td>
</tr>
<tr>
<td>6.</td>
<td>Use physical measurement devices.</td>
</tr>
<tr>
<td>4.</td>
<td>Use pattern devices.</td>
</tr>
<tr>
<td>37 (4).</td>
<td>Inspect products, objects, or equipment.</td>
</tr>
</tbody>
</table>

| Factor 2: Interpreting what is sensed. |
| 33.    | Notice differences or changes in sound. |
| 32.    | Notice different sound patterns. |
| 10.    | Use sounds. |
| 35 (3).| Judge speed of moving objects. |
| 31 (3).| Tell differences between colors. |

| Factor 3: Being aware of environmental conditions. |
| 7.    | Use features of nature. |
| 8.    | Use man-made features. |
| 30.    | Judge distances. |
| 38 (4).| Judge size or weight of objects without direct measurement. |
Factor 4: Using sensory information to make judgments.

13. Use taste.
12. Use odor.
36. Judge speed of some processes.

Factor 5: Using different means of communication.

1. Use written materials.
9. Use verbal communication.

Modifications: none.

DIVISION 2: MENTAL PROCESSES

Factor 6: Decision making/people

110. Schedule meetings with other people.
141. Identify causes of personnel problems.
139. Formulate policies.
123. Prepare plans and schedules.
135 (8). Draw up plans of action.
111. Assess the quality of other people's work.
112. Assign priorities to tasks.
108. Approve requests and/or proposals.
116 (8). Compile data for decisions.
148. Consider ideas and suggestions of subordinates.
113. Assign people to tasks.
119. Modify ideas, decisions, or procedures.
122. Predict future events.
138 (7). Estimate time, costs, and needs for projections.
39 (9). Arrange information into a meaningful order.
104. Analyze problems.
107. Anticipate manpower needs.
106. Anticipate the need for materials.

Factor 7: Decision making/things.

129. Select appropriate equipment.
128. Requisition equipment.
140. Identify the causes of equipment problems.
145. Provide first aid.
133. Distribute equipment.

Factor 8: Decision making/data.

43. Use percents, fractions, decimals.
44. Use algebraic or statistical methods.
42 (9). Subtract, multiply, or divide numbers.
146 (9). Dispense medication.

Factor 9: Organization of information.

40. Code and decode.
41. Maintain logs.
153. Maintain records.

Modifications: free item 40 to load on factor 9.

DIVISION 3: WORK OUTPUT

Factor 10: Performing skilled/technical activities.

144. Test equipment.
127. Repair equipment.
48. Use precise hand-held powered devices.
62. Take equipment apart or assemble it.
60. Set up or adjust machines.
118. Modify equipment.
45. Use tools that perform precise operations.

143. Supervise operation of equipment.

54 (13). Use devices that have fixed settings.

49 (12). Use hand-powered saws or drills.

59. Use remote-controlled equipment.

98 (14). Perform tasks that require a steady hand or arm.

53 (13). Use stationary machines or equipment that you control.

61. Use hands directly to form materials.

Factor 11: Performing materials handling/related manual tasks.

95. Make efforts equal to lifting 25-50 lbs.

96. Make efforts equal to lifting 50-100 lbs.

94. Move light objects on occasion.

121. Move equipment and supplies.

63. Arrange or pack objects or materials.

46 (12). Use long-handled tools.

47 (12). Use tools or devices for the purpose of handling other objects.

64. Perform tasks that require highly skilled bodily coordination.

Factor 12: Using miscellaneous equipment/devices requiring skill.

51. Use devices that apply something.

52. Use miscellaneous equipment or devices.

56. Use small boats.

58. Use man-moved mobile equipment.

Factor 13: General physical coordination.

97. Use finger movements.

55. Use keyboard devices.
50. Use devices that you draw with.

Factor 14: Activities requiring close control.

99. Coordinate hand and/or foot movement with what you see.

57. Drive cars or trucks.

100. Coordinate hand movements with what you hear.

Modifications: none.

DIVISION 4: RELATIONSHIPS WITH OTHERS.

Factor 15: Supervision and training of others.

130. Supervise others.

103. Instruct others in skill or knowledge.

117. Demonstrate techniques and procedures.

136. Encourage the efforts of others.

142. Accept responsibility for the decisions and actions of others.

105 (17). Answer questions from others.

137. Enforce directives.

131. Discuss issues and problems with others.

101. Advise people in resolving their problems.

132. Disseminate or provide information to others.

102. Persuade others to agree with some action or procedure.

79 (16). Contact trainees, apprentices, or students.

81. Supervise people who are not employees.

126. Resolve conflicting findings.

124. Preside over meetings.

125. Recommend procedures and actions.

134 (16). Draft written materials.
16. Treat the sick or injured.

Factor 16: Public and/or related personal contacts.

78. Contact the public.

80. Contact special interest groups.

74 (17). Contact clerical personnel as part of the job.

77. Contact buyers and purchasing agents.

65. Present information to public groups.

73 (18). Contact outside specialists as part of the job.

72 (18). Contact outside professionals as part of the job.

75 (18). Contact public customers.

67. Attending to the needs of others.

66. Perform to entertain others.

Factor 17: Exchanging job-related information.

150. Keep supervisor informed.

68. Contact senior officers or senior officials as part of the job.

70. Contact immediate supervisors as part of the job.

69. Contact middle-level officers or staff personnel as part of the job.

Factor 18: Contact specialists or those with special interests.

71. Contact specialists within the organization as part of the job.

76. Contact salesmen and suppliers.

Modifications: free item 16 to load on factor 15.

DIVISION 5: JOB CONTEXT

Factor 19: Working in hazardous or demanding job situations.

84. Take risks while serving others.
85. Perform in dangerous situations.

151. Work in hazardous job circumstances.

82. Operate in emergency situations.

83 (22). Deal with people in difficult situations.

109. Settle disputes among others.

Factor 20: Working in a stressful/unpleasant environmental area.

24. Working in a cramped space.

23. Work were you become dirty.

22 (21). Work under improper lighting conditions.

20. Work in polluted air.

21. Work in areas that subject you to vibration.

17. Work outdoors.

Factor 21: Working in a physically uncomfortable indoor environment.

27 (22). Work in an area with loud noises.

18. Work in an enclosed area that is hot.

19. Work in an enclosed area that is cold.

Factor 22: Dealing with others in stressful interpersonal situations.

25. Work in a quiet area.


Modifications: none.

DIVISION 6: OTHER JOB CHARACTERISTICS

Factor 23: Working under demanding job situations.

92 (24). Continually watch for frequent changes in your job situation.

93. Work in distracting situations.
90. Perform under time pressures.

149. Adjust to new situations.

91 (24). Continually watch out for events that happen rarely on your job but that are important or critical.

Factor 24: Interpersonal responsibility.

29. Accept responsibility for the safety of other employees.

28. Accept responsibility for the safety of the general public.

Factor 25: Performing repetitive activities.

86. Perform the same physical task over and over.

87. Perform the same mental task over and over.

Factor 26: being alert to changing job situations.

120. Monitor equipment.

147. Stand watches.

89 (27). Follow certain set procedures.

Factor 27: Performing unstructured vs. structured work.

88. Work according to a schedule that allows you some freedom as long as you finish your job.

Modifications: none.
APPENDIX F

Divisional factors from the Position Analysis Questionnaire

(PAQ; McCormick et al., 1972)
DIVISION 1: INFORMATION INPUT

1) Interpreting what is sensed.
2) Using various sources of information.
3) Watching/devices materials for information.
4) Evaluating/judging what is sensed.
5) Being aware of environmental conditions.
6) Using various senses.

DIVISION 2: MENTAL PROCESSES

7) Making decisions.
8) Processing information.

DIVISION 3: WORK OUTPUT

9) Using machines/tools/equipment.
10) Performing activities requiring general body movements.
11) Controlling machines/processes.
12) Performing skilled/technical activities.
13) Performing controlled manula/related activities.
14) Using miscellaneous equipment/devices.
15) Performing handling/related manual activities.
16) General physical activities.

DIVISION 4: RELATIONSHIPS WITH OTHERS

17) Communicating judgments/related activities.
18) Engaging in general personal contacts.
19) Performing supervisory/coordination/related activities.
20) Exchanging job-related information.
21) Public/related personal contacts.
DIVISION 5: JOB CONTEXT

22) Being in a stressful/unpleasant environment.

23) Engaging in personally demanding situations.

24) Being in hazardous job situations.

DIVISION 6: OTHER JOB CHARACTERISTICS

25) Working nontypical vs. day schedule.

26) Working in businesslike situations.

27) Wearing optional vs. specified apparel.

28) Being paid on a variable vs. salary basis.

29) Working on a regular vs. irregular schedule.


31) Performing structured vs. unstructured work.

32) Being alert to changing conditions.
APPENDIX G

Overall factors from all JEI responses (N=3594)
FACTOR 1: DECISION MAKING/COMMUNICATION/GENERAL RESPONSIBILITY

FACTOR 2: SKILLED JOB ACTIVITIES

FACTOR 3: UNPLEASANT, DEMANDING, OR STRESSFUL JOB ACTIVITIES

FACTOR 4: GATHER, PROCESS, AND DISTRIBUTE INFORMATION

FACTOR 5: MANIPULATE OBJECTS/PROVIDE SERVICES

FACTOR 6: EXTERNAL ORGANIZATIONAL CONTACTS

NB: the format is: item Number (factor with loading over .30)

1 (factor 4) Use written materials (examples: manuals, memos, notices).

2 (factors 2, 4) Use quantitative materials (graphs, tables of numbers).

3 (factor 2) Use pictures or picture-like materials (blueprints, maps).

4 (2) Use pattern devices (templates, stencils).

5 (2) Use visual displays (examples: gauges, computer terminals).

6 (2) Use physical measurement devices (rulers, pressure gauges).

7 (6) Use features of nature (examples: weather conditions, cloud formations).

8 (6) Use man-made features (examples: bridges, roads, buildings).

9 (3, 4) Use verbal communications.

10 (2, 3) Use sounds (examples: engine noises, alarms).

11 (2, 5) Use touch to get information (examples: judge temperature or texture).

12 (5) Use odors (applies to any odor you need to smell in order to do your job).

13 (5) Use taste (examples: food or beverage preparation).

14 (2, 4) Perform tasks that require you to see extreme detail of objects (reading very small print, setting ignition points).

15 (2) Perform tasks that require you to see moderate detail of objects (hammering nails, reading gauges).

16 (3) Perform tasks involving the care or treatment of sick or injured.
17 (4, 6) Work outdoors.

18 (3) Work in an enclosed area that is hot.

19 (3) Work in an enclosed area that is cold.

20 (3) Work in polluted air (dust, toxic fumes).

21 (2) Work in areas that subject you to vibration.

22 (2, 3) Work under improper lighting conditions (too dark, too much glare).

23 (2, 4, 5) Work where you become dirty easily.

24 (2) Work in a cramped or uncomfortable space.

25 (no significant loading) Work in a quiet area.

26 (4) Work in an area of moderate noise (e.g., office with typewriters).

27 (3) Work in an area with loud noises.

28 (3) Accept responsibility for the safety of the general public.

29 (1, 3) Accept responsibility for the safety of other employees.

30 (2, 3, 6) Judge distances.

31 (2) Tell differences between colors.

32 (2, 3) Notice different patterns in sound (Morse code, engines not running right).

33 (2, 3) Notice differences or changes in sound through loudness, pitch, or tone quality.

34 (2) Sense bodily position and balance (walking on I-beams, walking in unstable areas).

35 (2, 6) Judge speed of moving objects.

36 (5) Judge speed of some process (cooking time, developing pictures).

37 (2) Inspect products, objects, materials, or equipment.

38 (5) Judge size or weight of objects without direct measurement.

39 (4) Gather or arrange information into a meaningful order.
40 (No significant loading) Code and decode (radio codes, computer languages, Morse code).

41 (3, 4) Maintain logs.

42 (No significant loading) Add, subtract, multiply, or divide numbers.

43 (2, 4) Work with percentages, fractions, or decimals.

44 (2, 4) Use algebraic, geometric, trigonometric, or statistical methods.

45 (2) Use tools that perform precise operations (example: micrometers).

46 (5) Use tools with long handles (brooms, shovels).

47 (5) Use tools or devices for the purpose of handling other objects (examples: tongs, ladles).

48 (2) Use hand-held power devices that perform very precise or accurate operations (soldering irons, welding equipment).

49 (2) Use hand-held power tools (saws, drills).

50 (4) Use devices that you draw or write with.

51 (2, 5) Use devices that apply something (paint brushes, rollers).

52 (6) Use miscellaneous equipment or devices (examples: tractors, road grders, fork lifts, bicycles, rowboats, air/space vehicles).

53 (2) Use stationary machines or equipment that you control (examples: drill press, air compressor).

54 (2, 4) Use devices that have fixed or variable settings (TV selector switch, room thermostat).

55 (4) Use keyboard devices (typewriters, calculators, computers).

56 (6) Use powered water vehicles (boats, ships).

57 (6) Drive cars or trucks.

58 (5, 6) Use man-moved mobile equipment (wheelbarrows, hand trucks, floor polishers, lawn mowers).

59 (2) Use remote-controlled equipment (conveyors, cranes, ladders).

60 (2) Set up or adjust machines or equipment.

61 (2, 5) Use hands directly to form or change materials.
62  (2)  Take equipment apart or put it back together.

63  (5)  Arrange or pack objects or materials.

64  (No significant loading)  Perform tasks that require highly skilled bodily coordination.

65  (4, 6)  Present information to public groups.

66  (No significant loading)  Perform to entertain other people (play in a band, act in a play).

67  (5)  Attend to other's needs (attend to sick or injured people, waiting on tables, cutting hair).

68  (2, 3)  Contact senior officers or senior officials as part of the job (majors, assistant wardens, wardens, government officials).

69  (1, 4)  Contact middle-level officers or staff personnel as part of the job (captains, TDC staff).

70  (4)  Contact immediate supervisors as part of the job (sergeants, lieutenants).

71  (4)  Contact specialists within the organization as part of the job (technicians, photographers, law enforcement agents).

72  (4, 6)  Contact outside professionals as part of the job (doctors, lawyers, professors, engineers, consultants).

73  (4, 6)  Contact outside specialists as part of the job (draftsmen, designers, photographers, law enforcement agents, meteorologists).

74  (2, 3)  Contact clerical personnel as part of the job (secretaries, book keepers, receptionists).

75  (4)  Contact public customers (as in stores or restaurants).

76  (5)  Contact salesmen and suppliers.

77  (6)  Contact buyers and purchasing agents.

78  (6)  Contact the public (example: providing professional services).

79  (6)  Contact trainees, apprentices, or students.

80  (6)  Contact special interest groups (examples: government inspectors or regulators, property owners, clubs).

81  (No significant loading)  Supervise people who are not employees.

82  (3)  Operate in emergency situations.
83 (3) Deal with people in difficult situations (EEO or drug problems, law enforcement).

84 (3) Take risks while serving others.

85 (3) Perform in dangerous situations.

86 (3, 5) Perform the same physical task over and over.

87 (3, 4) Perform the same mental task over and over.

88 (No significant loading) Work according to a schedule that allows you some freedom as long as you finish your job.

89 (2) Follow certain set procedures on your job (follow a check-list while inspecting equipment).

90 (3, 4) Perform under time pressures.

91 (3) Continually watch out for events that happen rarely on your job but that are important or critical.

92 (3) Continually watch for frequent changes in your job situation (monitor inmate traffic, constantly watch gauges that change often).

93 (3) Work in distracting conditions.

94 (5) Move light objects on occasion.

95 (5) Make efforts equal to lifting about 20 to 50 pounds.

96 (5) Make efforts equal to lifting about 50 to 100 pounds.

97 (4) Use finger movements (as with drawing instruments, keyboard devices).

98 (2) Perform tasks that require a steady hand or arm.

99 (6) Coordinate hand and/or foot movement with what you see (driving a car, steering a boat).

100 (3) Coordinate your hand movements with what you hear.

101 (1) Advise people in resolving their problems.

102 (1) Persuade others to agree with some action or procedure.

103 (1) Instruct others, either formally or informally, in some skill or knowledge.

104 (1) Analyze problems.
105 (1) Answer questions from others.
106 (1) Anticipate the need for materials to accomplish work.
107 (1) Anticipate the need for manpower to accomplish work.
108 (1) Approve requests and/or proposals from others.
109 (1) Settle disputes among others.
110 (1) Schedule meetings with other people.
111 (1) Assess the quality of other people's work.
112 (1) Assign priorities to tasks.
113 (1) Assign people to tasks.
114 (1) Give formal briefings to others.
115 (1) Clarify goals and tasks for others.
116 (1, 4) Compile data for decisions.
117 (1) Demonstrate techniques and procedures.
118 (1, 2) Modify equipment.
119 (1) Modify ideas, decisions, or procedures.
120 (2) Monitor equipment.
121 (5) Move equipment and supplies.
122 (1) Predict future events.
123 (1) Prepare plans and schedules.
124 (1) Preside over meetings.
125 (1) Recommend procedures and courses of action.
126 (1) Resolve conflicting findings.
127 (2) Repair equipment.
128 (1, 2) Requisition equipment.
129 (1, 2) Select appropriate equipment and materials.
130 (1) Supervise others.
131 (1) Discuss issues and problems with others.
132 (1, 4) Disseminate or provide information to others.
133 (1, 5) Distribute equipment and supplies.
134 (1, 4) Draft written materials.
135 (1) Draw up plans of action.
136 (1) Encourage the efforts of others.
137 (1) Enforce directives.
138 (1, 2) Estimate time, cost, and other needs for projections.
139 (1) Formulate policies.
140 (2) Identify causes of equipment problems.
141 (1) Identify causes of personnel problems.
142 (1) Accept responsibility for decisions and actions of others.
143 (1, 2) Supervise the operation of equipment.
144 (2) Test equipment.
145 (5) Provide first aid.
146 (5) Dispense medication.
147 (3) Stand watches.
148 (1) Consider ideas and suggestions of subordinates.
149 (1) Adjust to new situations.
150 (1) Keep supervisor informed.
151 (3) Work in hazardous job situations.
152 (3) Carry firearms.
153 (1, 4) Maintain records.
APPENDIX H

Divisional factors based on all JEI responses (N=3594)
DIVISION 1: INFORMATION INPUT

Factor 1: Using senses to gather information.
Factor 2: Interpreting what is sensed.
Factor 3: Being aware of environmental conditions.
Factor 4: Using sensory information to make judgments.
Factor 5: Using different means of communication.

DIVISION 2: MENTAL PROCESSES

Factor 6: Decision making/people
Factor 7: Decision making/things.
Factor 8: Decision making/data.
Factor 9: Organization of information.

DIVISION 3: WORK OUTPUT

Factor 10: Performing skilled/technical activities.
Factor 11: Performing materials handling/related manual tasks.
Factor 12: Using miscellaneous equipment/devices requiring skill.
Factor 13: General physical coordination.
Factor 14: Activities requiring close control.

DIVISION 4: RELATIONSHIPS WITH OTHERS.

Factor 15: Supervision and training of others.
Factor 16: Public and/or related personal contacts.
Factor 17: Exchanging job-related information.
Factor 18: Contact specialists or those with special interests.

DIVISION 5: JOB CONTEXT

Factor 19: Working in hazardous or demanding job situations.
Factor 20: Working in a stressful/unpleasant environmental area.

Factor 21: Working in a physically uncomfortable indoor environment.

Factor 22: Dealing with others in stressful interpersonal situations.

DIVISION 6: OTHER JOB CHARACTERISTICS

Factor 23: Working under demanding job situations.

Factor 24: Interpersonal responsibility.

Factor 25: Performing repetitive activities.

Factor 26: Being alert to changing job situations.

Factor 27: Performing unstructured vs. structured work.