Version: August 3, 2000

A NOTE ON THE STRUCTURE OF JOB CONTENT DOMAINS

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Version: August 3, 2000

ABSTRACT

The methodology described in this paper follows conventional psychometric methods and procedures to determine the structure of job content domains. Basic item analysis and various forms of correlational analysis are used to summarize, analyze and evaluate a clerical task database. This paper describes a non-conventional solution of different representations of content domains of an occupational area (clerical) database. This paper outlines one of the options for a nonconventional statistical analysis design for job analysis data. Job analysis content can be in terms of task data, job skills/competency data, and might also include other descriptors of both affective expression or other job content characteristics. The nonconventional design used the inverse factor analysis methodology first attributed to L. L. Thurstone (1951) in the classic study of Supreme Court judge decisions and expanded by H. A. Toops (1959) on research methodology. The rationale for this paper is embedded in the notion that numerous sources of variance are amenable to statistical analysis, and interpretation is limited only by the ingenuity of the investigator.

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INTRODUCTION

The professional practice of quantitative job analysis has a history spanning more than 50 years. In the beginning and through to the present day, job analysis information in its various forms has been accepted at face value, typically without benefit of most forms of criterion reference. This includes basic job description data based on individual judgments of descriptor statements (of work activity or Knowledge, Skills, and Abilities (KSA-s)), in terms of importance or frequency.

Conventional methods of representing work activity and KSA content domains usually proceed along separate lines and involve the rational or statistical association of discrete components conceptualized as behaviors or cognitive elements. Because the work activity and KSA identifiers are routinely generated separately, the data combination methods are performed separately. The resulting descriptions of the domains do not easily retranslate into similar conceptualizations of the job. The non-conventional method described here links the work activity and KSA descriptors in the job analysis process resulting in domain characterizations which are consistent with one another and result in similar application implementation strategies.

METHOD AND PROCEDURE [1]

The design for this study included a survey of an occupational area, namely the clerical job family in positions in state government, using traditional incumbent subject matter experts or incumbent SMEs (Harvey, 1996). A second feature was the use of qualified professional method and content subject matter experts (*expert* SMEs) to perform a complex linkage analysis and judgments. That feature follows the design identified and described by Hughes and Prien (1988,1989) and, as further research by Vinchur, Schippmann and Prien (1991) as a non-conventional, analytical strategy.

The critical distinction in this study is the use of two different data handling and analysis strategies. The first approach consisted of a conventional survey of work activity and KSA descriptors and incumbent judgments of *importance*. **(**Exhibit 1). The second approach, which is a non-conventional and a completely separate analytical strategy, focused on new and unique information about the work activity and KSA's descriptors obtained from subject matter experts (expert SME's), in the form of linkage judgements. Since this is a very complex and

[1] Tables and Appendices referenced in this section are available from the senior author: William Wooten, Psychology Department University of Central Florida, Orlando, Florida 32816-1370.

abstract experimental design, specific attention is focused on the description and manipulation of the database (Exhibit 2).

The judgments, obtained from the content *expert* SME's are the main focus of this unique, non-conventional analysis. The statistical analysis of data generated by the *expert* SME's uses two different data handling and procedures applied to separate perspectives, or views, of the *expert* SME judgment content. Each view of content is interpreted in terms of the source of individual variation as captured by judgments concerning work activity and KSA descriptors conjoined through the *linkage* analysis. The attached schematic displays the methods and analytical strategies.

Linkage Data

For the study, *expert* SMEs rated the extent that each KSA descriptor, including both cognitive and affective descriptors, was required to perform each work activity, by entering a 1 if the KSA was required to perform the task, and a 0 if the KSA was not required to perform the task. This is essentially a judgment of validity, and represents the functional relationship of work activity to KSA descriptors on an item by item basis. Each *expert* SME made 46,155 rating judgments, linking the entire set of work activity and KSA descriptors. Using this procedure, ten *expert* SMEs generated a combined total of 461,550 judgements. For each KSA, 1,810 linkage judgements were made, and for each work activity descriptor statement, 2,550

judgments were made. Depending upon which type of data was being analyzed, the effective size of the resultant data sets were 255 x 1,810 and 181 x 2,550, respectively. (Exhibit 3).

The linkage data set then consisted of a matrix of judgments with 255 x 181 x 10 replications. Each KSA statement was linked to 181 work activity statements using the functional linkage instruction of "linkage required" or "linkage not required". Thus, the "score" for any work activity/KSA cell was simply the count (0 to 10) of the linkage judgments performed by the *expert* SME panel. However, any single KSA could be linked to more than one work activity statement. Thus, the number of linkages for each KSA statement could range from 0 to 10 across any number of tasks.

The result was a profile of 255 KSA:s using the 181 work activity linkage judgments. In this way, a profile was produced for each of the 255 KSA in terms of the 181-work activities.. In addition to orienting the data set by KSAs, the data set was also oriented by tasks, resulting in a profile of 181 work activities described in rating across 255 KSAs.

For each of the data sets described above, an intercorrelation matrix was generated. For the KSA data, this resulted in a 255 x 255 matrix. (Exhibit 4). Each cell in this matrix represented the intercorrelation of two KSA's across 181 x 10 work activity linkage ratings. In essence, KSAs with similar work activity linkage profiles would correlate, and KSAs with dissimilar work activity linkage profiles would not. Factoring this matrix results in the

identification of the different KSA dimensions necessary to define the work activity descriptors, in other words, the construct domain of the data set. Conversely, factoring the 181 x 181 work activity intercorrelation matrix results in the different work activity dimensions necessary to define the KSA descriptors, or the content domain of the data set. Based on the logic of the linkage analysis, the two domains (work activity content and KSA construct) should converge (e.g., result in similar factor structures), define each other explicitly, and result in the same application parameters regardless of which is used. Finally, the two separate correlation matrices represent the same data points but simply arrayed differently. This procedure is the essence of the inverse or transposed factor analysis methodology when applied to the work activity and KSA linkage judgments.

METHOD

A structured job analysis methodology was used to define, analyze, and evaluate the AAdministrative Support Assistant" family of jobs for a state government agency. Complete, accurate, and precise descriptions of job content are essential input for the validation of any selection instrument or, for that matter, in developing various other applications. Data was collected by using a variety of methods including a review of background information and the administration of a job analysis questionnaire (JAQ).

Administration of the Job Analysis Questionnaire (JAQ)

These lists of work activity and KSA statements were the basis of the Job Analysis

Questionnaire (JAQ), which was administered in a survey to incumbents at all locations. The JAQs were administered with regard to classification, location, department, size of office, race, and gender.

This information was gathered in order to determine the demographic characteristics of the incumbents who completed the JAQ. The job analysis survey instrument was completed by 760 incumbents. The focus of this stage of the data analysis was to simply compile a record of a descriptive (work activity and KSA content) database. These results are intended to constitute a database for deriving other human resource application designed to produce operations solutions. Thus, this is an intermediate step in the process of job analysis leading to intervention.

Factor Analysis of the Linkage Matrix (KSA's)

Complete work activity to KSA statement linkage ratings were completed by ten *expert* SME's. The resulting matrix was factor analyzed to identify and define the factors represented by clusters of KSA's, grouped on the basis of profile similarity across the work activity domain.

To further examine the KSA construct structure, the pool of 255 KSA statements included 32 items taken from the French (1976) taxonomy. These 32 items were identified by Dunnette in the *Handbook of Industrial-Organization Psychology* (1976) as the most salient for selection and research. They represent 10 construct dimensions (i.e. flexibility and speed of closure, fluency, inductive reasoning, associative memory, memory span, number facility,

perceptual speed, deductive reasoning, spatial visualization, verbal comprehension). Each dimension contained three or four items, which were randomly distributed through the KSA JAQ. These items were included to provide data for the *expert* SME linkage judgment factor analytic solution to an established cognitive construct framework. The French items, which can be identified by trailing "F" codes, are very heterogeneous and were used to facilitate defining the resultant factor structure. It was expected that these items would converge within the factor analytic solution of the clerical data and load together in a parsimonious manner. For example, if the final solution is valid, all of the "flexibility and speed of closure" items should load together on a single factor and should load with other items with similar content.

An additional enhancement to clarify the content-oriented structure was to include a sample of construct-related items representing personality-related content. A total of 25 items representing the Big Five constructs drawn from the Raymark, Schmitt and Guion Job Analysis Questionnaire (1997) were randomly distributed in the JAQ. These items were also intended for use as markers to clarify and exemplify the domain representation in the job analysis structure.

The task to KSA linkage matrix was factor analyzed using SPSS for Windows, version 7.0. The principal component method was used to extract the factors, and varimax method was used to rotate the factor structure. Prior research suggests that the clerical job domain is defined by approximately 20 factors. The scree plot was examined to identify inflection points corresponding to possible solutions (see Gorsuch, 1983 for a thorough discussion of alternative

methods for determining the number of factors to extract). The final decision was to extract 18 factors. These factors represent clusters of KSA's, grouped based on their profile similarity across the work activity domain. The 18-factor solution was further reviewed and expanded based on similarities and differences in item content. Factors 1 and 2 were split into two sub-factors each. Thus, the final solution contains 20 factors, the first two factors in the final solution were drawn from the first factor of the statistical solution, and the next two factors (factors 3 and 4) drawn from the second factor of the statistical solution. Factors 3 through 18 of the statistical solutions were then renumbered 5 through 20. The content of the final solution was homogeneous, interpretable, and consistent with prior studies analyzing clerical work. The twenty factors were labeled:

Factor 1:	Spoken Communication
Factor 2:	Customer and Client Reception
Factor 3:	Information Verification
Factor 4:	Error Detection and Correction
Factor 5:	Employee Supervision
Factor 6:	Information Storage and Retrieval
Factor 7:	Scheduling and Planning Work Activities
Factor 8:	Document Processing
Factor 9:	Computer Utilization
Factor 10:	Basic Arithmetic Computation
Factor 11:	Customer and Client Referral
Factor 12:	Comprehension of Complex Instruction
Factor 13:	Preparation of Written Documents and Reports
Factor 14:	Employee Orientation and Training
Factor 15:	Employee Relations
Factor 16:	Bookkeeping and Accounting
Factor 17:	Stenography and Written Record Taking

Factor 18: Preparing Written Documents
Factor 19: Posting, Receiving and Routing Mail
Factor 20: Equipment Operation and Repair

Factor Analysis of the Linkage Matrix (Work Activity)

A second investigation was conducted, focusing on defining the work activity content oriented structure. A factor analysis was conducted using work activity items (inverted linkage matrix). An analysis of the scree plot (eigenvalue plot) suggest that 20 factors could adequately define the data. This solution accounted for over 70% of the variance, making this a relatively comprehensive solution. The resulting factor structure was very similar to the KSA factor solution. After a review of the content, the first factor was rationally split into two components, and the last factor (Factor 20) was merged into one of these components. The following names were attached to the factors:

Factor 1A: Customer / Client / Employee Reception
Factor1b: Administrative Assistance
Factor 2: Written Forms and Document Completion
Factor 3: Document Processing
Factor 4: Computer Utilization
Factor 5: Information Filing, Storage and Retrieval
Factor 6: Equipment Operation and Repair
Factor 7: Posting Outgoing Mail
Factor 8: Basic Arithmetic Calculation
Factor 9: Scheduling and Planning Work Activities
Factor 10: Dissemination of Policy Changes And Interpretations
Factor 11: Information Verification
Factor 12: Employee Supervision
Factor 13: Cash Management
Factor 14: Receiving and Routing Incoming Mail

Factor 15: Written Record Taking
Factor 16: Office Management
Factor 17: Conducting Research
Factor 18: Budget Monitoring And Review
Factor 19: Property Management
Factor 20: (Moved To Administrative Assistance)

Based on a review and evaluation of the entire data set, some items failed to meet the assignment criteria (loadings of .50 or higher) and were rationally assigned to factors with similar content. These are indicated by AC appearing in the factor loading column.

DISCUSSION

Comparison of Solutions

Analyzing the matrix linking the work activities and KSA descriptors results in conceptual solutions which mutually explain the two domains. The task domain is conceptualized in terms of the KSA domain, as is the reverse. Extracting the KSA solution resulted in 20 factors which were very consistent with other solution presented in the literature. In addition, work activity descriptors defining the KSA dimensions are identified. For example, in addition to the 7 KSA descriptors which cluster on Factor 1: Spoken Communication Skills, 21 work activity descriptors were also identified (Table 1).

Analysis of the task domain resulted in a 20-factor solution thematically consistent with the KSA solution, representing a high degree of consistency between the two domain conceptualizations. It is noteworthy that most work activity and KSA descriptors loaded on a single factor, and very few descriptors required rational assignment.The advantage the linkage analysis procedure over conventional approaches is the generation of job specification output without the necessity of running an additional SME panel for that purpose. Factor analytic output is directly translated into application formats (e.g., test plan for selection applications). In developing selection procedures, for example, the construct solution provides a reference of

the relative importance of the identified KSA and trait dimensions, along which individual differences in performance is expected to vary. By specifying information in this manner, a test budget identifying the relative number of test items by dimension is possible. Because the clarity of the construct solution, preexisting individual differences measures (with demonstrable construct validity) could be possible be integrated in the assessment process. Having access to the construct solution along would make using external instruments a virtual necessity. However, access to the content solution provides the work activity specific descriptors needed to extract item content. The availability of the content solution, linked to the construct solution, allows the development of content and construct valid items. The availability of the content solution provides an additional benefit. Construct difficulty level can be directly and immediately assessed by referring to the linked work activity descriptors.

REFERENCES

Dunnette, M. D. (1976). Aptitudes, abilities, and skills. In M. D. Dunnette (ed.), *Handbook of industrial and organizational psychology*, pp. 473-520. Chicago: Rand McNally.

French, J. W., Ekstrom, R. B., & Price, L. A. (1963). *Kit of reference tests for cognitive factors*. Princeton: Educational Testing Service.

Gorsuch, R. L. (1983). *Factor analysis* (2nd ed.). Hillsdale, NJ: Erlbaum.

Harvey, R. J. (1986). Quantitative approaches to job classification: A review and critique. *Personnel Psychology*, *39*, 267-289.

Hughes, G. L., & Prien, E.P. (1988). Detecting job differences: When does a difference "make a difference"? Unpublished manuscript.

Hughes, G. L. & Prien, E. P. (1989). Evaluation of task and job skill linkage judgements used to develop test specifications. *Personnel Psychology*, *42*, 283-292.

Nunnally, J. C. (1978). *Psychometric Theory*. New York: McGraw-Hill Book Company.

Raymark, P.H., Schmit, M.J., & Guion, R.M. (1997). Identifying potentially useful personality constructs for employee selection. *Personnel Psychology, 50,* _____.

Thurstone, L.L. & Degan, J.W. (1951). A factorial study of the Supreme Court, Psychometric lab report #64, University of Chicago, 7 pp.

Toops, H.A. (1959). A research utopia in industrial psychology, *Personnel Psychology*, 12, 189-225.

Torgerson, W. S. (1965). *Theory and Methods of Scaling*. New York: John Wiley & Sons, Inc.

Vinchur, A. J., Prien, E. P., & Schippmann, J. S. (1993). An alternative procedure for analyzing job analysis results for content-oriented test development. *Journal of business and Psychology*, *8*(2),

Wherry, R.J. (1957). The past and future of criterion evaluation, *Personnel Psychology,* 10, 1-5.

Version: August 3, 2000

Table 1: Specification Table Demonstrating Construct/Content Identifiers

Factor 1: Spoken Communication Skills

Skill Statements

2. Skill in the use of telephone system operations to include how to transfer a call, how to place a call on hold, and how to connect a conference call.
3. Skill in the use of a switchboard or multiline phone system.
63. Ability to think rapidly of word groups or phrases.
83. Ability to project one's voice as needed to be understood when answering the telephone or operating a radio, answering questions and making requests, and communicating with the public.
86. Ability to communicate orally in order to understand others, asks relevant questions, and relay information concisely without the loss of necessary detail.
92. Ability to explain procedures, reasons for doing something, or sequence of events to others.
94. Ability to make informal reports or presentations to small groups.

Work Activity Statements

25. Requests files in writing or by phone from archives, central office, local office, other state agencies, etc.
32. Places messages on telephone sequencer machine.
33. Places phone calls for supervisors.
34. Provides directions, instructions and information to visitors/clients/general public.
35. Answers questions from the general public via telephone or face to face contact.
36. Greets / screens / escorts visitors.
4. Conducts orientation with new employees to include departmental background, offered benefits, and the tasks associated with the position.
75. Explains leave policies, benefits, department policy and procedure, hiring practices, etc. to employees and supervisors.
76. Conducts performance appraisals, preappraisals, and counseling sessions with employees.
5. Conducts onthejob training by demonstrating work activities and direct supervision.
147. Takes messages, complaints, and inquiries from public, coworkers, and external agencies and forwards to appropriate persons.
150. Provides information by talking with external and internal officials and employees.
152. Informs supervisor of problems encountered by clerical staff.
156. Gathers information by talking with staff and supervisor.
157. Requests files or gathers information by talking with individuals outside of the agency.

158. Verifies information by talking with individuals outside of the agency.
160. Talks with personal and professional references in order to gather information about prospective employees.
167. Acts as host, for example, greeting groups of visitors, conducting tours, or arranging and coordinating business related social events.
168. Communicates with advertisers in order to place advertisements in newspapers, magazines, etc.
174. Testifies at hearings. 176. Provides information over the phone or in person such as explaining regulations or policies.

EXHIBIT 1

Conventional Job Analysis

Compiles reports to include graphs, charts, data and narrative.	Skill in operating office equipment, such as telephone, fax, copier, and calculator.
Types legal documents such as contracts, leases, and subpoenas.	Skill in the use of telephone systems operations to include how to transfer a call, how to place a call on hold, and how to connect a conference call.
Composes letters and memos from notes or following general instructions.	Skill in the use of a switchboard or multi-line phone system.
Produces copies of correspondence, reports, etc. by operating copier.	Knowledge of two-way base radio operation and procedures.
Operates a variety of software, including work processing, spreadsheet, database, and presentation programs.	Skill in entering numerical or coded data into computer using keyboard operations.

Content of the Descriptors
Task/KSA

Job Analysis Operation Judgments
Incumbent Raters (SMEs)
Importance Ratings
Frequency Ratings

Statistical Analysis
Descriptive or Summary

Data Set
Work Activity or KSA

EXHIBIT 2

Non-conventional Job Analysis

Sample Work Activity Statements	Sample KSA Statements
Compiles reports to include graphs, charts, data and narrative.	Ability to learn combinations of words, numbers, and figures as would be used in editing reports including graphic material.
Checks and corrects spelling, punctuation, and grammar by proofreading written documents.	Ability to detect errors or discrepancies in the entry of records, posting data, or other log entries.
Verifies accuracy of information by proofreading or using diagnostic programs to check spelling or grammar as content is entered into computer.	Ability to detect errors in grammar or punctuation by proofing correspondence, reports, forms, tables, or codes.
Verifies accuracy and completeness of records by comparing forms or documents against original documents or master forms.	Ability to analyze one's prior mistakes or problems to improve performance.
Detects missing information and errors by reading forms, records, correspondence, etc.	Ability to compare letters, words, or symbols to identify the common factor.

Content of the Descriptors
Work Activity, KSA, Cognitive, Affective

Job Analysis Operation Judgments
Method & Content Experts
Linkage Judgments (functional linkage)
181 x 255 x 10 variable matrix

Statistical Analysis
Factor and inverse factor analysis

Data Set
Work activity and KSA conjoined

EXHIBIT 3

Linkage Data Matrix

KSA Descriptors

	1	*2*	*3*	*4*	*5*	*6*	...	*255*
1	.70	.00	.00	.00	.00	.20	---	.00
2	.30	.00	.00	.00	.00	.40	---	.00
3	.20	.00	.00	.00	.00	.10	---	.00
4	.90	.00	.00	.00	.00	.00	---	.00
5	.20	.00	.00	.00	.00	.30	---	.00
6	.30	.00	.00	.00	.00	.30	---	.00
...	---	---	---	---	---	---	---	
181	.00	,00	,00	,00	,00	.00	---	,00

Data set contains 181 x 255 x 10 linkage judgments.

Data set can be configured to analyze KSA profiles in terms of tasks (showing) or work activity profiles in terms of KSAs (inverse).

EXHIBIT 4

255 x 255 Correlation Matrix

	KSA Descriptors	*1*	*2*	*3*	*4*	*5*	*6*	...	*255*
	1	1.00	.36	.38	.26	.26	.11	...	-.06
	2	.36	1.00	.85	.28	-.10	.03	...	.17
	3	.38	.85	1.00	.21	-.08	.03	...	.01
	4	.26	.28	.21	1.00	.01	.09	...	-.02
	5	.26	-.10	-.08	.01	1.00	-.20	...	-.06
KSAs	*6*	.11	.03	.03	.09	-.02	1.00	...	-.02
	...	...	...	...	...	...	...	...	...
	255	-.06	.17	.10	-.02	-.06	-.02	...	1.00

Correlations are based task profiles across the 255 KSAs.

This matrix is factor analyzed to reveal dimension required to define the construct domain.

EXHIBIT 5

181 x 181 Correlation Matrix

Work Activity Descriptors

		1	*2*	*3*	*4*	*5*	*6*	...	*181*
	1	1.00	.65	.67	.26	.29	.64	...	-.01
	2	.65	1.00	.61	.19	.46	.82	...	.05
	3	.67	.61	1.00	.13	.16	.64	...	-.01
	4	.26	.19	.13	1.00	.17	.17	...	.01
T	*5*	.29	.46	.16	.17	1.00	.70	...	-.01
A	*6*	.64	.82	.64	.17	.70	1.00	...	-.02
S	...	...	...	...	...	...	...	...	...
K	*181*	-.01	.05	-.01	.02	-.01	-.02	...	1.00
S									

Correlations are based KSA profiles across the 181 work activities.

This matrix is factor analyzed to reveal dimension required to define the content domain.