Changing Demographics: Preserving Safety and Increasing Performance

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Abstract

While process plants under development hold promise for innovative technology, movement from analogue to digital control rooms, and the latest in automation features, little attention has been given to the shifting demographics of future operators. This discussion addresses the safety considerations relative to people in systems. It is well-recognized that the need for energy, new and upgraded plants, and operator demographics are of concern worldwide.

It is believed that increasing numbers of women as well as ethnic diversity are considerations. These populations impact anthropometric considerations. Moreover, as stated by at least one utility, the pool of operators for tomorrow's plant will come from the brightest and best of the high school students; therefore, at least for them a young demographic. This paper does not address that stance, so the assumption is that there will be a population of young people groomed to staff the plants. The shift in body type and size is an oft-discussed topic of the media. Will the plants and manual operations in the field, or those duties associated with the control room accommodate a young but larger, taller, and likely heavier workforce?

The operators of today are aging. Worldwide, the entire workforce is aging. The pool of persons for start-up endeavors is shrinking. The data show that largely the workforce for new and upgraded plants will be the young workers and older workers. For the most part middle-aged workers are not among the likely candidates. The petroleum industry calls this phenomenon the "big crew change". The Society of Petroleum Engineers (SPE) in 2005 predicted an "age crisis on the horizon" in light of the fact that at that time the average age of SPE members was 45 years old.

This paper primarily addresses the concerns and accommodations of an aging workforce. In the process industries new plants and plant upgrades are underway. Additionally, more and more leading edge technology is being embraced. New operations and maintenance philosophies and conduct of operations must accommodate older workers. For operations, this is particularly true

of control rooms. For the local plant, maintainers must be considered. It is believed that if older workers are accommodated then all the workers will be accommodated.

What is the impact of aging on worker health and safety? Addressing these effects means looking at the physical, psychosocial and cognitive issues related to aging. Society cannot continue to run business as usual. This paper addresses the concerns of a changing and an aging workforce.

It is known that human cognitive and physical capabilities change with age. Little research relative to aging has taken place outside of the experimental laboratory environment. The data relevant to operations is scarce. Nonetheless, quite a bit is known about older workers and how to accommodate them. The focus of this paper is on those issues of change and accommodation.

Topics such as physical changes, cognitive changes, the impact of shift work, learning and training abilities and technological innovations are discussed. Recommendations are provided relative to how best to design these plants to retain and recruit older workers while recognizing the value of younger workers and ensuring that safety is preserved and the possibilities of human error are eliminated regardless of age, demographic, gender, or ethnic background.

1. Introduction

Social, cultural, economic, and psychological forces affect both the process of growing old and the place of older people in society [1]. In particular the relationship between older workers, their employers, and their work environment is not static; it is subject to social and physical modification and change [2]. Older workers' perceptions of these forces and how these may affect quality of life, health, safety, and relations with colleagues are important considerations for exploring and understanding complex relationships of work, age, health, and organizational culture. It has been argued that further research into issues regarding aging and work is warranted [3].

"People are living longer; between 1900 and 1986 life expectancy at birth in the United States increased for White women from 49 to 79 years and for White men from 47 to 72 years" [4]. In addition to living longer, according to Taeuber [4] the quality of life has improved as evidenced by the state of people's well being. "More important than longevity is the fact that most older people are in good health. Only about 10% of those 65 to 74 years of age report that chronic illness prevents them from carrying out their usual responsibilities." [4]

In general, western society's workforce is aging. "The last 50 years of the 20th century have witnessed momentous changes in the size, composition, and characteristics of the U.S. labor force" [5]. The Bureau of Labor Statistics predicted that by 2008 Americans aged 55 and over will represent the greatest annual growth rate and will occupy 30% of the American population. Additionally, by 2008 civilian labor force participation rates for the 55 and older group will grow to 36.8% with the 55 to 64 age group expected to add 7.3 million workers [6].

"The age of the median worker is expected to rise from 35 in 1980 to 41 in 2008" according to Fullerton [7], [8]. This fact cannot be uncoupled from the fact that workplaces are coming up

short relative to willing, ready, and able workers [2]. Drake Beam Morin [9] indicated that "Most labor growth will be those aged 45+ years. This segment of the work force will increase from 33 percent to 44 percent. Those aged twenty-five to forty-four will drop from 51 percent to 41 percent. By 2012 more people will be leaving the workforce than entering."

America's workforce is changing. Baby boomers, defined as those born between 1946 and 1964, are now reaching the age where retirement is just around the corner. The official retirement age of the first of these boomers was 2011. "Once the oldest baby-boomers reach age 65 in 2011, the population will begin to age rapidly. The U.S. Census Bureau predicts that between 2000 and 2040, the number of Americans ages 65 and older will more than double, to 77 million, while the number of prime working-age adults, between the ages of 25 and 54, will increase by only 12 percent" [10].

"In 1790, the median age in America was 16; in 1890, it was 21; in 1990, it was 33; in 2040, it will be almost 39" [2]. The largest growing segment of American population is 85 years and older. This composition transcends every aspect of American or even Western culture as changes are witnessed in older student ratios, workers, and shoppers [11].

The number of workers age 45 and older has doubled since 1950. According to the American Association of Retired Persons [12], the number of older persons (55-plus) in the labor force, which stood at about 18.2 million in 2000, is projected to rise to 25.2 million in 2008 and to 31.9 million in 2025. The resulting increase is 38 percent over 10 years and a 75 percent increase over the full 25 years [13].

The working population in the United States and other developed countries is aging, people are staying in the workforce longer, and an increasing number of older persons are returning to the workforce after retirement [2], [14], [15]. According to the Canadian Centre for Occupational Health and Safety (CCOHS) [16], "In addition to individuals leaving the workforce, the number of older people who work part-time is also increasing."

Women are living longer than men and the gap between the life expectancy rates for men and women has been increasing since 1920. The U.S. Population Pyramids shows that the Baby-boom Echo Cohort born in 1985-1995 will live well into their eighty's and Millennials born 1996-2005 will live well into their 90's [17].

"The so-called baby boomers are coming of age. "Baby boomers are the largest group of workers ever to reach retirement age in the same generation." [18] The workplace can ill afford to lose the skills, knowledge, and abilities of those collectively aging.

2. The Problem

The literature refers to a crisis for America in terms of availability of workers in view of the low jobless rates and a high level of affluence in business [2], [19], [33]. The labor force participation for those in the aging bracket continues to rise because of the overall demographics of an aging society [20], [2], [21], [22]. "If current employment patterns persist, there will be fewer workers in the future available to produce goods and services, threatening standards of

living for Americans of all ages "(Johnson, 2004 p. 48). Aaron, Bosworth, & Burtless [23] stated, "More fundamentally, the aging of the population reduces the number of workers available to produce the goods and services that the economy needs. Without dramatic increase in productivity or changes in employment patterns, the looming worker shortage will reduce per capita output and lower living standards.

The case is built that society is generally aging and thus so are people in the workforce. Organizations need the older workers to be economically and productively viable in light of shifting demographics and a potential shortage of workers.

Laying that foundation brought some issues to the surface. There are a number of assumptions, stereotypes, and myths believed by management and organizations regarding older workers [24], [20], [25], [26], [27], [28], [29]. Attitudes and beliefs about older workers have been characterized as "ambivalent" [30] and "mixed" [31], that is, older workers are viewed as having both positive and negative attributes. Several studies [31], [28], [30], [32] reveal that, when compared to younger workers, older workers are viewed positively on a number of traits including low absenteeism, low turnover, work attitudes and motivation, job skills, and loyalty.

These same studies also report conflicting findings that are not as positive for older workers. For example, in Hassell & Perrewe's study [32], respondents believed that older workers have fewer accidents, whereas the 1995 AARP study showed that managers rated older workers below average on avoidance of workplace injury. Barth, McNaught, & Rizzi's research [30] revealed that, when it comes to older workers, managers are concerned about health care costs, their flexibility in accepting new assignments, and their suitability for retraining.

The NRC [33] stated, "Too many commonly held beliefs concerning the capabilities of older workers are either incorrect or based on inadequate data." According to Schultz and Salthouse [34] there is a belief among some employers that "Most middle-aged and older adults are poor employment risks. Compared to young adults, they do inferior work, have poorer attitudes because they are more set in their ways and more often become injured or ill." Goldberg [2] also maintained that an assumption about older workers by employers is that "Older workers are ill more often than younger workers." If organizations maintain these beliefs about older workers, they are less likely to retain or hire them.

Changes are occurring in the workplace regarding older workers that will lead to even more profound shifts in the next 5-10 years. Currently, there are over 16 million Americans over 55 who are working or actively seeking employment. By 2015, the number of employees over 55 will reach a record 31.9 million, compared to 18.4 million in 2000 [35]. It is not uncommon to know of workers in their upper 60s and 70s in most segments of the workplace. Financial need, longer life expectancy, and a desire to remain working are reasons that the workforce of individuals aged 55 and older continues to grow [36]. Many individuals retire from one job, start to draw a pension, and then realize that work is still an important or financially essential part of their lives. Herz [37] points out that since 1984, both the full- and part-time work of "retired" men younger than age 65 has increased noticeably.

Do these workers experience greater physical and mental discomfort at work compared with younger workers? Are they hurt more or less often, and do they hold different perspectives on work environment, job stresses, health and safety considerations, and organizational (employer) culture than other workers? "Many studies are looking at the effects older workers have on the workforce. They are also looking at the effects different types of work have on older workers' bodies, and how to keep them safe and free of injury" [16].

2.1 Significance of the Research

This study is significant for the sheer volume of people preparing, due to chronological age, to leave the workforce [2], [33], [25]. The CDC *Worker Health Chartbook* [22] indicated that "As the U. S. labor force grows, it becomes markedly older...the distribution of the labor force is shifting."

While their retention or later recruitment is critical, [38], [39] the workplace must recognize and accommodate those variables that contribute to the safety and health of the aging workers [40]. If the workers are in a state of well-being, are pain- or symptom-free, experience comfort on the job, they are likely to be more satisfied, and perform better. Ultimately, the older workers may stay on the job longer than opt for early retirement or even retire at the typical and usual suggested age [2].

It cannot be refuted that while the older workers are needed in the workplace, [38], [39] their safety and health and the control of occupational injuries like musculoskeletal disorders must be regarded with high priority for not only their well-being but economic survival as well [41], [33], [42]. Losing workers who are skilled and needed especially to a Cumulative Trauma Disorder (CTD) that could have been prevented is quite costly [43].

2.1.1 Beliefs Regarding Older Worker Injuries

These kinds of stereotypes make some businesses, who believe them, reluctant to hire older workers, [44], [45], [46], needless-to-say accommodate those currently in the workplace. Often a prevailing attitude exists based on stereotypes that older persons will get hurt more and therefore, there is nothing that can be done about it. Some organizations do not take a responsibility for the older workers seriously; others do not even hire them [48].

Some businesses see aging as a period of physical decline and voice worries about what it may mean for their organization [44]. They fear that older workers will be absent from work more than younger workers, that they will be sick more often, and that they will have more workplace accidents [49].

Hahn [48] suggested this lack of desire for employers to hire older persons stems from several stereotypes and persons of age. These stereotypes result from false assumptions that are influential and are magnified over time. It is not surprising that the stereotypes are so deeply influenced by public policy in this society [45], [46], [47].

Coberly and Newquist [49] maintained however that "Contrary to popular notions, older workers are safe workers; they have fewer workplace accidents than younger workers. Studies conducted by the Bureau of Labor Statistics find that workers over age 55 account for fewer than 10% of all workplace injuries even though they make up almost 14% of the labor force." And AARP Public Policy Institute [50] indicated that "it is younger workers who experience a disproportionate share of work-related injuries.

One prevailing belief is that older workers get hurt more. In part this research concerned itself with an exploration of this belief. There is no dispute that as people age, they change physically and psychologically; capabilities and limitations change as well [1]; however, are the changes performance limiting?

The review of the literature indicated that there are physical changes seen in older workers which may or may not influence work capacity or discomfort such as

1. Slowing of information processing speed has not been correlated with decreases in on-the-job performance [6]
2. There may be increased susceptibility to lifting injuries, but there is little relationship between age and the incidence of lifting injuries [51]
3. Poor sight and poor hearing as well as work disabilities are associated with occupational injuries in older workers [52]
4. Age alone is not associated with increased susceptibility to low back pain with related absenteeism, unless large body mass, smoking, and less job experience, are factors as well [51].

2.2 The Statistics

The workforce is aging. The American Association of Retired Persons (AARP) suggests that between 2000 and 2020, the number of those in the 55 to 64 age range will increase nearly 40 percent, and the number of those in the 65+ category will increase more than 40 percent. This will occur while other age brackets (25 to 34, 35 to 44 and 45 to 54) will decrease in size (AARP). According to Bureau of Labor Statistics (BLS), in 2002, those in the 25 to 54 age range made up approximately 76 percent of the working population, while those in the 55 and older age range make up approximately 13.6 percent of that population. BLS also shows that in 2001, those in the 25 to 54 age range experienced nearly 75 percent of the recordable injuries involving days away from work, while those in the 55 and older age bracket experienced only 10.4 percent of such injuries (BLS). (The remaining percentages come from those in the 14 to 24 age bracket and from those injuries in which age was not reported to BLS.) Does age affect error rates and thus injury and accident rates?

3. Definition of Terms

Absenteeism is the absence from work of an employee during normal working hours, whether voluntary or involuntary. Voluntary absence is usually considered to be avoidable and without reasonable cause; in effect the employee chooses to be absent. Involuntary absence is usually held to be unavoidable and outside the employee's control, for reasons such as unusually difficult weather conditions, breakdown of transport, or sickness. A high absenteeism rate is a

sign of organizational ill-health in a work organization. It is also likely that much of the absenteeism through sickness is job related, either physically in the form of industrial diseases or emotionally in the form of psychosomatic disorders. See also presenteeism.

Job Stress "Job stress can be defined as the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker. Job stress can lead to poor health and even injury". [54]

Musculoskeletal Disorders (MSDs) are "conditions that involve nerves, tendons, muscles, and supporting structures of the body" [54].

Presenteeism a form of absenteeism while remaining in the job. It is found among employees who are seriously disaffected from their organization.

Psychosocial issues include such things as: presenteeism, organizational legacy, shift work, job stress, overtime, job insecurity, over-regulation, and layoffs. These are defined below.

Retirement is the process of finishing one's full-time work life, traditionally at a designated or generally accepted age. Early retirement has increased greatly in recent years, though later retirement has also been noticed [15], [55].

Retirement on the job a term sometimes used of an employee who experiences such alienation from his job that he does the minimum possible in order to retain it while he waits for retirement. It may be the end result of presenteeism.

Wellness definition of health that was commonly accepted at the time: "that state of being, existing in the absence of disease" (Steiglitz 1952, p. 14). High level wellness for the individual is defined as an integrated method of functioning which is oriented toward maximizing the potential of which the individual is capable. It requires that the individual maintain a continuum of balance and purposeful direction within the environment where he is functioning [57].

Work-Related Musculoskeletal Disorders (WMSDs) are injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs, not including disorders caused by slips, trips, falls, or motor vehicle accidents.

4. Literature Review

4.1 Introduction Literature Review – Aging Workers

"The most useful starting point for the psychological study of aging is to consider the aging process in the context of psychological issues throughout the lifespan. The changes that occur in later life take place against a backdrop of a long adaptational history, in which the individual has confronted numerous physiological, psychological, and contextual challenges." [58]. Collective human history and individual lifespan events give rise to theory, knowledge and predictions about people, how they age, and the degree to which success can be metered relative to adaptation, accommodation, and even longevity. Whitbourne [58] said that, "From the

individual's perspective, this continuity is particularly salient, as a sense of the self as continuous over time is a central feature of lifespan psychological development. Although many changes occur in the later years of life, these changes must be seen in the context of both successful and unsuccessful adaptations to previous gains and losses throughout the earlier years of adulthood." Until recent times, if a person did not work, they did not eat. It was that simple. Government aid is a relatively new phenomenon.

Although romanticized by modern media, life was hard and etching out sustenance for oneself was arduous at the very least. Aside from limited knowledge relative to quality medical care, the longevity of people was undoubtedly inhibited through the trials of work. If lifespan and adult development are studied, the quality of life can improve, longevity increased, and increased safety, health, well-being and satisfaction can be achieved. This knowledge can be applied to work practices and standards and the design of work such that as people age: shifts, improvements, progression, decrements, deterioration, and diminished capabilities all can be at least acknowledged if not accounted for and accommodated.

There are social, cultural, economic, and psychological factors that affect both the process of growing old and the place of older people in society. "Research already shows the power of these factors; it shows that aging and the status of the elderly are not inevitably fixed but are subject to social modification and change. But more research is needed on how these factors operate. In order to enhance the quality of life for older people and to contain the personal and social costs of health care and dependency, more knowledge is required to strengthen the scientific basis for professional practice and public policy." [3] In general, western society is aging [59]. This fact cannot be uncoupled from the fact that workplaces are coming up short relative to willing, ready, and able workers. Therein lies a paradox. There are many aging persons who may be fully capable of fulfilling the needs of the workplace however; there are so many myths surrounding older persons that those myths may preclude the gap being bridged between the overall need for workers and the retention and/or recruitment of older workers.

There are numerous and erroneous myths [60], [20], [61], [62] that surround the aging workforce. In order to retain aging workers successfully in a state of well-being these beliefs must be examined in order to move forward. A self fulfilling prophecy among older workers may be self perpetuating insomuch that people come to believe that they should feel and act in a certain way with advancing age and thus fulfill erroneous expectations. Many businesses, the media, and the older workers themselves perpetrate these myths. One prevailing myth is that older workers get hurt more. In part this research concerns itself with an exploration of fallacy of the myths, and attempt to show that the aging workforce is viable and necessary to contemporary business. There is no dispute that as people age, they change physically and psychologically; capabilities and limitations change as well [1]; however, are the changes performance limiting?

4.2 Shifting Demographics

The aging of the U.S. population is affecting the demographics of the work force. Between 2000 and 2010, the age group experiencing the greatest growth will be those aged 55-64; by 2005, people aged 55 and over are projected to be nearly 20% of the working age population,

compared to 12.5% in 1990 [63], [30]. For a number of reasons, including financial need, longer life expectancy, and a desire to continue working, the number of individuals aged 55 and over in the work force is continuing to grow [36]. It is no longer unusual for individuals to retire from one job, begin drawing a pension, and seek new employment: since 1984, both the full- and part-time work of "retired" men younger than age 65 has increased noticeably [37].

The Bureau of Labor Statistics (BLS) (2000) predicts that by 2008 Americans aged 55 and over will represent the greatest annual growth rate and will occupy 30% of the American population. Additionally, by 2008 civilian labor force participation rates for the age 55 and older group will grow to 36.8%, a 6.5% increase over the participation rates for this group for 1996, with the 55 to 64 age group is expected to add 7.3 million workers. "The predicted median age of the labor force for 2008 is estimated at 40.7 years, an age not approached in the past because the median age peaked at 40.5 years in 1962. Coupled with this aging profile, employment in professional specialty occupations will increase the fastest and add the most jobs in the decade leading to 2008." [6].

Within the professional specialty professions, the majority of the employment increases are expected to occur in the service industry division. This fact demonstrates the change in the nature of work. Johnson [10] reported, "Non-physical job demands appear to have increased between 1992 and 2002. The proportion of older workers claiming that their jobs require intense concentration all or almost all of the time increased 8 percentage points (or 17 percent in relative terms), and the share claiming that their jobs always require skill in dealing with other people increased 10 percentage points (or 16 percent in relative terms)."

4.3 Retirement: An Outdated Notion

Retirement for future older workers is becoming an outdated notion [61]. From a societal perspective, the issue has changed from assisting older workers to retire and use leisure time to retaining and recruiting older workers. Recruitment and retention [64] become a key policy issue to satisfy the increasing demands for productivity, worker shortages, and retaining corporate knowledge [25], [65], [66], [67].

From a national policy perspective, increasing work life eases the social security burden [68], [69] reduces age discrimination [70] and requires programs for reemployment and continued employment of older workers [71], [72]. In the future, retirement will be interspersed with older workers cycling in and out of periods of active employment. Work will become an integral part of living [73], [74], [75]. In the future, baby boomers may not be able to retire due to frequent job changes, underemployment, and not having acquired a consistent retirement package such as one might earn over a working life in a one-career job [76]. LaRock [77] suggests that the small number of septuagenarians in the workplace indicates that workers are making the decision not to return to work. Retirement may become a self-imposed status determined by the worker rather than an institutional norm.

“The same social, demographic, and economic forces that influenced the level, growth, and composition of the labor force during the past 50 years will continue to influence the workforce in the coming decades" [5]. For a number of reasons, many older workers are making the

decision to stay in the workplace past the typical retirement age. Many have had stable careers in semi-skilled, skilled, and professional occupations and are actively planning for retirement. In fact, 33% of the workforce over the age of 55 is employed in managerial and professional occupations [78]. While not all wish or need to work fulltime, the option to be productive in meaningful jobs is desired by those who either choose or are required to be in the workforce. In addition, employers need the skill set, experience, and other values perceived as held by aging workers due to a phenomenal possibility of a mass exodus from the workplace by workers (baby boomers) in the near future coupled with a declining birthrate.

4.4 Increasing Longevity

Roszak [79] indicated that, "Demographically speaking, the baby boom of 1946 to 1964 was an aberration. Ever since the great public health campaigns of the nineteenth century, the life span in modern societies has been lengthening and the average age has been increasing." Roszak [79] substantiated his point with the following, "We know that life expectancy has to be refined by race and class. But in gross numbers for all races and both genders, life expectancy in the US rose from 63 (men, 60.8; women, 65.2) in 1940 to 76.7 (men, 74; women, 79.5, white women, 80) in 1999." As baby boomers begin to retire over the next few years, the DOL (1999) notes the workforce will shrink as those born from 1965 to 1985, a time with a declining birthrate, enter the workforce.

Yes, in the past, people died younger, aging and how one feels about it are relative indeed. Moreover, a new concept came to mind with the reading of Thane [80] and her very comprehensive exploration of people aging, their histories and a cultural comparison which is fascinating. Thane [80] said that, "Much of my recent work has been engaged with the history of and social meanings of aging and old age, an important phase of life throughout history but one which, with a cluster of rare exceptions written in the nineteen seventies, was hardly at all studied by historians until comparatively recently. It is field of study which has engaged closely with work in other disciplines in the Humanities and Social Sciences, and which requires, if all of its dimensions are to be understood, engagement with a wide range of qualitative and quantitative methods. Like many areas of social history it has gained from the insights of the 'cultural turn' whilst continuing to benefit from and to develop older approaches drawn from demographic, economic, and political history. Ideally, it fuses all of these approaches." That thinking seems certainly valid and merits admiration. Or more likely gratitude for allowing the springboard toward further inquiry.

Coughlin [81] makes a number of good points. He said for example that, "Society has invested billions of dollars to improve nutrition, health care, medicine, and sanitation to increase the average lifespan. In fact, longevity can be listed as one of the nation's greatest policy achievements." The average American can plan to live almost twice as long as his relatives did at the turn of the century. Life expectancy in 1900 was little more than 47 years. In 2000, life expectancy will be at least 77, and some argue that the real number may be in the early- to mid-80s. Instead of looking at the high likelihood of death upon turning 50, as was the case in 1900, Horace Deets, executive director of the AARP, has observed that "an American who turns 50 today has more than half of his or her adult life remaining." The thoughts created were to quantitatively look at the how and why of some of the myths themselves.

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4.5 Age Variability

There appears to be considerable variation in the concept of older worker as defined by age alone. The term older worker extends from 40 to 75 years of age. When workers at age 40 are referred to as older workers, age is linked to beginning thoughts about retirement decisions [82], the decline in training opportunities [83], the dispelling of myths about the productivity of an aging work force [84] or the need for older workers to stay on the job to mentor younger workers [85]. At the other end of the age continuum, older workers are identified as those in need of preretirement education and planning [86] or those considering gradual work reduction or seeking training for alternative careers [87]. The concept of older worker encompasses different ages depending on the purpose of the organization as well as the needs of the worker. Age alone may not be a defining characteristic of an older worker. Perhaps becoming an older worker is more situational than chronological.

Another new thought emerged insomuch one item not heretofore considered was that in the past people worked longer because they had to. Today however, many people work longer because they want to. Need and want are clearly two different items and there is a confidence that those are not mutually exclusive. Surely there is overlap. Aside from motivations for working, there are misconceptions stated about the older worker.

Thane [80] illustrated how aging has shifted the demographics. "It has been long assumed that most manual workers could not remain fully active at their trades much past age fifty, especially when performance depended upon such physical attributes as good eyesight." She pointed out that, "Literary evidence from the sixteenth century suggests that the fifties were regarded as the declining side of working maturity, the beginning of old age, as is still popularly assumed. For women old age was often thought to start earlier, in the late forties or around fifty, when the physical concomitants of menopause became visible; for men the defining characteristic was capacity for full-time work."

Thane [80] went on to say, "For both men and women in pre-industrial Europe old age was defined by appearance and by capacities rather than by age-defined rules about pensions and retirement, hence people could be defined as 'old' at variable ages. English poor relief records of the eighteenth century first describe some people as 'old' in their fifties, others not until their seventies. Supplicants for public service pensions in eighteenth century France ranged in age

from 54 to 80 years." The point among others is that people live longer, they want meaning and meaningfulness in their lives.

Moreover, it seems logical that they want choices, including those that include work of some form, if they want it. For example, forced retirement is viewed as unpleasant at best. Most in retirement continue to work even if unpaid. In addition, most people it is presumed that people want to live successfully, and that does NOT imply great hoard of money per se, but for the most part, it may be believed that while as many seek to simplify their lives with increasing age, which does not mean living uncomfortably (Rowe & Kahn, 1998). It is safe to assume, that if people have worked hard all their lives, that they did so to eat, to have shelter, and ultimately at some level self actualize according to the now famous hierarchy as defined by Maslow [88].

At the same time that the number of older persons available for and willing to work is increasing, the workplace is changing as businesses seek to become more competitive. The most notable changes include downsizing, increased use of technology, and less-hierarchical work structures that use teams. As a result of technological changes and greater dependence on teams, training and retraining are hallmarks of today's workplace. Older workers have not fared particularly well during these changes.

During the downsizing that took place from 1986 through 1991, proportionately more older workers were laid off, and, at the expense of retraining existing employees--especially older workers--firms spend more on training new entrants [36]. Kantor [89] refers to the aging work force as a "mixed blessing [because] many companies associate it not with a loyal, experienced workforce knowledgeable about its employers' businesses but with . . . uncertain returns from 'experience' in light of pressures for innovation and change".

Thus a paradox exists: an increasing proportion of the U.S. work force is aging at the same time the workplace is changing in ways that have been detrimental for older workers. By examining some of the myths and realities associated with older workers, this research explores whether perceptions that have led to adverse treatment of older workers are accurate.

The state of the aging, the need for them in the workplace, the myths about them, and a look at the development of adults have been reviewed and considered. The need for further research, study, evaluation, and theory generation cannot be dismissed or refuted. Of particular interest is the safety and health of the aging worker. One prevailing myth is that older workers are hurt more on the job. It is believed that is not so, and thus, one purpose of this study. These kinds of myths and stereotypes make some businesses, who believe them, reluctant to hire older workers, [45], [46], [47], needless-to-say accommodate those presently in the workplace. Often a prevailing attitude exists based on stereotypes and myths, that older persons will get hurt more and therefore, there is nothing that can be done about it. Some organizations do not take a responsibility for the older workers seriously; others do not even hire them [48].

Hahn [48] suggested this lack of desire for employers to hire older persons stems from several stereotypes and persons of age. These stereotypes result from false assumptions that are influential and are magnified over time. It is not surprising that the stereotypes are so deeply influenced by public policy in this society [45], [46], [47].

It is contended that aging workers are not hurt more than younger workers. Moreover if hurt, one of the most prevalent types of injuries recorded is musculoskeletal. BLS (2002) figures indicate that Cumulative Trauma Disorders (CTDs) accounted for over 56% of all Workers' Compensation claims in 1990, up from only 18% of claims in 1980. Estimates of annual costs to industry range from 20-50 billion dollars. NIOSH estimates that CTS affected 23,000 workers in 1991, at an average cost of $3,500 in benefits and rehabilitation [21].

Back injuries, some of which are CTDs, are a leading cause of absenteeism and disability, resulting in approximately 93 million lost workdays each year. Since heavy industry largely is not prevalent any longer in the United States [2], but musculoskeletal types of injuries have not decreased, [22], it is believed that these types of injuries have other sources. Such sources may be stress-related and are psychosocial in nature [90]. Thus this research intends to focus on psychosocial aspects that might give rise to discomfort and work-related injuries and accidents among older workers (those equal to or greater than age 45) compared with their younger colleagues.

Baby boomers are coming of age, they face retirement; however many prefer to continue to work, to stay active, and to relish the lives they have established. Is the workplace able to accommodate them and do so safely? Can the aging overcome the swirling myths [60], [20], [62] that surround them and thrive productively and successfully? This paper reviews statistics pertinent to changing demographics, myths, and realities surrounding the aging, as well as the need for retention of the aging in the workplace. Some consideration is given to physiological and psychological changes as well as means to accommodate aging persons in the workplace.

From the time of birth, growth and development occur to complete a life cycle to fruition. Lifespan development has been a source of study, speculation, and research for quite some time. In addition, it is irrefutable that people have always worked in order to survive, from hunting and gathering, through an agrarian society, to an industrial age and finally, to an age of information and technology. The study of people as they pass through their adult lives including their work, in some respects indicates who they are and how they have developed, adapted, adjusted and in society, work is often used as a measure of success. Thus, the study and understanding of facts about aging and lifespan development, while readily acknowledged as having influences from birth forward, is important toward design, development, and accommodation of people in the workplace. Since work is an inherent and incumbent responsibility of most adults absorbing much of their adult life, it is requisite to study development in order to better design work and more ably accommodate the people in the workplace.

4.6 Attitudes and Beliefs

Attitudes and beliefs about older workers have been characterized as "ambivalent" [30] and "mixed" [31], that is, older workers are viewed as having both positive and negative attributes. Several studies [31], [28], [30], [32] reveal that, when compared to younger workers, older workers are viewed positively on a number of traits including low absenteeism, low turnover, work attitudes and motivation, job skills, and loyalty.

These same studies also report conflicting findings that are not as positive for older workers. For example, in Hassell and Perrewe's study [32], respondents believed that older workers have fewer accidents, whereas the 1995 AARP study [28] showed that managers rated older workers below average on avoidance of workplace injury. Barth, McNaught, and Rizzi's research [30] revealed that, when it comes to older workers, managers are concerned about health care costs, their flexibility in accepting new assignments, and their suitability for retraining. Managers interviewed for the 1995 AARP study [28] were more likely to rate older workers as weak on flexibility, acceptance of new technology, and ability to learn new skills, all traits considered desirable for the changing workplace.

The contradictory attitudes displayed toward older workers may be attributed in part to managers themselves. In a study of the effect of age on performance evaluation and promotion, Siegel [91] found no significant difference between supervisors' performance evaluation for older managers compared to similar groups of younger mangers. However, older managers were less likely to be promoted. Hassell and Perrewe [32] found that, compared to younger supervisors, older supervisors are more negative in their beliefs about older workers, and based on his review of research McNaught [92] concluded that managers almost always underestimate the productivity of older workers. According to McNaught, "employers [and managers] were seen as stereotyping [older workers] as loyal and possessing good work habits, but inflexible and difficult to train" [92].

The workforce is aging and concurrent with that, so is businesses. Many businesses hold some beliefs that older workers get hurt more on the job as they age. Even older workers may hold such stereotypic beliefs because for so long such thinking has been foisted upon them and it may well have turned into a self-fulfilling prophecy of sorts [93].

4.7 Aging Development Background

The literature on adult lifespan development reveals a number of theories that have postulated developmental transitions or stages. For example, Erik Erikson [94], [95] formulated a psychosocial stage model that outlined the primary crises for the expanding ego from birth through old age. The ego challenge of middle age, generativity vs. stagnation, reflects a concern for establishing and guiding the next generation and emphasizes qualities such as productivity and creativity. Developmentally, the prediction is that a person moves beyond the self-directed concerns of identity prominent in adolescence and the interpersonal concerns of intimacy prominent in young adulthood to the phase of sharing one's knowledge and skill with younger individuals and assuming leadership and decision-making roles. These proposed changes are largely unexplored empirically. The final stage, integrity vs. despair, is perhaps the most subtle and appealing of Erikson stages. Many aspects of integrity have been identified: emotional integration, accepting one's life cycle as something that had to be, adapting one's self to the triumphs and disappointments of living, possessing a love of humankind rather than self, and achieving a spiritual sense that eliminates the fear of death. According to the theory, many people face the challenge of emotional integrity in old age.

Other models of personality development have paralleled or elaborated the stages proposed by Erikson. Jung [96] wrote about the process of self-illumination as an elder, which referred to a

turning inward to reflect about the meaning of life. Similarly, Charlotte Buhler [97] formulated basic life tendencies that work toward the fulfillment of life. Creative expansion, the eminent tendency of adulthood, referred to goals of advancing in the world and changing it creatively through physical or mental activities. Upholding internal order, the life tendency of old age was composed of different ordering principles that worked toward the unity of personality and behavior. Such principles are found in the integrating operations of goals, ideals, and self-assessments. Among contemporary scholars, Neugarten [98], [99] elaborated the personality challenges of middle age and old age. She proposed the "executive processes" of middle age that included qualities such as self-awareness, selectivity, manipulation and control of the environment, mastery, and competence. Individuals of this age viewed the environment as rewarding risk-taking and boldness. In contrast, the older person was seen as more conforming and accommodative to outer-world demands. This inward-turning was described as the "process of interiority, or as the active-to-passive mastery sequence." More recently, the works of Levinson [100], Gould [101], and Vaillant [102] have formulated personality transitions that individuals experience in the second half of life. A further array of popular works such as those by Sheehy [103], [104], Scarf [105], and [106] detail personality changes from the thirties to the sixties.

Those theorists have been criticized from many perspectives, for example, by those who argue that there is no essential change in personality in the second half of life [107]. First, the previous perspectives represent, either implicitly or explicitly, stage models. They formulate progressions of change that follow orderly, sequential patterns. Such models have generated much discussion as well as conflicting opinions within the lifespan developmental realm [108], [109].

Essentially, stage theory has been criticized for being too rigid and restrictive, for requiring sequences of change that are unidirectional, irreversible, hierarchical, universal, and so on. Such requirements were less difficult to meet as one followed the biological growth and development of the child, but when applied to adulthood and aging, the requirements flew in the face of individual differences, cohort effects, social change, and personal idiosyncrasies. Thus, "there ensued a period of berating stage models, accompanied by arguments that there is no overarching ground plan to adult development" [99]. Those who continued to endorse stage models were seen as naive and had to suffer the awkwardness of advocating theories that were especially neat and tidy.

Neugarten [99] and Whitbourne [58] discussed other theorists and stated that interest in the progressions of change described by Erikson, Buhler, Jung, and others has allowed for the continued commitment to scrutinizing and extending their works despite the associated criticism. Clearly, it was not that their theories were orderly, neat, and tidy. "The attraction rather was that they formulated spiraling progressions of improvement for the individual. Each theorist had formulated ways in which the individual could continue to develop, become more differentiated, and function at a higher level. It was this quality, these spiraling progressions of improvement, which captured and sustained interest. Admittedly, such conceptions of personal improvement are likely to be intertwined with individual differences, cohort effects, and cultural variability, but such effects do not discount the impact these models have as guiding ideals that influence what people become and how they develop" develop" [58]. Such images of human fulfillment are central to understanding how people conceive of lifespan development. Those conceptions

may give rise to the myths about older workers or they may empirically give rise to increased support of the older worker in the workplace.

4.8 Physical Changes

It cannot be disputed that there are changes that do occur as a human ages. This aging process starts almost at the time of birth. Whitbourne [58] discussed physiological and psychological or cognitive changes. "Psychologists who focus on aging regard as a second central theme the need to distinguish between normal aging and disease. There is a natural tendency to assume that as individuals age, they develop chronic health problems such as arthritis, cardiovascular disease, and diabetes, but as prevalent as these problems may be, they are not considered inherent in the normal aging process. At the same time, psychologists who treat elderly individuals must be familiar with the more common diseases so that they can provide more effective services. What appear to be psychological difficulties such as, for example, depression may be caused by physiological dysfunctions that have psychological side effects."

Normal physiologic changes related to aging include decreased motor, sensory, and cardio respiratory function. Changes in the musculoskeletal system involve decreased bone density, muscle mass, strength and fitness. Decreased motor function is evidenced by decreased reflex time, coordination and reaction speed. The implication for older workers is their ability to maintain a healthy posture, which protects the spine from injuries. Heavy lifting, awkward positions and static postures are all risk factors for workplace injuries. Tasks requiring grip force and exertion as well as repetitive tasks are more difficult with decreased strength and endurance.

Decreased sensory function is evidenced by decreased visual acuity, hearing loss, and auditory sensitivity. The older worker requires two to three times as much light as a twenty year old to see the same thing. Hearing loss and increased sensitivity to noise also lead to distractions from tasks, which require focused concentration.

Age-related hearing loss, known as presbycusis, is very common, and can occur in 20 to 25 percent of persons 65 to 75 years of age [110]. The causes are not well understood, and a variety of genetic and environmental factors have been suggested. There are apparently substantial differences in presbycusis among populations defined geographically or socioeconomically, suggesting the importance of non-occupational noise and other environmental factors. Among the most important occupational causes is noise exposure, and considerable effort has been spent understanding the mechanisms and management [111].

Cardio respiratory and thermoregulation are key predisposing factors for injury, especially in heavy labor and construction industry workforce. Decreased cardio respiratory function is related to decreased lung capacity. Decreased ability to oxygenate red blood cells results in fatigue, which occurs more quickly. Depending on the physical demands of the job, older workers may need to take more frequent breaks. Decreased ability for thermoregulation also affects the older worker as they become more sensitive to the effects of hot and cold extremes.

Chronic disease and co-morbidities influence the extent that the aging person remains active. Older persons incapacitated with a chronic condition do not have the stamina to remain active and maintain their health through physical activity.

"The most frequent co-morbidities identified in aging include obesity, arthritis, high blood pressure, diabetes, depression and heart disease" [112]. Medications prescribed to regulate and control these diseases often create other safety issues due to side effects that include drowsiness, dizziness, and decreased mental acuity.

4.8.1 A closer look at vision

Vision is by far the most important sensory channel. Humans receive a wider range of information from light than all other senses combined. Approximately 90 % of most of the information most people learn in a lifetime enters through the eyes. A 60-year-old person may require 2 - 3 times the amount of light as a 20 year old. The amount of light required doubles for each 13 years after the age of 20 [113], [114].

Normal age related changes in vision include impaired ability to adapt to changes in light levels, extreme sensitivity to glare, reduced visual acuity (ability to discern detail), restricted field of vision and depth perception, reduced contrast sensitivity, and restricted color recognition. The lens of the eye after 60 becomes thicker, harder and more yellow and the pupil reduces in size. The hardening of the lens reduces its ability to change shape and therefore to accommodate for variations in distance. Decreases in depth perception and color differentiation are common in normal aging; visual memory is also reduced. Impaired depth perception may cause a person to perceive a shadow on the floor as a step or a hole and the visual misinterpretation based on visual misinformation can severely impair an individual's ability to function safely [115].

Loss of vision can be divided into two categories: 1) inability to form a clear image on an otherwise normal retina or 2) presence of retinal or optic nerve disease such as diabetes. There are three common functional vision losses which includes overall blurred vision, central vision loss and peripheral (side) vision loss [116].

4.8.2 Hearing Loss

Age-related hearing loss

The permanent threshold of hearing rises progressively with age, with the loss of hearing greatest in the higher ranges of frequency and more pronounced in men than in women. Taking a frequency of 3000 Hz as standard, the average loss of hearing to be expected at various ages is as follows:

50 years	10 dB
60 years	25 dB
70 years	35 dB

The audiogram of age-related hearing loss differs from that due to exposure to noise in that the loss of hearing increases progressively as the frequency is raised so that the highest frequency still audible shows the greatest shift in its threshold. The dip in the curve at 4000 Hz, characteristic for noise exposure in the west, is not evident in cases of age deafness.

Older workers often show the combined effects of age deafness and noise deafness, and it may be difficult to distinguish between the two.

The risk of hearing loss

From the evidence of many comparisons between exposure to noise and the frequency of impaired hearing, it is now possible to estimate the risk of hearing damage in noisy factories. The International Standards Organization (ISO) sets out comprehensive publications about this risk in relation to age, duration of exposure and the intensity of the noise.

The table data show that the risk of damage increases both with sound intensity and duration of exposure, *the damaging intensities being those above approximately 90dB(A).*

Factory workers are often exposed to noise that varies widely and it has been shown that interruptions, or periods of relative quiet, reduce the risk of damage to hearing.

To assess the extent of such risk, the equivalent noise level over the 8-h working day must be calculated. The relation between length of exposure and intensity of sound to create the same degree of risk is as follows:

Hours	*dB(A)*
8	90
6	92
3	97
1.5	102
0.5	110

4.8.3 Aging and Musculoskeletal Injuries

One of the most prevalent workplace injuries is musculoskeletal [117]. Due to the physiological changes previously discussed, the older worker is predisposed to back injuries. In addition, arthritis ranks second only to heart disease in the number of disability claims filed each year in the U.S. [118], [119]. It affects 1 out of 7, making it one of the nation's most common crippling conditions. Muscles support bone and must be exercised. Each day that muscles are not used approx one thirtieth of a person's strength disappears, resulting in "orthostatic hypotension" or

low blood pressure. Muscular endurance and age related muscle loss is not seen to the extent in older persons who remain active and lift weights.

Another predisposing factor is weakened abdominal walls that do not support the structure of the back. There has been much research done on the role of spinal stability exercises and its effectiveness in reducing musculoskeletal disorders [120], [121], [43]. Spinal Instability is a predictor of back pain, which affects approximately 1/4 to 1/3 of the population.

4.8.4 Causes of Back Pain

The principal cause of back pain is mechanical. Excessive mechanical stress on spinal structures such as the muscles, ligaments, and disc will lead to damage. Once the back pain is felt, the damage has already occurred. Muscles and ligaments provide stability. A spinal segment consists of adjacent halves of two vertebra and all the structures between and relating to them including the intervertebral disc, facet joints, ligaments, deep and superficial muscles. Ligaments control the direction and range of motion that will occur [122], [121], [43].

Each person is taller in the morning than they were before they went to bed. Fluid enters the disc during rest at night or when lying down during the day. An analogy is a well-inflated tire [122]. During the day, especially if one sits for long periods, fluid squeezes out and the disc becomes less stiff or under-inflated. As with an under inflated tire, which leads to separation of tread, the disc responds similarly and can contribute to tears and separation of the smaller structures.

4.8.5 Spinal Instability

The two primary factors in stabilizing the spine are ligament elasticity and muscular tone. Muscles have four characteristics: strength, speed, endurance, and agility. Endurance and agility in that order are primary elements in achieving spinal stabilization. The best exercise for muscles is an awareness of maintaining correct posture. This develops muscle endurance. Strength is the least valuable component of spinal stabilization. However, it is important to note that repeated joint popping leads to weakness of the muscles and should be avoided [120], [3], [122]. Bones can be strengthened by weight bearing activities such as walking. Since ligaments control direction and range of motion, a ligament that has lost its elasticity will be unable to play an "active" role in the stabilization of the spine meaning more stress on the muscles and the bony architecture [122], [43].

Muscular fusion holds the spine in a neutral position that removes all possibility of further tissue injury and sensitization of the system. This is the best way to begin treatment for instability and is the first step in treating chronic low back pain.

Measurements of the nucleus of the third lumbar vertebrae show that there is considerably more pressure on the nucleus when sitting as compared to standing. There is even more pressure if a person is slumped in their chair. In this position, a person is hanging on the ligaments, which lead to fatigue of the spinal structures [119], [123]. There is 30% increase in weight on the lower lumbar discs than if one was standing or sitting with a rolled towel against their lumbar spine,

which enforces the natural curve of the lower back. The presence of the natural curve places 30% of the load on the facets and relieves excess pressure on the discs [124].

Discs age over time and supporting them through spinal stability significantly decreases the risk of injury. The disc of a teenager is extremely gelatinous and very large. Discs probably reach their peak of health by age 20. In the twenties, the gelatinous nucleus begins to disappear. When younger, the nucleus can absorb two to three times its volume of water. By age 30, the nucleus begins to look creamy. By 50, the gelatinous structure changes to become rather dense collagen and loses most of its ability to bind with water. Most disc protrusions occur between ages 28-50 because they can. By 70, the internal nucleus has flattened and spread outward in all directions [124], [120], [3], [122].

4.8.6 Cervical Spine

Instability of the cervical spine is often caused by ostephytes, which develop and can eventually interfere with the spinal cord (impingement). It is good practice to avoid unnecessary backward bending of the neck and other exercises such as rolling the head in circles that incorporate backward bending [119], [123].

4.8.7 Vibration

Studies show that vibration is a factor in tissue damage. Truck drivers experience more back pain than those who unload trucks. Truck drivers sustain three times the amount of back pain as those who unload trucks at some of the larger transport terminals. According to NIOSH, whole body vibration plays a significant role in back pain and leads to disc problems and musculoskeletal disorders [125], [126].

4.9 Psychosocial Issues

Many older workers have a dual load at home still taking care of their own children and perhaps grandchildren while also taking care of aging parents. Some may have lost a partner or are dealing with assisting their partner in a chronic illness or disabling injury. Older workers looking at retirement, realize that they may have limited financial resources to enjoy retirement years. These same workers may then add years onto their work history to accommodate for financial issues [20].

In an era where there is also doubt and question about work ability, baby-boomers work side by side with Generation X (born between 1963 and 1984) persons. Gen X'ers have a different commitment and approach to work and diversity must be encouraged [127], [128].

According to Kahana and Kahana, [129] "the psychological dispositions serve as antecedents of preventive and proactive adaptations and comprise the internal resources associated with successful aging." They go on to say that "Psychological feeling states, broadly descriptive of morale, life satisfaction, happiness, and positive affect, have served as proxies for successful aging" [130]. The actual elements identified by Kahana and Kahana are: "hopefulness, altruism, self esteem, acceptance reframing, and life satisfaction." If people view themselves as viable in

life, then aging for them is one more challenge, however, now with new and certain unique stressors associated with it.

Whitbourne [58] states that, "Not only are older adults seen as able to navigate the sometimes difficult waters of later life, but are seen as creating new challenges, goals, and opportunities for themselves. The concept of control has also emerged as a major research focus, based on the belief that individuals can, to a certain extent, control their own destinies with regard to the aging process, and through personal effort, creativity, and determination, manage their own aging, if not actually "beat" it." These are the kinds of people that not only live up to Kahana and Kahana's theories in their own right, but are also the ones that are effectively destroying the unpleasant myths as set-up by early studies in gerontology.

Whitbourne [58] like Bengston [130] discusses elements or aspects of how one views themselves, she indicates that, "although adults may not be aware of these subdivisions within identity, they have a subjective sense of the self based on the implicit assumption of being "loving, competent, and good"—a positive ego-enhancing bias that allows individuals to maintain their self-esteem in the face of potentially threatening or challenging information about the self that may come in one of any number of identity domains.

The "loving" component of this positive triad is that one is loved by family and other significant people. The "competent" component…pertains to the view of oneself as healthy, strong, and able in these domains. The "good" component of this triad refers to the view of the self as morally and ethically upstanding. Individuals prefer to see themselves as honest, as adhering to society's major values, and as possessing integrity." It would appear that this schema allies itself nicely with Bengston's model and that again, if in life one has a positive view of life and a solid sense of self, then that carries with them into aging. These attributes are, it would appear, fundamental to one's character and coping abilities.

These attitudes, beliefs, and psychologically based behaviors that typify Kahana and Kahana's elements [129], [131] are quite contrary to Beck, Rush, Shaw, & Emery's [132] theory of depression. In Beck's theory, depressed individuals are seen as being given to negative views about the self, the world, and the future. "The positive triad with regard to identity may be thought of as the set of organizing principles used by normal, non-depressed individuals as their implicit positive bias for viewing themselves in relation to their experiences." [58].

Baltes and Baltes [133], [134], summarizing a vast body of research, suggested a series of strategies for successful aging in which they viewed aging as a life-long adaptive process, an ongoing dynamic of selective optimization with compensation. In their view, "old age, if approached properly, harbors many opportunities for positive change and productive functioning."

According to Nussbaum, Pecchioni, Robinson and Thompson [135], "Successful aging within the selective optimization with compensation model, then, entails an adaptive interplay of gains and losses. The three elements of this model are selection, optimization, and compensation. As an individual grows older, increasing restrictions are imposed by physical and cognitive limitations. Individuals select or focus their efforts into areas of high priority. Although the

individual may not perform as well in all aspects of life as he or she once did, this does not preclude the individual from setting new priorities or goals in life." That seems to beautifully represent the concepts of Kahana and Kahana [129], [131].

"The successfully aging individual continues to engage in behaviors that enrich and augment his or her physical and mental reserves. This optimization process allows individuals to continue to maximize their chosen life courses." [135]

4.10 Cognitive Issues

Among the major psychological characteristics of individuals are their personality or psychological adjustment and their mental (or cognitive) functioning. Relatively little change with age has been found in the level of most personality traits [136], [137]. However, increased age has been found to be associated with reports of greater happiness, less negative affect, reduced amounts of occupational stress [138], and lower levels of depression and anxiety [139]. At least one study has also reported that older workers have slightly higher levels of occupational well-being than younger workers [140].

"The aging process includes increased incidence of sleep disorders and greater risk of depression, which can negatively impact physical and cognitive functioning." [141] Many medications frequently cause decreases in cognitive function as a side effect. However, the myth that cognitive competence declines in older workers has been disputed through research. Decline of tests on mental speed is greater than on tests of mental power. Age related decline varies by task complexity and by stress conditions. It is not until after age 70 that a marked decreased in performance is consistently observed [142].

4.11 Health Management Strategies

Many of the changes related to aging can be prevented, or delayed. Much of what was once thought normal for an aging person is now being disputed. The evidence is strong that taking care of oneself adds years to life and life to years. Thus knowledge of proactive and preventive health strategies presumably would allow for a person to stay in the workplace longer should they desire it. The whole concept of retirement, especially forced retirement comes into question and merits further attention.

With regard to the aging, older people do change physiologically, their anthropometrics change, they shrink in stature and may gain weight. Without proper nutrition and exercise a number of things can change and such things as nutrition and exercise, do confound the variables. Response time may increase and dexterity and strength may decrease. Kroemer [143] is clear that age is not a good predictor and that it has not been well studied.

Nonetheless, many workplaces now encourage and incorporate stretching programs into their day. Addition of spinal stability exercises would promote increased back strength, decreased injuries and overall contribute to the level of health of each individual.

In job situations where the risk of falls and other unintentional injury is high, older workers will likely sustain more fractures for a given amount of trauma, due to age-related increases in bone fragility and architectural changes [144]. Several approaches to preventing age-related osteoporosis, other bone loss, and fractures are possible, including increasing calcium and vitamin D intake, maintaining an active exercise program, and screening and treatment for osteoporosis. The emphasis on bone health is not often prominent in worker health promotion programs, but with an increasing number of older workers, this may become more important.

Muscle mass can be built by lifting weights and engaging in weight bearing activity. Bone loss, which contributes to low bone density resulting in osteoporosis and fractures, can be prevented by intake of adequate amounts of daily calcium, especially in females prior to age 40. Again, weight-bearing activities such as walking also prevent bone loss in the older person [121], [43].

Many changes in the workplace can be made to accommodate vision changes in the aging worker. There are three workplace changes that significantly improve vision. They are adequate lighting, use of contrast, and elimination of glare. In order for the aging worker to see as effectively lighting must be two to three times brighter. Contrast between light and dark colors allows for definition of objects, and elimination of glare reduces eyestrain and helps to accurately identify objects.

Normal hearing loss, presbycusis, begins to occur at approximately age 40. Reducing noise in the work environment eliminates sensitivity, increases focus and concentration. Decreased noise levels also make it easier for the person with hearing loss to discern what is being said. The sound range for normal voice is between 500hertz (Hz) for vowels and bass and 2000Hz for high frequencies and consonants. Lower frequencies, including male voices, are heard better. Many products are available which possess sound dampening properties. On the other end of the spectrum, warning lights and sounds should be sufficient to ward off the most profound hearing and visually impaired worker.

The cardio respiratory status of older workers can be improved by improving aerobic capacity through increased activity. However, the older worker will still need more frequent breaks. This is especially true for physical labor positions. Other strategies that have helped reduce fatigue of the older worker include flexible work scheduling, compressed workweek, job redesign, and job sharing between physical labor and clerical activities [141]. Ergonomic consultations can dramatically influence the degree of work involved in physical labor positions. Thermoregulation can also be addressed through environmental controls in the workplace as well as use of adaptive clothing designed to preserve body heat or promote heat loss.

Co-morbidities for the older worker must be addressed because of the significance they place on workplace illnesses and injuries. This one area calls for employee personal responsibility. Management of weight related issues, compliance with medication regimens, and monitoring the effectiveness of medical treatments are all part of what an employee can do. Employee wellness programs that assist employees in establishing healthier practices have been extremely effective in reducing risk factors and overall costs to employers. When health issues compromise the employee's safety on the job, it is time to consider transition to alternative options. These

include decrease to part time, bridge jobs to transition out of employment, retraining for other job opportunities, and job reassignment.

Psychosocial issues related to loss, family concerns, and depression could be impacted in the workplace through use of an Employee Assistance Program. Cultural diversity programs help employees to understand each other in view of different values and work ethic. Cognitive issues related to medication use for co-morbidities often can be improved by changing medications. Many side effects go away once the individual has adapted to the medication. In the meantime, transfer to a safer position may be needed. For example, transfer from a job involving operation of heavy equipment for an employee who started taking beta-blockers for their heart. This class of medications can cause extreme fatigue and temporarily moving that person to a low risk construction or clerical position is a proactive approach to preventing injury.

4.12 Individual Differences

According to Whitbourne [58] in studying normal aging is the importance of individual differences. "Gerontologists have been working for decades to refute the erroneous notion that all older people are alike. Instead, it is now a well-established principle that as people grow older they become more different. The many and varied experiences that older people have over their lifetimes cause them to become increasingly diverse. Although elders who share the same ethnic or cultural background may share certain life experiences, their reactions to these experiences are likely to reflect their own unique psychological and physical capacity to cope with the events in their lives."

Another point to consider is the extent to which an age-related change can be slowed down, is preventable, or can be compensated. Although the ultimate result of the aging process is a progressive loss of function, there are many steps that individuals can take to slow down the aging process, or to prevent deleterious effects of aging before they become apparent. Some of these behaviors fall into the category of "use it or lose it"; in other words, exercise and activity can keep the system in question better maintained than inactivity. Another group of behaviors fall into the category of "bad habits," or behaviors that the individual interested in maintaining positive functioning will avoid. Individuals can take advantage of their capabilities, on the one hand, or suffer unnecessarily due to bad habits.

Finally Whitbourne [58] says, "…in examining the normal psychology of aging, it is essential to keep in mind the resilience that many elders show when faced with the potential stresses associated with the aging process. The study of coping has assumed an increasingly large role in the psychology of normal aging, as new evidence continues to be gained about the coping capacities of elders. Not only are older adults seen as able to navigate the sometimes difficult waters of later life, but are seen as creating new challenges, goals, and opportunities for themselves.

The concept of control has also emerged as a major research focus, based on the belief that individuals can, to a certain extent, control their own destinies with regard to the aging process, and through personal effort, creativity, and determination, manage their own aging, if not actually "beat" it." In examining the various aspects of lifespan, it becomes apparent that there

are many spontaneous coping strategies used successfully by many older workers to compensate for and adapt to the changes they experience.

4.13 Myths and Hindrances

It is important as a precursor to a discussion relative to aging research to understand that according to the United States Census Bureau [145], "Disability rates among the older population were declining in developed countries but were likely to increase in developing countries." Thus the prevailing myth of the frail, disabled, or ill aging population is certainly weakened. Moreover, the Census Bureau went on to report that, "Older people in the United States were more educated than in most other countries, but educational attainment of the older population was projected to increase in most countries over the next several decades."

This comment is important for several reasons, first the older citizens of the United States certainly has a collective wisdom, knowledge as well as the incumbent skills and abilities to stay within the workplace and take their place at the table as viable contributing members to productive, meaningful, and successful work. The second point while educated, a logical thought may be that those older persons are more aware than their contemporaries regarding their own health, well-being, and prevention opportunities at their disposal, including self care. Finally, typically developing countries have looked to the United States and other Western countries for guidance, knowledge, and instruction relative to the use and management of their resources. It is easily conceived that which is known and what could be learned through further research related to aging, older citizens in the workforce, and the preservation of vitality, both physically and psychologically, would mutually benefit seniors in developed countries as well as those countries that are not yet experiencing the same success.

4.13.1 Changes and Myths

The baby boomer generation is becoming the "geritol" generation. Many are experiencing those life changes that only recently they associated with their parents' generation. It is becoming very clear that aging has to do not only with physiological and psychological changes (some even say decrements) but also social, cultural, and economic changes. Research already shows the power of these factors; it shows that aging and the status of the elderly are not necessarily fixed but are subject to social modification and change. But more research is needed on how these factors operate and that is why it is important. In order to enhance the quality of life for older people and to contain the personal and social costs of health care and dependency, more knowledge is required to strengthen the scientific basis for professional practice and public policy. Bengston and Schaie [146] pointed out that some have even abandoned the development of theory. With so many myths and misconceptions, the research community can ill-afford to do so.

"Although many changes occur in the later years of life, these changes must be seen in the context of both successful and unsuccessful adaptations to previous gains and losses throughout the earlier years of adulthood. This issue of continuity versus change is a major theme in lifespan developmental psychology as applied to the adult years and beyond." [58].

All too often aging is co-joined with disease, frailty, senility, and decreasing physical or psychological wellness. Research into the impacts of aging may help to rectify those preconceived notions and allow for a greater understanding of the mature adult and more importantly, recognition and embracing of that adaptive wisdom that gave us society as it is known today.

Bengston and Schaie [146] maintained that theory is important because it is the mechanism by which explanations are generated. And while Bengston brought out many advantages of theory generally, perhaps the most important relative to the topic of aging is the development of theory relative to "improving the human condition" [130] [146]. There is no apparent relationship between the passage of time and the impact of aging. While some people appear old at age 40, others at nearly 80, show no signs it. Why and how can that be? The passage of time does not mean or hold the same consequences for all people. While it is know that people do change at different times, they do not however change in the same ways or at the same rate. Some are emotionally mature at a young age; some never seem to be emotionally capable. Some experience physical decrements at a surprisingly young age and yet others are vigorous well beyond expectations. And some are cognitively sharp at an advanced age while others far younger seem not to have their cognitive abilities intact. Surely one would suspect that lifestyle, geographic location, culture, ethnic background, self-care in younger days, environmental (literally, pollutants, drinking water, air, and the like), nutrition, nature of work, even economic status, and one's gene pool all either take a toll on senior years or even, better those years. Therefore, theory has yet another significant application.

Most of the negative images associated with aging are exaggerated or downright wrong. According to Feinson [147] "The most prevalent myth regarding the mental health of older adults is the belief that they are more depressed than younger adults." This myth is not only held by individuals, it is touted in the media and embraced by major organizations. It is striking to trace the persistence of this myth in the absence of clear empirical support. Also here is a list of statements according to Denmark [62] that people perceive as the truth, which are definitely false.

1. Increasing age brings about greater psychological distress.
2. Older adults are more depressed than younger adults.
3. As individuals reach old age, they become preoccupied with memories of their childhood and youth.
4. Older adults are less satisfied with their lives than younger adults.
5. Older adults are alienated from the members of their families.
6. Because older adults generally do not reside with their children; they rarely see them.
7. Increasing age brings about a decline in sexual desire and interest.
8. Older adults are not physically capable of engaging in sexual intercourse.
9. Older adults are very isolated from their communities.
10. Social contacts decrease with increasing age.
11. Older women focus mainly on keeping families together.
12. Older women suffer from poor physical health.

One is inclined to think that all these myths could be turned into theory and expounded upon, disproved, and that knowledge passed publicly. With increased knowledge based upon facts, the likelihood that the well-being of older workers in the workplace is likely to be preserved or enhanced.

4.13.2 Facts Regarding a Shift of Age in the Workplace

The literature reviewed is resplendent with research related to the aging and those needs that are yet to be addressed. No avenue of research mechanism or style was overlooked in the pursuit of facts relative to the changing for workforce and workplace, aging, and the marriage of those two entities driven by a changing society. Quantitative data was reviewed where people and workplaces were surveyed, historical data, especially by the government agencies cited, showed the complexion of the workforce in earlier times as well as the progression of a generation toward being aged.

"The age structure of the labor force is changing. With the aging of the baby-boom generation, the older age cohorts are expected to make up a larger proportion of the labor force in the next two decades. The 55-and-older age group, which made up 13 percent of the labor force in 2000, is projected to increase to 20 percent by 2020. It is anticipated that, by 2050, the group will make up 19 percent of the labor force." [5]

"The aging of the baby boomers will result in significant changes in the age structure of the labor force, chief among them an increase in its median age. The rise in the median age is projected to continue until 2010 and reach 40.6. With the retirement of the baby-boom generation after 2015, the median age of the labor force will decrease slowly and is projected to be 39.7 by 2050." [5]

Among all the age categories in the labor force, the 55-and-older group is expected to undergo the most sweeping changes in the years to come, due primarily to the aging of the baby-boom cohorts. The group's share in the labor force was 17 percent in 1950. As a result of a number of factors, including the availability of Social Security to men 62 years of age since 1960, the increased availability of disability awards, and the money accrued in pensions, the share of those 55 and older decreased to 13 percent in 2000. However, the share is projected to increase again in the next 50 years, reaching 20 percent of the total labor force in 2020 and then decreasing to 19 percent in 2050. The growth rate of the 65-and-older age group--1.2 percent in the 1980-90 period--rose to 2.0 percent during 1990-2000. The growth rate of this group within the labor force is projected to be 2.6 percent in the 2000-10 period, 5.1 percent in 2010-15, and 3.4 percent between 2015 and 2020. After 2020, the growth rate of the 65-and-older age group is projected to taper off as baby boomers begin to leave the labor force in increasing numbers.

The decrease in the labor force growth rate over this period is also a result of the increase in population in age groups with lower participation rates [2]. The share of the 35-44 age group peaked in 2000 at 27 percent. This group is expected to decline in numbers as the baby boomers continue aging, but it will maintain its share of the labor force--between 21 and 22 percent--over the next 50 years. The labor force share of the 45-54 age group is projected to decrease from 22 percent in 2000 to 20 percent in 2020 as a result of retirements and because of departures from the labor force. Baby boomers are the largest group of workers ever to reach retirement age in the same generation [18]. According to Niznik [148] "The future looks bright for baby boomers.

According to the most recent employment projections released by the U.S. Bureau of Labor Statistics, baby boomers are taking control of the labor force into the new millennium."

To make the future even brighter, the unemployment rate heading into year 2000 is the lowest in the U.S. since January 1970, when it was 3.9 percent during President Nixon's stay in command. "The statistics are favorable, the job outlook is great. A low unemployment rate, tight labor market, shortage of high-tech workers, and healthy U.S. economy are all good signs for generation-X and baby boom generation, technical job seekers." [148] U.S. economy forecasters see strong growth in the year 2000 and beyond.

According to a qualitative survey of professional forecasters, accomplished by Federal Reserve Bank in Philadelphia [149] "Anticipating that the forecasts might be affected by the revision, we asked the forecasters to make a qualitative comparison of their current forecast over the next five quarters with that of three months ago. Thirty-eight forecasters answered the question, and 20 (53 percent) said that, on the basis of economic fundamentals, their current outlook is stronger than that of three months ago; three forecasters indicated that their current forecast is weaker; and 15 (39 percent) said their current forecast is about the same as that of three months ago. On average, these results suggest a slightly stronger outlook for real growth over the near term. Indeed, the current forecasts for the rate of unemployment…are slightly lower than those of the last survey. The forecasters now predict the unemployment rate will average 4.2 percent in 1999 and 4.3 percent in 2000, down from 4.3 percent and 4.4 percent, respectively, in the last survey."

The start of the new millennium surely seemed to be an excellent time for high-tech baby boomers to make some career moves. However, since 1980 the Fortune 500 companies have furloughed 4.4 million workers. There were 8.4 million people out of work as of March 2003, contributing to an unemployment rate of 5.8%, with 10.2% for African Americans, according to the Bureau of Labor Statistics [150]. According to the Washington Times, [151], "The unemployment rate shot up to 6.4 percent last month as a surge of 611,000 workers looking for jobs met a drop in positions available, the Labor Department reported yesterday."

The Washington Times [151] went on to say, "As with the nearly 400,000 job losses seen since February, the 30,000 layoffs reported last month were concentrated in manufacturing. A drop of 56,000 factory jobs overwhelmed more-meager employment growth in construction, education, health care, hospitality and a few other areas." Fortunately those setbacks seem to be righting themselves. The research shows that all is not gloomy for the aging workforce however.

"There are over 16 million Americans over 55 who are either working or seeking work. Older workers are getting new jobs at an annual rate of 4.1 percent. This is more than double the .8 percent rate in the general population. Older Americans make up 10 percent of the workforce, but account for 22 percent of the nation's job growth. By 2015, the number of employees over 55 will reach a record 31.9 million, compared to 18.4 million in 2000. Extensive research has found no relationship between age and job performance.

Americans age 55 and above take fewer sick days, adapt to new technologies successfully, and are more loyal to their employer than thirty-somethings. A survey of human resource professionals found that 62 percent are hiring retired employees as consultants. By 2010 there

will be a severe labor shortage as baby boomers begin to retire and fewer younger workers are available because of slow population growth between 1966 and 1985. Unless we can keep older, productive people working, labor tightness will slow down the economy." [152]

The United States is not unique in these respects. Researchers in the United Kingdom found similar statistics. For example British United Provident Association Limited [153], reported that "An ageing population means an ageing workforce. According to Government figures there are currently almost six million people aged between 50 and state pension age employment - an employment rate for the age-group of 69 percent. Since 1997 the percentage of over-50s holding down jobs risen faster than the employment rate of working age population as a whole. By 2006, 45-59 year olds will form the largest group the labor force."

They continue, "Add to this the raising of Social Security normal retirement from 65 to 67, and the likelihood of further increases. The Social Security Earnings Test has been eliminated. Moreover, a long established trend toward early retirement has reached an abrupt halt according to the Employee Benefits Research Institute. The number of people 65 and older who are working or looking for work numbers almost 4.5 million, according to the Census Bureau — a rise of almost 50% between 1980 and 2002." [153]

4.13.3 The Age Myth

There appears to be considerable variation in the concept of older worker as defined by age alone. The term older worker extends from 40 to 75 years of age. When workers at age 40 are referred to as older workers, age is linked to beginning thoughts about retirement decisions [82], the decline in training opportunities [83], the dispelling of myths about the productivity of an aging work force [84], or the need for older workers to stay on the job to mentor younger workers [85]. At the other end of the age continuum, older workers are identified as those in need of preretirement education and planning [86] or those considering gradual work reduction or seeking training for alternative careers [87]. The concept of older worker encompasses different ages depending on the purpose of the organization as well as the needs of the worker. Age alone may not be a defining characteristic of an older worker. Perhaps becoming an older worker is more situational than chronological.

4.14 The Good News

According to Tattrie, Gotz, and Liu [21], "The numbers of jobs held by older workers will more than double between 1995 and 2020 as baby boomers – the 19-year generation born between 1945 and 1964 – near retirement. Because older workers injured on the job have higher costs per claim than younger workers, it is important to assess how this increase in the number of older workers will affect workers' compensation systems."

They accomplished a study to analyze the effects of the changing age distribution on workers' compensation claim characteristics from 1970 to 2020 as the size, industry mix and age of the workforce changed in eight states (California, Connecticut, Florida, Georgia, Massachusetts, Minnesota, Pennsylvania and Texas). [21]

According to their study, the growing number of older workers in the workforce occurring between 1995 and 2020 will have little effect on workers' compensation costs. Total workers' compensation costs will be .07 percent lower than they would have been if the age of the workforce had not changed. This conclusion is different from what many would expect. [21]

Several issues were brought to the surface:

"Older workers have only slightly higher average costs per claim than middle-aged workers. Because the preponderance of baby-boomers reached middle age by 1995, the increase in costs as this generation becomes "older workers" is not large.

Younger workers will outnumber older workers in the workforce. Although the baby boom generation is substantially larger than the generation it precedes, it is not much larger than the generation that follows. By 2010 this next generation surpasses the baby boomers in size, resulting in far greater numbers of younger workers than older workers. Even a doubling of the number of older workers in the workforce, then, translates into only a small percentage increase in the proportion of older workers to younger workers.

Older workers file fewer claims than younger workers, offsetting their somewhat higher claim costs". [21]

Their study also found the aging of the labor force had a significant effect on costs – but it occurred largely from 1970 to 1995 as the baby boomers moved from the lower cost "young worker" group to the higher cost "middle aged" group. This phenomenon was one contributing factor to the general escalation of workers' compensation costs that were occurring in the 1980s and early 1990s.

Further, according to Anderson [154], "Three broad factors could affect the injury rate. First, workplaces may become safer because of factors under the control of employers, including safer equipment, better safety rules and better training. Second, injury rates may drop because of changes in the workforce; older, more experienced workers generally have lower than average injury rates. Third, injury rates may fall because of a change in the types of things firms do, i.e., because of shifts in employment between industries." The point is there are fewer claims since 1995. Relative to this discussion then, taken together with the Tattrie [21] study older workers do get hurt less on the job, and if hurt, the associated costs are not greater than younger workers. Yet another myth empirically challenged.

"America must quickly get a grip the new reality in view of the hoards of over 60 baby boomers shortly to descend upon it. As author Theodore Rozak puts it, "The future belongs to maturity." A synopsis of the evidence from the MacArthur Foundation Study [20], [60], [155] also contravenes the myth of being old means being ill. Among its findings, the study establishes that older people are much more likely to age well than to become decrepit and dependent. In fact, relatively few elderly people live in nursing homes, 5.2% which is down from 6.3% in 1982. Of those ages 65 to 74, fully 89% report no disability whatsoever.

The study concluded that senior citizens are generally healthy. Even in advanced old age, an overwhelming majority of the elderly population has little functional disability, and the proportion that is disabled is being whittled away over time. Historical research indicates that much of this is due to a huge reduction in acute infectious illnesses in the twentieth century, and more recent decline in precursors to chronic disease such as high blood pressure, high cholesterol levels and smoking.

Further, a study by Seeman, Berkman, Charpentier, Blazer, Albert, & Tinetti [156] examined relatively thoroughly the behavioral and psychological predictors of physical performance. Their longitudinal study of high-functioning adults showed that physical performance is preserved and enhanced by exercise among their subjects. Social support, as substantiated by other literature and research, is also important. More importantly however, Seeman, et al., [156] reported that, "Observed patterns of both decline and improvement in performance suggest that older age is not uniformly associated with declines." The summary of their methods and findings are reported thusly, "The influences of baseline behavioral, social, and psychological characteristics on patterns of change in performance over 2.5 years are examined. A cohort of relatively high-functioning men and women, aged 70-79, identified in 1988 by sub-sampling from three community-based studies on the basis of physical and cognitive function."

Baseline assessments included physical performance, socio-demographic characteristics, health status, and behavioral, social, and psychological characteristics. A summary measure of physical performance was developed from tests of balance, gait, lower body strength and coordination, and manual dexterity. In-home assessments were repeated at follow-up in 1991. Linear regression models were used to identify significant behavioral, social, and psychological predictors of better performance at follow-up, controlling for known socio-demographic and health status predictors. Significant, independent associations with better performance were found for participation in moderate and/or strenuous exercise activity and greater frequency of emotional support from social networks, particularly among those reporting low frequency of instrumental support. These effects remained significant independent of incident health conditions during follow-up.

None of the psychological characteristics was a significant predictor. Maintenance of better physical performance within a high-functioning cohort is influenced by prior exercise behavior and social network emotional support." [156]

Thus first this discussion is intended to aid in the retention and recruitment of older workers, this allows for selection and optimization as described by Broderick and Blewitt [1]. This can be accomplished in eroding some of the prevailing myths especially regarding health and safety of the older worker and their capabilities. The value of work as a source of personal identity and reward remains a strong component of many aging person's lives [157]. Not only should the older worker be valued and fully employed if they choose to be, but in a state of well-being.

Organizations are experiencing an attitudinal shift, seeing the value and importance of training older workers. During the past decade, advocates concentrated on convincing employers that older workers are capable of learning [27]. Today, advocates are demonstrating that with training to maintain, enhance, or update skills, older workers are contributing to organizational

productivity and may even surpass younger workers in reliability and consistency [158], [159], [160]. By implementing systematic changes in training and workplace design, the productivity of older adults can be enhanced [161], [162]. Older adults are now viewed as assets in terms of work ethic, reliability, accuracy, and stability [163], [164]. However, myths about aging still are present [165], [166] and some workplace supervisors still are unsure that hiring older workers is a sound investment [167].

Older workers are also asking more of the workplace and asserting their right to make decisions to return or remain in the workplace based on availability of training, need to be engaged, or desire to develop a second career. Older workers are becoming entrepreneurs, beginning new businesses and hiring other older workers [168]. Managers are advised to create meaningful work and to consider the role of work in the lifestyle of an older adult [169]. States are considering planning processes to expand meaningful work and to help create work environments attractive to older adults [71]. Rather than declining in productivity, older workers are becoming viewed as an asset that should not be neglected by organizations or by society.

4.14.1 Optimism

Voltz [170] contended that based on a new paradigm that purports that memory and cognitive functions do not necessarily decline with age. Birren [171] argued that prevailing perceptions about aging do not match the actual longevity, demographic, and social characteristics of the aging population. He further contended that the outdated notions will gradually disappear as older people become more visible through their active participation in society. Successful aging suggests that maintaining cognitive functioning is crucial Vander-Zanden [172]. In spite of the good news regarding aging people, accidents and injuries persist on the job, age notwithstanding.

There are many changes in today's society occurring in parallel. The workforce is aging, and aging is occurring it would appear in a positive fashion such that more and more of those desire to stay in the workplace can do so. The workplace itself has changed and continues to do so. The United States passed from the Industrial Age to the Information Age. Thus the complexion of work itself has changed. Heavy industries have become to a certain degree, a thing of the past. In American workplaces today, the worker is more likely to be a monitor rather than an operator. Workers may have become more and more distant from the physical demands of work known in the past. Additionally, society rightfully so, demanded safer workplaces and today, most places allow for work stoppages if safety is questionable. The environment and its impacts upon workers is increasingly well-known, thus, people are protected by distancing them in some fashion, through personal protective equipment and reducing exposures. High risk, heavy jobs are becoming a thing of the past.

According to the Social Security Administration [173]. "There is even more room for debate over what constitutes a physically demanding job and how to measure it. Several measures indicate the physical demands of various occupations, but there is no consensus among experts about which measure is best or what score or sum of job characteristics makes a job "physically demanding' and what does not. Further, none of the measures takes account of characteristics of different types of workers--older or younger, male or female--that may make a job more

demanding for some than for others. And none takes account of the physical hazards or environmental risks that are inherent in some occupations."

Health status is determined not only by the physical demands of a job but also by the industrial environment including dust, smoke, chemical contamination, and risk of injury. Recent evidence indicates that older individuals who worked in "less healthy" industries, such as mining, are more likely to report that they are in poor health than individuals who worked in "healthy" industries [174]. If over the next 40 years the industrial mix in the economy should change so that a smaller proportion of the population works in "less healthy" industries, one would expect the health status of older workers in the future to improve as a result of this change.

Studies support more optimism about the effectiveness of workplace interventions to prevent MSDs. Several studies have reported a positive impact of ergonomic interventions on low back and other MSDs among workers performing lifting and related manual material handling tasks [175], [176], [177], [178]. Others have found positive effects among workers using video display units [179], [180], [181], [182]. Positive outcomes of comprehensive interventions, including job redesign and organizational change, have also been reported for MSDs among hospital workers [183] and office workers [184]. Negative results were found among a small group of assembly workers after jobs were redesigned to be more varied, less repetitive, and more autonomous [185].

A review of interventions aimed at reducing exposure to mechanical stressors concluded that there were significant benefits [186]. A review of studies for carpal tunnel syndrome suggested the need for better-designed intervention investigations [187]. In three recent intervention studies, ergonomically modified jobs have also been associated with more rapid return to work after work related MSDs [188], [189], [190].

There is a premise and fundamental tenet in ergonomics or human factors which is, the one designs for the population of users. While seemingly straightforward and simple, in many cases, it has not been practiced. Moreover data related to workplace design, the capabilities and limitations of humans, and the body size and dimensions of people were based on data from a "captive" audience and that was military members, predominately male and aging from 18-24 years old. Those demographics fit few places today, although that data is a springboard to more solid design. The point is, if the workplace is designed to accommodate at least 90% of the population of workers, the 5^{th} percentile female – 95^{th} percentile male, then by default the aging are accommodated as well. Likewise, the reciprocal of that is true. If the aging are accommodated in the workplace, then everyone is accommodated [143], [125], [126].

The Social Security Administration [173] study describes the categories of work as determined for the study pertinent to retirees and subsequent ill health. "For this study jobs were classified as being physically demanding based on their strength requirements, i.e., the amount of time spent walking or standing rather than sitting; the amount of time spent lifting, carrying, pulling, or pushing objects; the weight of these objects; and the circumstances of intensity, duration, and body position in relation to movement of objects that may affect the degree of difficulty in moving them. Weight of objects moved was the primary criterion.

Basically, jobs were classified as having medium strength requirements if they entailed lifting up to 25 pound objects regularly, heavy strength requirements if they entailed lifting up to 50 pounds regularly, and very heavy if they involved lifting 50 pounds or more regularly. The heavy and very heavy categories are combined here and termed "heavy" [191]. The report goes on to show that heavy workloads are decreasing, "Persons who have jobs with heavy strength requirements represent a declining share of the U.S. labor force: They accounted for 20.3 percent of the labor force in 1950, compared with 9.1 percent in 1980" [191] and will continue to do so. They continue by postulating that the heavy jobs typical of industry of the past will continue to decline.

"As a group ages, the decline in the incidence of physically demanding jobs is somewhat less sharp than for the labor force as a whole--at least during periods of rapid change in technology and in demand for output. For example, 18.6 percent of those aged 40-44 were in jobs with heavy strength demands in 1950; when they were 20 years older in 1970, the percentage in physically demanding jobs had declined to 12.6 percent. For the labor force as a whole, the decline was from 20.3 percent to 9.9 percent." [173] All the better then for all workers and particularly those who are aging.

The Social Security Administration [173] indicates that, "the existing data on the prevalence of chronic illness and limitation appear to indicate an increase in limitation, but a number of factors make this conclusion unclear. In addition, many non-health related factors determine the ability or willingness to continue to work (e.g., economic conditions, job structure, sick leave and disability provisions, and family structure). Therefore, it is difficult to predict the ability or unwillingness to continue to work solely on the basis of illness and limitation."

Several factors suggest that future changes in the environment will increase the health of the population. Projected changes in the occupational mix of the economy over the next 40 years indicate that the proportion of the labor force in physically demanding jobs will decline. Theoretically that decrease may result in improved health status. However, it has been argued that although the proportion of workers in physically demanding jobs has decreased and is expected to decrease further, the proportion of workers in psychologically demanding occupations has been increasing and is likely to increase further.

4.15 Relationship between Stress and Physical Discomfort

Over a 6-year period, those aging people caring for a spouse with Alzheimer's disease or another brain disorder exhibited a dramatic average increase in blood concentrations of a protein involved in immune regulation [192]. During that same time, seniors with healthy spouses displayed a much smaller increase in blood concentrations of the substance, interleukin-6 (IL-6).

"As people age, they typically produce IL-6 in larger quantities. Earlier investigations linked particularly high concentrations of IL-6 to heart disease, osteoporosis, arthritis, type 2 diabetes, certain cancers, periodontal disease, and intensified reactions to viral infections" [193].

After an impaired spouse died, IL-6 concentrations in the blood of the former caregiver continued to rise at an elevated rate for as many as 3 years, the researchers report in the *Proceedings of the National Academy of Sciences* [192].

New research suggests that work-related stress can be as harmful as smoking. In a study published in the British Medical Journal, Harvard University researcher Yawen Chang, Ph.D., [194] surveyed more than 21,000 women and found that those with the most demanding jobs, little control over their work environment, and lack of support from co-workers and supervisors were more likely to suffer from stress than those more content with their jobs. They also found that women suffered physical effects: Symptoms ranged from anxiety to difficulty performing daily tasks like climbing stairs.

But in a new twist on an old issue, researchers don't suggest behavioral changes for alleviating on-the-job stress. Instead, they recommend that employees alter their work conditions--by reducing workload, increasing control over their work environment and seeking more social support.

In a related study, Tesfaye Belay, Ph.D., [195] a microbiology researcher at Atlanta's Morehouse School of Medicine, confirmed that stress can make a person physically sick. In lab studies, Belay mixed bacteria with the stress hormones epinephrine and nor-epinephrine and found that increasing the hormones' quantities caused the growth of certain bacteria--some of which can lead to health problems like pneumonia. In light of his findings, presented at an American Society for Microbiology meeting, Belay said that "if [people] take measures to help themselves relax, the risk of contracting an infection will probably be reduced."

Cheng [194] indicated that " Stressful job conditions, characterized by low control, high demands, and low social support, increase the risk of cardiovascular disease. She further stated that, "Previous cross sectional studies suggested that job strain is associated with low functional health status".

One of the most notable contributors to the field of Occupational Stress, Karasek [196], says that job stress occurs because the `demands' of employment exceed the `controls' of the individual needed to interact with those demands. The Karasek `Demand-Control Job Strain Model' has highlighted two key workplace conditions that increase hypertension: high psychological demands combined with little control in meeting those demands. People with high job demands describe themselves as "working very fast", "working very hard" and not having "enough time to get the job done". And employees with little workplace controls describe themselves as lacking the ability and/or authority to make decisions or impact their job. In recent studies, this model has included a third factor: the beneficial effects of workplace social support. Simply stated, if the demands placed on a person at work are higher than the perceptions of control, job strain will occur.

The job strain model as conceptualized by Karasek and Theorell postulates that a combination of high psychological demands with low control at work leads to mental and physical illnesses. [196], [197], [198] Previous studies have linked job strain to hypertension, cardiovascular

disease, cigarette smoking, psychosomatic symptoms, depression, and adverse birth outcomes. [196], [198], [199], [200], [201], [202], [203], [204]

With few exceptions, [205], [206] previous studies have assessed job strain on only one occasion. Although older workers have been reported to be more susceptible to job strain, it is unclear whether age is a proxy for cumulative exposure [199], [207]. Moreover, most studies have focused on conventional measures of mortality and morbidity. The impact of job strain on health functioning and sense of wellbeing have been reported in only a few recent studies [208], [209], [210].

Vigilance, situational awareness, and monitoring activities of people which distance them from their work, seems to be a prime candidate for theoretical development and research relative to the aging workforce [211]. To the extent that some of these occupations result in excessive levels of stress and anxiety, disability caused by mental disorders or stress-induced physical disorders could increase. This is yet to be fully assessed, but also, it may be confounded by what is perceived by many, including the aging in a stress-filled and chaotic world generally.

According to Whitbourne [58], the "issue of continuity versus change is a major theme in lifespan developmental psychology as applied to the adult years and beyond." Bengston [146] maintains that theory is important because it is the mechanism by which explanations are generated. And while Bengston brings out many advantages of theory generally, perhaps the most important relative to the topic of aging is the development of theory relative to "improving the human condition."

4.16 Injury at Work

4.16.1 Musculoskeletal Disorders

In spite of the fact that heavy industry is no longer part and parcel of the American or Western business environment, people continue to get hurt on the job. Historically, one of the most prevailing injury categories is musculoskeletal otherwise known as Cumulative Trauma Disorders (CTDs). Ergonomic evaluation is often aimed at reducing the number and severity of CTDs in the workplace. CTDs are a class of musculoskeletal disorders involving damage to the tendons or tendon sheaths, and related bones, muscles, and nerves of the hands, wrists, elbows, shoulders, neck, and back.

Although the full extent of damage caused by repetitive motions is uncertain, [212], rapidly growing public awareness has made cumulative trauma disorders "the No. 1 occupational hazard of the 1990's" [213]. CTDs are especially common among employees whose work involves repetitive, often forceful, physical motions [214], [215]. An ergonomic hazard is any risk created by factors including employee posture, force, repetition, [216], [212] and the overall work environment (for example, lighting and temperature). Essentially, physical/environmental demands of the workplace which exceed an individual's capacity to tolerate these demands constitute the commonly believed culprit.

4.16.2 Psychosocial Sources

However, there must be other reasons than those usually put forward as the source of these disorders. Thus this research goes further to delve into the psychosocial issues associated with musculoskeletal disorders, particularly as related to the aging workforce. In a recent review of the literature on mental workload Manzey [217] gives a survey of the psycho-physiological variables that have been proposed as indices of the amount of workload. Among them are spontaneous EEG activity in the different frequency bands, event-related brain potentials, and in particular the amplitude of the P300 component, cardiovascular indices, such as heart rate (HR), heart rate variability (HRV), and indices related to respiration and the oculomotor system. Such an example relative to mental workload and computer workstations is discussed by Åborg, Fernström, & Ericson [218].

They indicated that "Work has become more demanding, leading to an increase in mental workload on a lot of jobs. On the other hand, partitioning tasks has become a source of boredom and dissatisfaction, diminishing the human role in data entry tasks or operating a system with reduced degrees of freedom."

There are other psychosocial issues as well, which include: aging workforce, shift work, crew complement, more overtime, life stressors, and uncertainty related to work, organizational stability and life generally. These must be considered. There is anecdotal evidence that some claims relative to CTDs essentially have no "work-related" basis, but nonetheless the symptoms are real.

In addition, a related issue is a social-psychological aspect of illness behavior [219]. It is possible that people under psychological stress could develop specific physical symptoms (such as sore wrists) that would legitimate their general psychological discomfort and pain. Having pain in the wrists and fingers is an acceptable disorder, whereas feeling depressed is not considered as acceptable. Thus the effects of psychological disturbances might be reflected in physical disorders of the musculoskeletal system. This is akin to mass psychogenic illness [220] or psychosomatic disorders [221], in which psychologically induced disturbances lead to physical impairment.

4.16.3 Organizational Variables

The organizational context in which work is done can often influence worker stress and health [222]. Career considerations such as over- and under-promotion, status in-congruence, and lack of job security have been linked to worker stress [223], [224]. Job future ambiguity has a stress connection for various occupations, such as factory and office work [225]. These organizational conditions might create a working climate of distrust, fear, and confusion that could lead employees to perceive more aches and pains and report more CTDs.

4.16.4 Presenteeism and Organizational Legacy

Organizational Legacy is a construct yet to be defined in a useful and workable way. In a climate of change, organizations can be observed to die slowly and others quite quickly. In either case, the impact of the history of an organization upon its employees, especially the older

ones, is conjectured to be quite stressful. There is a phenomenon known as survival syndrome, those who suffer consequences of being left in an organization while others are dismissed, downsized, or right-sized; those who may be left waiting for the organization to finally fade. Americans are quite familiar with the demise of the steel, lumber, automotive, and other industries. There are however, locations and/or organizations where the legacy was based on pride, spirit, loyalty, patriotism, and other values that were both intrinsically and extrinsically motivating to workers.

When pride turns to shame, or when years of loyalty turn to insecurity, what is the toll on those workers, clearly aging that remains? There are some remediation, recovery, and clean-up or decommissioning and decontamination sites found that suffer from the effects of what can loosely be defined as "cold war hangover". The workers are to actually go work themselves out of a job. Thus the motivation is not great and injuries almost seem like income insurance for those who believed they would retire on their own terms when ready.

While psychosocial issues that may lead to musculoskeletal disorders are many and typically stress-related, two of interest, are presenteeism and organizational legacy. These are drawn out and discussed here due to relative unfamiliarity of these concepts pertinent to this kind of study. Presenteeism according to Burton and Conti [226] is being present at work but not working or being productive. Very little research has been done in this area. However, presenteeism is perceived to be very costly. Metrics for presenteeism are being developed just as metrics are already used relative to absenteeism.

Organizational legacy briefly described are those historical aspects of an organization which makes it what it is today, and even if changed with time, management, mission, or focus has residual effects that could conceivably impact workers. Presenteeism, concerns itself with instances where people are at work, but not working. According to Statt [227] "presenteeism: A form of absenteeism while remaining in the job.

It is found among employees who are seriously disaffected from their organization." Statt [227] defined retirement on the job: A term sometimes used of an employee who experiences such alienation from his job that he does the minimum possible in order to retain it while he waits for retirement. It may be the end result of presenteeism." Often the literature refers presenteeism relative to illness on the job, often depression is cited where people are depressed and do not work or accomplish much if anything. One outcome of this work may be to allow for further study of presenteeism, and its possible scope and breadth beyond depression and common illnesses at work and look at other variables that cause people not to be productive or actually doing work in the workplace. Speculation is that both of these variables, organizational legacy and presenteeism are variables that may well influence the onset of musculoskeletal disorders.

4.17 Literature Review Summary

The conjecture is that older workers are not hurt with greater frequency than younger workers. They may even have fewer accidents and injuries due to job experience and wisdom that accompanies learning a task well. However, when they are hurt, to what can those injuries be attributed especially if the nature of the work-related injury is musculoskeletal? Suitability for

work, that is, physical well-being may not be significantly different between older workers and younger workers. Older workers have been "doing the job" and are conditioned to do the job, whereas the younger worker may have led a more sedentary lifestyle prior to entering the workforce. Thus a view of other variables that contribute to these costly occupational illnesses could likely be psychosocial rather than physical.

The psychosocial variables could hold a great deal of meaning for many aging organizations. These could be in fact measured by job content surveys and other instruments geared toward assessing both physical demands of job and their impact on workers as well as those variables that contribute to job stress which is credited for physical manifestations.

There are social, cultural, economic, and psychological factors that affect both the process of growing old and the place of older people in the workplace. "Research already shows the power of these factors; it shows that aging and the status of the elderly are not inevitably fixed but are subject to social modification and change. But more research is needed on how these factors operate. In order to enhance the quality of life for older people and to contain the personal and social costs of health care and dependency, more knowledge is required to strengthen the scientific basis for professional practice and public policy." [3]

It would appear that getting old is not easy, neither is studying it. The theories may answer why people do age differently. Why it is that some appear and/or act old at 50 and some at 80 cannot be kept up with easily? One thing observed that the theories do not seem to treat, and that is, why it seems that when something like an accident, illness or some difficulty hits an older person, it is attributed to their age, but when the same events happen to younger people, the cause is attributed to other things.

More theories are needed to explain phenomena associated with aging that is true. But even more theories are needed to debunk myths and set people right. It gives one pause to think about all the misdiagnoses, needless suffering perhaps of those who were not attended to properly or sustained medical neglect when some symptoms were merely written off to aging.

Bengston and Schaie [146] discuss "collective psychology". They make a great deal of sense in that regard. For example, so much is heard relative to changing socialization and social support of older people. It is a given that socialization is crucial in one's well-being and seniors can find themselves isolated due to life changes of their children and perhaps the loss of a spouse. Bengston and Schaie [146] are clear about the extent to which research of older adults can aid in the betterment of the whole while in reality gaining an understanding of the individual. Learned dependency as described is particularly meaningful, thinking of it as a means to control one's environment makes a lot of sense. That is presumed to include continued meaningfulness relative to work.

It was refreshing to read that the research and data hold up that being a senior does not mean dependence. Aiding persons who are at risk for being unnecessarily dependent is an excellent application of the theory. The theories would be helpful in finding the balance between self-sufficiency and neglect, isolation and socialization, and survival and quality of life. It would appear to allow for continued work and continued life success if desired. And while the typical

statistics do not include it, seniors or aging workers do not wither upon retirement. The countless hours of volunteer work are not counted. Most aging workers work even if unpaid.

It is likewise significant that while theories do recognize the losses sustained by the collective whole, that indeed for some, and hopefully due to the application of social theory, that not only are losses sustained, but that hope and greater incentives will be strategized for increasing gains. It is subsequent to retirement that many find new careers, take up new hobbies, develop new relationships, and optimize socialization, and often, even return to the workplace. This research is intended to support that possibility in a meaningful and factual way.

5. Progressive Nature of Aging

5.1 Loss of Cerebral Function

Aging is associated with a progressive death of neurons, and since these cells cannot be replaced, some deterioration of mental function might be anticipated. Many aspects of cerebral function depend as much upon the extent of inter-neuronal connections (which increases with age), as upon the total count of living neurons. Implying, if an individual remains in good health, it is difficult to demonstrate any loss of intelligence prior to the eighth decade of life. Since there is sensory loss and deterioration, the rate of response to some signals is slowed, and older workers may he handicapped where rapid decisions are required. Other problems are a weakening of recent memory and an increased rigidity of response. Researchers have shown that as we age, our brake response time slows. Over a driver's life time there is an average of a 50 millisecond reduction in brake response time.

Theoretical researchers have indicated that there is performance benefit from experience and task familiarity. Salthouse [228] posed some interesting questions – Can age-related differences be attenuated or eliminated with additional practice or training? Do age-related differences disappear when individuals have extensive experience with relevant activities? Another dilemma arises when considering workers vs. average citizens carrying out their day-to-day life skills type tasks. Many researchers have shown that there are losses in memory, reaction time, decision-making time and general mental processing time as we age, but these findings apply not to workers, but to experimental subjects in a laboratory setting. In a work setting, we are not sure how or if these findings affect the performance of older workers. [229] While the performance parameters have been shown to be affected by age, the question remains as to whether performance is affected. If not, it appears that workers are developing their own accommodations or they are benefiting from the experience they have gained, allowing them to complete their tasks more efficiently or effectively.

According to Walker, Fain, Fisk and McGuire, [230], older adults make decisions more slowly than younger adults. This is worsened if time pressure is present. In an industrial setting, there may not be sufficient time to allow increased decision-making time. While this has not been thoroughly researched or quantified, it appears that if decision-making time can be increased, we could gain assurances that older workers may make fewer errors. Adding 30-45 seconds may be all the time needed to complete a task without errors or operational upsets. [231]

According to Sit and Fisk [232] and Korteling, [233], older adults have more difficulty managing multiple tasks. Although the mechanism is not reported, this difficulty seems to be in the area of prioritizing the tasks and in keeping all tasks active. While production schedules or demand forecasts in general, tend to dictate tasks, priority and rate, task designers do have the opportunity to influence this during the design phase. However, in today's complex automated control systems, task demand is not stable. The automated control system can be designed to provide task or at least alarm prioritization. For example, the system automatically opens a valve in response to high level in a vessel. But it can also provide greater emphasis of the need to open the valve by highlighting which control should be implemented first in response to a particular operational upset.

Haight [229] also suggested consideration for managerial adjustments to account for the multi-task environment. Considerations such as allowance of longer response time, additional practice to increase task familiarity, frequent refresher training, frequent reinforcement of task priority, reduction in the need for simultaneous performance of two or more tasks or designing the system to be operated with low sensitivity to task order are issues for the task and system designer to integrate into his or her design. System and task designers can also gain useful information for their design by talking with older workers about some of the accommodations that they have already made for themselves in order to maintain task performance in the face of declining capacities. [231]

5.2 Aging Workers and Human Error

Many of today's industrial processes are complex and their operation requires employees to be in good physical and mental condition. Safe and efficient operation places high demands on memory, vision, range of motion, strength, decision making and reaction capabilities. Errors can lead to catastrophic events, potentially involving loss of life. A body of literature suggests that older people are less likely to respond quickly to upset conditions; less likely to see critical aspects of the process changing; more likely to become fatigued; and less likely to function at full strength or full alertness for the whole shift.

While many human functions deteriorate with age, one important parameter would seem to help improve performance. Intuitively, one might expect diminished capacity to result in diminished job performance. However, one might also expect experience to moderate an increase in the error rates of older workers. For example, the experience level of older workers would seem to make for a controlled, efficient and effective response to dangerous upset conditions. However, the research literature is equivocal on the subject; therefore, more research is needed in this area across all workplaces.

Until this is fully understood, from a practical point of view, it makes sense to try to better understand the needs of various segments of the workforce and adjust accordingly. If industry representatives understand the age profile of the workforce, theoretically, adequate consideration can be given to work assignments, work hours, workspace design and performance expectations relative to the age of the workers. For example, the need for good vision, good reaction time, good memory, quick reflexes, full strength and range of motion would be considered when making job assignments. In positions that require a high level of experience, efficient planning

and forecasting, and measured effective responses, workers who possess those attributes may receive consideration. Knowing worker capabilities also allows management to redesign tasks and positions to account for workers' limitations.

Increased age is frequently associated with lower performance on various measures of cognitive functioning [228]. Many questions are posed in the literature about differences in age-related performance in cognitive functioning. These include:

- Are the differences confined to novel or abstract tasks?
- Are these differences reduced or absent in measures from familiar or concrete tasks?
- Can age-related differences be attenuated or eliminated with additional practice or training?
- Do these differences disappear when individuals have extensive experience with relevant activities [228]?

It has been suggested that experience can be a moderator of potential errors due to decrement in cognitive functioning. However, the literature is not conclusive [228]. Other researchers also show that there is decrement in memory, reaction time, decision-making time and general mental processing time.

For example, in a nuclear power plant, operators monitor plant status (temperatures, pressures, flows, levels, etc.). As these parameters change, operators must determine whether the change is within operational limits—they are looking for any limit exceedance and the rate of that change. Operators have to detect (visual, auditory, tactile) a change in process conditions, then they must assess and interpret (mental processing, decision making, etc.) the change data to determine whether it is normal. Once they decide what to do, they must respond (vision, strength, range of motion, etc.) to address the change. They must make decisions quickly and act decisively to either address another parameter or take action to correct an abnormal situation [234]. These performance parameters are affected by age.

Such processing requires cognitive functioning. Often, operators must monitor and respond to two or more inputs. They must make decisions and execute more than one action in response. Decision making can be a problem among older adults, as they make decisions more slowly than younger adults [230]. In driving, research shows that when taking a trip older adults take longer to make decisions about route selection, especially when route speed increased. Confidence about the decision made was also a function of route speed [230]. Slower decision making is exacerbated when there is perceived time pressure.

However, it is noteworthy that decision quality did not seem to be affected by age. When an older person finally made a decision, it was usually as correct as those made by younger people (Walker, et al). Therefore, as long as the task is familiar and there is sufficient time to make the decision, the performance outcome of older workers should not decline. The problem in industry is that there may not be sufficient time to allow the older worker to respond.

Depending on task complexity, older adults are slower to respond. Response speed has a linear relationship with task complexity [232]. The more complex the task is the slower the response time. Older adults also have more difficulty managing or coordinating multiple tasks [234]. If a

particular response requires more than two tasks at once or that they be performed quickly, an older person may have difficulty prioritizing the tasks and keeping all tasks active. Some research has suggested that age-related difference in performance of multiple tasks is reduced through training [235]. Other research has suggested that performance is improved further if task performance order is flexible—meaning the worker can decide what order to perform tasks without penalty [236]. It is also interesting that performance difference between older and younger workers decreased in a multiple-task environment when a specific task was emphasized as more important than others [232].

Older adults also allocate attention differently than younger adults. Multiple task performance research indicates that with age-related limitations in cognitive processing, as well as other physical sensitivity reductions, age-related decline in performance is most attributable to the declining ability to manage or coordinate multiple tasks [232]. This is more pronounced when task complexity is higher, tasks are unfamiliar, or time demands are short.

Therefore, given that older adults process information more slowly, have working memory deficits or have inhibitory problems adjustments must be made in task design [232]. Key considerations include allowance of longer response time, additional practice to increase familiarity, frequent refresher training, frequent reinforcement of task priority, and reduction in the need for simultaneous performance of multiple tasks, or designing the system to be operated with low sensitivity to task order.

Training and learning warrant further discussion. In emergencies or situations where response time requirements are immediate and actions required are simultaneous and numerous, humans need to rely on automatic attention responses (AAR) to bring the situation under control. An AAR is a well-learned response to a stimulus that does not need to be mediated by attention. It occurs immediately, unconsciously and even involuntarily in the presence of an eliciting stimulus [237]. A simple example would be turning toward a person when s/he calls your name. If alarm A activates, close valve B… Such responses result after extensive, consistent practice.

Research shows that older adults, while they improve with extensive and consistent practice, do not develop new AARs [237], [238], [239], [240], [241]. Therefore, younger people may be better able to handle the multiple task demands of an emergency because they can accomplish some tasks without demand on their attention (assuming they have developed appropriate AARs). In older adults, while training and practice result in improvement, a multiple-task environment will continue to demand their attention. The likely error would, therefore, be one of omission. However, if the task becomes disrupted and a particular AAR is no longer appropriate, a younger person would be more likely to make the error. Because older adults keep their attention engaged, they exhibit better performance when the situation requires flexibility in response to changing stimuli [237].

The results of Korteling's 1994 study [233] indicate a pervasive tendency, although indistinct, toward decreased psychomotor learning and unlearning capabilities in later adult life. However, older adults respond positively to training and practice. Even though they learn differently than younger adults, this can potentially be overcome with more frequent hands-on refresher training. One might also implement frequent emergency response drills with hands-on activities included

for older adults. With experience, practice and training, it is possible that age-related error differences may be reduced.

6. Physical and Mechanical Limitations in Older Workers

Physical capabilities decline with age. Capabilities that relate to performance of industrial tasks include strength, range of motion, speed of movement, fatigue, motor skills and healing after injury. Around age 50, it is thought that perceptive-motor capacities may begin to decline. For example, in evaluating the vehicle cockpit in reach motion posture research, Chaffin [242] showed that older adults tend to exhibit a more conservative reach. They kept the elbow closer to the torso and did not elevate the shoulder (abduct) as much as younger participants. Although this conservative posture is not explained, it could be due as much to concern about an overextension injury and perceived lack of strength as to a true loss of range of motion. The difference is more pronounced in longer reaches. Either the older person does not reach the control or s/he accidentally manipulates a closer control, which could force the wrong response from the system [242]. Therefore, reach should be minimized for tasks performed by older workers.

Driving and similar tasks (for example, operating a large piece of machinery) require responding continuously to spatial and temporal information from the environment and the equipment. In doing so, one must coordinate movement of the head, neck and upper and lower limbs [243]. Motor control is critical when one must brake, steer, turn, change lanes, merge, recover from a skid, start a pump, drop the level in a storage tank, etc. [243]. One of the most pervasive findings in age-related research is that motor performance slows with aging [244].

Age-related motor impairments have been linked to loss of sensory receptivity, decrease in muscle mass and elasticity, decrease in bone mass, and reduction in central and peripheral nerve fibers. These changes affect a worker's ability to control movement rapidity and accuracy [243]. Research by Stelmach [243] evaluated a driving task, but because it was basic to all human motor capability, the results should extrapolate to similar tasks that require a motor response to a stimulus. The researchers found that there is age-related slowing in all facets of movement initiation—including response preparation, selection, programming and complexity. Movement execution was also found to slow with aging [243].

The literature also shows a disturbing trend in fatalities from falls. Fatality rates from falls increase beginning in the 45 to 54 age group and account for 20 percent of the fatalities among workers over age 55 (nine percent for all other ages) [245]. In 1981, Root reported that one-third of all compensable injuries to workers over age 65 were due to falls [246]. It appears that ladders are most often involved in falls among older workers. Researchers suggest that this may be due to a decline in balance and coordination among these workers. Loss of control of postural stability, which could be related to increased risk of falling, tends to begin in the 50 to 60 age group [247] Reduced strength may also affect an older worker's ability to recover balance or lost footing to avoid a fall [248].

Fatigue, which is thought to occur more readily in older workers, may also be a causal factor [245]. Adapting the workplace for an aging workforce may, therefore, involve reducing the need

for elevated work and eliminating the use of ladders where possible. As noted, in industrial settings, workers must often operate various controls. This could involve turning valve hand wheels, pushing or pulling levers, and turning dials or knobs of various shapes and sizes.

In a 1988 study, elderly females were found to have difficulty generating enough torque in water faucet handles of various shapes [249]. It has been established in the literature that older workers experience a decrease in strength. Therefore, any design that does not allow an older worker to apply maximum strength would not be suggested. A large paddle-wheel-type handle design is compatible. The worst of the designs studied was a multipoint design that did not permit subjects to develop a strong grip [249]. Given the reduced strength in older workers, any design that compromises grip, leverage or mechanical advantage would not be suitable. Bordett, [249] also reported that studies conducted by Nichols, Johnson and Woods show that a lever control is preferred over knobs because twice as much torque can be exerted. If one cannot operate controls adequately, errors can be expected.

7. Quantification of Error Potential and Experience Offsets

Several intuitively expected hypotheses proposed in the literature say that experience moderates the error rate difference between younger and older workers. A complete review of the existing research, however, does not provide unequivocal proof of these hypotheses [228]. Several researchers have found that many age-related performance differences between older and younger people are reduced when task familiarity and experience are considered [232], [228].

However, this area has not been thoroughly explored in an applied, industrial, task-based setting. Quantification of the difference reduction or offset in error rates relative to experience level has not been accomplished in age-related performance research. In general, research has shown that while errors increase among older adults as they accomplish life-skill tasks, the same losses have not been shown in performance of work tasks. In other words, decreased capacity with potential increase in error rates does not necessarily lead to performance decrement at work.

In driving research, experience has been shown to result in improved navigation performance; this is due to improved driving strategies that develop as experienced drivers are able to devote more attention to the navigating task. They make fewer glances of shorter duration at navigational aids, leaving more of their spare visual capacity to focus on improved performance. Inexperienced drivers must devote much of their spare visual capacity to concentrate on the newness of the task—the novelty effect [250], [251]. Unfortunately, similar research has not been conducted in industrial settings.

Salthouse claims that, at the time, existing cognitive research was still too equivocal to allow firm conclusions to be reached that age-related differences in performance of familiar activities are smaller than those on novel activities [228]. There does not appear to be an update to this conclusion. Motor learning research may be another body of literature that supports the experience is an error rate moderator hypothesis. Attention is one human process variable that affects physical and mental performance.

As noted, attention capacity is a performance variable that appears to deteriorate with age. Some research proposes that attention is related to the idea that people have a limited capacity to process information [252]. This raises several questions: Why is it easy for a skilled second baseman to effectively do all that is required in completing a double play when a beginner has so much difficulty? Why can a skilled typist carry on a conversation with someone while continuing to type? Why does a physical therapy patient tell the therapist not to give him/her so many instructions at once? Why is a skilled gymnast or dancer able to smoothly and effortlessly carry out a complex routine whereas a beginner is rough and inefficient [252]? The intuitive answer is that experience in motor tasks decreases the need for attention capacity.

Magill [252] mentions the limited capacity theory proposed by Kahneman [253] and states that while there is a limited capacity for attention, several factors affect available capacity. These include a person's arousal level, enduring dispositions (demand on involuntary attention), momentary intentions and evaluation of demands on capacity. While aging seems to result in a general decreased attention capacity and other age-related limitations also reduce the factors which affect capacity, the literature implies that experience reduces the need for attention capacity. This may be true for pure motor skills, but has not yet been unequivocally proven in industrial task performance. Although some suggest that research in an applied setting will be a challenge due to the difficulty of maintaining a consistent experimental setting [228], pursuing this line of research is no less important.

As this literature review shows, older workers are at a disadvantage when it comes to overall task performance. They are more likely to make errors than younger workers unless adjustments are made to the workplace, task design, time demands or strength requirements. Older workers also have decreased capacity in areas such as vision, hearing, strength, balance, memory, response time, action time, decision making and mental processing.

Although much of the literature does not explicitly state that older workers suffer increased error rates, it does implicitly show this to be a concern. Some literature shows that older workers enjoy the benefits of more experience, which may allow for more efficient execution of their tasks. Some research also shows that experience serves to moderate the difference in task performance between older and younger workers. Task familiarity, training and practice seem to moderate the performance deficit in older workers as well. However, evidence suggests that in an applied work setting, not enough is yet known to claim this across the board.

While much of the research has been conducted in a laboratory setting and often has involved driving tasks, it can, at least partially, be extrapolated and applied to similar activities performed by operators in industrial settings such as a nuclear plant, oil refinery, chemical or pharmaceutical plant, or paper mill. Although the onset of age-related performance decrement begins to occur in those over age 45, it does not appear to become significant until age 50 and above. If a workforce has a significant number of employees older than age 50 (for example, more than 10 percent), work setting changes may be warranted. An encouraging finding is that age-related errors and performance decrement appear to be manageable.

Some general suggestions for consideration in accommodating older workers and reducing the likelihood of errors include:

1. Improve illumination.
2. Eliminate heavy lifts, elevated work from ladders and long reaches.
3. Design work floors and platforms with smooth and solid decking while still allowing some cushioning.
4. Remove clutter from control panels and computer screens.
5. Reduce noise levels.
6. Lengthen time requirements between steps in a task.
7. Reduce the need for simultaneous performance of two or more steps in a task.
8. Increase the time allowed for making decisions.
9. Consider necessary reaction time when assigning older workers to tasks.
10. Provide opportunities for practice and time to develop task familiarity.
11. Educate industry about the needs of older workers.

While these suggestions focus on age-related error concerns, before age-related loss of capacity can be accounted for several questions must be answered. Key questions might include:

1. How much illumination is enough and for what ages should adequate illumination be targeted?
2. NIOSH has a lifting guide to ensure that workers do not strain their backs during heavy or awkward lifts. How should that lifting guide be adjusted for age?
3. How much floor cushioning is needed and what is the age-related offset for stability versus cushioning?
4. How much computer screen clutter is too much and at what age do workers require less clutter?
5. While OSHA has a guideline for protecting workers' hearing through limiting exposure, how much more should it be reduced to help older workers concentrate?
6. Which and how many control signals should be changed from an auditory signal to help ensure that older workers do not overly reduce priority of tasks associated with auditory instructions or signals?
7. How much time do older workers need to make decisions? Is it also dependent on the number of steps in the task?
8. Since multitasking is common, how many simultaneous steps are too many? Is there a difference in how many steps can be handled by a 45- year-old and a 50-year-old or maybe a 58-year-old?
9. Research has shown that decisions made by older workers, if given enough time to make them, were as good as the decisions made by younger workers. What if there is not enough time to allow better decisions to be made? How much time is enough? How much time is necessary to respond to a stimulus? How do we consider or quantify the need for additional time for older workers to process the stimulus (to make the decision that a motor reaction is needed) and to generate the motor response action?
10. Experience is critical to helping older workers maintain error-free performance even as their physical and mental capabilities are becoming limited. However, how much experience is needed to offset the potential increased error rate? Based on the research reviewed, one might expect older workers to experience higher injury rates. However, AARP and BLS data do not support that hypothesis. Is this due to the experience offset

concept or some other phenomenon, such as adopting a more conservative approach to completing work tasks?

This list of suggestions and questions is designed to encourage readers to think about the needs of an older workforce. Unfortunately, there are more questions than suggestions. While specific, quantified answers may not be available for all of the questions posed additional consideration during the design process of workers' age should result in a workplace that experiences fewer errors due to age-related limitations. Implementing any of the suggested improvements would likely benefit all workers, not just older workers. However, the current literature does not quantify this benefit, making it another topic for future research. Building codes and design criteria often do not consider the limitations and constraints of older workers, but design engineering groups should be educated about these needs. With respect to task design, more can be done to account for older workers. More research is needed in this area to help fill in the quantification of experience gap as well as more industry-applied information.

8. Shift Work Considerations

8.1 Effect of Age

Resistance to the special stresses of night work declines with age. Most burdensome is the need to change over to being active during the sluggish period of the night. The older worker is less adaptable and tires more easily. On the other hand many older workers do not require as much sleep as they did when they were younger. The sleep of the elderly is easily disturbed. *Hence, some older night workers suffer both from greater stresses and fewer opportunities to recuperate from them.* In fact, many surveys have shown that shift workers in age groups over 40 are distinctly more prone to disturbed sleep and complain of ill health. Having reviewed the literature, Haermae [254] recommends:

1. Working time arrangements should consider older workers' personal preferences
2. Many older workers prefer to start work earlier than younger shift workers and dislike night shifts
3. Continuous night work should be voluntary
4. Regular health checks should be done after the age of 40 years

8.1.1 Specific risks for women

Costa [255] states that shift work, especially night work, may have specific adverse effects on women's health. This may be related to their periodical hormonal body functions and to additional domestic activities, particularly for those who have children. Costa found evidence for more frequent perturbations of the menstrual cycle and of more menstrual pain as well as more frequent abortions and lowered rates of pregnancies and deliveries. Female night workers with children have shorter and more frequently interrupted day sleep and suffer from more cumulative tiredness than men and women without children.

9. Productivity

If the worker in question produces a physical end product, it is possible to measure productivity directly. Mathematically it can be simply calculated as,

Productivity = (Number of items of acceptable quality)/ (Time spend at work)

The worker's productivity is then expressed in terms of number of end products produced per hour.

Today, most physical end products are manufactured as a team effort between younger and older workers. It thus becomes difficult to attribute a specific productivity to an individual worker. If the task demands heavy physical work, inferences about productivity may also be drawn from the aerobic work capacity and muscle strength, since rates of working that demand the use of more than a fixed fraction of either peak oxygen transport or maximal voluntary force are fatiguing. The productivity of the worker may also depend upon occupancy (whether the individual in question actively seeks fresh work or passively awaits instructions), effectiveness (the degree to which an appropriate task is selected) and efficiency (the degree to which an optimum task approach is adopted).

9.1 A Reshaped Compensation Curve

In the business world, the compensation of a worker usually rises with age. This would mean that the highest compensation is due towards the end of an individual's career. This compensation profile usually maintains the same trend across various industries. Researchers have established that the productivity profile shows a decline after attaining a peak value somewhere during the middle of an individual's professional life [256].

10. Recommendations to Recruit, Retain, and Encourage Reentry While Enhancing Performance and Preserving Safety

Knowing that there is no one-size-fits-all solution, the following are suggestions that can increase workplace safety and productivity for an aging workforce:

- If human system interfaces are designed with seniors in mind, all users are accommodated
- Improve illumination, add color contrast – more light is not necessarily better
- Eliminate heavy lifts, elevated work from ladders, and long reaches
- Design work floors and platforms with smooth and solid decking while still allowing some cushioning
- Reduce static standing time
- Remove clutter from control panels and computer screens and use large video displays
- Reduce noise levels
- Install chain actuators for valve hand wheels, damper levers or other similar control devices – this brings the control manipulation to ground level – helps reduce falls
- Install skid resistant material for flooring and especially for stair treads – helps reduce falls

- Install shallow-angle stairways in place of ladders when space permits and where any daily elevated access is needed to complete a task – helps reduce falls
- Use hands free volume adjustable telephone equipment
- Increase task rotation which will reduce the strain of repetitive motion
- Lower sound system pitches, such as on alarm systems, as they tend to be easier to hear
- Lengthen time requirements between steps in a task
- Increase the time allowed for making decisions
- Consider necessary reaction time when assigning older workers to tasks
- Provide opportunities for practice and time to develop task familiarity
- Consider when designing maintenance tasks, that on average, women are only about two-thirds as powerful as men
- Perform usability testing and gather data from the users
- Employee participatory design
- Fully standardize and make consistent all system components – hardware, software, and all associated documents and labels
- Learn about population stereotypes and use those expectations in design principles.

11. Conclusion and Summary

The literature shows that the population generally is aging. People are living longer than at any time in history and more are achieving human lifespan. Coupled with longevity, due to technology, advancements in medicine and the fact that people are more educated and involved in their own well-being, older people are more fit and less likely to be disabled or have chronic illnesses with advancing years. Thus with more aging people in a better state of health, more of those people desire to continue work beyond conventional retirement age.

Baby Boomers---individuals born between 1946 and 1964---as a nontraditional demographic group may be the most controversial classification of those in the workplace of tomorrow. However, Baby Boomers have become nontraditional through the simple process of aging. The first wave of boomers, born between 1946 and 1954, started to turn 62, a traditional peak retirement age, in 2008. Older Baby Boomers represent a sizable labor pool---if they can be convinced to remain in or to re-enter the job market---and also have characteristics that make them appealing to the public sector [257].

It is recognized that more people are working longer than ever. Some leave the workplace and take up a second or even a third career. While the reputation of these aging people as workers is shown to be of high quality, and since they exhibit many characteristics and attributes desired by employers and businesses, it is surprising that many businesses persist in believing stereotypes and myths about older workers and may discriminate against them. The discrimination may be overt, such as refusing to hire older workers, or it may be more subtle and take the form of marginalizing older workers who are employed or not allowing them the benefits of training, advancement, or delegating jobs to them that do not hold meaning.

This investigation yielded many negative stereotypes held by business, the public, and even older people themselves. One of these beliefs is that older workers are hurt more or experience more

recordable injuries than younger workers, and thus they assume that if they do not retain or hire older workers, their risk is mitigated.

Older workers are not hurt more than younger workers [258]. This is in keeping with the literature review that supported the notion that older workers do not have a higher injury rate. "As the percentage of the workforce aged 55 and over increases injury rates for the whole work population decreases while productivity increases" [61].

Even today in some organizations, senior management still maintains their accident and injury rates are due to the aging of the workforce. Even presented with their own data which is contrary to those beliefs, they fail to accept or act upon the facts. Rather there is persistent hand-wringing and a quick willingness to blame rather than accept the responsibility of changing the work practices and standards which would allow for greater safety among all the workers.

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