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Development of the Williams Work Estimator (W2E): A Tool for Determining the Most Effective Match between Worker Capabilities and Job Task Requirements

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DEVELOPMENT OF THE WILLIAMS WORK ESTIMATOR (W^2E):

A TOOL FOR DETERMINING THE MOST EFFECTIVE

MATCH BETWEEN WORKER CAPABILITIES

AND JOB TASK REQUIREMENTS

By

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Demographics indicate that the United States and many other industrialized nations are currently experiencing what is called the "graying" of the workforce (Hayslip & Panek, 1993). Today the majority of the workers in many companies are in the age groups of 40-44 and 45-49 years. However, by the year 2010, the largest proportion of workers will probably be in the age groups of 55-59 and 60-64 years (Ilmarinen, 1995). Thus, a growing concern of employers in the near future will be the assignment of older workers to specific job tasks and responsibilities (Williams & Crumpton, 1996) as well as other issues pertinent to the employment of older workers.

As workers age they typically experience physiological and psychological changes which must be estimated to minimize the mismatch between their capabilities and job demands as well as to prevent work related injuries such as over exertion injuries.

Early identification of declines in work ability and implementation of ergonomic interventions are key to sustaining older and more experienced workers in the workplace (Williams et al., 1996). If preventive measures are not taken, older employees are likely to experience a decline in work capacities (Ilmarinen, 1994). Therefore, reliable and valid measures of one's ability to perform physical work activities are essential for preventing work-related injuries.

Hence, the focus of this research project is to develop a diagnostic tool that can be used by employers to estimate their workers' ability to perform daily work activities. Specifically, the Williams Work Estimator (W^2E) is designed to provide information concerning workers' ability to perform physical work activities such as lifting, lowering, pushing, pulling, etc. A field research study involving 32 employees at a beer distribution warehousing facility was conducted to evaluate the following attributes of the W^2E: (a) test-retest reliability, (b) concurrent criterion validity, and (c) predictive validity.

Test-retest reliability of the W^2E was assessed using Pearson correlation coefficients. The overall correlation coefficients obtained on both the task evaluation (.64) and the self-evaluation (.58) were near minimal acceptable levels (.60 or greater) for each job task evaluated. In addition, the W^2E ranged from 50 to 100% accurate when identifying persons who had experienced a work-related injury within the past year. Findings of this research study suggest the W^2E represents a promising new tool for assessing work capability and deserves further study to improve reliability and validity.

DEDICATION

This dissertation is dedicated to the memory of my dear friend Ms. Katie Brown who fought the good fight, finished the race, and kept the faith. Wear your crown with pride Ms. Katie. I miss you!

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CHAPTER I

INTRODUCTION

The "Graying" of the Workforce

Demographic indicators have revealed a trend that suggests the American workforce will change drastically over the next decade. By the year 2010, it is projected that the largest proportion of workers will probably be in the age groups of 55-59 and 60-64 years (Ilmarinen, 1995). For a variety of reasons, such as economic and personal factors, increased longevity, and federal legislation, more individuals are remaining in the work force past traditional retirement ages (Paneck, 1997). Thus, as the current demographic trend continues, a growing concern of employers in the near future will be the assignment of older workers to specific job tasks and responsibilities (Williams & Crumpton, 1996).

Benefits of Retaining Older Workers

Older workers bring a level of knowledge and experience to the job that is often very difficult to replace. In general, older workers possess a stronger work ethic, are more serious about their work, and are highly reliable. In fact, older workers provide a base of stability that is very beneficial for training and mentoring younger personnel. The use of older workers as mentors and trainers provides two primary benefits: 1) it is an effective way to transfer knowledge and lessons of experience to young workers; and 2) it allows the mentor to avoid the physical demands of regular job assignments (Stalnaker, 1998). Thus, employers may find the benefits of retaining older employees outweigh the cost of accommodating an older workforce.

Designing for an Aging Workforce

The current demographic trends in the workforce have resulted in an increased interest in "industrial gerontology". Industrial gerontology, which is the study of aging and work, focuses on a variety of employment, working environment, retirement, and related issues pertinent to middle-aged and older workers (Hayslip & Panek& Alexander, 1986; 1987). The issues associated with designing work tasks, work activities, and work environments for older workers naturally fall into the domain of ergonomics and human factors engineering. Ergonomics is the applied science concerned with the design of products, machines, and environments to match the capabilities, limitations, and desires of people, thereby enhancing opportunities for optimizing system performance and reducing the risk of injury, illness, and discomfort (Vercruyssen et al., 1995). Similarly, human factors engineering focuses on adapting the work environment to the work force, in such areas as training, workplace design, job design and equipment design (Sterns et al., 1994). Information on the effects of age-related changes in functional abilities can be used by ergonomists and human factors professionals to determine which design changes should be made as well as successfully incorporation of design changes into the workplace. Thus, as the number of older workers increases, ergonomists and human factors professionals will be faced with the challenge of developing techniques and instruments to assess how age-related changes affect job performance.

Age, Work Ability and Job Performance

Some researchers suggest employees' performance abilities (Vercruyssen et al., 1995) are affected as a result of age-related declines in their work ability (Cremer, 1996). However, age alone may be a poor indicator of an employee's performance abilities. Kok et al.(1994) suggest satisfactory job performance depends on both the characteristics of the individual employee and the conditions of the work environment. Difficulties in job performance may occur if the employee's capabilities do not meet the job demands. If work demands exceed an employee's ability, overstrain may result; while, work demands that are lower than the worker's resources may result in understrain (Ilmarinen et.a., 1991). Therefore, it is extremely important for employers to recognize the specific abilities of employees to prevent the assignment of job tasks that are either too demanding for the employee to perform or which do not present a challenge for the employee's abilities. In addition, knowing the capabilities of older employees can help minimize the mismatch between their physical and mental capabilities and the demands of their jobs.

Assessing the Work Ability of Older Employees

To determine the extent to which employees, particularly older employees, are capable of performing specific job tasks, work capacity should be assessed and periodically monitored (Williams & Crumpton, 1997). Although much research has been conducted to assess the functional status of older persons with impairment and disability, most techniques have been developed to identify functional limitations in the dependent and frail elderly. Assessment methods for characterizing the higher end of the functional spectrum, especially those older persons that are still actively involved in the workforce, are relatively novel (Kingusa et al, 1996). Assessment tools that can be easily and readily used within industrial settings must be developed to help employers maximize the benefits of retaining older workers.

Few instruments are available for determining whether a person is physically or mentally capable of coping with the daily demands of work. However, researchers at the Finnish Institute of Occupational Health (FIOH) have conducted several studies to investigate the relationship between age and work ability. Findings of this research have led to the identification of both personal factors (such as health status and functional status) and work factors (such as work tasks demands and work environment) which affect work ability (Ilmarinen et al., 1991c; Ilmarinen, 1994, Kuomi et al, 1991). In addition, the Finnish have also developed a tool that has been used extensively in recent years to assess the work capacity of older workers in various occupations (Williams & Crumpton, 1998, 1997; Williams et al., 1997, 1996; Ilmarinen, 1996, 1995, 1994; Ilmarinen

& Tuomi, 1992; Ilmarinen et al., 1991a, 1991b, 1991c; Cremer, 1996; Eskelinen et al., 1991; Goedhard et al., 1996; Nygard et al., 1991a; Suvanto et al., 1991; Torgen et al., 1992; Tuomi et al., 1994).

The Work Ability Index (WAI)

The Work Ability Index (WAI) (Appendix A), developed by the Finnish Institute of Occupational Health (FIOH), is based on subjective estimations of work ability in relations to disease, job demands and psychological resources as well as information about illness and work absenteeism. The index is designed to provide an overall estimation of the employee's ability to perform work (Ilmarinen & Tuomi, 1992) and, according to the authors, has proven to be a suitable method for identifying early signs of decreasing work ability. The seven topics of the work ability index are illustrated in Table 1.1 (Ilmarinen & Tuomi 1992; Ilmarinen, 1995).

On the basis of participants' responses to queries about their physical, mental, and social capabilities a WAI score ranging from 7 to 49 points can be derived. The subject's work ability is then categorized as excellent (44-49 points), good (36-43 points), moderate (28-35 points) or poor (7-27 points). Once the workers who need measures of support are identified (based on the work ability category), preventive measures are determined as illustrated in Table 1.2. The work ability index can also be used to evaluate the effects of the measures implemented by re-administering the index following periodic health examinations or other types of screening procedures (Tuomi et al., 1994).

Table 1.1

Items Included in the Work Ability Index (WAI)

Item	Scale	Explanation
1. Subjective estimation of present work ability	1-10	0=very poor 10=very good
2. Subjective work ability in relation to job demands	2-10	2=very poor 10=very good
3. Number of physician diagnosed diseases	1-5	1=5 or more diseases 2=4 diseases 3=3 diseases 4= 2 diseases 5= 1 disease
4. Subjective estimation of work impairment	1-6	1= fully impaired due to disease 6 = no impairment
5. Absence due to sickness during the past year	1-5	1= 100 days or more 2= 25-99 days 3= 10-24 days 4= 1-9 days 5= 0 days
6. Own prognosis of work ability after two years	1,4,7	1 = hardly able to work 4 = not sure 7 = fairly sure
7. Psychological resources (enjoying daily tasks, activity and life spirit, optimistic about the future	1-4	1= very poor 4= very good

Table 1.2

Classification of Work Ability Index Objective Measures.

Points	Work Ability Level	Objectives of measures
44-49	Excellent	Maintain Work Ability
36-43	Good	Support Work Ability
28-35	Moderate	Improve Work Ability
7-27	Poor	Restore Work Ability

Problem Statement

Findings of the Finnish research suggest work ability is inclusive of both personal factors (such as health status and functional status) and work factors (such as work tasks demands and work environment) (Ilmarinen et al., 1991c; Ilmarinen, 1994, Kuomi et al, 1991). Based on these findings, the WAI was designed to produce a tool capable of providing an overall estimation of the employee's ability to perform work (Ilmarinen & Tuomi, 1992). Thus, the WAI allows for identification of the specific health changes that occur as a result of the aging process. However, specific information pertaining to the performance of specific work activities (i.e. lifting, pushing, pulling, reaching, etc.) is not provided in the WAI. Simply querying employees to rate their abilities in relations to the physical and mental demands of the job (item 2 of the WAI) or to provide an estimation of their work impairment (item 4 of the WAI) does not provide enough information on which to base job modification decisions. Therefore, outcome information obtained using the current version of the WAI is limited.

Research Objectives

Findings of previous research investigating the WAI as a tool for assessing work ability suggest that the questionnaire data must be supplemented by other job analysis methods before generalizations can be made and firm conclusions drawn about work capability (Williams et. al, 1997; Williams & Crumpton,1997; Williams & Crumpton, 1996). Thus, the overall goal of this project is to develop a diagnostic tool that can be used to provide information about the abilities of the worker in relation to their specific work activities. Specifically, the Williams Work Estimation (W^2E) will be designed to: 1) determine the most effective match between worker capabilities and job task requirements, and 2) provide information that will be useful in job design, job rotation and job placement as well as injury prediction.

Dissertation Outline

The following chapters provide a detailed description of the activities to be performed in this research project. Chapter 2 includes a summation of the literature that was reviewed to provide a basis for the methodology for the proposed study. The development of the W^2E is described in Chapter 3. Chapter 4 provides a discussion of the content validation evaluation of the W^2E questionnaires. A description of the experimental procedure followed in this research study is included in Chapter 5. A summation of the findings of the W^2E is presented in Chapter 6. The findings of the reliability and validity analyses are presented in Chapters 7 and 8 respectively. The final chapter contains a discussion of the inferences drawn from the study and provides suggestions for future research aimed at developing techniques to evaluate work capacity.

CHAPTER II

LITERATURE REVIEW

Introduction

The information presented in this chapter is illustrative of work relevant to the older worker functioning in the work environment. It should be noted that age-related average deterioration is accompanied by a marked increase in individual differences (Small, 1987). Thus, the changes identified in this chapter may not apply to all older workers.

Age-Related Changes in Health Status

Aging is often associated with an increase in the prevalence and incidence rate of diseases. Thus, many studies have been conducted to identify those diseases that are most prevalent among older adults. Seitsamo & Klockars (1997) explored changes in the health of aging workers that occurred from 1981 to 1992. The health of the subjects was assessed using questionnaires. The presence of diseases was based on a general question about the presence of a chronic disease, one question on the presence of impairment or injury, and also on a list of specific physician diagnosed diseases. Findings of this study revealed the prevalence of cardiovascular, musculoskeletal, respiratory, and mental diseases diagnosed by a physician increased during the 11-year follow-up.

Crimmins et al. (1999) examined time trends in the prevalence of a number of major diseases and conditions, as well as trends in the likelihood that these diseases cause inability to work using data from the National Health Interview Survey from the period of 1983-1993. Major diseases and conditions that cause disability were identified as arthritis, diabetes, mental disorders, musculoskeletal/orthopedic conditions, cerebro/cardiovascular diseases, and respiratory diseases (asthma, emphysema, and chronic bronchitis. Findings of this investigation revealed these diseases accounted for 73% of the disability in the older working-age and early retirement-age population (those 50 to 69 years of age). In addition, cerebro/cardiovascular diseases and arthritis were more prevalent than the other diseases among the participants in this study.

Tuomi et al. (1991) investigated the prevalence and incidence rates of diseases and work ability in different categories (primarily mental, physical or mixed job demands) of municipal occupations. A questionnaire which included 46 different diseases was used to study changes in the health status of 4255 employees by calculating cumulative incidence rates in 1981-1985 and prevalence rates in 1981 and 1985. The poorest health and work ability was found in jobs with primarily physical demands. In addition, diseases of the musculoskeletal system prevailed as the complaint affecting more than half of the participants followed by diseases of the cardiovascular system.

Health Status Assessment Techniques

Although health status is generally assessed by medical professionals in clinical settings, the self-rating of health has been shown to be strongly predictive of chronic disease prevalence. Eskelinen et al. (1991) investigated the relationship between the self-assessment and clinical assessment of health status and work ability. Health status was determined using the results of clinical examinations which included cardiorespiratory, musculoskeletal, and psychological measurements. While work ability was determined based on subjective estimations of work ability in relation to diseases, job demands and psychological resources using the work ability index. The results revealed the questionnaire responses on health and work ability related well with the clinically assessed factors at the group level however some divergence was detected at the individual level.

Health Risk Assessments (HRA) are assessment techniques that have found application not only in clinical medicine and health education, but also in work site-based health promotion programs. HRA techniques basically consist of three essential components. First, there is some type of measurement of personal health habits known to relate to the risk of mortality with possible supplementation by selected biomedical measurements such as height, weight, blood pressure, urinalysis, and/or blood chemistry. Second, HRAs include an estimation of personal risk of death over a defined period of time (usually the ensuing 10-year period) based on available epidemiological data. Finally, most HRAs include some type of educational message and follow-up counseling related to specific risk factors identified in the assessment procedure (DeFriese & Fielding, 1990).

The Sickness Impact Profile (SIP) (Bergner, et al., 1981) is a measure of health status that incorporates multiple dimensions. The SIP contains 136 statements which are arranged into 12 Scales: Sleep and Rest, Eating, Work, Home Management, Recreation and Pastimes, Ambulation, Mobility, Body Care and Movement, Social Interaction, Alertness Behavior, Emotional Behavior, and Communication. The statements represent adverse impacts on health in a wide range of areas including emotional, social, role and physical function. Subjects affirm statements only if they are true at the time of the SIP administration and related to his or her health. The SIP provides a global score as well as scores for two dimensions (Physical and Psychosocial). A score of zero on any component (scale, dimension, or total score) of the SIP indicates that a person has no dysfunction due to his or her health while increasing scores indicate increasing disability or decreasing health status.

The Short Form 36 Health Survey, or SF-36 (Ware & Sherbourne, 1992) is a profile health status measure that does not provide a single unified index score. The SF-36 has 36 questions about health that provide eight distinct scales as well as one item used to score “transition” in health during the previous year. The eight scales of the SF-36 include Social Functioning, Bodily Pain, Physical Functioning, Role-Physical, Role-Emotional, Mental Health, Vitality, and General Health. Responses to each question are scored from 0 (negative health) to 100 (positive health). The subscale scores of the SF-36 increase as a person's health status improves.

The Quality of Well-Being questionnaire (QWB) (Patrick et al, 1973) was developed as a measure of health status that would include utilities (preferences) for different health states. It provides a single index score, summarizing information form multiple scale components. The QWB is administered in a two part interview. In the first section, the interviewer reads a "symptom-problem complex" (SPX) list. SPX items are then assigned standard weights that rank their relative severity. The second part of the interview scores the person's level of limitation for each of three dimensions: mobility, physical activity, and social activity. The QWB scores range from 0 to 1 where 1 represents a state of "symptom free" health and 0 represents death.

Age-Related Changes in Physical Functions

Panek (1997) suggests in relation to the older worker and the work environment, the most relevant physiological changes occur in the musculoskeletal, cardiovascular and respiratory systems. Much of the decline appears to be linked with such physiological changes as the thickening of the walls of the air sacs in the lungs and the hardening of connective sheaths that surround muscles (Rybash et al., 1995). Table 2.1 lists some of the structural changes that are associated with aging and the functional effects of these structural changes (Wiswell, 1980).

Table 2.1

Physiological Declines Associated with Aging

Musculoskeletal System	
Structural Changes	**Functional Effects**
1. Muscular atrophy with decrease in both number and size of muscle fibers. 2. Neuromuscular weakness 3. Demineralization of bones 4. Decline in joint function-loss of elasticity in ligaments and cartilage 5. Degeneration and calcification on articulating surface of joint	1. Loss of muscle size 2. Decline of strength 3. Reduced range of motion 4. Reduced speed of movement 5. Joint stiffness 6. Declining neuromotor performance 7. Changes in posture 8. Frequent cramping 9. Gait characteristics affected: a. Center of gravity b. Span (height/arm length) c. Stride length, speed d. Width of stance 10. Shrinkage in height 11. Increased flexion at joints due to connective tissue change
Respiratory System	
Structural Changes	**Functional Effects**
1. Hardening of airways and support tissue 2. Degeneration of bronchi 3. Reduced elasticity and mobility of the intercostal cartilage	1. Reduced vital capacity with increased residual volume 2. Reduced O_2 diffusing capacity 3. Spinal changes lead to increased rigidity of the chest wall 4. Declining functional reserve capacity
Cardiovascular System	
Structural Changes	**Functional Effects**
1. Elastic changes in aorta and heart 2. Valvular degeneration and calcification 3. Changes in myocardium a. Delayed contractility and irritability b. Decline in oxygen consumption c. Increased fibrosis d. Appearance of lipofuscin 4. Increase in vagal control	1. A diminished cardiac reserve 2. Increased peripheral resistance 3. Reduced exercise capacity 4. Decrease in maximum coronary 5. Elevated blood pressure 6. Decreased maximal heart rate

Rybash et al. (1995) suggest one of the major reasons for a decrease in physical performance during adulthood is a reduction in muscle strength. Research indicates that muscular strength reaches its peak at about age 30 years (Nygard et al., 1991b; Spirduso & Gilliam-MacRae, 1990); at age 45 years, muscle strength is approximately 90% of the level at age 25 years; and 75% at age 65 years. Muscular endurance also declines with age, although at a slower rate than muscular strength (Spirduso & Gilliam-MacRae, 1990). Further, muscle tone changes and there is a redistribution of fat and subcutaneous tissue with aging (Panek, 1997).

Of the many changes that occur with aging, the degeneration of the cardio-respiratory system is the one that causes considerable morbidity and mortality (Kemper, 1994). At approximately age 25, the heart rate is at is peak efficiency; by age 45, the heart rate is at 94% of peak efficiency; and by age 65, the heart rate is at 87% peak efficiency (Panek, 1997). Additional research findings suggest the lungs lose, on average, 30-59% of their maximum breathing capacity between the ages of 30 and 80 years (Panek, 1997).

Physical Functioning Assessment Techniques

The Multilevel Assessment Instrument (MAI) developed in 1982 by M. Powell Lawton was designed to measure the overall well-being of elderly persons and covers health problems, activities of daily living skills, psychological well-being, environmental quality and social interaction. The MAI comprises seven dimensions with 147 items taken from a wide variety of established indices. The questionnaire provides information about functional activity in seven areas: social resources, mental health, physical health and activities of daily living (ADLs), time use, personal adjustment and perceived environments (McDowell and Newell, 1987).

The Tokyo Metropolitan Institute of Gerontology (TMIG) Index of Competence is a self-reported measure designed to evaluate higher levels of functioning (Koyano et al., 1991). The index is based on Lawton's hierarchical model and consists of three subscales: Instrumental Self-Maintenance, Intellectual Activity, and Social Role (Kinugasa et al., 1996). When tested for construct, discriminant, and predictive validity the TMIG was more discriminatory than traditional Activity of Daily Living (ADL) inventories, but limited in assessing high-functioning populations (Kinugasa et al., 1996).

The OARS Multidimensional Functional Assessment Questionnaire (MFAQ) was developed to give a comprehensive profile of the level of functioning of older persons. The MFAQ contains 105 questions and can be administered in approximately one hour. The questionnaire provides information about functional activity in five areas: social resources, economic resources, mental health, physical health and activities of daily living (ADLs) (Kane & Kane, 1981; McDowell & Newell, 1987).

Waly et al. (1998) proposed the development of a comprehensive functional capacity assessment (FCA) battery to aid in the prediction of return to work and activities of daily living. In a study using a group of back pain suffers, physical and functional measurements were evaluated. Physical measures included isometric strength measurement of grip, arm, shoulder, back, composite, leg, trunk extension, trunk flexion and knee extension; isokinetic measurement of trunk flexion and extension; flexibility measured as trunk range of motion, hip range of motion, and straight leg raise; psychomotor evaluation of upper extremities; evaluation of walking speed and stride length. Functional measures included tolerance of sitting, standing, walking and climbing; exertional lifting, carrying, pushing, pulling and sliding; mobility while squatting, kneeling, stooping and crouching. Preliminary results obtained suggest the use of the FCA measures are good predictors of rehabilitation success and return to work.

Abdel-Moty et al. (1992) developed a Functional Capacity Assessment (FCA) test battery that included physical, physiological, functional, and work-related categories. Various measures were obtained in each of these categories. For example, two physical measures obtained included static muscular strength and flexibility. Static muscular strength of the fingers, hands, arms, shoulders, back trunk and total body were assessed using pinch testing, grip strength testing, and extension and flexion. Flexibility of the trunk and neck were assessed during flexion, extension, and lateral movements using an electronic goniometer. Under the physiological category, muscular endurance and cardiovascular endurance were assessed. Muscular endurance was measured in terms of fatigue curves for a specified muscle group using a computerized exercise and evaluation system. Cardiovascular endurance was assessed using a motorized treadmill to determine cardiovascular capacity in terms of heart rate and oxygen consumption. Briefly, the approach of FCA is focused on the individual's capacities as related to work physiology, work methods, and work design.

The 60+ functional fitness test battery (Osness et al., 1990) was developed as an alternative to invasive and noninvasive clinical tests. Development of the test was prompted by a need for baseline and change data for older adults in good health (Mobily & Mobily, 1997). The test measures muscular strength, coordination, agility, and flexibility. Muscular strength was assessed using hand weights to perform tricep curls. Coordination was assessed using the preferred hand to move small cans to various locations. Participants placed cones at equal distances to determine agility. Flexibility was assessed as the distance stretched along a measured line. Previous research suggests that the 60+ functional fitness battery is reliable for field use, easy to administer, safe for participants, and inexpensive (Mobily & Mobily, 1997).

Researchers from the Tokyo Metropolitan Institute of Gerontology-Longitudinal Interdisciplinary Study on Aging (TMIG-LISA) examined the extent to which a battery of physical performance tests could be used to assess functional status of older adults (Nagasaki et al., 1995). Physical performance measures consisted of four tests to assess grip strength, fine motor speed, cardiovascular endurance, and balance. Using multivariate analysis techniques, a Basic Motor Ability score was derived which can be a useful index of an individual's overall physical performance (Kinugasa et al., 1996).

The Functional Independence Measure (Stineman et al., 1997) originally designed as an 18-item instrument intended to measure major gradations in independent and dependent behavior. The FIM measures independent performance in self-care, sphincter control, transfers, locomotion, communication, and social cognition. FIM scores range from one to seven: a FIM item score of seven is categorized "complete independence," while a score of one is "total assist" (performs less than 25% of task). Scores falling below six require another person for supervision or assistance. By adding the points for each item, the possible total score ranges from 18 (lowest) to 126 (highest) level of independence.

Age-Related Changes in Cognitive and Sensory Functions

Aging is commonly accompanied by a decline in cognitive functioning. However, the rate and magnitude of this functional decline with advancing age may display considerable variability among older individuals (Chodzko-Zajko & Moore, 1994; Hertzog, 1985; Schaie, 1989). One of the pervasive findings in aging research is that motor performance slows with increasing age (Salthouse, 1996). Motor functions including reaction speed, simple reaction time, and choice reaction time have all been found to decline with age (Tuomi et. al., 1997; Spirduso & Gilliam-MacRae, 1990; Rabbit, 1980). Research findings on motor performance suggest declines are presumably caused by diffuse change in the central nervous system (Gottlob & Madden, 1999) rather than the slowing down of the sensory functions (Ilmarinen, 1996).

Population-based epidemiological studies have demonstrated a decline in visual acuity with aging (Klein et al., 1991; U.S. Department of Health, Education and Welfare, 1977). The four most prevalent ocular diseases and the four leading causes of significant decline in visual acuity and visual field include age-related macular degeneration, open-angle glaucoma, cataracts, and diabetic retinopathy (Carter, 1994; National Society to Prevent Blindness, 1980; Kahn et al., 1977). Age-related mascular degeneration (ARMD) occurs when drusen (residue of intracellular digestion) are deposited extracellularly in the mascular region between the retinal pigment epithelial cells and Bruch's membrane (Carter, 1994). Open-angle glaucoma (OAG) occurs when a sustained increase in the intraocular pressure damages the retinal never fibers (Carter, 1994). Cataracts form as a result of age-related changes in metabolism, UV light exposure, medications, alcohol and cigarette consumption, systemic disease, and nutritional deficiencies of antioxidants, riboflavin, and glutathione (Carter, 1994). Diabetic retinopathy is generally associated with decreased acuity, contrast sensitivity, color perception, and dark/light adaptation, as well as glare disability and scotomas (Carter, 1994).

In addition to declines in visual acuity which result from ocular diseases, presbyopia, decreased contrast sensitivity, delayed glare recovery, and decrease in dark/light adaptation have been identified as visual problems commonly associated with aging in the absence of ocular disease (Rybash et al., 1995; Carter, 1994). Presbyopia (or the reduction of near vision) is a condition that results in a substantial decline in the ability of the lens to focus or maintain an image on the retina (Schieber, 1992). Contrast sensitivity, the ability to discern the difference between an object and its background, decreases due to a decrease in retinal sensitivity, retinal luminance, and CNS changes (Carter, 1994). Weale (1986) suggests age-related changes in glare sensitivity are largely due to changes in the lens such as the lens becoming progressively thicker, less flexible, and more opaque with age. Also, the lens takes on a yellowish tint with increasing age that results in less light reaching the retina. Dark/light adaptation decreases because the retinal rod photosensitive discs are not replaced as efficiently with aging, resulting in an inability of the eye to respond to changes in light intensity (Carter, 1994).

Similar to the visual changes that occur with age, changes in auditory acuity are among the most commonly occurring and recognized as related to aging. Hearing is, in fact, one of the major problems for many older adults (Small, 1987). Presbycusis, which is the decline in the ability to hear high-pitched sounds, is an auditory problem commonly associated with aging. This loss of auditory acuity for high-pitched sounds has been found to be greater among men than women (Pedersen et. al., 1989; Schieber, 1992), which has often been attributed to gender differences in noise exposure (Moscicki et al., 1985). Another specific hearing disorder associated with aging is tinnitus, a constant high-pitched ringing or whistling sound in the ears, which has been reported in nearly 11 percent of those between 65 and 74 years of age (Rockstein & Sussman, 1979). In addition, research findings indicate increasing age often results in more difficulty hearing speech sounds which becomes especially noticeable when processing speech sounds under noisy conditions (Rybash et al.,1995).

Cognitive and Sensory Functioning Assessment Techniques

Suvanto et. al (1991) utilized sub-tests of the Wechsler Adult Intelligence Scale (WAIS) to determine changes in visual search ability, short-term memory, and fine motor performance in aging municipal employees in different work content categories (mental, physical and mixed). Verbal concept formation was measured with the similarities sub-test. In this test participants were orally presented a series of paired words and asked to explain the similarity of the objects or concepts they represented. Visuoconstructive ability was assessed with the block design sub-test. The block design sub-test required the participants to replicate a set of modeled or printed two dimensional geometric designs using two-color cubes. Basic perceptual and conceptual abilities were assessed with the picture completion sub-test. This test required the participants to identify what was missing from pictures of common objects or events.

In follow-up studies, visual search, auditory short-term memory and fine motor speed were also assessed. Visual search was assessed using the Bourdon-type letter cancellation test. This task was to search and cancel five given letters in the rows of letters on a standard size (A-4) sheet of paper. Auditory short-term memory was measured with the number repetition (digit span) sub-test of the WAIS. In this test sequences of digits of increasing length was presented verbally and participants were asked to repeat the digits in reverse order. Fine motor speed was assessed using finger-tapping test. This test required participants to depress a lever as quickly as possible. Results of this study suggests that mental capacity of workers in mental work is better than that of the workers in physical and mixed work content groups.

McSweeney et al. (1993) introduced a standardized regression-based (SRB) approach to the evaluation of cognitive change. The SRB approach uses test-retest performances from a control sample to develop regression equations that predict retest scores from observed baseline scores. A standardized change score can be obtained by dividing the difference between the predicted and observed retest scores by the standard error of the estimate from the regression model. This SRB change score can be used to determine both the direction and the magnitude of change for an individual patient or a group of while controlling for test-retest confounds.

Morris et al. (1994) developed the Minimum Data Set (MDS) Cognitive Performance Scale (CPS), an instrument used to assess cognitive impairment in nursing home populations. The authors used five MDS items to construct the CPS, including two cognitive measures, one communication measure, one ADL measure, and comatose status. Modeling of the CPS scale is based on two standard cognitive assessment tools, the Mini-Mental State Examination and the Test for Severe Impairment. The CPS can be used to assign residents to one of seven easily understood cognitive performance categories: intact, borderline intact, mild impairment, moderate impairment, moderate severe impairment, severe impairment, and very severe impairment.

Work Factors That Affect the Job Task Performance of Older Workers

Results of a 4-year follow-up study (Ilmarinen et al., 1991c) of 6257 aging Finnish workers revealed three groups of risk factors which add to the deterioration of the work ability of aging workers (Table 2.2). Based on the findings of this study Ilmarinen (1994) identified work content, work organization, and work environment as key factors of work which have a central role in successful aging in work life. Similarly, Genaidy & Christensen (1997) suggest to allow flexibility in analysis, work task demands can be characterized by task contents (physical and mental demands) and task context (environmental demands such as the physical environment and organizational environmental conditions).

Table 2.2

Work Factors that Affect the Job Task Performance of Older Workers

Physical Demands that are too high	**Stressful and dangerous work environment**	**Poorly organized work**
Static muscular work Use of muscular strength Lifting and carrying Sudden peak loads Repetitive movements Simultaneously bent and twisted work postures	Dirty and wet workplaces Risk of work accidents Hot workplaces Cold workplaces Changes in temperature during the workday	Role conflicts Supervision and tackling of work Fear of failure and mistake Lack of freedom of choice Time pressure Lack of influence on own work Lack of professional development Lack of acknowledgement and appreciation

Kemper (1994) suggests if physical workloads remain constant with age and work capacity decreases, an imbalance is introduced which could lead to disease and inability to work. Kemper proposed two possibilities to prevent the imbalance between workload and worker capacity: 1) decreasing the physical load by implementing ergonomic measures in the workplace; or 2) increasing or retarding the decrease in physical capacity of the workers by implementing employee fitness programs.

Halpern et al. (1996) investigated the application of the ability requirements approach to study the relationship between back injuries and job demands. The study utilized groups of active workers to construct profiles of job demands by rating physical abilities needed to perform various job tasks. In addition, worker ratings of job demands were correlated with back injury rates. Results of this study confirmed that back injuries are associated with tasks perceived by active employees as physically demanding.

Zwerling et al. (1996) assessed potentially important risk factors for occupational injuries among older workers, including both personal characteristics of the workers and characteristics of their jobs. The study utilized data from the Health and Retirement Study (HRS), a population-based sample of Americans 51 through 61 years old. Results of this investigation revealed occupational injuries were associated with jobs requiring heavy lifting and jobs requiring good vision. In addition, findings revealed occupational injuries were most common among workers with visual and auditory impairments. Results of this study emphasize the importance of a good match between job demands and work capabilities.

Karasek (1979) proposed that the negative effects of work demand are mitigated if employees have high levels of decision latitude. More specifically, Karasek hypothesized that there are two elements of the work environment that impact an individual's level of well-being and the quality of his or her work, namely, job demands and decision latitude. Job demands reflect the amount of work required from the employee, the extent to which he or she has to work under time pressure, and the degree to which the employee is expected to complete conflicting job demands. Decision latitude (work control) refers to the extent that employees can exert influence over tasks and conduct during a normal working day. The model postulates that psychological strain results from the interaction of job demands and work control.

Techniques Available for Assessing the Work Environment

Sullivan & Corlett (1998) highlighted a number of methods that could be easily and readily used by non-ergonomists for evaluating the workplace (Table 2.3). The techniques presented measure work demands and their causes, equipment and environment analysis procedures and techniques that assess the potential for musculo-skeletal injuries. The methods presented by Sullivan & Corlett represent only a small sample of those that are available but were chosen because of their relative simplicity.

The Aberg Loading and Causes Survey (Aberg, 1981) is a readily useable method for identifying job demands and their causes with limited training. Using this survey each load or job demand factor is examined against the possible causes with a number, typically ranging from 0 to 3 (with 0 representing no causal factor and 3 representing a strong cause), being allocated according to the assessed strength of that cause. The total score, which is computed for each causal factor, represents a priority rating or starting point for corrective measures.

Table 2.3

Tools for Assessing the Workplace

Assessment Technique	**Used For:**	**Author**
Overall Survey • Aberg loading and causes survey	• Assessing an entire job to determine the primary problem areas on which to focus solutions	• Aberg
Impact of work on the worker • Borg Scale • Body Discomfort Scale • Featured scaling based on MCH	• Measuring physical effort • Measuring postural effort • Measuring effectiveness of performance	• Borg • Corlett & Bishop • Wickens
Equipment and environment • Checklists • Feature scaling	• Determining if relevant aspects have been considered • A profile of the adequacy of matching of people and equipment	• Various • Sullivan & Corlett
Special Situations • Ovaka Working Analysis System (OWAS) • Rapid Upper Limb Assessment (RULA)	• Measuring gross errors of postures • Determining potential for upper limb disorders	• Karhu et al. • McAtamney & Corlett

The Borg Scale (Borg, 1985) is a method frequently used to assess the physical demands of a job task. The scale was designed for the identification of physiological loads using subjective ratings. It is useful in determining the level of exertion experienced by workers while performing a job task.

The Body Part Discomfort (BPD) diagram is a technique frequently used to assess postural load (Corlett & Bishop, 1976). This technique uses a body diagram to: 1)identify those body parts in discomfort is experienced during the performance of work tasks, 2) rate the intensity of the discomfort experienced using a 5 or 7 point discomfort scale, and 3) identify the job tasks being performed when the discomfort is experienced. The BPD provides information concerning the reasons for discomfort and thus is useful in determining workplace changes that should be made to eliminate improper work postures.

The Modified Cooper-Harper scale (MCH) has been used to assess workload in systems where perpetual, cognitive and communication activities were present (Wierwille &, Casali, 1985). The rating scale consists of a decision tree procedure that is used to elicit workload ratings. Wickens (1987) proposed the development of a feature scaled checklist where features of the MCH were been combined with job task elements which require attentional resources, from which either further investigation or corrective action may be implemented.

Using a modified version of the chair feature checklist (CFCL) developed Shackel et al. (1969) allows each aspect of a chair relevant to the interface between the user and the seat to be evaluated on the basis of subjective suitability. Completion of this checklist helps to identify subjective estimations of problems associated with use of the chair as well as the necessary corrective actions required.

The three-stage checklist developed by Wilson (1994) is a checklist that was developed for use by design engineers. The three stages permit 1) the identification of design features which are potentially areas of concern, 2) the examination and delineation of the factors involved, and 3) a detailed analysis of proposed designs (Aickin et al., 1994).

The Ovako Working Posture Analysis System (OWAS) is a method which can be used to evaluate postural loads in different work tasks and then identify solutions for the reduction of poor work postures in co-operation with workers, managers, health care and safety personnel (Karhu et. al., 1977). The procedure involves observing working postures using observation techniques, videotaping or still photography. The work postures and position of the head, arms, trunk and legs as well as the load or force being used is classified using a numerical code (Wilson & Corlett, 1995) which describes the severity of the posture.

Similar to the OWAS, the Rapid Upper Limb Assessment (RULA) developed by McAtamney & Corlett (1993) is an assessment technique that can be used to describe the body postures relevant to upper limb loading in a numerical code. Using RULA, numerical scores are determined by combining the recording angles adopted by the segments of the upper limb with the recordings of the posture at the neck, trunk and legs. The RULA analysis identifies both the level of likely risk of upper limb disorders (higher scores represent greater likelihood) and the directions in which changes should be implemented.

The Work Environment Inventory (WEI) developed by Amabile & Gryskiewicz (1989) is a 78-item paper and pencil instrument constructed to assess stimulants and obstacles to creativity in the work environment. The WEI is grouped into eight scales which each describe characteristics of an environment that influences perceived support for creative ideas in that environment. Six of the eight scales describe directional influences that serve as environmental stimulants to creativity: 1) challenging work, 2) freedom, 3) organizational encouragement, 4) sufficient resources, 5) supervisory encouragement, and 6) work group support. The two remaining scales describe directional influences that serve as environmental obstacles to creativity and are labeled: 1) organizational impediments and 2) workload pressure. Two additional assessment scales are included on the WEI for validation purposes. The first of these validity scales measures perceived productivity of work in the organization. The second validity scale assesses perceived levels of overall creativity in the organization.

Developing and Validating Assessment Techniques

The Assessment of Occupational Functioning (Watts et al., 1986) is a screening tool based on the Model of Human Occupation. The tool is intended to screen overall occupational function of physically disabled and/or psychiatric patients/residents in long-term settings such as state hospitals and intermediate care residential facilities. The purpose of the assessment is to provide the therapist with self-report information concerning the patient's values, personal causation, interests, roles, habits, and skills.

Instrument development was based on the four-step process for instrument development described by Benson & Clark (1982) which involved planning, construction, quantitative evaluation, and validation. A study of 83 community and institutionalized elderly subjects was conducted to examine the AOF's dimensionality, test-retest reliability, interrater reliability, concurrent validity, and ability to discriminate between healthy and institutionalized adults. Data collection involved audiotaped AOF interviews by a therapist and the administration of two other measures that have evidence of concurrent validity, the Geriatric Rating Scale (GRS) and the Life Satisfaction Index-Z (LSI-Z). The audiotapes were rated by the therapist and two other researchers to examine interrater reliability. The AOF was readministered to the institutionalized subjects after 14 to 21 days to examine test-retest reliability.

To examine test-retest reliability, Pearson product-moment correlations were calculated for each of the six items and for the total score of the AOF. Interrater reliability was estimated by computing intraclass correlation coefficients for individual items and for the total score for all institutionalized subjects.

Concurrent validity was examined by computing Pearson correlations for the item and total scores form the AOF, with the LSI-Z total score and the GRS total score. The validity of the AOF was also explored by determining whether scores would discriminate between healthy community subjects and subjects in institutions. The linear discriminant function procedure was used to classify subjects into the healthy or institutionalized groups.

The Physical Disability Index (PDI) (Gerety et al., 1993) is an observer administered, performance-based instrument that measures physical disability in frail-elderly persons without severe cognitive impairment. Development of the PDI involved a nominal group process to identify critical construct areas in the domain of physical function. Sixty-five items in four sub-scales encompassing Range of Motion (ROM), Strength (STR), Balance (Bal), and Mobility (MOB) were identified. The pilot process for the instrument was undertaken in two phases. First, 20 nursing home residents were assessed by a physical therapist to refine administration procedures. Next, the PDI was administered to residents of five nursing homes to assess feasibility and acceptability, and to generate data for item reduction and scoring procedures. Using correlation matrices, cluster analysis, and regression techniques, the scale was reduced to 54 items. All individual item values were standardized and aggregated into sub-scale and summary PDI scores, each with a range of 0-100.

Three instruments were used to evaluate construct validity of the PDI. The Folstein Mini-Mental State Exam (Folstein et al., 1975) was chosen to evaluate discriminant validity, and both the Physical Self-Maintenance Scale (Lawton & Brody, 1969) and the Sickness Impact Profile (Bergner, et al., 1976; Bergner et al., 1981) were chosen to evaluate convergent validity. Test-retest and interrater reliability were evaluated using Pearson correlation coefficients.

Lechner et al. 1994 examined the interrater reliability and validity of a newly developed test of physical work abilities. The Physical Work Performance Evaluation (PWPE), a test designed to assess a person's physical work capability, consists of 36 tasks that evaluate dynamic strength, position tolerance, mobility, balance, endurance and coordination, and fine motor skills. The dynamic strength, position tolerance, and mobility sections of the test are used to determine the overall level of work for which a person is capable and, were the focus of the reliability and validity study.

The PWPE was used to evaluate 50 subjects between the ages of 18 and 65 years with a variety of musculoskeletal disabilities. The testing procedure involved two physical therapists independently and simultaneously scoring the subjects as they performed 19 tasks. From these scores, an appropriate level of physical work was determined for each task. The physical work levels from the individual tasks were then combined to determine physical work levels for the three major sections of the test: dynamic strength, position tolerance, and mobility. The levels of work assigned to the three sections of the test were then used to determine an overall level of physical work for which the subject was qualified. A subject participation/cooperation score was also obtained by comparing the subject's perception of his or her maximum ability to the therapist's observations of physical signs of maximum effort in the dynamic strength section or quality of performance in the position tolerance and mobility sections.

A comparison of the two independent evaluations was used to determine the test's interrater reliability. A Kappa κ coefficient with free marginals was calculated for the maximal effort and quality of performance scores for each task, for each of the three major sections of the test, and for the test as a whole. Kappa κ coefficients were also calculated for the subject cooperation scores for each task. To determine concurrent criterion-related validity, a Spearman ρ correlation coefficient was calculated to determine the correlation between the overall work level recommended by the PWPE and the level of work currently being performed by the subject at the time of the PWPE.

Simonsick et al. 2001 conducted a study to develop and validate scales that quantify the severity of upper and lower extremity functional limitations to better understand disablement and transitions from impairment to disability. The study population consisted of participants in the Women's Health and Aging Study (WHAS), a prospective study of the causes and course of disability in women aged 65 years and older. Scales assessing severity of upper and lower extremity functional limitations were constructed from commonly available questions on functional difficulty.

Construction of the upper extremity functional limitation scale entailed three steps. The first step of scale construction involved assignment of a score from 0 to 4 to 12 tasks that were classified in one of the following four domains: mobility/exercise tolerance, upper extremity, higher functioning (instrumental activities of daily living) and self-care (activities of daily living) based on the participants' reported level of difficulty. Because less than 20% of the participants had scores above 4, categories were then collapsed to yield a 7-point scale ranging from 0 to 6. The third step involved adjustment of the scale scoring to improve face validity.

Construction of the lower extremity functional limitation scale also entailed three steps. First, a score from 0 to 4 was assigned based on participants' reported difficulty walking for ¼ mile and a score of 5 or 6 was assigned based on participants' reported difficulty walking across a small room. Secondly, a score ranging from 0 to 2 was assigned based on participants' reported difficulty walking up 10 steps without resting. Lastly, a score of 0 or 1 was assigned based on participants' reported difficulty stooping, crouching, and kneeling.

To determine criterion-related validity of the upper and lower extremity functional limitation scales, the prevalence of self-reported difficulty was examined with the respective upper and lower extremity-related performance-based measures at each level of functional limitation. Upper extremity impairment measures included grip and pinch strength. Three tests were used to assess participants' upper extremity functional limitation including: a) ability to lift a 10-lb water jug using both arms from the lap to eye level to up over the head, b) capacity to fully internally and externally rotate the left and right shoulders, and c) time needed to pick up and place 10 pegs in a peg-board with the dominant hand. Two tests were used to capture upper extremity disability: a) ability to put on and button a blouse and b) ability to pick up a key and open a lock. Lower extremity performance battery items including standing balance, repeated chair stands, and usual gait speed. For the statistical analysis, the chi-square test for trend was used for dichotomous variables such as ADL difficulties; Pearson correlation coefficients were calculated for all continuous measures such as strength and timed performance; and Spearman correlation coefficients were calculated for ordinal variables.

Summary

In summary, journal articles, books, and other references were reviewed to identify age-related changes that may be directly contributing to the deterioration of work ability in older workers. Literature from the fields of ergonomics and human factors engineering, industrial engineering, gerontology, psychology, physiology, and occupational medicine were explored to identify techniques available for assessing health status, cognitive, sensory and, physical functioning as well as techniques for evaluating the work environment. Techniques for developing and validating functional capacity assessment instruments were also examined. Information from these references will be used in all aspects of instrument development.

CHAPTER III

INSTRUMENT DEVELOPMENT

Introduction

Development of the W^2E was similar to the four-phase process for instrument development described by Benson & Clark (1982) which involves planning, construction, quantitative evaluation, and validation. The planning phase begins with the formulation of a statement of the purpose of the intended instrument. The statement should include a specification of the domain (content area) or construct (abstract psychological trait) to be measured and the target group for which the instrument is intended. This phase also includes a review of the related literature to ensure that an appropriate, reliable, and valid instrument does not already exist.

The construction of the instrument begins with listing the specific objectives of the instrument that pinpoint the purpose of the instrument and indicate the content areas to be assessed. The construction phase also includes preparation of a table of specification, development of test items and format, content validation and qualitative evaluation. The final step in the construction phase involves the development of new test items or revision of existing items.

Quantitative evaluation of the instrument is substantially accomplished through pilot testing. The first pilot study provides quantitative data on each item together with reliability estimates for the total instrument. When this data is interpreted with the information gathered in the debriefing and qualitative assessment sessions, the test constructor can make a sound judgement regarding which items should be retained, revised, or discarded. The second pilot test usually results in a final form of the instrument and established that the reliability of the instrument is acceptable.

The validation phase is essential because it allows the developer to be confident that the instrument is actually measuring what it is intended to measure. Since there are several methods for establishing the validity of a given instrument, the selection of a method is dependent on the intended use of the instrument. A detailed discussion of the methods used to establish validity it presented in Chapter 8.

Phase I - Planning

The first step in the development of the W^2E involved planning. To develop a worker assessment tool adequate for industrial use, an understanding of age-related characteristics associated with work performance is needed. Therefore, a comprehensive literature review was conducted. Findings from this extensive material identified age-related changes in health status, physical functioning and cognitive and sensory functioning as those personal factors that have the greatest impact on work performance. In addition, the literature review identified the need for an instrument that is useful for more than just assessment purposes. Thus, an instrument was planned to: 1) determine the most effective match between worker capabilities and job task requirements, and 2) provide information that will be useful in job design, job rotation and job placement as well as injury prediction.

Phase II – Construction

Findings of the Finnish research suggest work ability is inclusive of both personal factors (such as health status and functional status) and work factors (such as work tasks demands and work environment) (Ilmarinen et al., 1991c; Ilmarinen, 1994, Kuomi et al, 1991). Similarly, this project focuses on the development of an instrument that is inclusive of information about functional status as well as information about work task demands. Specifically, the Williams Work Estimator (W^2E) combines information obtained using a self-evaluation questionnaire with information obtained using a task evaluation questionnaire to determine the most effective match between worker capabilities and job task requirements.

The initial content of the self-evaluation questionnaire was derived based on the 20 physical work demands identified in the U.S. Department of Labor's (1981) Dictionary of Occupational Titles (DOT) (Table 3.1). The factors described in the DOT express both the physical requirements of the job and the physical capacities a worker must have to meet job demands. However, only those 15 factors frequently mentioned in the literature as ergonomic risk factors were included in the original draft of the employee self-evaluation questionnaire (Appendix B).

Table 3.1

Twenty Physical Work Demands Listed in the Dictionary of Occupational Titles (DOT)

Standing*	Climbing*	Reaching*	Kneeling*
Pulling*	Crawling*	Lifting*	Fingering*
Crouching*	Seeing	Stooping*	Pushing*
Hearing	Sitting*	Handling*	Talking
Walking*	Balancing	Carrying*	Feeling

* Frequently mentioned ergonomic risk factors.

The task evaluation questionnaire was designed to obtain information concerning job task requirements using job analysis technique, a method frequently used by ergonomists to assess the physical demands of work. Medsker & Campion (1997) suggest job analysis can be broadly defined as a number of systematic techniques for collecting and making judgements about job information. Information derived from job analysis can be used to aid in recruitment and selection decisions, determining training and development needs, develop performance appraisal systems, and evaluate jobs for compensation, as well as to analyze tasks and jobs for job design. Job analysis may also focus on tasks, worker characteristics, worker functions, work fields, working conditions, tools and methods, and products and services. Job analysis data can be derived from job incumbents, supervisors, and analysts who specialized in the analysis of jobs. Data may also be obtained from higher management or subordinates.

The initial content of the task evaluation questionnaire was derived based on the critical incident job analysis method developed by Flanagan (1954). The critical incident job analysis method identifies job-related behaviors of job incumbents that are critical to job performance. Similarly, the task evaluation questionnaire identifies the physical work activities that are critical to the performance of a job task. A copy of the original draft of the task evaluation questionnaire is included in Appendix C.

Phase III – Content Validation Evaluation

Following the development of the original draft of the W^2E, a group of experts was asked to evaluate the content of the questionnaires. Revisions were made after consultation with the experts to clarify rating items and to insure that the W^2E has content validity. The results of this evaluation were compiled and the revised W^2E was retained for use in the next phase of instrument development. A complete discussion of this research activity is included in the following chapter.

Phase IV – Reliability & Validity Evaluation

The final phase of the development of the W^2E involved evaluating the reliability and validity of the instrument. To begin this process, statistical tests were utilized to assess various aspects of questionnaire reliability and validity. The details of these analyses are presented in chapters 7 and 8.

CHAPTER IV

CONTENT VALIDATION EVALUATION

Introduction

Benson & Clark (1990) suggest once the content area has been written, careful review of the instrument is necessary to determine if: 1) the items are clearly stated, 2) the items conform to a selected format, 3) the response options for each item are plausible, and 4) the wording is familiar to the target group. Since there is no index of content validity that is generally agreed on, professional judgement is usually the basis for estimating its adequacy (Wernimont, 1988). Thus, an instrument is considered to be content valid when the items adequately reflect the process and content dimensions of the specified objectives of the instrument as determined by expert opinion (Benson & Clark, 1990). A description of the content validation evaluation of the W^2E follows.

Procedure

A group of six advisors was solicited to evaluate the content of the W^2E to insure that the instrument precisely and efficiently elicits the desired information. Six advisors were chosen with the intention of including one person with expertise from each of the fields referenced in the literature review (occupational medicine, industrial engineering, gerontology, physiology, ergonomics, and psychology). Habeck et. al. (1998) used a similar method to develop an employer self-assessment survey instrument to obtain empirical evidence about the relationship between workplace policies and practices and the incidence and outcomes of work disability.

The Delphi Method, an analytical technique useful for decision-making, was employed to analyze the responses obtained from the expert advisors. The Delphi method consists of a series of repeated interrogations, usually by means of questionnaires, of a group of individuals whose opinions or judgments are of interest. After the initial interrogation of each individual, each subsequent interrogation is accompanied by information regarding the preceding round of replies, usually presented anonymously.

A statement of the purpose of the W^2E as well as a list of the specific objectives of the instrument was provided to each expert. The experts were then required to complete an evaluation form that included eight statements concerning the content of the W^2E questionnaires as included in Table 4.1. The advisors were asked to indicate the degree to which they agreed with each statement using a rating scale that ranged from 1 (strongly disagree) to 5 (strongly agree). The advisors were also asked to provide additional suggestions for improving the content of the W^2E questionnaires. A copy of the evaluation form used by the expert advisors is included in Appendix D.

Revisions were made based on the comments included in the initial evaluation and the W^2E was resubmitted to the advisors for further evaluation. After the second group evaluation, the W^2E was revised and retained for use in the validation study. Copies of the revised W^2E questionnaires are included in Appendices E and F.

Table 4.1

Statements Included in the Content Evaluation Form

1. The questionnaires identify specific **PHYSICAL** work activities that are likely to be problematic for employees (specifically older employees).
2. The language (wording) of the self-evaluation questionnaire can be understood by employees with various educational levels
3. The self-evaluation questionnaire is structured such that employees understand what they are being asked to assess (i.e. vagueness of the questionnaire).
4. The anchors provided in the self-evaluation questionnaire help to identify the degree of impairment between the physical work activity and the worker's capabilities
5. The language (wording) of the task evaluation questionnaire can be understood by employees with various educational levels
6. The task evaluation questionnaire is structured such that users understand what they are being asked to evaluate (i.e. vagueness of the questionnaire)
7. The anchors provided in the task evaluation questionnaire provide enough information to help users make a distinction between each choice
8. The content of the W^2E is sufficient for estimating the match between work capabilities and job task requirements.
9. Please provide recommendations for improving the questionnaires.

Results

The results of the initial evaluation of the W^{2}E questionnaires are shown in Figure 4.1. Statements 1 and 4 on the evaluation form received the highest overall ratings. These statements were rated 4 (agree) or higher by all of the experts. While statements 2, 3 and 5 received the lowest overall ratings, ranging from 2 (disagree) to 5 (strongly agree). The ratings for statements 6, 7, and 8 ranged from 3 (disagree) to 5 (strongly agree).

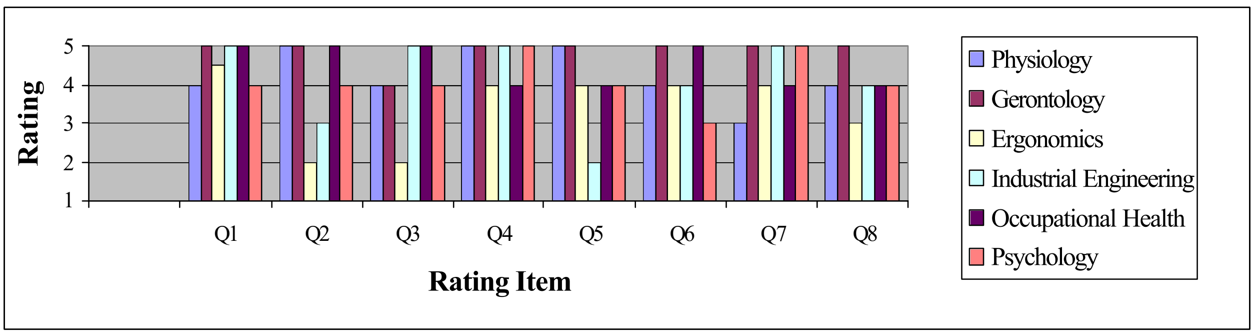

Figure 4.1 Results of the Initial Content Evaluation of the W^{2}E.

One of the primary concerns of the experts in the initial evaluation of the W^{2}E involved the lack of clarity presented by four of the physical work activities (fingering, handling, stooping, and crouching) listed in the Dictionary of Occupational Titles (DOT). The advisors suggested fingering might not be easily understood by users of the questionnaire and recommended inclusion of an example to further illustrate the meaning of this activity or elimination of this activity. In addition, it was suggested that the word grasping be used rather than handling to aid in user comprehension. To further improve

W^2E questionnaire comprehension, it was also recommended that the word bending be used rather than stooping or crouching since both activities involve bending.

Another comment frequently expressed concerned the scale used to ascertain the educational level of the participants. The advisors suggested the categories used to denote education was inadequate for the target users and suggested simplifying the language. It was recommended that more standard education levels be used including an option for on-the-job training (OJT).

The advisors also provided some suggestions for improving the clarity of the questionnaires which primarily involved making wording changes to the anchors. A suggestion was also provided for improving the readability of the task evaluation questionnaire. It was recommended that the anchors be placed directly above the descriptors (as in the employee self-evaluation questionnaire) to prevent the rater from having to retain information while completing the questionnaire..

The results of the follow-up evaluation of the W^2E are shown in Figure 4.2. Statements 1, 2 and 6 on the evaluation form received the highest overall ratings. These statements were rated 5 (strongly agree) by all of the experts. The remaining statements were rated 4 (agree) or higher by all experts except statements 4 and 8 which each received a rating of 3 by one expert.

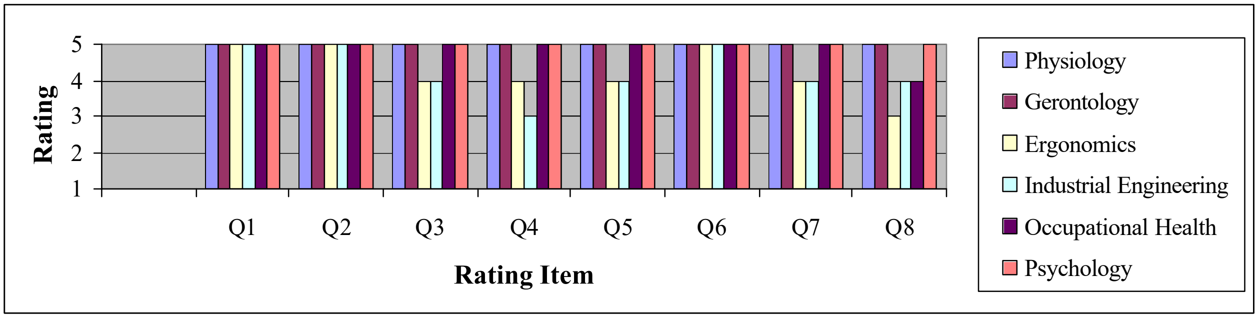

Figure 4.2 Results of the Follow-up Content Evaluation of the W^{2}E.

The major concern expressed by the advisors in the follow-up evaluation involved the wording used in the anchors. The advisors suggested the anchors excellent and good used in the self-evaluation questionnaire describe the degree of difficulty, while the anchors moderate and fair describe the frequency of difficulty. The advisors also suggested that the anchors did not properly reflect the descriptive statements included in the questionnaires. Additional recommendations were provided for improving the wording of the anchors.

Summation of Findings

Since there is no index of content validity that is generally agreed on, professional judgement was used as the basis for estimating the adequacy of the content of the W^{2}E. Comments provided in both the initial evaluation and the follow-up evaluation were used to revise the W^{2}E. Based on the comments provided by the expert reviewers, it appears that the W^{2}E provides adequate information for determining the extent to which physical work capabilities match job task requirements and is useful for the intended purposes. Copies of the final version of the W^2E questionnaires are included in Appendices G and H.

CHAPTER V

METHODOLOGY

Participants

To assess reliability and validity of the instrument, the W^2E was used to evaluate four job tasks (night loading, sales, bay delivery, and bulk delivery) performed in the beer distribution industry. The self-evaluation questionnaire was completed by 32 male employees between the ages of 19 and 57 years with a mean age of 34.5 years. The study included 17 participants at one warehousing facility and 15 participants at a similar facility. The participants were selected based on length of employment and type of work activities involved in their daily job tasks. This selection criteria was chosen to include participants employed six months or longer in job tasks primarily consisting of manual material handling activities (i.e. lifting, pushing, pulling, etc.) as illustrated in Figures 5.1 – 5.4.

In addition, the task evaluation questionnaires were completed by five employees who worked in supervisory capacities. The supervisors were solicited based on their knowledge of the four job tasks that were evaluated in this study. Descriptive information on the study participants is summarized in Tables 5.1 and 5.2.

Figure 5.1. The Night Loading Task

Figure 5.2. The Sales Task

Figure 5.3. The Bay Delivery Task

Figure 5.4. The Bulk Delivery Task

Table 5.1

Descriptive Data on the Employee Participant Group

Job Task	Job Facility	No. of Participants
Loading	□□ 1	3
	□□ 2	3
Sales	□□ 1	4
	□□ 2	4
Bay Delivery	□□ 1	4
	□□ 2	5
Bulk Delivery	□□ 1	6
	□□ 2	3

Table 5.2

Descriptive Data on the Supervisory Participant Group

Job Title	Job Facility	Task(s) Evaluated
Delivery/Sales Manager	1	Sales Delivery (Bulk & Bay)
Warehouse Coordinator	1	Loading
Warehouse Coordinator	2	Loading
Sales Director	2	Sales
Operations Director	2	Delivery (Bulk & Bay)

Instrumentation

The Williams Work Estimator (W^2E) was developed as a tool for estimating an employee's ability to perform daily work activities. The instrument is intended for use with employees, specifically older employees, who perform job task that primarily involve manual material handling activities (lifting, pushing, pulling, etc.). The objective of the instrument is to provide an indication of the match between an employee's physical work capabilities and his/ her job task requirements. However, the W^2E does not provide a single index score but rather a recommendation concerning the match between worker capabilities and job task requirements. The instrument is designed to provide information that is useful in job design, job rotation and job placement as well as injury prediction.

The W^2E is a two-part instrument and is based on subjective responses to test items. The test items on both parts of the instrument consist of 13 of the 20 physical demands of work defined by the Department of Labor in the Dictionary of Occupational Titles. The complete screening process involves two brief interviews that require approximately 15 to 30 minutes to administer. There is no training required for administering this instrument, however some training may be necessary to understand the scoring procedure.

In the first session, the task evaluation questionnaire is administered to employees who have knowledge of the requirements of the job task(s) being evaluated. The respondents are ask to identify one of four statements that they feel best describe the criticality of the 13 physical work activities included in the questionnaire. The statements contained in the self-evaluation questionnaire include: 1) The job task does not require this work activity (Not Required), 2) The job task requires this work activity infrequently (Necessary), 3) The job task requires this work activity frequently (Critical), and 4) The job task can not be performed without this activity (Very Critical).

In the second part of the interview, the self-evaluation questionnaire is administered to employees who are currently performing the job task being evaluated. (However, if the W^2E is used for placement purposes, this interview would be conducted with newly hired employees or job applicants.) The respondents are asked to identify one of four statements that they feel best describe their ability to perform the 13 physical work activities included in the questionnaire. The statements contained in the self-evaluation questionnaire include: 1) I can perform this activity with extreme difficulty (Fair), 2) I can perform this activity but with moderate difficulty (Moderate), 3) I can perform this activity with only minimal difficulty (Good), and 4) I can perform this activity with no difficulty (Excellent).

The Work Ability Index (WAI), developed by the Finnish Institute of Occupational Health (FIOH), was also administered to evaluate the concurrent criterion validity of the W^2E. The WAI is designed to provide an overall estimation of the employee's ability to perform work (Ilmarinen & Tuomi, 1992) and, according to the authors, has proven to be a valid and suitable method for identifying early signs of decreasing work ability. The WAI is based on subjective estimations of work ability in relations to disease, job demands and psychological resources as well as information about illness and work absenteeism. On the basis of participants' response to queries about their physical, mental, and social capabilities, a WAI score ranging from 7 to 49 points can be derived. The participant's work ability is then categorized as excellent (44-49 points), good (36-43 points), moderate (28-35 points) or poor (7-27 points).

Testing Procedure

Individual interviews were conducted with each participant to collect data for this study. After receiving an explanation of the purpose of the study, the participants were asked to read an explanatory statement and sign a consent form (Appendix I). A signed copy of the consent form was given to each participant and the researcher retained a copy.

Data collection for this study included two components. The first component of data collection involved administration of the W^2E task evaluation questionnaire. Five supervisors from the beer distribution warehousing facilities were selected to evaluate the loading, sales, bay delivery, and bulk delivery tasks. Each job task was evaluated to determine the criticality of 13 physical work activities using descriptive statements provided in the questionnaire.

In addition, the work ability index and the W^2E self-evaluation questionnaire were administered to 32 male employees who perform the loading, sales, bay delivery and bulk delivery tasks. Completion of the Work Ability Index (WAI) required participants to respond to queries concerning their physical, mental, and social capabilities. Completion of the W^2E self-evaluation questionnaire required participants to identify descriptive statements that they felt most accurately reflected their ability to perform 13 physical work activities.

The second component of the data collection involved the re-administration of the W^2E two weeks after the initial interview at facility 1 to assess test-retest reliability of the instrument. The re-test included the two supervisors who initially completed the task evaluation and 13 of the employees who initially completed the self-evaluation. At the conclusion of the testing procedure, the extent to which physical work capabilities matched job task requirements was determined for each participant.

Scoring Procedure

Development of an instrument that simply provides a score, does not provide adequate information for making job task modifications. The instrument must identify the degree of impairment that exists between the worker and the work environment. Therefore, the W^2E does not provide a single index score but rather a profile of the goodness of fit between physical job task requirements and worker capabilities.

Using the critical factors evaluation method, responses obtained using the self-evaluation questionnaires were combined with the responses obtained using the task evaluation questionnaires. Based on the evaluation criterion shown in Table 5.3, the W^2E categorizes work ability into one of four categories (similar to the WAI) which describe the match between the participant's physical work ability and the job task requirements.

Table 5.4 provides an example of the critical factors scoring method using responses provided by three salesmen at facility 1 and responses provided by a Sales supervisor at facility 1. Column 1 (criticality of work activity) is based on the supervisor's evaluation of the sales job task. The work activities rated 1 by the supervisor are activities that the supervisor feels are not necessary to perform the sales task. Activities rated 2 by the supervisor represent those activities that the supervisor feels are necessary but are only required infrequently. The activities rated 3 by the supervisor are activities that the supervisor feels are critical because they are required quite frequently. The activities rated 4 by the supervisor are most critical because they must be performed in order to do the sales task.

Table 5.3

Evaluation Criteria used to Determine the W^2E Recommendation.

Match Between Work Ability & Job Requirements	**Evaluation Criterion**
Excellent	A self-rating of 4 in all work activities identified by the evaluator as very critical and a self-rating of 3 or greater in all work activities identified by the evaluator as critical
Good	A self-rating of 3 or greater in all work activities identified by the evaluator as either critical or very critical
Moderate	A self-rating of less than 3 in only one work activity identified by the evaluator as either critical or very critical
Poor	A self-rating of less than 3 in two or more work activities identified by the evaluator as either critical or very critical

Columns 2, 3 and 4 contain the responses provided by the participants on the self-evaluation questionnaires. The work activities rated 1 represent activities the respondents feel are extremely difficult to perform. Activities rated 2 represent activities the respondents feel they can perform with moderate difficulty. The activities rated 3 represent activities the respondents feel they can perform with minimal difficulty. A work activity rated 4 reflects an activity that the respondents feel they can perform with no difficulty.

Using the critical factors scoring method, the match between each participant's physical work capabilities and the job task requirements is determined using the evaluation criterion described in Table 5.3. Findings of this evaluation suggest there is a poor match between the physical work capabilities of participant 13 and the sales task job requirements. Thus, it would be recommended that this employee be assigned to another job task. In contrast, findings of this evaluation revealed a good match between the physical work capabilities of participant 12 and the sales task job requirements. Therefore, it would be recommended that this employee remain in this job task.

Table 5.4

Example of the Critical Factors Scoring Method.

	(Column 1) Criticality of Activity	(Column 3) Participant 11	(Column 4) Participant 12	**(Column 2)** Participant 13
Physical Work Activities				
Bending	4	3	4	2
Carrying	4	3	4	3
Climbing	2	3	2	4
Crawling	1	3	4	3
Grasping	4	3	4	4
Kneeling	4	3	4	2
Lifting	4	2	3	2
Pulling	2	2	3	4
Pushing	2	3	4	3
Reaching	3	3	3	3
Sitting	4	3	4	2
Standing	4	3	3	3
Walking	4	3	4	3
W^2E Recommendation		Moderate	Good	Poor

Interpretation of the W^2E Recommendations

Once the scoring procedure is completed, the W^2E recommendations can be used to determine the extent to which their workers' capabilities match job task requirements. Categorization of work capability as good or excellent suggests the employee's physical capabilities are well matched with physical job task requirements. The findings also suggest the likelihood that the employee will experience a work-related injury is low. While categorization of work capability as moderate or poor suggests the employee's capabilities are not well matched with job task requirements and that there is an increase likelihood of the occurrence of a work-related injury.

CHAPTER VI

RESULTS

Results Obtained Using the Williams Work Estimator (W^2E)

The results obtained using the W^2E are depicted by job task in Figure 6.1. Based on the participants' responses to the W^2E, the work capability of 83% of the loaders, 25% of the salesmen, 56% of the bay deliverymen and 44% of the bulk deliverymen was determined to be an excellent match for the job task requirements. Findings of the W^2E also suggest that there is a good match between the work capabilities and the job task requirements of 25% of the salesmen, 44% of the bay deliverymen and 22% of the bulk deliverymen. In addition, the W^2E suggests that 25% of salesmen and 33% of the bulk deliverymen are moderately matched with their job requirements, while 17% of the loaders and 25% of the salesmen are poorly matched with their job task requirements.

Results Obtained Using the Work Ability Index (WAI)

The overall work ability categories derived from responses to the WAI are depicted by job task in Figure 6.2. Based on the participants responses to the WAI, 83% of the responses from loaders, 12.5% of the responses from the salesmen, 56% of the responses from the salesmen, 56% of the responses from the bay deliverymen, and 78%

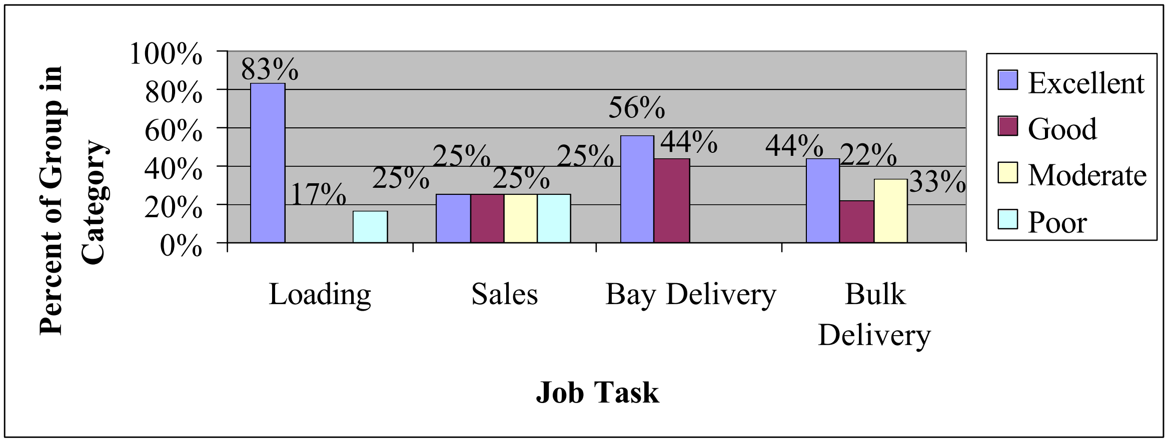

Figure 6.1. Categorization of Work Capability Using the W^{2}E.

of the responses from the bulk deliverymen were classified in the excellent category (44-49 points). The good category (36-43 points) consisted of 17% of the loaders, 62.5% of the salesmen, 44% of the bay deliverymen and 22% of the bulk deliverymen. Twenty-five percent of the responses from the salesmen were classified in the moderate work ability category (28-35 points). None of the responses from the participants were classified in the poor work ability category (7-27 points) using the work ability index.

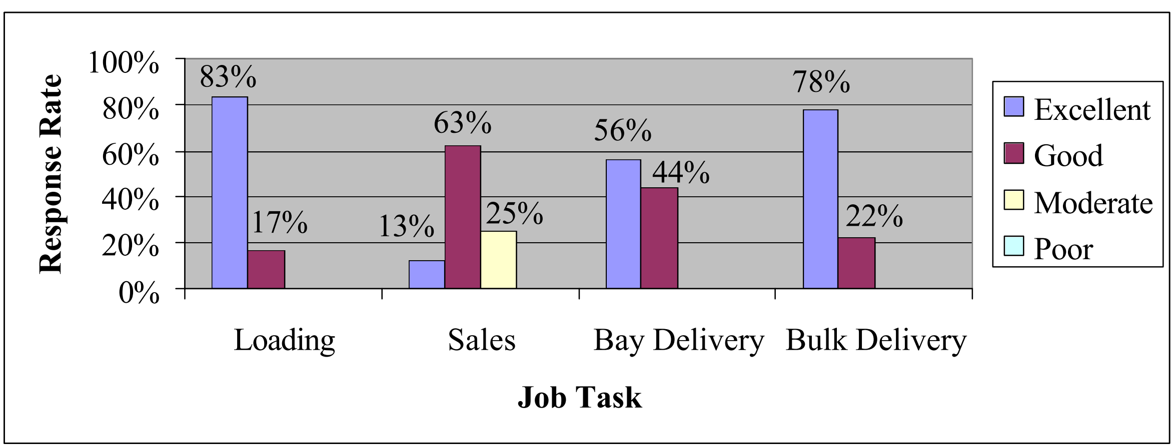

Figure 6.2. Categorization of Work Capability Using the WAI.

CHAPTER VII

RELIABILITY ANALYSIS OF THE W^2E

Introduction

Reliability reflects the degree of consistency of an individual (or group of individuals) in performing a test (Safrit & Wood, 1995). Several methods exist for estimating the reliability of an instrument. The method chosen to establish reliability depends on the intended purpose of the instrument. Table 6.1 includes three methods of estimating instrument reliability, the types of instruments for which each reliability coefficient is required, the procedure for calculating the reliability coefficient, and the generally accepted value recommended by Benson & Clark (1990) for the observed coefficient.

For the purposes of the W^2E, test-retest reliability was considered the most important form of reliability. Test-retest reliability (intrarater reliability) refers to the consistency of a measurement made by the same administrator across time (Feinstein et al., 1986). This type of reliability was required to evaluate the stability of the W^2E over a two week time interval. A discussion of the findings of this analysis follows.

Table 7.1

Methods of Estimating Instrument Reliability

Type of Reliability	Types of Instruments	Procedures	Accepted Values
Stability (test-retest)	Instruments used to predict or select	Give the same test to the same group at two different times, correlate the two scores using the PPM	.60 or greater
Equivalence (parallel form)	Any tests that have alternate forms	Give Form 1 immediately followed by Form 2; correlate the two scores using the PPM	.80 or greater
Internal Consistency	Instruments used to infer an underlying construct	For tests with dichotomously scored items use KR20, for all other tests use Coefficient Alpha	.80 or greater

Note:
PPM = Pearson Product –Moment Correlation Coefficient
KR20 and Coefficient Alpha formulas can be found in Mehrens & Lehmann

Procedure

To examine test-retest reliability, the W^2E was re-administered two weeks after the initial interview at facility #1 to assess test-retest reliability of the instrument. The re-test included the two supervisors who initially completed the task evaluation and 13 of the employees who initially completed the self-evaluation. Test-retest reliability was determined for each job task and the overall findings of the instrument.

Results

The results obtained in the retest using the W^2E are depicted by job task in Figure 7.1. Based on the participants' responses in the retest evaluation, the work capability of

66.7% of the loaders, 33.3% of the salesmen, and 33.3% of the bulk deliverymen were determined to be an excellent match for the job task requirements. Findings of the retest evaluation also suggest that there is a good match between the work capabilities and the job task requirements of 33.3% of the salesmen, 75% of the bay deliverymen and 66.7% of the bulk deliverymen. In addition, the retest suggests that 33.3% of loaders and 33% of the salesmen and 25% of the bay deliverymen are poorly matched with their job task requirements.

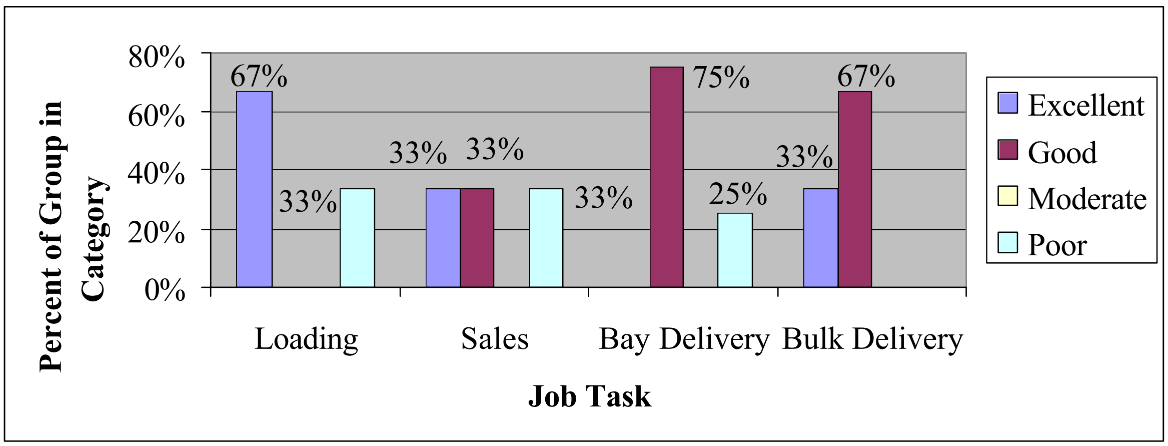

Figure 7.1 Categorization of Work Capability Using the W^2E (Retest).

Pearson correlation coefficients were calculated for each job task using the responses provided on the self and the task evaluations in both the initial and re-test testing sessions. The correlation coefficients obtained using the task evaluations ranged from .39 to .85. This is above the minimal acceptable reliability identified by Benson & Clark (1990) as .60 or greater for all job tasks except the sales task. The correlation coefficients obtained for using the self-evaluations ranged from .28 to .86, which was above the minimal acceptable level for both the night loading and the bulk delivery tasks. The overall correlation coefficient for the W^2E was .64 for the task evaluations and .58 for the self-evaluations. Results of the reliability analyses are shown in Tables 7.2 and 7.3.

Table 7.2

Test-Retest Reliability (task evaluations)

Job Task	Correlation Coefficient
Night Loading	.68**
Sales	.39**
Bay Delivery	.85*
Bulk Delivery	.85*
Overall Correlation	.64**

*p < .01; ** p < .05

Table 7. 3

Test-Retest Reliability (self-evaluations)

Job Task	Correlation Coefficient
Night Loading	.86*
Sales	.14*
Bay Delivery	.28**
Bulk Delivery	.60*
Overall Correlation	.58**

*p < .01; ** p < .05

CHAPTER VIII

VALIDATION OF THE W^2E

Introduction

Validity is the accuracy with which a test or other selection device measures the attribute it is intended to measure (Safrit & Wood, 1995). Its measurement is the demonstration of the relationship between a predictor and a criterion of success. This "demonstration" can take many forms, however empirical validation is generally based upon the statistical significance of correlation coefficients, percentages, or of differences between average scores (Wernimont, 1988). Table 8.1 includes the three general classes of procedures used to demonstrate validity: criterion-related, content and construct.

1. Criterion-Related Validity refers to the comparison of performance on a test with other independent measures of the same attribute (Lechner et. al, 1991). The two primary forms of criterion validity are concurrent and predictive validity. Concurrent criterion validity represents the degree to which a test correlates with a criterion measure i.e., a measure that is already known to be valid (Rikkli & Jones, 1997), while predictive validity refers to a measure's ability to predict future occurrences (Lechner et al., 1991). In both concurrent and predictive methods, statistical techniques are used to evaluate the

relationship between test and criterion performance (Wernimont, 1988).

2. Content Validity is the degree to which a test (or test battery) reflects a defined "universe" of content (APA, 1985). A first step in ensuring the content validity of a test is to identify, typically through a literature review, an expert panel, and/or factor analysis, the important components of the construct (domain) or interest (Rikkli & Jones, 1997).
3. Construct Validity is the degree to which a test measures a particular construct of interest (Rikkli & Jones, 1997). A construct is an attribute that exists in theory but cannot be directly observed (i.e. intelligence, personality) (Rikkli & Jones, 1997). A combination of content and criterion related evidence is required to establish construct validity (Wernimont, 1988).

For the purposes of the W^2E, content validity and criterion validity (concurrent and predictive) were investigated. A detailed discussion of the findings of the content validation procedure was included in Chapter 4. Following is a discussion of the findings of the concurrent and predictive validity analyses.

Table 8.1

Methods of Estimating Instrument Validity

Type of Validity	Use of the Instrument	Procedure	Type of Instrument
Content	To determine how well an individual performs at one point in time for a given content domain	Provide an expert with a copy of the objectives, table of specifications and the instrument; the expert judges whether the content domain has adequately been assessed	Achievement or physical performance test
Criterion-Related	To predict future performance	Give the test and correlate the results with the criterion variable. The criterion may be obtained concurrently or at some time in the future.	Tests used to select or classify
Contruct	To infer some amount of a hypothetical trait	Based on a theory underlying the trait, hypotheses are set up and tested regarding the behavior of persons who possess large or small amounts of the trait	Any test that purports to measure a hypothetical trait

Procedure

The W^2E was used to evaluate four job tasks (loading, sales, bay delivery, and bulk delivery tasks) at a beer distribution warehousing facility. Five supervisors completed the task evaluation and 32 male employees who perform the loading, sales, bay delivery and bulk delivery tasks completed the W^2E self-evaluation and the work ability index. At the conclusion of the testing procedure, the work capability of each participant was determined using both the W^2E and the WAI. The results were used to evaluate the concurrent criterion validity of the W^2E. A discussion of the findings of this analysis follows.

Results

To evaluate the concurrent criterion validity of the W^2E, Chi-square (χ^2) statistical analysis was performed to determine if the results obtained using the W^2E were statistically significantly different from the results obtained using the WAI. The null hypothesis tested in this analysis is that there is no statistically significant difference between the findings of the W^2E and findings of the WAI. The alternative hypothesis is that the findings of the two instruments are statistically significantly different.

$$Ho: \mu_{W^2E} = \mu_{WAI}$$

$$H_{\perp}: \mu_{W^2E} \neq \mu_{WAI}$$

The W^2E was considered valid if there was no statistically significant differences between the findings of the two instruments.

Table 8.2 contains the Chi-square (χ^2) test statistic obtained for each job task. χ^2 values computed for all job tasks indicate that the findings of the W^2E and the WAI were not statistically significantly different when evaluated at an alpha level of 0.05. Results of this analysis provide evidence in support of concurrent criterion validity.

Table 8.2

Findings of the Chi-Square (χ^2) Analysis

Task	χ^2	p-value
Night Loading	5.991	0.3679
Sales	7.815	0.3056
Bay Delivery	3.841	0.3628
Bulk Delivery	5.991	0.1482
Overall	7.815	0.1575

Validation of the W^2E also included an assessment of the instruments' predictive validity. Accident report data were employed to evaluate the accuracy of the W^2E recommendations. The accident report data used in this study included all OSHA recordable injuries that occurred at each warehousing facility during the past year. Measures of accuracy used to assess predictive validity included:

1. Percent Accurate: "the ratio of the number of correctly classified injuries and non-injuries over the total number of observations"
2. Sensitivity: "the ratio of the number of correctly classified injuries over the total number of injuries"
3. Specificity: "the ratio of the number of correctly classified non-injuries over the total number of non-injuries"
4. Percent False Negatives: "the ratio of the number of incorrectly classified injuries as non-injuries over the sum of all observations classified as non-injuries"
5. Percent False Positive: "the ratio of the number of incorrectly classified non-injuries over the sum of all observations classified as injuries"

The W^2E recommendations were considered accurate under the following conditions: 1) if the categorization was "moderate" or "poor" and a participant had experienced a work-related injury within the past year or 2) if the categorization was "good" or "excellent" and a participant had not experienced a work-related injury within the past year.

Table 8.3

Findings of the Accuracy Analysis of the W^2E

Job Task	% Correct	Sensitivity	Specificity	% False Negative	% False Positive
Night Loading	100	100	100	0	0
Sales	50	0	50	0	50
Bay Delivery	66.7	0	55.6	33.3	0
Bulk Delivery	66.7	50	85.7	16.7	16.7

Findings of the accuracy analysis are presented in Table 8.3. The recommendations provided by the W^2E were most accurate when identifying persons performing the loading task (100%) who had experienced a work-related injury within the past year and least accurate when identifying persons performing the sales task (50%) who had experienced a work-related injury within the previous year. In addition, the recommendations of the W^2E were 66.7% accurate when identifying persons performing both the bay and bulk delivery tasks who had experienced a work-related injury within the previous year.

CHAPTER IX

CONCLUSIONS

Summary of Findings

In summary, this project aimed to develop an instrument that can be easily and readily used within industrial settings to help employers determine the extent to which work capabilities match job task requirements. It was also anticipated that the instrument would provide information that will be useful in job design, job rotation and placement as well as injury prediction. Using a four-step method of instrument development, the Williams Work Estimator (W^2E) was planned and constructed. A group of six advisors with expertise in the fields of occupational medicine, industrial engineering, gerontology, physiology, ergonomics, and psychology was solicited to evaluate the content of the W^2E to insure that the instrument precisely and efficiently elicits the desired information. In addition, a field study was performed at a beer distribution warehousing facility using four physically demanding job tasks to provide evidence of reliability and validity. Data generated as a result of this study lead to the following conclusions and recommendations.

Conclusions

Test-retest reliability of the W^2E was assessed using Pearson correlation coefficients. The overall correlation coefficients obtained on both the task evaluation (.64) and the self-evaluation (.58) were near minimal acceptable levels (.60 or greater) for the four job tasks evaluated. Although these findings demonstrate stability reliability, further refinement of the test items, rating scale and/or scoring procedure may improve the reliability of the W^2E.

In addition, the results of this study provide some evidence of concurrent and predictive validity. However, the validation of a newly developed instrument is seldom accomplished through one study or by one researcher. In fact, numerous research efforts are often required to establish validity. Therefore, further study of the W^2E is warranted to improve the results of the validity evaluation.

Limitations of the W^2E

One of the major limitations of the W^2E is that the instrument appears to collect enough information to determine "where" (which work activities) difficulties exist however, it is unclear if the W^2E identifies "why" the difficulty exists. However, this information may impact the modifications that are implemented. Therefore, it may be necessary to supplement the findings of the W^2E with other job analysis techniques (such as the WAI) to clarify why work activities are difficult (i.e. injury, disease/condition).

In addition, feedback obtained in the content validation evaluation suggests that some of the physical work activities are somewhat ambiguous. For example, the terms “lifting” and “carrying” implies some range of weight that may or may not be difficult to perform. Similarly the term “reaching” does not make a distinction between reaching above the shoulder and reaching below the shoulder. Thus, the responses for these items may vary significantly based on the individual interpretation of the respondent.

Recommendations for Future Research

Findings of this study suggest the W^2E represents a promising new tool for assessing work capability and deserves further study in a variety of populations to identify additional applications. For example, some companies and agencies are recognizing that the assignment of women to physically demanding jobs may require some special training program. The analysis of physical work capabilities, utilizing the methods described, can lead to the development of company-sponsored conditioning and exercise programs emphasizing the appropriate physical proficiencies required for effective job performance and skill maintenance (Fleishman, 1979).

In addition, the W^2E was initially intended for use as a tool for identifying changes in the work capabilities among individuals (i.e. age differences). However, research suggests that age-related average deterioration is accompanied by a marked increase in individual differences (Small, 1987). Thus, future research emphasis should also include longitudinal studies to evaluate whether the W^2E is responsive to changes over time and can be used as an evaluative outcome measure.

Finally, an individual's work capacity depends on the ability to find a match between personal factors (such as health status, cognitive and sensory capabilities and physical capabilities) and work factors (such as work task requirements and work environment). Although all these factors are important and should be included in a full assessment of work capability, the research conducted in this project focused on the design of an instrument to determine the match between physical capabilities and job task requirements. However, additional research is warranted to develop similar tools that are capable of determining the match between cognitive and sensory capabilities and job task requirements.

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APPENDIX A

WORK ABILITY QUESTIONNAIRE

INSTITUTE OF OCCUPATIONAL HEALTH

WORK ABILITY INDEX QUESTIONNAIRE

On this form, please give your opinion of your work ability and factors that might affect your work ability. Your responses will be used to determine the need for any supportive action and also the need for improving your work conditions. Please fill out the form carefully and answer every question. Answer the questions by circling the number of the alternative you feel best reflects your opinion or by writing your response in the space given. ALL OF THE INFORMATION GIVEN WILL BE TREATED WITH THE UTMOST CONFIDENCE, AND IT WILL BE USED ONLY FOR OCCUPATIONAL HEALTH CARE PURPOSES.

Date ______/______ 20______

Surname and first names____

Date of birth____

BACKGROUND

SEX

Female.................................. 1
Male...................................... 2

AGE _________ years

MARITAL STATUS

Unmarried............................. 1
Married.................................. 2
Common-law relationship...... 3
Separated............................... 4
Divorced................................ 5
Widow/widower.................... 6

BASIC EDUCATION

Elementary school................ 1
Comprehensive school.......... 2
Intermediate school.............. 3
Secondary school................. 4

VOCATIONAL/PROFESSIONAL EDUCATION

Vocational course for the unemployed
(at least 4 months)..................................... 1
Other vocational course
(at least 4 months)..................................... 2
Vocational school...................................... 3
Vocational institution/college..................... 4
University.. 5
Other training, what................................... 6
....

OCCUPATION AND WORK TASK

____

____

WORKPLACE AND DEPARTMENT

____

____

WORK ABILITY INDEX

1. Current work ability compared the lifetime best

Assume that your work ability at its best has a value of 10 points. How many points would you give your current work ability?
(0 means that you cannot work at all)

0 1 2 3 4 5 6 7 8 9 10

completely unable to work — work ability at its best

2. Work ability in relation to the demands of the job

How do you rate your current work ability with respect to the physical demands of your work?

very good......................................	5
rather good...................................	4
moderate......................................	3
rather poor...................................	2
very poor.....................................	1

How do you rate your current work ability with respect to the mental demands of your work?

very good......................................	5
rather good...................................	4
moderate......................................	3
rather poor...................................	2
very poor.....................................	1

3. Number of current diseases diagnosed by a physician

In the following list mark your current Diseases or injuries. Also indicate whether A physician has diagnosed or treated these diseases. For each disease, therefore, there can be 2,1, or no alternative circled.

	yes own opinion	physician's diagnosis
Injury from accident		
01 back...........................	2	1
02 arm/hand..........................	2	1
03 leg/foot............................	2	1
04 other part of body, where and what kind of injury?... ______________________	2	1
Musculoskeletal diseases		
05 disorder of the upper back or cervical spine, repeated instance of pain.....	2	1
06 disorder of the lower back, repeated instance of pain.....	2	1
07 (sciatica) pain radiating from the back into the leg..........	2	1
08 musculoskeletal disorder affecting the limbs (hands, feet) repeated instance of pain.....	2	1
09 rheumatoid arthritis.............	2	1
10 Other musculoskeletal disorder, what?................... ______________________	2	1
Cardiovascular diseases		
11 hypertension (high blood pressure)..........	2	1
12 coronary heart disease, chest pains during exercise (angina pectoris).................	2	1
13 coronary thrombosis, myocardial infarction..........	2	1
14 cardiac insufficiency...........	2	1
15 other cardiovascular disease, what?..................... ______________________	2	1
Respiratory diseases		
16 repeated infections of the respiratory tract (also tonsilitis acute sinusitis, acute bronchitis............................	2	1
17 chronic bronchitis................	2	1
18 chronic sinusitis..................	2	1
19 bronchial asthma................	2	1
20 emphysema.........................	2	1
21 pulmonary tuberculosis.......	2	1
22 other respiratory disease, what?.................................. ______________________	2	1

	yes own opinion	physician's diagnosis
Mental disorders		
23 mental disease or severe mental health problem (for example severe depression, mental disturbance)................	2	1
24 slight mental disorder or problem (for example, slight depression, tension anxiety, insomnia)........	2	1
Neurological and sensory diseases		
25 problems or injury hearing........................	2	1
26 visual disease or injury (other than refractive error)....	2	1
27 neurological disease (for example, stroke, neuralgia, migraine, epilepsy)......	2	1
28 other neurological or sensory disease, what?............. ____________	2	1
Digestive disease		
29 gall stones or disease...	2	1
30 liver or pancreatic disease........................	2	1
31 gastric or duodenal ulcer...........................	2	1
32 gastric or duodenal irritation....................	2	1
33 colonic irritation.........	2	1
34 other digestive disease, what?......................... ____________	2	1
Genitourinary disease		
35 urinary tract infection.	2	1
36 kidney disease...........	2	1
37 genital disease (for example fallopian tube infection in women or prostatic infection in men)........	2	1
38 other genitourinary disease, what?......................... ____________	2	1
Skin disease		
39 allergic rash/exzema...	2	1
40 other rash, what?........	2	1
Tumor		
42 benign tumor......................	2	1
43 malignant tumor.................	2	1
(cancer) where?..................	2	1
Endocrine and metabolic diseases		
44 obesity................................	2	1
45 diabetes...............................	2	1
46 goitre or other thyroid disease.................................	2	1
47 other endocrine or metabolic disease, what?....................... ____________	2	1
Blood diseases and birth defects		
48 anaemia................................	2	1
49 other blood disorder, what?.................................... ____________	2	1
50 birth defects, what?............... ____________	2	1
Other disorder or disease,		
51 what?...................................... ____________	2	1

4. Estimated work impairment due to diseases

Is your disease or injury a hindrance to your current job? Circle more than one alternative if needed.

There is no hindrance/ I have no diseases...................................	6
I am able to do my job, but it causes some symptoms...................	5
I must sometimes slow down my work pace or change my work methods....................	4
I must often slow down my work pace or change my work methods.........................	3
Because of my disease, I feel I am able to do only part-time work.................................	2
In my opinion, I am entirely unable to work..	1

5. Sick leave during the past year (12 months)

How many whole days have you been off work because of a health problem (disease or health care or for examination) during the last year?

none at all................................	5
at the most 9 days....................	4
10-24 days...............................	3
25-99 days..............................	2
100-365 days...........................	1

6. Own prognosis of work ability two years from now

Do you believe that, from the standpoint of your health, you will be able to do your current job two years from now?

unlikely....................................	1
not certain................................	4
relatively certain......................	7

7. Mental resources

Have you recently been able to enjoy your regular daily activities?

often...	4
rather often..	3
sometimes..	2
rather seldom..	1
never..	0

Have you recently been active and alert?

always...	4
rather often..	3
sometimes..	2
rather seldom..	1
never..	0

Have you recently felt yourself to be full of hope for the future?

continuously..	4
rather often..	3
sometimes..	2
rather seldom..	1
never..	0

APPENDIX B

SELF-EVALUATION QUESTIONNAIRE (ORIGINAL DRAFT)

Williams Work Estimation (W^2E)
Self-Evaluation Questionnaire

Date ________/________ / 20________

SECTION I. PERSONAL INFORMATION

Last name_____________________ First name_____________________ MI_____

Date of birth___________________ Sex _______ M ________F

Workplace____________________ Department __________________________

Job Title_____________________ Number of Years in Present Position ______

Basic Education
- Elementary school................ 1
- Comprehensive school.......... 2
- Intermediate school.............. 3
- Secondary school................. 4

Vocational/Professional Education
- Vocational Training Course………..1
- Jr. / Community College..................2
- University…………………….……….3
- Other training, what..........……........4

SECTION II. WORK ABILITY INFORMATION

Directions: Please rate your ability to perform each of the physical work activities listed by placing a check in the space provided beside the statement you feel best reflects your opinion.

	Poor I always find it difficult to perform this work activity	Moderate I can perform this work activity but I often find it difficult	Good I can perform this work activity with very little difficulty	Excellent I have no problem performing this work activity
Physical Work Activities				
Carrying				
Climbing				
Crawling				
Crouching				
Fingering				
Handling				
Kneeling				
Lifting				
Pulling				
Pushing				
Reaching				
Sitting				
Standing				
Stooping				
Walking				

APPENDIX C

TASK EVALUATION QUESTIONNAIRE (ORIGINAL DRAFT)

Williams Work Estimator (W^2E)
Task Evaluation Questionnaire

Evaluator's Name: Evaluator's Title:

Job Task Being Evaluated: Date of Evaluation:

SECTION I. CRITICALITY OF WORK ACTIVITIES

DIRECTIONS: Please evaluate the criticality of each of the work activities listed to the performance of the job task using the following rating scale:

1 – The job task can be performed without this work activity
2 - The job task can be performed without this work activity but with difficulty
3 – The job task can not be performed without this work activity

	Criticality of Work Activity to Job Task		
	1	2	3
Physical Work Activities			
Carrying			
Climbing			
Crawling			
Crouching			
Handling			
Kneeling			
Lifting			
Pulling			
Pushing			
Reaching			
Sitting			
Standing			
Stooping			
Walking			

APPENDIX D

CONTENT EVALUATION FORM

Williams Work Estimator (W^2E)

Content Evaluation Form

Purpose of this Project

The purpose of this project is to develop a tool useful for estimating an employee's ability to perform daily work activities. The instrument is intended for use with employees, specifically older employees, who perform job task that primarily involve manual material handling activities (lifting, pushing, pulling, etc.). The objective of the instrument is to provide an indication of the match between an employee's physical work capabilities and his/ her job task requirements.

The Williams Work Estimator (W^2E) is a two-part instrument and is based on subjective responses to test items. The test items on both parts of the instrument consist of 15 of the 20 physical demands of work defined by the Department of Labor in the Dictionary of Occupational Titles. Self-evaluation of physical work capability obtained using the Self-Evaluation Questionnaire and job task requirements information obtained using the Task Evaluation Questionnaire will be used to determine the most effective match between work capabilities and job task requirements.

Directions

Evaluate the proposed content of the questionnaires based on the following statements using the rating scale below. Also, provide additional comments as needed.

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

1. The questionnaires identify specific **PHYSICAL** work activities that are likely to be problematic for employees (specifically older employees).

   Rating:

   Comments:

2. The language (wording) of the employee self-evaluation questionnaire can be understood by employees with various educational levels

   Rating:

   Comments:

3. The employee self-evaluation questionnaire is structured such that employees understand what they are being asked to assess (i.e. vagueness of the questionnaire).

   Rating:

   Comments:

4. The anchors provided in the employee self-evaluation questionnaire help to identify the degree of impairment between the physical work activity and the worker's capabilities

   Rating:

   Comments:

5. The language (wording) of the employer task evaluation questionnaire can be understood by employees with various educational levels

   Rating:

   Comments:

6. The employer task evaluation questionnaire is structured such that users understand what they are being asked to evaluate (i.e. vagueness of the questionnaire).

   Rating:

   Comments:

7. The anchors provided in the employer task evaluation questionnaire provide enough information to help users make a distinction between each choice

    Rating:

    Comments:

8. The content of the W^2E is sufficient for estimating the match between worker capabilities and job task requirements.

    Rating:

    Comments:

9. Please provide recommendations for improving the questionnaires.

    Comments:

APPENDIX E

SELF-EVALUATION QUESTIONNAIRE (REVISED DRAFT)

Williams Work Estimator (W^2E)
Self-Evaluation Questionnaire

Date ________/________ / 20________

SECTION I. PERSONAL INFORMATION

Age_________ Sex _______ M ________F

Circle the number that represents your highest level of education

K 1 2 3 4 5 6 7 8 9 10 11 12
13 – OJT (On the job training)
14 – Vocational School
15 – Associate's Degree
16 – Bachelor's Degree
17 – Master's Degree (M.S., M.B.A, etc.)
18 – Professional Degree (Ph.D., MD, etc.)

SECTION II. WORK ABILITY INFORMATION

Directions: Please identify the statement you feel best describes your ability to perform each of the following physical work activities.

	(1) Fair I can perform this activity but always find it difficult	(2) Moderate I can perform this activity but often find it difficult	(3) Good I can perform this activity with very little difficulty	(4) Excellent I can perform this activity with no difficulty
Physical Work Activities				
Bending				
Carrying				
Climbing				
Crawling				
Grasping				
Kneeling				
Lifting				
Pulling				
Pushing				
Reaching				
Sitting				
Standing				
Walking				

APPENDIX F

TASK EVALUATION QUESTIONNAIRE (REVISED DRAFT)

Williams Work Estimator (W^2E)
Task Evaluation Questionnaire

Date of Evaluation:____________

Evaluator's Title:____

Job Task Being Evaluated:____

Job Site:____

DIRECTIONS: Please assess the criticality of each of the work activities listed to the performance of the job task using the rating scale provided.

	(1) Not Required Job task does not require this work activity	(2) Necessary Job task requires this work activity infrequently	(3) Critical Job task requires this work activity frequently	(4) Very Critical Job task can not be performed without this activity
Physical Work Activities				
Bending				
Carrying				
Climbing				
Crawling				
Grasping				
Kneeling				
Lifting				
Pulling				
Pushing				
Reaching				
Sitting				
Standing				
Walking				

APPENDIX G

SELF-EVALUATION QUESTIONNAIRE (FINAL DRAFT)

Williams Work Estimator (W^2E)
Self-Evaluation Questionnaire

Date ________/________ / 20________

SECTION I. PERSONAL INFORMATION

Age_________ Sex _______ M ________F

Job Task____________________________ Length of Employment _________

Circle the number that represents your highest level of education

K 1 2 3 4 5 6 7 8 9 10 11 12
13 – OJT (On the job training)
14 – Vocational School
15 – Associate's Degree
16 – Bachelor's Degree
17 – Master's Degree (M.S., M.B.A, etc.)
18 – Professional Degree (Ph.D., MD, etc.)

SECTION II. WORK ABILITY INFORMATION

Directions: Please identify the statement you feel best describes your ability to perform each of the following physical work activities.

Physical Work Activities	(1) Fair I can perform this activity with extreme difficulty	(2) Moderate I can perform this activity but with moderate difficulty	(3) Good I can perform this activity with only minimal difficulty	(4) Excellent I can perform this activity with no difficulty
Bending				
Carrying				
Climbing				
Crawling				
Grasping				
Kneeling				
Lifting				
Pulling				
Pushing				
Reaching				
Sitting				
Standing				
Walking				

APPENDIX H

TASK EVALUATION QUESTIONNAIRE (FINAL DRAFT)

Williams Work Estimator (W^2E)
Task Evaluation Questionnaire

Date of Evaluation:_______________

Evaluator's Title:____

Job Task Being Evaluated:____

Job Site:____

DIRECTIONS: Please assess the criticality of each of the work activities listed to the performance of the job task using the rating scale provided.

	(1) Not Required Job task does not require this work activity	(2) Necessary Job task requires this work activity infrequently	(3) Critical Job task requires this work activity frequently	(4) Very Critical Job task can not be performed without this activity
Physical Work Activities				
Bending				
Carrying				
Climbing				
Crawling				
Grasping				
Kneeling				
Lifting				
Pulling				
Pushing				
Reaching				
Sitting				
Standing				
Walking				

APPENDIX I

PARTICIPANT CONSENT FORMS

INFORMED CONSENT

Sabrina N. Williams
Development of the Williams Work Estimator (W^2E): A Tool for Determining the Most Effective Match Between Worker Capabilities and Job Task Requirements
(Department of Industrial Engineering/ Mississippi State University)

I am doing a research study to develop a survey that can be used to help employers determine the best match between worker capabilities and job requirements. The study will use 36 employees from an industrial work environment. This study will require you to rate your ability to perform 13 physical work activities (such as lifting, pushing, pulling, etc.) using a 4 point rating scale. In addition, you will be asked to participate in an interview in which the Work Ability Index (WAI) will be administered. Completion of the WAI will require you to rate your work ability in relations to job demands and physical and mental capability.

Your participation in this study is voluntary. Refusal to participate will involve no penalty or loss of benefits. You may stop the study at any time or refuse to answer any question you don't feel comfortable answering. There are no reasonably foreseeable risks or discomforts that might occur from this study. Also, any personal information written or discussed during this study will be kept strictly confidential.

Informed consent MUST be obtained with a written consent form approved by the IRB, and signed by you or your legally authorized representative. A waiver of this requirement can only be granted by the Mississippi State University Institutional Review Board for the Protection of Human Subjects in Research. Also, you WILL be given a copy of this form for your records.

Copies of the signed consent forms will be kept in a locked filing cabinet located in the Ergonomics Laboratory at Mississippi State University. (Please note that these records will be held by a state entity and therefore are subject to disclosure if required by law.) Although the results of the research may be published or provided to your employer, at no time will your name or identity be used.

If you have any questions about this research project, please feel free to contact Sabrina N. Williams at (601) 792-8467. For additional information regarding human participation in research, please feel free to contact Tracy Smart Arwood at the MSU Regulatory Compliance Office at (662) 325-0994.

______________________________ ____________________
Participant's Signature Date

______________________________ ____________________
Investigator's Signature Date

INFORMED CONSENT

Sabrina N. Williams
Development of the Williams Work Estimator (W^2E): A Tool for Determining the Most Effective Match Between Worker Capabilities and Job Task Requirements
(Department of Industrial Engineering/ Mississippi State University)

I am doing a research study to develop a survey that can be used to help employers determine the best match between worker capabilities and job task requirements. Development of this aspect of the survey will involve participation from 2 people who are knowledgeable of the physical activities involved in the various job tasks in your facility. Participation in this study will require you to evaluate the criticality of 13 physical work activities (such as lifting, pushing, pulling, etc.) to the performance of various job tasks using a 4 point rating scale.

Your participation in this study is voluntary. Refusal to participate will involve no penalty or loss of benefits. You may stop the study at any time or refuse to answer any question you don't feel comfortable answering. There are no reasonably foreseeable risks or discomforts that might occur from this study. Also, any personal information written or discussed during this study will be kept strictly confidential.

Informed consent MUST be obtained with a written consent form approved by the IRB, and signed by you or your legally authorized representative. A waiver of this requirement can only be granted by the Mississippi State University Institutional Review Board for the Protection of Human Subjects in Research. Also, you WILL be given a copy of this form for your records.

Copies of the signed consent forms will be kept in a locked filing cabinet located in the Ergonomics Laboratory at Mississippi State University. (Please note that these records will be held by a state entity and therefore are subject to disclosure if required by law.) Although the results of the research may be published or provided to your employer, at no time will your name or identity be used.

If you have any questions about this research project, please feel free to contact Sabrina N. Williams at (601) 792-8467. For additional information regarding human participation in research, please feel free to contact Tracy Smart Arwood at the MSU Regulatory Compliance Office at (662) 325-0994.

______________________________ ________________
Participant's Signature Date

______________________________ ________________
Investigator's Signature Date