The Relationship of Career Evaluation Systems (CES) Test Batteries with Work Production in a Sheltered Workshop

Blake Hegarty
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The Relationship of Career Evaluation Systems (CES)

Test Batteries with Work Production in a Sheltered Workshop

(TITLE)

BY

Blake Hegarty

THESIS

SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF

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IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
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I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
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ABSTRACT

The purpose of the study was to examine the relationship between performance on Career Evaluation Systems' (CES) test batteries and performance on production tasks at CCAR Industries' Manufacturing Plant. Fleishman's factor analytic studies of psychomotor performance were reviewed to demonstrate the conceptual basis for the development of the test batteries. Hester's development of the CES batteries and the factors they measure were discussed.

The subjects were 112 CCAR Industries' clients who were administered Career Evaluation Systems' test battery during vocational evaluations at CCAR Industries' Manufacturing Plant between 1986 and 1992. Fifty-nine subjects met the criteria for inclusion in the final analysis.

The criterion measures of worker performance included both rate of improvement in production as measured by piece rate change over employment history and mean piece rate of production. The predictors were the aptitude categories of Unilateral Motor Ability, Bilateral Motor Ability, Lifting Ability, Perceptual Ability, Perceptual-Motor Coordination, and Cognitive Ability. The following tasks were analyzed: Paste Up Fixture, Handwire, and Machine Tipping.

A multivariate analysis of the criterion scores with the predictors produced no significant findings at the .05 level of significance. A Pearson correlational analysis was
performed between all variables. Mean piece rate of Paste Up Fixture was significantly related to unilateral motor ability and perceptual-motor coordination.

A backward stepwise multiple regression analysis was performed for each production task. A .05 level of significance was used for all tests. The regression slope coefficient of Paste Up Fixture was significantly related to the combination of aptitude categories. The aptitude categories of cognitive ability, perceptual-motor coordination and perceptual ability were significant univariately, when adjusted for the other aptitude categories. After the poor predictors were excluded, the combination of unilateral motor ability, perceptual-motor ability, and cognitive ability categories were significantly related to mean production piece rate. Unilateral motor ability was a significant adjusted univariate predictor of performance on the Handwiring task.

Subjects demonstrated improvement in their performance over time on task. However, the rate of improvement was not significant. Lack of significant improvement suggests that the mean production piece rates of each subject are valid for comparison to the industry standard and that the mean production rate is an appropriate measure for determination of each subject's level of experienced production. There was an inverse relationship between cognitive ability and level of improvement.
DEDICATION

In memory of:

OPIE WASHINGTON CLANCY

and

FRANK E. HUSTMYER, JR.
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   Melinda Hegarty

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   John Reardon

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INTRODUCTION

The purpose of this study was to determine the relationship between performance on Career Evaluation Systems' (CES) test batteries (Botterbusch, 1984) and performance on production tasks at CCAR Industries' Manufacturing Plant. Analyses were conducted with worker improvement and production rate as the criterion variables and aptitude category scores as predictors.

CES has developed test batteries to determine occupational potential. Combinations of similar and different tests were developed for use with different populations: the series 100 Career View system for the average and above average normal adult population, the series 200 VocScan system for persons with physical difficulties that would limit job opportunities, the series 230 VocScan system for the low literate population with or without physical disabilities and the series 300 Job Support system for use by agencies serving individuals with mental retardation (Graham, 1989; Williamson, 1988).

The conceptual basis of the test batteries was developed from Fleishman's factor analytic studies of psychomotor performance (Williamson, 1988). Fleishman was responsible for developing testing procedures to select pilots for the United States Air Force (Fleishman, 1954, 1958, 1972, 1975; Fleishman & Hemple, 1956). From this
research he began to develop a taxonomy of human performance (Fleishman, 1975). He hoped to classify different abilities to account for differences among individual’s psychomotor performance. The goal was to produce a limited number of abilities that could be used to meaningfully describe performance in many psychomotor tasks.

Factor analytic techniques were applied to intercorrelations of tasks to more precisely determine common sources of variance over a wide variety of tasks. The factor analysis technique was used, because it reduces the number of abilities required to describe variance in many different psychomotor tasks. Fleishman conducted research to describe aptitudes that could be used to develop objective, reliable and valid aptitude tests in the psychomotor area (Fleishman, 1954). In a 1954 study, he described his factor analysis of a battery of 38 apparatus and printed psychomotor tests. He tested the tenability of the factors, attempted to reduce general factors into more specific factors and examined the extent to which the specific factors accounted for variance in complex psychomotor tasks. He also investigated the utility of printed tests to reproduce specific factors previously requiring apparatus tests. Ten factors emerged from the study: Wrist-Finger Speed, "rapid wrist flexing and finger movements" (p. 449); Finger Dexterity, "the ability to coordinate finger movements in performing fine
manipulations" (p. 449); Rate of Arm Movement, "the speed with which rather gross arm movements can be made" (p. 450); Aiming, "the ability to perform quickly and precisely a series of accurately directed movements requiring eye-hand coordination" (p. 450); Arm-Hand Steadiness, "precise, accurate arm-hand movements...which minimize strength and speed" (p. 451); Reaction Time, "the speed with which an individual can react to a stimulus when it appears" (p. 451); Manual Dexterity, "the ability to make skillful arm-hand movements" (p. 451); Psychomotor Speed, "is best defined by two printed tests which emphasize simply speed of marking an answer sheet" (p. 451); Psychomotor Coordination, "representing either coordination of the large muscles of the body, in movements of moderate scope, or coordination of such movements with the perception of visual stimulus" (p. 451-52); and Spatial Relations, "the ability to relate different responses to different stimuli where either stimuli or responses are arranged in spatial order" (p. 452).

In 1956, Fleishman and Hempel conducted a study to investigate and clarify psychomotor factors from previous studies. Fleishman and Hempel analyzed sixteen apparatus and seven printed tests used by the Air Force and Navy during personnel selection. The printed tests were included to determine the efficacy of their use as alternatives to the apparatus tests. The following factors emerged:
Psychomotor Coordination-I, "this factor is interpreted as representing the ability to control muscular movements involved in making fine, accurate adjustments." (p. 100); Psychomotor Coordination-II, "This factor appears to involve coordination between muscle groups in making more gross adjustments, where the use of more than one body member is required." (p. 100); Spatial Relations-I, "the interpretation of the spatial relations of the stimuli before the proper response can be determined." (p. 100); Spatial Relations-II, "This factor appears to represent the abilities to make rapid discriminations as to directions of motion." (p. 101); Integration, "This factor involves the ability to utilize and coordinate a number of disparate cues and activities quickly and accurately in order to produce an appropriate integrated response." (p. 102); Rate Control, "to make anticipatory adjustments relative to changes in speed and direction of a continuously moving object." (p. 102); Peceptual Speed, "This factor involves facility in making rapid comparisons of visual forms and the notation of similarities and differences in form and detail." (p. 102); Manual Dexterity, "involving skillful, well-directed arm-hand movements." (p. 103); and Visualization, "the ability to make mental manipulations of visual images." (p. 103).

The results of the Fleisher and Hempel study showed that certain psychomotor factors could be measured by
printed tests. Perceptual speed was in fact confined to printed tests. Four of the factors could be identified by both printed and apparatus tests. Fleishman and Hempel concluded that:

Contrary to previous belief that motor skills are narrow in scope and highly specific to the task, the present results confirm that there are certain broad group factors of psychomotor skill which may account for performance on a wide variety of different psychomotor tasks (p. 104).

In 1958, Fleishman conducted a study to develop separate factors under the category of movement reactions. He felt that the movement reactions class of psychomotor skills was the most important in accounting for individual differences in complex skills. The objectives of the analysis were to replicate previous studies, obtain more precise definitions of the factors and to study the relationship of factors to complex tasks under different levels of difficulty.

The following factors were identified under the movement reactions category: Response Orientation, "involving rapid directional discrimination and orientation of movement patterns" (p. 449); Fine Control Sensitivity, "the ability to make fine highly controlled (but not overcontrolled) adjustments at some critical stage of performance" (p. 449); Reaction Time, "the speed with which
S can react to a stimulus when it appears" (p. 450); Speed of Arm Movement, "the speed with which S can make a gross, discrete arm movement" (p. 450); Arm-Hand Steadiness, "the ability to make precise and steady arm-hand movements of the type which minimize strength and speed" (p. 450); Multilimb Coordination, "simultaneous manipulation of multiple limbs" (p. 451); and Rate Control, "to make anticipatory adjustments relative to changes in speed and/or direction of a constantly moving object" (p. 451). The results of the study showed that movement reactions could be more precisely defined.

Fleishman (1972) attempted to link the concepts and methods of basic and applied psychology. He reviewed the literature related to aptitude measurement, learning, training and human task performance. He wanted to show that complex human behavior could be understood by using combinations of experimental and correlational methods. Factor-analysis and correlational studies have provided the empirical basis for categorization of human skills. Ability is a general capacity of an individual, whereas skill involves proficiency on a specific task. Fleishman's research indicates that abilities can be used to describe and/or predict performance in complex skill activities. The greater the broad abilities, the greater should be the complex skill performance and vice versa: "The assumption is that the skills involved in complex activities can be
described in terms of the more basic abilities" (p. 1018).

Fleishman's research technique consisted of giving several hundred subjects batteries of tests and examining the resulting correlation patterns. New task variations were added in an attempt to more clearly define the ability factors postulated. The purpose was to define the most useful and meaningful ability categories to describe variance in a wide variety of tasks.

Common variance can be described by eleven perceptual-motor factors and nine physical proficiency factors that consistently emerged from Fleishman's studies. The following is a list of the perceptual-motor factors and the instruments that have the purest loading of each factor:

- Multilimb Coordination, "ability to coordinate the movements of a number of limbs simultaneously, in operating controls...(test: Complex Coordinator)" (p. 1019);
- Control Precision, "common to tasks that require highly controlled and precise muscular adjustments of controls where larger muscle groups are involved, extending to arm-hand as well as to leg movements...(test: Rotary Pursuit)" (p. 1019);
- Response Orientation, "general to tasks requiring rapid selection of controls to be moved or directions to move them in...(test: Choice Reaction Time)" (p. 1019);
- Reaction Time, "speed with which the individual is able to respond to a stimulus when it appears...(test: Visual or Auditory Reaction Time)" (p. 1019);
- Speed of Arm Movement,
"represents simply the speed with which an individual can make gross, discrete arm movement; accuracy is not required (test: Two-Plate Tapping Test)" (p. 1019); Rate Control, "involves the precise timing of continuous responses relative to changes in speed and direction of a continuously moving target or object (test: Single Dimension Pursuitmeter)" (p.1019); Manual Dexterity, "skillful, well-directed arm-hand movements are involved in manipulating fairly large objects under speed conditions (test: Minnesota Rate of Manipulation)" (p. 1019); Finger Dexterity, "ability to make skillful, controlled manipulations of tiny objects involving primarily the fingers (test: Purdue Pegboard)" (p. 1019-20); Arm-Hand Steadiness, "ability to make precise arm-hand positioning movements where strength and speed are minimized...(test: Track Tracing)" (p. 1020); Wrist Finger Speed, "requires rapid tapping of the pencil in relatively large areas (test: number of taps in large circles)" (p. 1020); and Aiming, "best measured by highly speeded printed tests requiring dotting a series of small circles (test: dotting in circles less than 1/4 inch in diameter)" (p.1020).

Fleishman also conducted extensive studies into the area of motor performance frequently designated as physical proficiency (Fleishman, 1964a, 1964b, cited in Fleishman, 1972). The following factors account for performance in over 100 physical fitness tasks that were investigated, the
factors, brief definitions and tests are as follows: Static Strength, "maximum force that can be exerted against external objects (lifting weights, dynamometer tests)" (p. 1020); Dynamic Strength, "muscular endurance in exerting force continuously or repeatedly; the power of the muscles to propel, support, or move one's body over time (e.g., pull-ups)" (p. 1020); Explosive Strength, "ability to mobilize energy effectively for bursts of muscular effort (e.g., sprints, jumps)" (p. 1020); Trunk Strength, "limited dynamic strength specific to trunk muscles (e.g., leg lifts or sit-ups)" (p. 1020); Extent Flexibility, "ability to flex or stretch trunk and back muscles (twist and touch test)" (p. 1020); Dynamic Flexibility, "ability to make repeated, rapid, flexing trunk movements; resistance of muscles in recovering from strain (rapid repeated bending over and floor touching test)" (p. 1020); Gross Body Coordination, "ability to coordinate action of several parts of the body while body is in motion (cable jump test)" (p. 1020); Gross Body Equilibrium, "ability to maintain balance with nonvisual cues (rail walk test)" (p. 1020); and Stamina, "capacity to sustain maximum effort requiring cardiovascular exertion (600-yard run-walk)" (p. 1020).

Several findings with regard to the abilities involved at different levels of practice or stages of learning, related to performance and prediction of those abilities to describe complex skill performance, were discovered
Fleishman's taxonomy of human performance is particularly useful in vocational evaluation, because it is applicable to tasks encountered in "real world" job applications. It was found that the relative weighting of abilities involved in performance changes as practice on a task increases. The changes are systematic and progressive and eventually stabilize.

In tasks that are described as perceptual-motor, non-motor abilities such as spatial and verbal factors are important in early acquisition, but their importance decreases as a function of practice when compared to motor abilities. As a function of practice, the factor specific to the task increases when compared to other factors. For example, verbal and spatial ability measures are better predictors of initial task performance, and motor abilities are better predictors at advanced proficiency levels on particular motor tasks. These findings have been replicated in the areas of job simulations, actual job situations and tests that predict job performance (Fleishman & Fruchter, 1960; Ghiselli & Haire, 1960, cited in Fleishman, 1972). Performance on a task is more closely associated with different aptitudes at different levels of practice.

The change in factor importance for task performance prediction has significant implications for professionals involved in predicting task performance. Evaluators must be aware of the different abilities' relative weighting to
accurately predict final skill proficiency and proficiency during training. The importance of this will be discussed later as it relates to prediction of subject performance in workshop settings. One example would be that evaluators and trainers should concentrate on developing abilities required for final proficiency, rather than abilities for initial acquisition during training periods, to increase final productivity.

Marc Gold (1973) studied the relationship between IQ and performance capability. Studies with the mentally retarded found that IQ was related to acquisition, but not to final production. Acquisition and production were defined as "the process of learning a task to some criterion of errorless performance. Errors during acquisition are interpreted as an indication that the task has not been learned. Production is defined as performance following acquisition, where rate is the primary measure" (p. 41).

Gold found a statistically non-significant relationship between IQ and final production and a non-significant relationship between acquisition and production. The results suggest that IQ is a poor predictor of individual performance capability (Gold, 1972, 1973).

Gold's studies with the mentally retarded were consistent with Fleishman's studies of the normal population. Both suggest that different factors account for production speed at different levels of task experience.
Thus, tests that are significantly correlated with production or performance during learning may not be significantly correlated with production after an individual is experienced at a task (Fleishman, 1972, 1975; Gold, 1972, 1973).

Brickley (1982) studied the relationship between IQ, dexterity tests and the Bender Gestalt with task performance using subjects with mental-retardation. Task performance was separated into acquisition, intital performance and experienced performance conditions. He noted that Fleishman and Gold found that intital task performance was significantly related to nonmotor factors. These factors were spatial orientation, visualization, mechanical experience and perceptual speed. Experienced performance was significantly related to motor factors. Thus, Brickley hypothesised that perceptual motor and dexterity tests should predict intial performance, while dexterity tests should be significantly correlated with experienced performance. It is assumed that the results of the dexterity tests used for prediction are not contaminated with nonmotor factors.

The results showed that correlations between dexterity and performance increased with experience on task. Correlations of IQ and the Bender Gestalt with performance decreased with experience on task. The correlation for dexterity with early speed was .62, while it was .91 for
later speed.

The Brickley and Gold studies show that the relationship between task performance and dexterity tests function similarly with normal and retarded populations. They also suggest that motor and nonmotor factors function similarly regardless of IQ (Brickley, 1982; Gold, 1972, 1973).

Sheltered workshops have traditionally used a work sample approach for prediction of subsequent performance. Since it has been shown that initial performance is not a good indicator of experienced performance, short work sample approaches that do not assess experienced performance are limited measures of an individual's capacity to perform on a task (Chan, Parker, Carter & Lam, 1986). Static measures of performance may lead to underestimations of a subject's performance potential. In the short work sample approach, a subject's performance at the acquisition phase is compared to performance of experienced competitively employed workers. Given the aforementioned research, it doesn't appear to be a proficient method of evaluation. Given that individuals with mental retardation have longer acquisition periods due to lower nonmotor abilities, it seems even less suited as a method of prediction in the sheltered workshop setting.

Blakemore and Coker (1982) demonstrated the magnitude of the practice effect with mentally retarded workers. Twenty sheltered workshop clients performed a eye-hand-foot
coordination task. During initial practice, only one subject performed at the industrial standard. After five days of working six hours per day, eleven subjects met or exceeded the industrial standard. Average improvement for all subjects was 30.7%. All subjects improved in performance rate. There was a rapid increase in speed during the first three days, with rates stabilizing in days four and five. If only the first day's performance had been used to determine future performance, based on meeting the industrial standard, then none of the subjects would have qualified to perform the task. The study shows that static one time trials on complex tasks will underestimate a subject's potential performance (cited in Chan, Parker, Carter & Lam, 1986). "It may be grossly unfair to compare the one time performance of relatively inexperienced vocational evaluation clients directly with performance of well practiced industrial workers" (Chan, Parker, Carter & Lam, 1986, p. 97).

To further illustrate this point, Chan, Parker, Carter and Lam (1986) had 30 sheltered workshop subjects perform an electrical assembly task. During acquisition, none of the sheltered workshop subjects could perform at the industrial standard. After 5 days, 4 of the 30 met or exceeded the industrial standard. Average improvement was 40.7%.

The five days required for experienced performance is impractical in the context of most vocational evaluation
situations due to the amount of staff time required and economic pressure. Also, most evaluators and sponsors prefer short-term assessment techniques (Botterbusch, 1983, cited in Lam, Chan & Thorpe, 1988).

The logical flaw in the short work sample approach is simple; traditional techniques of static job sample performance assume that performance is stable over time. That assumption is incompatible with what is now known about acquisition and practice effects. Thus, static measures underestimate the production potential of the disabled and are not valid predictors of such (Chan, Parker, Carter & Lam, 1986).

A more appropriate approach would be to allow vocational evaluation clients to practice a task for the amount of time required to achieve their maximum proficiency and compare that rate to the industrial norm. Even short periods of practice can improve performance. Lam, Chan and Thorpe (1988) demonstrated that 10 minutes of practice on a finger dexterity task had a significant performance effect. They suggest that practice should be allowed on tasks prior to comparing the results to industrial norms. The aforementioned studies demonstrate that Fleishman’s principles are applicable to individuals with mental retardation and that different factors account for an individual’s performance during different levels of task practice.
Prediction of worker performance is an inherent aspect of vocation evaluation (Lam, Chan & Thorpe, 1988). Hester (1969, cited by Graham, 1989) began applying Fleishman’s principles at Goodwill Industries of Chicago for the prediction of vocation potential with disabled employees. In the late 60’s, Hester became dissatisfied with the work sample approach for the following reasons: specificity to the task being sampled; complications of training time; poor research results; lack of information provided with regard to aptitude identification; and repeated testing discouraged subjects and thus lowered validity.

Throughout Hester’s testing it was observed that many job samples required the same aptitudes. If a subject had poor eye-hand coordination, then the subject tended to do poorly on all tasks that required the aptitude. He observed that different jobs required different amounts and combinations of aptitudes. Using Fleishman’s factor analysis approach, Hester analyzed many different jobs and job samples. He began to identify and isolate factors required for successful performance and developed valid ways to measure them. Through this process, Hester developed and identified testing instruments that were required to measure the observed factors. By the early 70’s, Hester had identified 28 aptitudes and selected tests that could measure them.

CES, with Hester's assistance, refined many of his
original instruments. Many of the tests were not developed by CES or Hester, but were selected from nationally known test publishers (Graham, 1989; Williamson, 1988). The following is a brief description of the tests and the aptitudes/abilities they purport to measure: Purdue Pegboard, finger dexterity; Tapping Board, wrist-finger speed; Hole Steadiness Plate, arm-hand steadiness; Minnesota Manual Dexterity Test, manual dexterity; Two-Arm Coordination Test, two-arm coordination; Etch-A-Sketch with Maze Overlay, two-hand coordination; Hand-Tool Dexterity Test, hand-tool dexterity as well as general bilateral motor ability; Foot-Operated Stapler, multilimb coordination; Paper Feeder, machine feeding; Electro Tach, perceptual speed; Depth Perception, depth perception from binocular and monocular cues (this test is not given at CCAR Industries); Hole Steadiness Plate--Aiming, aiming ability; Multi-Choice Reaction Time, reaction time and response orientation; Polar Pursuit Tracker, fine perceptual coordination; Mirror Tracing Apparatus, visual motor reversal; Oral Directions Test, ability to follow oral directions; Hand Dynamometer, hand strength; Lifting Platform, ability to lift; Revised Minnesota Paper Form Board Test, spatial perception; Raven's Standard Progressive--Sets A, B, C, D, E, specific abstract reasoning; Gates-MacGintie Reading Test, reading comprehension; Wide Range Achievement Test--Revised (Level 2), arithmetic skills; Similarities, perceptual accuracy;
SRA Verbal, verbal reasoning; Gates-MacGintie, reading ability; IPAT CAB-C’s Decision Speed, decision speed; IPAT CAB-Cf Hidden Designs, response orientation; SRA Leadership Opinion Questionnaire, leadership; SRA Sales Attitude Checklist, sales attitude. A full explanation of administration and scoring procedures can be found in the CES testing manual (Botterbusch, 1984).

The next stage was to develop a method to evaluate the aptitude measurements to predict performance on a variety of employment options. CES developed computer software that relates aptitudes to job criteria as listed in the Department of Labor’s (DOL) Dictionary of Occupational Titles (DOT) (Graham, 1984, 1989). The DOT uses a behavior description approach to describe worker functions in terms of people-negotiating, data-analyzing, and things-handling. This approach was developed by Fine (Fleishman, 1975). Each category ranges from simple to complex criteria. Data-analyzing involves information, knowledge, ideas and concepts. People-negotiating involves interaction with human beings or animals. Things-handling involves materials, machines, equipment and products (U.S. Department of Labor, 1977, cited in Graham, 1984, 1989). CES’s software produces specific job potentials from measured aptitudes and provides a list of jobs from the DOT that are compatible with the measured aptitudes as they relate to the Data, People and Things categories (Graham, 1984, 1989;
Botterbusch, 1984).

CES has conducted extensive research into the psychometric properties of its tests and batteries (Graham, 1989). The most critical element of evaluation and testing systems is reliability (Brown, 1980, cited in Graham 1984, 1989). In a 1979 study, the test-retest reliabilities of all the CES tests were from .72 to .95. The retest period was from four to six weeks. Seventy-eight percent of the job families were the same for the two testings. The results demonstrated a slight increase in ability scores from the first to second testing (Hester, 1979, cited in Graham, 1984, 1989). This increase is consistent with the effects of practice cited previously. Individual test reliabilities and other psychometric properties can be found in the individual test’s manuals (Bottenbusch, 1984; Graham, 1989).

CES has established construct validity through the technique of factor analysis (Graham, 1989). A recent study of the Career View battery revealed that out of 253 correlation pairs, only 15 were greater than .50; a majority of the correlations were less than .25. Of 605 correlation pairs on the VocScan only 12 were greater than .50; 80% were under .25 (Graham, 1989). A correlation of .25 represents less than 6% related variance. Correlations of .50 are considered to be sufficiently independent to be included in test batteries by most factor analysts.
(Williamson, 1989). Thus, the individual tests measure independent aptitudes that are both logically and mathematically separate and distinct.

Predictive validity refers to "how well scores on the test are related to some other performance" (Graham, 1989, p. 5). A 1985 study conducted by CES showed that of 26 persons placed, 24 were currently employed in a position from their individually generated job list (Graham, 1989). The length of time for successful employment was not listed. A 1983 study revealed that 30 individuals placed at jobs from their CES printout were all successfully employed after 11 months. Other informal studies and reports from system users consistently report high levels of user satisfaction (Graham, 1989).

CES uses criterion-referenced score interpretation. The process of deriving criterion-referenced test scores consists of obtaining test scores, obtaining criterion scores, determining the relationship between test and criterion scores, then expressing the scores in such a manner that the test scores can be interpreted in terms of expected criterion performance (Pophim, 1978, cited in Graham, 1984, p. 12).

CES derived its criterion-referenced standards from the DOL's DOT's Data, People and Things scale. The relationship between job requirements and test performance is direct (Graham, 1989).
Criterion-referenced tests are recommended by the Equal Employment Opportunity Commission (EEOC) to guard against norming bias. Many widely used vocational evaluation instruments are based on norming (Owing & Siefker, 1991). Owing and Siefker (1991) recommend criterion-referenced vocational evaluation instruments to guard against violation of EEOC guidelines, decrease possible discriminatory predictions and increase the validity of predicted vocational potential.

Nationally normed vocational evaluation instruments will often score individuals with disabilities beneath the mean. The Americans with Disabilities Act and the Civic Rights Act of 1991 require criterion-referenced standards in the selection of applicants for employment (Cusick & Fafrak, 1992). Norms can be helpful if used in the proper context. Cusick and Fafrak (1992) recommend that evaluators develop local norms to allow for comparison of clients with similar disabilities. "Local" means relative to the setting in which the norms are used.

There are several advantages to using local norms. Local norms are generally more homogeneous than national norms. Past performance by individuals with similar disabilities can be used to determine prediction outcomes of similar individuals. Programming can be developed to improve service to targeted populations. Critical cut off levels can be set to aid in prediction of vocational
outcome. In effect, local, criterion-referenced standards can be established. It is important to use the norms within the populations and environments in which they are developed (Elliot & Bresting, 1980, cited in Cusick & Fafrak, 1992).

CCAR Industries' Manufacturing Plant has been certified by the Commission for the Accreditation of Rehabilitation Facilities as a qualified sheltered workshop. A sheltered workshop is:

- a charitable organization or institution conducted not for profit, but for the purpose of carrying out a recognized rehabilitation program for handicapped workers, and/or providing such individuals with remunerative employment or other occupational rehabilitative activity of an educational or therapeutic nature (U.S. Department of Labor, cited in Bellamy, Rhodes, Bourbeau & Mank, 1986, p. 260, cited in Schuster, 1990, p. 233).

CCAR Industries' Manufacturing Plant provides vocational training for adults with developmental disabilities, physical handicaps or those who are otherwise vocationally handicapped and reside in the Illinois counties of Coles, Cumberland or Douglas (CCAR Industries, 1993). The program also provides vocational evaluation, job coaching, janitorial skills training, sheltered employment and community job placement.
The definition of vocational disability has generated substantial debate (Stewart, Chubon & Ososkie, 1988). CCAR Industries follows the guidelines set forth by the Department of Rehabilitation Services and the Illinois Department of Mental Health and Developmental Disabilities in providing evaluation services. Vocational evaluations are usually conducted over two to four week periods. The CES batteries, work samples, interest inventories, professional observations and additional evaluative instruments are used to determine occupational potential and answer specific questions regarding an individual's vocational potential.

A wide variety of production tasks are performed at the manufacturing plant. The work is performed concurrent with and after the evaluation process. The work ranges from simple application of adhesive labels to complex metal working. Some of the production jobs include: assembling flashlight reflectors, lens rings and headbands; pouring paraffine molds for graphite casting; wire and fibre cutting; machine looping and tipping; application of price and UPC labels, wire stripping, clipping and welding.

Production is calculated by piece rate. Piece rate is determined by calculating the number of units completed, divided by the product of hours worked and standard units per hour (industrial standard). An individual's piece rate on tasks is significant for several reasons. Payment for
most production tasks is determined by piece rate. Extended employee status is determined by exceeding a minimum overall piece rate. High piece rate is often used as an indicator that an individual is ready for competitive employment.

Preference for available work is generally assigned to individuals who have the highest piece rate on a given task. At present, a reliable method has not been established to determine which production tasks a program participant would be able to perform successfully given his/her CES test scores. Professional judgement and work samples are the primary methods used to determine which tasks a program participant could or will be allowed to perform. A participant is often tested on a variety of tasks for a short period of time until a task is found that the individual is able to perform successfully.

Tasks performed at the manufacturing plant do not appear on the CES generated job list printout. In essence, the full capacity of the evaluative instruments, including the CES, have not been empirically tested to determine their usefulness with regard to prediction of success on manufacturing plant production tasks. In many ways, the selection procedure for participant task placement currently used has many of the drawbacks that inspired Hester to develop the system the CCAR Industries currently uses. The limitations of the short worksample approach have been thoroughly discussed previously. Short amounts of time on
task are not valid predictors of performance potential. Individuals with high non-motor abilities may be given preference to work particular jobs due to fast initial acquisition but not long term potential for success.

Substantial staff time and training are required to teach many individuals tasks they may or may not have the necessary aptitudes to perform. Little insight into most factors required for a task is obtained seems to be obtained. Consequently, training in those areas is not adequately concentrated on and developed. Given the current growth of opinion concerning the financial and philosophical liabilities of sheltered workshops, it is important to have valid and empirically tested procedures for improving participant production and selection procedures (Schuster, 1990).

In summary, the purpose of this study was to determine if any relationship exists between performance on manufacturing plant production tasks and measured aptitude categories of the CES. This is important for several reasons. If relationships are found, then production could be increased. This would occur through appropriate worker placement, allowing staff to determine if initial speed or long term success is required for a particular contract. It would increase client satisfaction through increased performance and salary, decrease staff time spent on training individuals for tasks that they do not have the
required aptitudes to perform, allow for development of local norms and criterion-referenced standards, aid in the isolation of the most important factors required for particular tasks, and aid in determining which factors need to be concentrated on and developed for long term success.
METHOD

Subjects

The subjects were 112 CCAR Industries' clients who were administered Career Evaluation Systems' test battery during vocational evaluations at CCAR Industries' Manufacturing Plant between 1986 and 1992. Two subjects were administered the Career View system, 54 were administered the VocScan system, and 56 were administered the Job Support system. Fifty-three subjects did not meet the criteria for inclusion in the final analysis due to not performing at least five months on the selected production tasks.

Fifty-nine subjects met the criteria for inclusion in the final analysis. One was administered the Career View system, 23 were administered the VocScan system, and 35 were administered the Job Support system. The number of subjects who performed the selected production tasks were: MTS-9 Paste Up Fixture (n = 39), MTS-14 Handwire (n = 46), and MTS-16 Machine Tipping (n = 21). There were 34 Caucasian males, 22 Caucasian females, 2 African American females, and 1 listed as Other male. Ages ranged from 18 to 54 years with a mean age of 26 years.

Instruments

All subjects were administered Career Evaluation Systems' (CES) test batteries. This battery is a standardized vocational aptitude instrument employing
various mechanical apparatus and paper and pencil tests.
The subscales resulted from factor analytic techniques and
their development has been reviewed previously. Rationale,
description, norms, testing apparatus, administration and
scoring procedures are described in the CES testing manual
(Botterbusch, 1984) and The Official User's Manual for the
(Graham, 1989).

Procedure

Test battery results were collected from vocational
evaluation files. Each subject was issued an identification
number by the chronological order of evaluation and
administration. An exhaustive review of each subject's
payroll reports was conducted, and all production tasks were
transferred to a matrix representing production tasks
performed by each subject. Over 70 production tasks were
represented. Most subjects performed several tasks. The
range of production tasks performed by each subject was from
0 to 39. The number of subjects performing each task ranged
from 1 to 73.

To provide adequate sample size for analysis, all
production tasks with less than 40 subjects were eliminated.
Six production tasks had 40 or more subjects. The tasks and
the number of subjects who performed each task were as
follows: MTS-9 Paste up Fixture (n = 73), MTS-14 Handwire
(n = 82), MTS-17 Roll Bag Form (n = 59), MTS-16 Machine
Piece rates were compiled from each subject's monthly payroll reports and recorded by subject, month, and selected production task. To examine improvement of subject performance over a reasonable time period, only the jobs that a subject performed for at least five months were included in the analysis. The distribution of subjects with five or more months performed per task was as follows: MTS-9 Paste up Fixture (n = 39), MTS-14 Handwire (n = 46), MTS-17 Roll Bag Form (n = 12), MTS-16 Machine Tipping (n = 21), MTS-5 Bag Form Zip-lock (n = 3), and Apply 1 UPC Label (n = 6). Since subject's piece rates tended to stabilize by the end of one year, a maximum of twelve months of production for each subject per task was compiled. MTS-17 Roll Bag Form, MTS-5 Bag Form Zip-lock, and Apply 1 UPS label were discarded due to insufficient sample size.

Data Analysis

The criterion measures of worker performance included both rate of improvement in production as measured by piece rate change over employment history and mean piece rate. Piece rate is a percentage of the industrial standard calculated as follows: number of units completed, divided by the product of hours worked and standard units per hour (industrial standard). For example, if the standard units per hour is 100 and a subject works for 1 hour and completes
50 units, then his/her piece rate would be .50, i.e. 50 divided by the product of 1 x 100 = .50, if 75 units were produced, the piece rate would be .75, 125 units would result in 1.25 or 50%, 75%, and 125% of the industrial standard.

The first month that a subject performed a task was recorded as month 1, the second month that a subject performed a task was recorded as month 2 and so on, regardless of whether or not the actual calendar months were consecutive. Regression slope coefficient over months on the task and mean piece rate over months on the task were calculated for each worker on the 3 selected jobs. The number of subjects who showed significant improvement on the production tasks were as follows: Paste Up Fixture (n = 4), Handwire (n = 11), and Machine Tipping (n = 7).

The predictors in this study were factors on the CES. Only factors sampled by instruments common to all the CES batteries were included for comparison in the analysis. The instruments that sample the individual factors (aptitudes) were grouped into broader aptitude categories suggested by CES (Botterbusch, 1984) to reduce the number of predictors due to the restricted sample size. The experimenter combined the CES aptitude categories of intelligence and achievement/ability to form the aptitude category of cognitive ability. This resulted in six aptitude categories. Unilateral Motor Ability (UMA) included the

The subject's raw score on each instrument was converted to a C-score ($m = 5$, $s = 2$) from the 200/230 series norms. If there were multiple raw scores for a particular factor, they were combined following the formulas listed in Graham, 1989. The factors (aptitudes) C-scores were averaged to obtain each aptitude category C-score. An SPSS data file was created by entering each subject's identification number, regression slope coefficient, mean piece rate of each task performed, and C-score for each aptitude category.

**Results**

A multivariate analysis of the criterion scores (regression slope coefficient and mean piece rate of
production) with the predictors (cognitive ability, lifting ability, perceptual-motor coordination, perceptual ability, bilateral motor ability, and unilateral ability) was not significant for MTS-9 Paste Up Fixture, \( F(12, 60) = 1.82929, p > .05 \), MTS-14 Handwire, \( F(12, 72) = .69651, p > .05 \), or MTS-16 Machine Tipping, \( F(12, 24) = .97933, p > .05 \). See Table 1 for descriptive statistics of the variables.

A Pearson correlational analysis was performed between all variables. Mean piece rate of MTS-9 Paste Up Fixture (MJ1) was significantly related to unilateral motor ability, \( r = .3853, p < .05 \), two-tailed, and perceptual-motor coordination, \( r = .3908, p < .05 \), two-tailed. There were no other significant relationships of regression slope coefficient or mean piece rate of production with aptitude categories. See Table 2 for correlation coefficients of the variables.

A backward stepwise multiple regression analysis was performed for each production task. The criterion measures were regression slope coefficient over months on the job and mean piece rate of production over months on the job. The six aptitude categories were used as predictors for the analysis. Initial regression was computed with all aptitude category scores entered into the equation. At each subsequent step the aptitude category with the largest adjusted univariate significance value (i.e., least
significant contributor to regresional effect) was discarded from the regression equation. The criterion for exclusion was set at an alpha level equal to .5, and the regression analysis continued discarding predictors until there were no more aptitude categories with a probability value greater than .5.

**Job #1 Paste Up Fixture**

The regression slope coefficient of Paste Up Fixture (BJ1) was initially significantly related to the combination of aptitudes, $R = .56, F(6, 32) = 2.42, p < .05$. The aptitude categories of cognitive ability, perceptual-motor coordination and perceptual ability were significant univariately when adjusted for the other aptitude categories: cognitive ability, $t = -2.76, p < .01$; perceptual-motor coordination, $t = 2.01, p = .05$; perceptual ability, $t = 2.37, p = .02$. After the aptitude category of unilateral motor ability was excluded, the value of $F$ improved slightly, $F(5, 33) = 2.98$.

The mean production piece rate for Paste Up Fixture (MJ1) was initially not significantly related to the combination of aptitudes, $R = .48$. None of the adjusted aptitudes were univariately significant. After bilateral motor ability, perceptual ability and lifting ability were excluded, the remaining combination of aptitude categories (unilateral motor ability, perceptual-motor coordination, and cognitive ability) was significantly related to MJ1, $R =$
.47, \( F(3, 35) = 3.28, p = .03 \).

Job #2 Handwire

The regression slope coefficient of Handwire (BJ2) was not significantly related to the combination of aptitude categories initially, \( R = .29, \ p > .05 \), or after the high \( p \) predictors were excluded. None of the adjusted predictors were univariately significant initially or after the high \( p \) predictors were excluded at alpha .05.

The mean production piece rate for Handwire (MJ2) was not significantly related to the combination of aptitude categories either initially, \( R = .36, \) or after the high \( p \) predictors were excluded, \( R = .35, \) at alpha .05. Unilateral motor ability was a significant adjusted univariate predictor of performance, \( t = 2.09, \ p < .05, \) initially and after the high \( p \) predictors were excluded.

Job #4 Machine Tipping

The regression slope coefficient of Machine Tipping (BJ4) was not significantly related to the combination of aptitude categories either initially, \( R = .44, \) or after the high probability aptitude categories were excluded, \( R = .38, \) at alpha .05. None of the adjusted predictors were univariately significant initially or after the high \( p \) predictors were excluded, at alpha .05.

The mean production piece rate for Machine Tipping (MJ4) was not significantly related to the combination of
aptitude categories either initially, $R = .50$, or after high $p$ predictors were excluded, $R = .46$, at alpha .05. None of the adjusted predictors were univariately significant either initially or after the high $p$ predictors were excluded, at alpha .05.
DISCUSSION

The purpose of the study was to examine the relationship between performance on the Career Evaluation Systems' (CES) batteries and performance on production tasks. Performance on the production tasks was analyzed with regard to improvement and average production rates. Subjects demonstrated improvement in their performance over time on task. However, the rate of improvement was not significant. Some subjects did demonstrate significant improvement on particular tasks, but overall there were no tasks that had a significant increase in production.

Lack of significant improvement suggests that the mean production piece rates of each subject are valid for comparison to the industry standard and that the mean production rate is an appropriate rate for determination of each subject's level of experienced production. Thus, the relationship between ability categories and production rate can be thought of in terms of abilities required for experienced production, but not necessarily for early acquisition.

Fleishman (1975), Gold (1973), and Brickley (1982) found that motor and dexterity abilities are the best predictors of performance at advanced proficiency levels on motor tasks. This is consistent with the results of the analysis. Unilateral motor ability and perceptual-motor coordination were significantly correlated with production.
on the Paste Up Fixture task. Unilateral motor ability and perceptual motor ability were two of the three aptitude categories that in combination were significantly related to production on the Paste Up Fixture task in the regression analysis. Also, unilateral motor ability was univariately significant, when adjusted for the other aptitude categories, to production on the Handwire task.

Due to the production data being represented monthly and not in smaller time period increments, initial improvement when averaged with the rest of the first month's production may not have been low enough to reduce the initial month's average piece rate to show significant improvement over later months when that improvement was represented as a regression slope coefficient. Further investigation of initial rates of improvement would require that the data be represented in smaller increments during the initial month of performance on a task.

Another explanation of the lack of improvement effect could be the process of the evaluation and task selection procedure. Since subjects are tried on many tasks until they initially perform well and then are kept on that task due to their initial performance, the lack of improvement may be a reflection of workshop staff placing subjects on tasks that they had the skill to initially perform successfully. The criterion of a minimum of five months on task for inclusion in the analysis may have been a demand
characteristic for the selection of workers with initial success on the tasks, since it is unlikely that a subject would have been allowed to perform a task on which he/she was initially unsuccessful for such an extended period of time.

Although the results indicate that on average there is not a significant increase in performance over a five to twelve month period, they do not indicate that individuals do not have the capacity to improve significantly during that time. In fact, 21 subjects did show significant rates of improvement. Other factors may have had significant influence on rate of improvement.

Correlations of .50 or less are considered to be sufficiently independent to be included in test batteries by most factor analysts (Williamson, 1989). Although the individual aptitudes of the CES were combined to form aptitude categories for the analysis, only two pairs of the categories had correlations greater than .50. Thus, the majority of the aptitude categories can be thought of as separate and distinct (See Table 2).

Several of the ability categories were significantly related to production tasks. Cognitive ability, when adjusted for the other predictors, was univariately significant with regard to improvement on the Paste Up Fixture task. As rate of improvement increased, the cognitive ability score decreased. Interestingly, while
cognitive ability was not significantly related to any of the slopes in the correlational analysis, it had an inverse relationship with all of the production tasks' regression slope coefficients.

Gold (1973) found a non-significant relationship between IQ and final production. His findings are generally consistent with the results of this analysis. Cognitive ability was not univariately significant, when adjusted for the other aptitude categories, with production rates on any of the tasks. However, it was one of the three aptitude categories that in combination were significantly related to production on the Paste Up Fixture task in the regression analysis.

Lifting ability appears to be a poor predictor of performance. Although the ability category was included in the significant combination of ability categories with regard to improvement on the Paste Up Fixture task, it was not included in any other significant combinations or as an adjusted univariate factor in any of the analyses. In fact, it was excluded during the backwards stepwise regression analysis in four of the six regression formulas.

Perceptual-motor coordination was significantly related to mean production of the Paste Up Fixture task in the correlational analysis. It was also univariately significant, when adjusted for the other predictors, with regard to the regresional analysis of the Paste Up Fixture
task. Thus, the perceptual-motor coordination ability category appears to be a good predictor of performance with regard to rate of improvement on the Paste Up Fixture task.

Perceptual ability was univariately significant with improvement, when adjusted for other predictors, on the Paste up Fixture task. Thus, it appears to be a good predictor with regard to improvement on the task. However, with regard to mean production rate of the task it is not significant, in fact, it was excluded from 4 of the 6 regression equations.

Bilateral motor ability appears to be a poor predictor of improvement or average production of the tasks. It was excluded from 3 of the regression equations and was not univariately significant with any of the tasks for improvement or production.

Unilateral motor ability was significantly related to production on the Paste Up Fixture task in the correlation analysis but, paradoxically, was not univariately significant, when adjusted for the other predictors, with regard to the regression analysis of the task's production. The ability was univariately significant, when adjusted, in the regressional analysis involving improvement on the Handwiring task. Thus, unilateral motor ability appears to be a good predictor of improvement on Handwiring and was part of the significant combination of ability categories with regard to improvement and production on the Paste Up
The Paste Up Fixture task had the highest degree of associated variance with regard to the combination of ability categories. It was the only task that had a significant relationship between combinations of ability categories with improvement and production. Thus, of the three tasks, Paste Up Fixture had the greatest relationship or most explained variance by performance on the CES test batteries.

The results of the analysis have to be considered with regard to the low sample size of the production tasks. With six predictors and sample sizes of 39, 46, and 21, there are restricted degrees of freedom and a corresponding lack of power. A more informative analysis would be possible with more subjects. This, however, can only occur after more subjects have completed evaluation and performed the same production tasks for the minimum number of months. The low sample size of 21 on the Machine Tipping task may be the primary reason that no significant relationships were found. The purpose of the study was to determine the extent of the relationship between aptitudes and production task performance. However, for a more powerful analysis of the tasks to be conducted greater sample size may be required.

Summary

In summary, the following conclusions emerged from the
study. There was no significant improvement in performance over time on the production tasks. There appeared to be an inverse relationship between cognitive ability and rate of improvement. Low sample size appeared to affect power with regard to the Machine Tipping task. Paste Up Fixture had the most significant level of associated variance related to performance on the CES. Increased sample size would provide a more powerful analysis of the relationship between CES battery performance and performance on production tasks.
Table 1

Descriptive Statistics of the Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CRITERION SCORES</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paste Up Fixture</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>.54</td>
<td>2.00</td>
<td>39</td>
</tr>
<tr>
<td>m</td>
<td>29.69</td>
<td>14.19</td>
<td>39</td>
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<tr>
<td>Handwire</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>1.17</td>
<td>2.19</td>
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<tr>
<td>m</td>
<td>30.77</td>
<td>11.50</td>
<td>46</td>
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<tr>
<td>Machine Tipping</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>2.30</td>
<td>2.20</td>
<td>21</td>
</tr>
<tr>
<td>m</td>
<td>35.25</td>
<td>12.25</td>
<td>21</td>
</tr>
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<td><strong>PREDICTORS</strong></td>
<td></td>
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</tr>
<tr>
<td>UMA</td>
<td>4.47</td>
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</tr>
<tr>
<td>BMA</td>
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<td>.97</td>
<td>59</td>
</tr>
<tr>
<td>LA</td>
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</tr>
<tr>
<td>P</td>
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<tr>
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<tr>
<td>COG</td>
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<td>59</td>
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</table>

b = regression slope coefficient

m = mean production piece rate
Table 2

Correlation Coefficients of the Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>UMA</th>
<th>BMA</th>
<th>LA</th>
<th>P</th>
<th>PMC</th>
<th>COG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paste Up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
b   | .1046 | .0838 | .1445 | .2543 | .2849 | -.2119 |
m   | .3853* | .2857 | .1758 | .2561 | .3908* | .2676 |
| Handwire   |      |      |      |      |      |       |
b   | .1412 | .1014 | .0280 | .1032 | -.0313 | -.0943 |
m   | .2790 | .0705 | .0368 | .0777 | .1596 | .0650 |
| Machine    |      |      |      |      |      |       |
| Tipping    |      |      |      |      |      |       |
b   | -.1009 | -.0148 | .0959 | -.0331 | -.3442 | -.0977 |
m   | .1210 | .1415 | .3744 | -.2439 | .1704 | -.1795 |
| UMA        | 1.0000 | .5985** | .3383** | .3726** | .4633** | .4303** |
| BMA        | 1.0000 | .3185* | .3397** | .4533** | .3062* |
| LA         | 1.0000 | .0213 | .2397 | .0482 |      |
| P          | 1.0000 | .2818* | .5451** |      |
| PMC        | 1.0000 | .3218* |      |      |
| COG        | 1.0000 |      |      |      |

* - Signif. LE .05  ** - Signif. LE .01 (2-tailed)
References


