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ABILITY REQUIREMENT IMPLICATIONS OF JOB DESIGN: AN INTERDISCIPLINARY PERSPECTIVE

MICHAEL A. CAMPION
Krannert School of Management
Purdue University

If job design and job ability requirements are related, then job redesign could have staffing, training, and compensation implications. This study adopts an interdisciplinary perspective by measuring multiple approaches to job design and examining relationships with a wide variety of ability requirements. Hypotheses are tested with two separate and distinctly different samples (total $N = 213$ jobs), different measures of job design, and ability requirements from the *Dictionary of Occupational Titles*. Results substantiate previous findings that motivational attributes of jobs relate positively to mental ability requirements. Furthermore, the results extend our understanding by showing that other approaches to job design relate negatively to mental ability requirements, and another approach relates to physical ability requirements. The findings are discussed in terms of potential unexpected consequences and trade-offs of job redesign.

This study is based on the premise that if job design and job ability requirements are related, then job redesign could have staffing, training, and compensation implications. Previous research is initially reviewed to summarize existing knowledge that increased motivational attributes of jobs are related to heightened mental ability requirements. Then an interdisciplinary perspective is adopted and hypotheses are formulated to replicate this previous finding, to demonstrate that other approaches to job design relate negatively to mental ability requirements, and to show that physical ability requirements also relate to job design.

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Correspondence and requests for reprints should be addressed to Michael A. Campion, Krannert School of Management, Purdue University, West Lafayette, IN 47907.

Previous Research

A few previous studies in psychology and the organizational sciences have focused on the relationships between job design and ability requirements of jobs. Dunham (1977) argued that these relationships were important to establish in order to understand the staffing implications of job redesign. His study examined relationships between job design and job ability estimates based on the Position Analysis Questionnaire (McCormick, Jeanneret, & Mecham, 1972). Schneider, Reichers, and T. M. Mitchell (1982) argued similarly that job redesign could fail if resulting ability requirements were incompatible with the abilities of the incumbents. Their study explored correlations between job design and ability estimates from the *Dictionary of Occupational Titles* (DOT; U.S. Department of Labor, 1977). Rousseau (1982) examined the link between job design and indirect indicators of ability requirements defined in terms of the occupational classification indices of data, people, and things developed by Fine (1955) and embodied in the DOT. Taber, Beehr, and Walsh (1985) also related job design to indirect estimates of ability requirements by using constructs from wage and compensation plans, which they assessed using the evaluation system developed by the National Electrical Manufacturing Association (Midwest Industrial Management Association, 1974). Lastly, in an effort to examine the construct validity of measures of job design, Gerhart (1988) also found relationships with ability estimates based on the DOT.

All these studies operationalized job design in terms of incumbents' perceptions of the motivational attributes of the jobs. This theoretical orientation reflects the research on job enrichment and enlargement (R. Ford, 1969; Herzberg, 1966), characteristics of motivating jobs (Hackman & Lawler, 1971; Hackman & Oldham, 1980), and related psychology-based conceptual frameworks (Steers & Mowday, 1977). This approach focuses on features of jobs that enhance satisfaction and motivational potential, such as variety, autonomy, and task significance. Measurement in this area of research has typically involved the Job Diagnostic Survey (JDS; Hackman & Oldham, 1975), studies leading to the JDS (Hackman & Lawler, 1971; Turner & Lawrence, 1965), or related instrumentation (Sims, Szilagyi, & Keller, 1976).

With few exceptions, the findings of these studies suggest that motivational attributes of jobs relate positively to mental ability requirements of jobs. Dunham (1977) and Schneider et al. (1982) found positive correlations with intelligence, verbal and numerical abilities, and with some perceptual and psychomotor abilities. Neither study measured gross physical abilities like strength. Rousseau (1982) found positive correlations with data- and people-oriented skills (which reflect job complexity or mental

abilities; Cain & Treiman, 1981) but almost no correlations with things-oriented skills (which reflect motor skills). Taber et al. (1985) found positive correlations with mental ability indicators like experience, judgment, training, and responsibility, but almost no correlations with physical ability indicators like physical effort, job hazards, or working conditions. Likewise, Gerhart (1988) found a positive correlation with a complexity measure but no correlations with measures of physical demands or working conditions.

Although these studies are only correlational in nature, taken together they suggest that redesigning jobs to increase motivational attributes could potentially increase the mental ability requirements. In turn, this might inadvertently result in staffing, training, and compensation costs for the organization.

This study raises the question of whether previous research has found positive relationships with mental ability requirements because job design has been measured only in terms of motivational attributes, which primarily reflect job complexity (Aldag, Barr, Brief, 1981; Drasgow & H. Miller, 1982; Stone & Gueutal, 1985). Other academic disciplines also address job design: for example, industrial engineering and ergonomics. If job design were measured more broadly, perhaps other approaches to job design would relate negatively to mental ability requirements. That would provide job design guidance to decrease staffing and compensation costs, or at least help make appropriate trade-offs between these organizational costs and the individual outcomes of satisfaction and motivation. Furthermore, measuring job design more broadly might reveal relationships with other ability requirements, such as physical abilities. The purpose of this study, therefore, is to examine the relationships between a wide array of job ability requirements and job design as assessed from an interdisciplinary perspective.

Interdisciplinary Perspective on Job Design

The interdisciplinary perspective on job design (Campion, 1988; Campion & Thayer, 1985, 1987) started with the observation that a number of approaches to job design exist, but they are all fairly parochial in viewpoint. Each approach focuses primarily on its particular school of thought without great consideration of other viewpoints. Although there is some overlap in the recommendations made for proper job design, there is also considerable divergence and even some direct conflict in advice. Yet proponents from each school claim their approach positively influences a wide spectrum of outcomes for both individuals and organizations (e.g., from job satisfaction to productive efficiency). Campion and Thayer (1985) addressed this confusion by adopting an interdisciplinary perspective. They reviewed and integrated this diverse literature and delineated taxonomies of job design approaches and outcomes. Then in a field study, they demonstrated that each approach was actually oriented toward the optimization of different sets of outcomes. This original research was recently replicated in an entirely different setting (Campion, 1988). The four approaches to job design and their corresponding outcomes are as follows.

First, the *motivational* approach derived from the aforementioned literature on job enrichment, enlargement, and characteristics of motivating jobs, and from theories of work motivation (T. R. Mitchell, 1976; Steers & Mowday, 1977; Vroom, 1964) and psychological principles from sociotechnical approaches (Cherns, 1976; Englestad, 1979; Rousseau, 1977). Its primary discipline base is organizational psychology. It is oriented toward outcomes such as satisfaction, intrinsic motivation, and involvement, as well as performance and attendance. Because this approach reflects job complexity, previous studies suggest that it will also relate positively to mental ability requirements of jobs.

Second, the *mechanistic* approach derived from classic industrial engineering and reflects recommendations from scientific management, time and motion study, and work simplification (Barnes, 1980; Gilbreth, 1911; Maynard, 1971; Mundel, 1970; Taylor, 1911). Illustrative design recommendations include task specialization, skill simplification, and repetition. It is oriented toward human resource efficiency and flexibility outcomes such as staffing ease and low training times. As such, it suggests designing jobs with reduced mental demands and should relate negatively to jobs' mental ability requirements.

Third, the *biological* approach emerged from biomechanics (Tichauer, 1978), work physiology (Astrand & Rodahl, 1977), anthropometry (Hertzberg, 1972), and much of the ergonomics literature (Grandjean, 1980). It focuses on minimizing physical stress and strain by recommending limits on job attributes like strength and endurance requirements and noise and climate levels. Jobs designed with this approach have more comfortable employees who report less physical effort and fatigue, fewer aches and pains, and fewer actual health complaints. It is predicted, therefore, to relate negatively to jobs' physical ability requirements.

Fourth, the perceptual/motor approach, deriving largely from experimental psychology, emerged from research on human factors engineering (McCormick, 1976; Van Cott & Kinkade, 1972), skilled performance (Welford, 1976), and human information processing (Fogel, 1967; Gagne, 1962). Its goal is to not exceed human mental capabilities and limitations, primarily with regard to attention and concentration requirements of jobs. Recommendations include a consideration of the proper design of work stations and equipment variables such as lighting and displays/controls, as well as restrictions on the information processing requirements of jobs. It has shown favorable relationships with reliability outcomes (e.g., reduced likelihood of errors and accidents) and positive user reactions (e.g., reduced mental overload, fatigue, and stress, and favorable attitudes toward work stations and equipment). Because it encourages the reduction of mental demands, it is also predicted to relate negatively to jobs' mental ability requirements.

In summary, this study extends previous research by testing three hypotheses:

Hypothesis 1: An encompassing definition of the motivational approach to job design will relate positively to a wide variety of mental ability requirements.

Hypothesis 2: Other approaches to job design, notably the mechanistic and perceptual/motor approaches, will relate negatively to mental ability requirements.

Hypothesis 3: Physical ability requirements will also be important to job design, primarily through negative relationships with the biological approach.

Method

The job design data for this research came from two previous samples researched by the author. These samples not only allow a replication, but they differed in three ways that enhance generalizability. First, sample 1 (Campion & Thayer, 1985) included blue-collar manufacturing jobs from a low-technology industry, while sample 2 (Campion, 1988) included both blue- and white-collar manufacturing and development jobs from a high-technology industry. Second, the samples differed in average expected ability requirements of the jobs, with sample 1 higher on physical abilities and sample 2 higher on mental abilities. Third, job design measurement differed in the two samples, with an analyst-completed measure used in sample 1 and a self-report measure used in sample 2.

Sample 1

Sample description. Job design data were collected by observation of 121 jobs from five operations of a large forest products company: plywood plant (40 jobs), sawmill (33 jobs), fiberwood plant (25 jobs), wood treatment (e.g., landscape timber) facility (14 jobs), and merchandiser (i.e., log sorting/grading) facility (9 jobs). Statistical power to detect a .30 correlation between job design scales and job ability requirements was estimated at 96% ($p < .05$, one-tailed test; Cohen, 1977).

The sample was the complete census of hourly production jobs in these plants, with 23 skilled/craft, 63 semi-skilled/operative, 34 unskilled/labor, and 1 clerical job. Employees on these jobs averaged 6.1 years of company tenure, 2.5 years of job tenure, and 11.3 years of education. Pay level ranged from $5.25 to $9.18 in 1982 dollars, with a mean of $6.19 ($SD$ = $.98).

Job design measurement. Job design measurement was accomplished using the Multimethod Job Design Questionnaire (MJDQ; Campion, 1985; Campion & Thayer, 1985). This instrument was completed by a trained analyst on the basis of observation of the jobs. An analyst-completed measure was used for two reasons. First, this measure was part of an earlier study (Campion & Thayer, 1985) that collected other data from the incumbents themselves, thus self-report job design measurement might have created method bias (Glick, G. Jenkins, & Gupta, 1986; Salancik & Pfeffer, 1977; Stone & Gueutal, 1984). Second, concerns existed that a self-report measure might tax the reading-level abilities of some of the respondents in this setting.

The MJDQ was developed by rewriting the specific job design recommendations from each approach into principles that were broad enough to be applicable across diverse jobs, yet specific enough to allow objective and quantifiable judgments. The MJDQ has four sections, one corresponding to each of the four job design approaches: motivational (16 items, Cronbach's (1951) coefficient alpha = .89), mechanistic (13 items, alpha = .82), biological (18 items, alpha = .86), and perceptual/motor (23 items, alpha = .85).

Each item has a 5-point rating scale (with 5 highest) anchored with appropriate adjectives (from Bass, Cascio, & O'Connor, 1974), verbal descriptions, definitions, and examples to enhance interrater reliability. Because additive models are as good as multiplicative models for combining job design elements (Pierce & Dunham, 1976) and unit weighting is often preferred in general (Einhorn & Hogarth, 1975; Wainer, 1976), total scores for each approach are calculated as simple averages of applicable items. In short, the questionnaire provides a measure of the degree to which a job is well designed with respect to the recommendations of each of the four approaches. A pilot study had two independent analysts complete the MJDQ on 30 diverse jobs. Interrater reliabilities ranged from .89 ($p < .05$) to .93, and mean absolute agreement ranged from .12 to .17, across the four total scores. These levels of reliability and agreement were considered very good for an observational instrument (cf. C. Jenkins, Nadler, Lawler, & Cammann, 1975). The MJDQ was completed by an analyst on the job site on the basis of a 15 to 30 minute observation period with occasional informal questioning of the worker about less observable job aspects (e.g., infrequent tasks). Example items from the analyst-completed MJDQ, as well as further information on its construction and scale properties, are contained in Campion and Thayer (1985). The entire instrument is contained in Campion (1985).[1]

Sample 2

Sample description. Job design data were collected from 1,024 employees on 92 diverse jobs in a manufacturing and development facility of a large electronics company. Statistical power to detect a correlation of .30 at the job level was estimated at 90% ($p < .05$, one-tailed test; Cohen, 1977). Using variance estimates from the data, employee population statistics, and standard sampling formulas (Warwick & Lininger, 1975), the 10.7 (SD = 2.65) respondents per job yielded average 95% confidence intervals around job design estimates of 3.2%.

The 92 jobs were a representative sample of the most populated jobs in this organizational setting and constituted 79.3% of such jobs. Job types were 17.4% managerial, 27.2% professional, 19.6% technical, 21.7% manufacturing, and 14.1% administrative. Nearly all (99.8%) respondents had at least one year of company tenure, 91.4% had at least six months of job tenure, and 60.5% had at least two years of college. Pay levels were not available for this sample, but job evaluation level based on a point-method system combining both exempt and nonexempt jobs ranged from 1 to 16, with a mean of 8.45 (SD = 3.61).

Job design measurement. Job design measurement was accomplished using a self-report version of the original analyst-completed MJDQ (Campion, 1988). A self-report version was used for two reasons. First, this sample included many managerial and professional jobs that could not be analyzed via observation (e.g., long task cycles, difficult-to-observe tasks, complex job content, confidentiality of some job content, obtrusiveness of observational approach). Second, limited reading level abilities of employees—and potential method bias from collecting all measures on the same instrument—were not a concern in this sample as they were in sample 1 (Campion & Thayer, 1985).

Like the original MJDQ, the self-report version assesses the degree to which a job is well designed with respect to recommendations of each of the four approaches. The number of items has been reduced from 70 to 48 by eliminating redundancy and items with low applicability to a wide range of jobs. Incumbents indicate the extent to which each statement is descriptive of their job using a 5-point scale ranging from 5 = "strongly agree" to 1 = "strongly disagree," including a blank = "don't know or not applicable"

[1] All job design measures are available from the author.

TABLE 1

Example Items from the Self-Report Multimethod Job Design Questionnaire (MJDQ)

Motivational scale (18 items, alpha = .87, intraclass r^a = .55)

1. *Autonomy*: The job allows freedom, independence, or discretion in work scheduling, sequence, methods, procedures, quality control, or other decision making.
13. *Achievement*: The job provides for feelings of achievement and task accomplishment.

Mechanistic scale (8 items, alpha = .64, intraclass r = .86)

20. *Job specialization*: The job is highly specialized in terms of purpose, tasks, or activities.
25. *Repetition*: The job requires performing the same activity(s) repeatedly.

Biological scale (10 items, alpha = .86, intraclass r = .84)

30. *Strength*: The job requires fairly little muscular strength.
33. *Seating*: The seating arrangements on the job are adequate (e.g., ample opportunities to sit, comfortable chairs, good postural support, etc.).

Perceptual/Motor scale (12 items, alpha = .85, intraclass r = .74)

41. *Lighting*: The lighting in the work place is adequate and free from glare.
47. *Information input requirements*: The amount of information you must attend to in order to perform this job is fairly minimal.

[a] df = 91,931; all significant at $p<.05$.

alternative. Total scores are calculated as averages across applicable items. Example items are contained in Table 1; the complete instrument is contained in Campion (1988).

In the pilot study, three independent analysts completed the self-report MJDQ on 30 diverse jobs on the basis of a review of detailed job descriptions. Interrater reliability (average intercorrelations using r to z transformation; Silver & Dunlap, 1987) ranged from .78 ($p < .05$) to .95, and mean absolute agreement ranged from .40 to .65 across the four total scores. The levels of agreement were considered acceptable, although they were somewhat lower than with the original MJDQ because the latter was constructed especially for analysts and had detailed scale anchors. To assess similarity between analysts and incumbents and to avoid concerns about basing reliability studies on analyses of job descriptions (compare Jones, Main, Butler, & Johnson, 1982, with Friedman & Harvey, 1986, and Harvey & Hayes, 1986), the average analyst data were compared with average incumbent data. Correlations ranged from .66 ($p < .05$) to .89, and mean absolute agreement ranged from .43 to .62 across the four total scores. These levels of reliability and agreement were similar to those among analysts. Note that aggregate analyses such as these do not ensure reliability and agreement between individual analysts and incumbents (James, 1982).

Coefficient alphas (Cronbach, 1951) and intraclass correlations for the mean of a group of raters (M = 10.7 incumbents per job; Cronbach, Gleser, Nanda, & Rajaratnam, 1972; James, 1982) were all moderate to high (Table 1). Unlike coefficient alphas, which are heavily influenced by the number of items per scale, the intraclass correlations are more influenced by the objective and observable nature of the items. Thus, the motivational scale had a larger internal consistency but a lower intraclass correlation than the mechanistic scale. In the analyses that follow, job-level data represent averages of incumbent responses within each job.

Subsequent research on the self-report MJDQ has provided evidence of convergent validity between the motivational scale and the JDS (Hackman & Oldham, 1975) and discriminant validity between the other three scales of the MJDQ and the JDS (Campion, Kosiak, & Langford, 1988). In addition, this subsequent research provided evidence for the convergence of MJDQ responses between incumbents and supervisors.

Employees in each job were randomly sampled using systematic selection (i.e., every nth incumbent) from alphabetical listings provided by the company. Questionnaires were sent through company mail with a cover letter from the director of personnel explaining that the study was for research purposes only and questionnaires were anonymous and confidential. Job titles were precoded on the questionnaires to ensure consistency and accuracy, and employees could indicate if their titles had changed. The 1,024 respondents represented a 69.6% return rate.

Job Ability Requirements Measurement

The DOT was designed to be a job placement tool for the U.S. Employment Service (U.S. Department of Labor, 1977). Even though some of the indices seem to be indirect reflections of ability requirements (e.g., working conditions, worker functions), the obvious ability orientation is clear from their intended use for assessing candidate qualifications, classifying jobs, and then matching the two (U.S. Department of Labor, 1977, pp. xxix–xxxii). The personnel selection focus is further evidenced by the inclusion of ratings on the subtests of the General Aptitude Test Battery (GATB), which is the selection test administered by the U.S. Employment Service. The ability orientation is also suggested by the provision of various training indices. That the focus of the DOT is on the requirements of the job, as opposed to the profiles of current employees, is indicated by the method of data collection. The ratings are made by trained occupational analysts working in field centers throughout the country. Ratings are based upon on-site job analyses, of which there were over 75,000 conducted from the mid 1960s to the mid 1970s alone (U.S. Department of Labor, 1977, p. xiv). Description of the data gathering process is contained in job analysis handbooks (U.S. Department of Labor, 1972, 1982) and in reviews of the DOT (Cain & Treiman, 1981; A. Miller, Treiman, Cain, & Roos, 1980).

DOT data were used for estimates of job ability requirements for several additional reasons. First, the DOT contains a broad spectrum of job requirements, including needed physical abilities and working conditions, as well as a variety of mental abilities and training times. Second, studies support the reliability of the DOT data and potential value for occupational research (Cain & Green, 1983; Cain & Treiman, 1981; A. Miller et al., 1980). Finally, the DOT represents an extensive depository of job analysis information, with data available on 12,099 different jobs.

Computerized listings of the job ability requirements data were obtained from the U.S. Employment Service for all the jobs in the fourth edition of the DOT (U.S. Department of Labor, 1977) and the supplement to the fourth edition (U.S. Department of Labor, 1986). Additional job ability requirements data were also obtained from a related document (U.S. Department of Labor, 1981). All 31 of the ability-related scales were used, and they are described briefly in Table 2.

With the design of the present study, reliability of these measures can only be estimated indirectly because they are single-item scales. The most relevant evidence comes from a study by Cain and Green (1983) in which actual U.S. Employment Service analysts evaluated a sample of job descriptions on a subset of the ratings. Results were analyzed using a generalizability theory framework (Cronbach et al., 1972). The "medium" reliabilities reported in Table 2 consider rater effects plus residual as error, and they are close to the values observed for average interrater correlations. Most of the reliabilities appear adequate. Estimates of reliabilities are not available for those ratings not included in the Cain and Green study. However, factor analyses described below bear on the relationships among all the ratings.

DOT codes were determined for each job by matching DOT descriptions with detailed and current job descriptions from the organizations. Reliability of the matching process was assessed by having two independent analysts, the author and an assistant, find the DOT codes for a random sample of 30 jobs (15 from each sample). Up to two DOT codes per job were allowed. Ninety percent agreement was observed on the total number of matches.

For 30.6% of the jobs in sample 1 and 27.2% of the jobs in sample 2, two DOT codes were needed to adequately cover the content of the jobs. In those cases, average ability estimates were calculated. However, if the jobs required the skills of both codes, the highest ability estimates from both were taken. For example, an engineering manager job was assigned the higher ability estimates from both the appropriate manager and engineer DOT codes. Hierarchical jobs (e.g., specialty saw operator versus helper, senior versus junior programmer) were typically assigned the same code. A match between a job and one or more codes was considered adequate if the content of the job was largely covered by the code(s). Overall, an adequate match between job and code(s) was accomplished in 89.3% of the jobs in sample 1 and 79.3% of the jobs in sample 2. If an adequate match could not be made, the closest match(es) possible was (were) made. Nearly identical results were obtained without the poorer matching jobs in both samples; thus only results using all the jobs will be presented.

TABLE 2

Job Ability Requirements from the Dictionary of Occupational Titles (DOT)

Label	Description	Min	Max	Rel[a]
Training times				
GED	General educational development	1	6	.82
MATH	Mathematical development	1	6	.61
LANG	Language development	1	6	.74
SVP	Specific vocational preparation	1	9	.80
Worker functions[b]				
DATA	Working with numbers, letters, etc.	0	6	.85
PEOPLE	Working with people	0	8	.87
THINGS	Working with objects, machines, etc.	0	7	.46
Physical demands				
STRENGTH	Lifting, pushing, standing, etc.	1	5	.54
CLIMB	Climbing or balancing	0	1	
STOOP	Stooping, kneeling, crouching, etc.	0	1	
REACH	Reaching, handling, fingering, etc.	0	1	
TALK	Talking or hearing	0	1	
SEE	Seeing	0	1	
Working conditions				
LOCATION	Indoor, indoor/outdoor, or outdoor	1	3	.66
COLD	Extreme cold and temperature changes	0	1	
HEAT	Extreme heat and temperature changes	0	1	
WET	Wet or humid	0	1	
NOISE	Noise or vibration	0	1	
HAZARDS	Danger to life, body, or health	0	1	
ATMOSPHERE	Fumes, dust, poor ventilation, etc.	0	1	
General Aptitude Test Battery (GATB)[b]				
INTELLIGENCE	General learning ability	1	5	
VERBAL	Understand and use words	1	5	
NUMERICAL	Perform arithmetic operations	1	5	
SPATIAL	Visualize geometric forms	1	5	
FORM	Perceive detail in objects or shapes	1	5	
CLERICAL	Perceive detail in letters or numbers	1	5	
MOTOR	Coordinate eyes and hands	1	5	
FINGER	Move fingers and manipulate objects	1	5	
MANUAL	Move hands in placing and turning	1	5	
HAND-FOOT	Coordinate eyes, hands, and feet	1	5	
COLOR	Match or discriminate colors	1	5	

[a] Medium interrater reliability estimates from Cain and Green (1983) are indicated where available.

[b] Scoring reversed such that larger values indicate greater ability requirements.

Results

Table 3 shows the means and standard deviations for the measures. Range restriction and ceiling effects are generally not apparent, except for a few of the physical demands and working conditions. As expected, *t* tests indicate that jobs in sample 1 are typically higher on physical ability requirements and lower on mental ability requirements than jobs in sample 2.

Table 4 shows intercorrelations among job design scales. The motivational scale has negative correlations with the mechanistic and perceptual/motor scales and positive correlations with the biological scale. The mechanistic scale has positive correlations with the perceptual/motor scale and zero or negative correlations with the biological scale. The biological and perceptual/motor scales have both positive and negative correlations.

Table 4 also shows correlations between the job design scales and job ability requirements. Many moderate to large correlations are present, and the pattern of correlations is quite consistent across variables. The correlations are also similar across samples; the coefficient of congruence (Levine, 1977; Wrigley & Neuhaus, 1955), which reflects both pattern and magnitude similarity between sets of correlations, is .64.

As predicted by Hypothesis 1, the motivational scale correlates positively with most of the mental ability requirements, such as the four training times, DATA and PEOPLE worker functions, and the INTELLIGENCE, VERBAL, and NUMERICAL GATB ratings. As predicted by Hypothesis 2, the mechanistic and perceptual/motor scales show consistent and usually large negative correlations with these mental ability requirements. As predicted by Hypothesis 3, the biological scale shows many moderate to large negative correlations with the physical ability requirements, such as many of the physical demands and working conditions, as well the THINGS worker function and the MOTOR, FINGER, and MANUAL GATB ratings in sample 2.

In terms of relationships for which hypotheses were not developed, the biological scale has positive correlations with most of the mental ability requirements. The motivational, mechanistic, and perceptual/motor scales have scattered mixed correlations with the physical demands and working conditions. The THINGS worker function, and the SPATIAL, FORM, and CLERICAL GATB ratings show a pattern similar to the mental ability requirements. Finally, the MOTOR, FINGER, and MANUAL GATB ratings tend to show different correlations in each sample.

The job ability requirements were factor analyzed to simplify and clarify the results. Principal components analysis with varimax rotation (programmed by SAS Institute, Inc., 1982) was used because the purpose was to explain the maximum amount of variance and provide the simplest representation of the variables (J. Ford, MacCallum, & Tait, 1986). The ratio

TABLE 3

Means, Standard Deviations, and T Tests on Job Design Scales and Job Ability Requirements

	Sample 1 (n = 121)		Sample 2 (n = 92)		
	M	*SD*	*M*	*SD*	t^a
Job Design Scales					
Motivational	3.14	.48	3.64	.26	
Mechanistic	3.55	.48	2.79	.37	
Biological	3.18	.52	3.55	.47	
Perceptual/Motor	3.36	.36	2.90	.29	
Job Ability Requirements					
Training times					
GED	2.35	.65	4.23	.98	−16.01*
MATH	1.36	.67	3.71	1.40	−14.84*
LANG	1.30	.61	3.81	1.17	−18.73*
SVP	3.11	1.38	6.22	1.78	−13.84*
Worker functions					
DATA	.50	1.09	3.70	1.85	−14.73*
PEOPLE	.24	.84	1.74	1.62	−8.07*
THINGS	2.45	1.89	2.60	2.69	−.45
Physical demands					
STRENGTH	3.12	.65	1.73	.73	14.64*
CLIMB	.04	.20	.02	.15	.82
STOOP	.41	.45	.09	.28	6.41*
REACH	1.00	.00	.75	.44	5.51*
TALK	.05	.21	.58	.50	−9.55*
SEE	.64	.46	.88	.33	−4.38*
Working conditions					
LOCATION	1.54	.50	1.03	.18	10.39*
COLD	.00	.00	.00	.00	.00
HEAT	.02	.13	.01	.10	.36
WET	.01	.09	.00	.00	1.00
NOISE	.56	.48	.09	.28	9.00*
HAZARDS	.34	.44	.08	.27	5.52*
ATMOSPHERE	.11	.31	.02	.15	2.83*
General Aptitude Test Battery (GATB)					
INTELLIGENCE	2.33	.45	3.58	.78	−13.61*
VERBAL	2.14	.34	3.52	.89	−14.13*
NUMERICAL	1.95	.58	3.32	.99	−11.84*
SPATIAL	2.49	.47	3.18	.84	−7.02*
FORM	2.28	.44	3.19	.69	−11.08*
CLERICAL	1.64	.54	3.17	.75	−16.56*
MOTOR	2.54	.53	2.55	.66	−.06
FINGER	1.97	.46	2.72	.74	−8.49*
MANUAL	2.81	.37	2.64	.70	2.19*
HAND-FOOT	1.81	.77	1.35	.47	5.43*
COLOR	1.20	.37	1.70	.85	−5.31*

[a] *t* tests on job design scales not calculated because scales differ between samples.
*$p<.05$ (two-tailed tests).

of 213 jobs to 31 variables of approximately 7 to 1 is between the various rules of thumb (e.g., 5 to 1 of Gorsuch, 1974; and 10 to 1 of Nunnally.

TABLE 4

Intercorrelations Among Job Design Scales and Correlations with Job Ability Requirements

	Motivational	Mechanistic	Biological	Perceptual/ Motor
	Job Design Scales			
Mechanistic	−69*/−43*			
Biological	33*/ 31*	−06 /−42*		
Perceptual/Motor	−29*/−38*	21*/ 72*	47*/−23*	
	Job Ability Requirements			
Training times				
GED	51*/ 46*	−44*/−73*	22*/ 60*	−20*/−65*
MATH	51*/ 44*	−51*/−67*	17*/ 48*	−27*/−56*
LANG	48*/ 43*	−46*/−69*	28*/ 70*	−14 /−58*
SVP	58*/ 46*	−53*/−78*	23*/ 46*	−30*/−72*
Worker functions				
DATA	54*/ 41*	−53*/−76*	15 / 52*	−28*/−69*
PEOPLE	42*/ 30*	−43*/−61*	10 / 49*	−16*/−36*
THINGS	53*/ 03	−38*/ 11	20*/−40*	−23*/ 00
Physical demands				
STRENGTH	−26*/−17	−01 / 38*	−45*/−74*	−10 / 23*
CLIMB	04 / 01	−07 /−05	15 /−43*	02 /−23*
STOOP	−21*/ 02	17*/ 01	−28*/−55*	−10 /−15
REACH	00 /−26*	00 / 47*	00 /−39*	00 / 27*
TALK	27*/ 26*	−26*/−54*	07 / 48*	−10 /−40*
SEE	45*/−09	−33*/ 13	21*/−15	−10 /−01
Working conditions				
LOCATION	−10 /−15	17*/−06	−36*/−45*	−04 /−18*
COLD	00 / 00	00 / 00	00 / 00	00 / 00
HEAT	10 /−03	−03 /−05	29*/ 08	11 /−02
WET	−08 / 00	07 / 00	−18*/ 00	−12 / 00
NOISE	−02 /−07	20*/ 15	−14 /−41*	−29*/ 08
HAZARDS	−21*/−10	11 /−02	−29*/−56*	−02 /−09
ATMOSPHERE	25*/−02	−10 / 14	07 /−19*	−08 / 18*
General Aptitude Test Battery (GATB)				
INTELLIGENCE	48*/ 39*	−34*/−68*	19*/ 66*	−28*/−57*
VERBAL	45*/ 34*	−49*/−66*	26*/ 65*	−13 /−59*
NUMERICAL	54*/ 37*	−46*/−62*	17*/ 55*	−32*/−48*
SPATIAL	51*/ 32*	−49*/−49*	11 / 13	−19*/−45*
FORM	35*/ 20*	−17*/−19*	03 /−01	−28*/−22*
CLERICAL	48*/ 12	−42*/−35*	37*/ 50*	−05 /−26*
MOTOR	35*/ 00	−32*/ 10	−05 /−28*	−32*/−03
FINGER	45*/−15	−29*/ 40*	15 /−39*	−29*/ 30*
MANUAL	27*/−21*	−08 / 38*	18*/−53*	−05 / 29*
HAND-FOOT	08 / 17	−05 /−22*	−06 /−07	−02 /−19*
COLOR	03 /−04	−05 / 00	14 / 00	−03 / 04

Note: Decimals omitted. Sample 1 left of slash ($n=121$ jobs)/Sample 2 right of slash ($n=92$ jobs).
* $p<.05$ (one-tailed tests).

1978). Decisions on the number of factors retained were based on the criteria of a minimum eigenvalue of 1.0, variance explained, and interpretability

TABLE 5

Correlations Between the Job Design Scales and Job Ability Factor Scores

Job ability factor scores	Job design scales: Motivational	Mechanistic	Biological	Perceptual/ Motor
Substantive Complexity	55*/ 46*	−51*/−80*	07 / 57*	−35*/ −68*
Motor Skills	54*/−11	−35*/ 29*	14 /−43*	−35*/ 16
Physical Demands	−18*/ 17	03 /−29*	−41*/−39*	−18*/ −40*
Coordination	16*/ 32*	−25*/−60*	−12 / 15	−08 / −56*
Working Conditions	28*/ 05	−02 / 02	10 /−10	−17*/ 06

Note: Decimals omitted. Sample 1 left of slash ($n=121$ jobs)/Sample 2 right of slash ($n=92$ jobs).
* $p<.05$ (one-tailed tests).

(Kim & Mueller, 1978). Five factors were retained explaining 69.2% of the total variance. Factors were interpreted by examining the largest loadings, generally no smaller than .40, and by reference to previous research.[2]

Four of the five factors extracted are nearly identical to those found in a larger sample analysis of the DOT variables by Cain and Treiman (1981). The first factor is what Cain and Treiman called Substantive Complexity (explaining 36.6% of the total variance). It has high loadings with the four training times, the DATA and PEOPLE worker functions, the INTELLIGENCE, VERBAL, NUMERICAL, SPATIAL, FORM, and CLERICAL GATB ratings, and the TALK physical demand. It has negative loadings with several of the other physical demands and with working conditions.

The second factor Cain and Treiman called Motor Skills (12.7% of variance). Its highest loadings are with the MOTOR, FINGER, and MANUAL GATB ratings, the THINGS worker function, and the REACH and SEE physical demands. The third factor Cain and Treiman called Physical Demands (8.4% of variance). Its highest loadings are with the STRENGTH and STOOP physical demands, and the LOCATION and HAZARDS working conditions.

The fourth factor is entitled Coordination (6.0% of variance) and has high loadings with SPATIAL, MOTOR, and HAND-FOOT GATB ratings, SEE physical demand, and LOCATION working condition. The fifth factor corresponds to what Cain and Treiman called Working Conditions (4.8% of variance) and has high loadings with NOISE and ATMOSPHERE working conditions.

Exact factor scores were calculated and correlated with job design scales (Table 5). The correlations are somewhat similar across the samples, with a coefficient of congruence of .46. As predicted by Hypotheses 1 and 2, the motivational scale shows positive correlations, and the mechanistic and

[2] Factor loadings for the individual variables are available from the author.

perceptual/motor scales show negative correlations, with the Substantive Complexity factor. As predicted by Hypothesis 3, the biological scale shows negative correlations with the Motor Skills and Physical Demands factors.

In terms of the other relationships, the biological scale has a positive correlation with Substantive Complexity in sample 2. The motivational scale has some positive correlations with Motor Skills, Coordination, and Working Conditions and a negative correlation with Physical Demands. On the other hand, the mechanistic and perceptual/motor scales have mostly negative correlations with Motor Skills, Physical Demands, and Coordination.

A canonical correlation analysis was conducted to provide an overall multivariate examination of the relationship between job design scales and job ability factor scores (Darlington, Weinberg, & Walberg, 1973; Harris, 1975). Three significant ($p < .05$) canonical correlations emerged in sample 1 and two in sample 2. These canonical correlations reflect orthogonal links between the two sets of measures, and usually the nature of the links can be determined by examining the correlations between the measures and the canonical variates (Cooley & Lohnes, 1971; Darlington et al., 1973; Levine, 1977; Meredith, 1964). Unfortunately, correlations with the variates do not enhance interpretation in this case, with most measures correlating with all variates. The finding of mental and physical demands links as observed in previous interdisciplinary job design research (Campion, 1988; Campion & Thayer, 1985) is only suggestive here. Redundancy indices (Cooley & Lohnes, 1971; Stewart & Love, 1968) indicate that job design scales explain a total of 18% of the variance in job ability factor scores in sample 1 and 29% in sample 2.[3]

Jobs higher in hierarchical level usually have higher mental ability requirements and lower physical ability requirements. So partialling job level out of the relationships with job design has provided an assessment of discriminant validity in previous interdisciplinary research (Campion, 1988; Campion & Thayer, 1985). Controlling for job level defined by pay in sample 1 and job evaluation in sample 2 reduces the correlations between the job design and ability measures somewhat, with 6 of the 25 significant correlations in Table 5 becoming nonsignificant (average drop across the Table of $r = .11$). Hypothesized relationships are largely unaffected, however. Most reductions occur in the relationships between the motivational scale and the Physical Ability factors and between the biological scale and the Substantive Complexity factor. This could be considered a rather stringent test of discriminant validity because job design, ability requirements, and job evaluation are highly related both conceptually and empirically (Campion & Berger, 1988). So job level, at least as defined by job evaluation indices, may not be a confound in the present context, and partialling out job evaluation may take away some true covariance between job design and ability requirements.[4]

[3]Canonical correlation analyses between job design scales and job ability factor scores are available from the author.

Discussion

In two separate samples of highly different jobs from different industries, with different overall skill levels and different job design measures, the relationships between multiple approaches to job design and a wide spectrum of job ability requirements were replicated.

Through Hypothesis 1, results substantiate previous findings by showing that an encompassing definition of the motivational approach to job design relates positively to a wide variety of mental ability requirements of jobs (Campion, 1988; Campion & Thayer, 1985; Dunham, 1977; Gerhart, 1988; Rousseau, 1982; Schneider et al., 1982; Taber et al., 1985). In addition, the motivational approach relates positively to skill and coordination physical abilities but negatively to physical effort and stress. These relationships are especially apparent in sample 1 because the jobs with the most motivational features were craft jobs, which tend to require many psychomotor skills but not excessive physical effort. This latter interpretation is supported by the fact that craft jobs tended to be the higher-level jobs in sample 1, and partialling out job level reduced or eliminated the correlations between the motivational approach and physical ability requirements.

Results support Hypothesis 2 that other approaches (i.e., mechanistic and perceptual/motor) relate negatively to mental ability requirements. The goal of the mechanistic approach, to specialize tasks and simplify skills in order to reduce staffing and training costs, is very consistent with lower mental ability requirements. Likewise, the goal of the perceptual/motor approach, to not exceed workers' mental capabilities in order to reduce error likelihood and stress, is consistent with lower mental ability requirements.

These approaches are negatively related to some physical ability requirements as well. Perhaps aspects of the mechanistic approach such as skill simplification also apply to physical skills, and aspects of the perceptual/motor approach like proper equipment design and workplace layout also reduce physical ability requirements.

As predicted by Hypothesis 3, the physical demands of jobs are most strongly related to the biological approach with its total focus on minimizing the physical costs of work. The biological approach also relates

[4]Partial correlations between job design scales and job ability factor scores controlling for job level are available from the author.

positively to some mental ability requirements. This latter relationship can probably best be understood as the spurious consequence of hierarchical job level. Higher-level jobs tend to have more mental and less physical requirements. Controlling for job level reduces the correlations between the biological scale and mental ability measures.

Factor analysis suggested that a mental versus physical abilities distinction helps simplify the ability measures, as well as the relationships between job design and ability measures. These results are consistent with previous factor analytic research on DOT variables (Cain & Treiman, 1981) and previous interdisciplinary job design research (Campion, 1988; Campion & Thayer, 1985).

The mental versus physical abilities distinction is also consistent with the GATB validation research conducted by Hunter for the U.S. Department of Labor and by others. This research showed that the abilities measured by the GATB cluster into three factors (U.S. Department of Labor, 1983a): Cognitive, Perceptual, and Psychomotor. Furthermore, job complexity moderates validity, with cognitive ability tests increasing (and psychomotor ability tests decreasing) in validity with higher job complexity (Guttenberg, Arvey, Osburn, & Jeanneret, 1983; Hunter, 1986; U.S. Department of Labor, 1983b). In terms of the present sample, mental ability predictors may be more valid with jobs higher on the motivational and lower on the mechanistic and perceptual/motor scales, while psychomotor predictors may be more valid in the reverse case.

Results of this study must be interpreted with caution for three reasons. First, the process of assigning ability data required matching specific jobs in organizations to occupational categories in the DOT. The DOT occupations represent aggregations of jobs with similar content (Cain & Treiman, 1981), so ability data may contain some degree of contamination or deficiency. The fact that job design scales explained 18% (sample 1) and 29% (sample 2) of the variance in the methodologically separate ability measures is noteworthy, given these attenuating factors. Nevertheless, the imprecision introduced by using these data suggests that the sizes of the observed relationships are probably underestimates of the true relationships.

Second, the job level of analysis used in this study affects the proper inferences that can be made. The results of this study can be interpreted as indicating that jobs with certain design features also tend to have certain ability requirements, but this does not indicate that all employees on these jobs will necessarily have these abilities. A related limitation is created by the fact that the data bear primarily on between-job differences. Thus the data cannot be interpreted as necessarily reflecting the relationships between job design and ability requirements within a given job or job family. In fact, the precise implications of this study for individual employees and

within-job relationships is only suggestive, given the problematic nature of cross-level inferences (Glick, 1980).

Third, the correlational design of this study is also a limitation in that inferences of causality cannot be drawn. For instance, it could be that job design and ability requirements correlate to some degree because the jobs are designed around the abilities of the types of employees available, rather than job design causing the ability requirements. Although the ability data were collected through analyses of the jobs rather than the incumbents, this possibility of reversed causation cannot be ruled out in the present study. One solution is to examine actual redesign of jobs in future research. Perhaps using an experimental or quasi-experimental strategy, a priori predictions could be made from the interdisciplinary perspective, and a broad range of both individual and organizational costs and benefits evaluated.

Historically, matching employees and jobs was accomplished by selecting employees with the right abilities (Schneider & Schmitt, 1986). This study of job design suggests the alternative strategy of changing jobs in order to adjust the abilities required of employees. If future research demonstrates the causal relationship between job design approaches and job ability requirements, this research may have several implications for job redesign. First, it reconfirms earlier suspicions that job enrichment, enlargement, or other motivationally based redesign efforts could potentially increase the mental demands of jobs, thus creating staffing and training difficulties or increased compensation needs (Campion & Berger, 1988; Campion & Thayer, 1985; Dunham, 1977; Schneider et al., 1982).

Second, through the mechanistic and perceptual/motor approaches, this research offers theoretical orientations and job design recommendations that are oriented toward reducing mental demands, thus reducing the organizationally important outcomes of staffing, training, and compensation requirements.

Third, the interdisciplinary perspective suggests that attention should not be limited to just mental ability requirements. Physical abilities may also be important, and the biological approach offers a theoretical and practical link to these requirements. Knowledge of physical ability implications of job design may help control individual costs such as discomfort and injury (Ayoub, 1973; Campion & Phelan, 1981; Grandjean & Hunting, 1977; Van Wely, 1970) and organizational costs such as staffing difficulties (Campion, 1983; Fleishman, 1975; Hogan & Quigley, 1986). Other recent studies also suggest expanding the scope of job design research to include physical demands (Cornell, 1984; Stone & Gueutal, 1985; Taber et al., 1985; Zaccaro & Stone, 1988).

Finally, with an interdisciplinary perspective, it becomes apparent that there are conflicts among some of the approaches. Most notably, the motivational approach encourages design features that may enhance mental ability requirements, while the mechanistic and perceptual/motor approaches give nearly opposite advice, which may reduce mental ability requirements. This suggests a basic trade-off. On the one hand, there could be organizational costs that come from high mental ability requirements such as increased staffing difficulties, training times, error likelihoods, and compensation requirements. On the other hand, there could be individual costs of low mental ability requirements such as decreased satisfaction, motivation, and compensation. The interdisciplinary perspective helps to clarify these compromises. This may help avoid unintended consequences from job redesign, and it may also help discover opportunities where positive gains can be made on a number of approaches, thus minimizing both individual and organizational costs.

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