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Tackling the challenges of an aging workforce with the use of wearable technologies and the quantified-self

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Abstract
The world's population is aging at an unprecedented rate, this demographic shift will change all aspects of life, including work. The aging of the worforce and a higher percentage of workers who will work past traditional retirement years presents significant challenges and opportunities for employers. Older workers are a valuable resource, but in order to ensure they stay in good health, prevention will be key. Wearable technologies are quickly becoming ubiquitous, individuals are turning to them to monitor health, activities and hundreds of other quantifiable occurences. Wearable technologies could provide a new means for employers to tackle the challenges associated with an aging workforce by creating a wide spectrum of opportunities to intervene in terms of aging employees and extend their working lives by keeping them safe and healthy through prevention. Employers are already making standing desks available, and encouraging lunch time exercise, is it feasible for Wearables to make the jump from a tool for individuals to a method for employers to ensure better health, well-being and safety for their employees? The aim of this work is to lay out the implications for such interventions with Wearable technologies (monitoring health and well-being, oversight and safety, and mentoring and training) and challenges (privacy, acceptability, and scalability). While an ageing population presents significant challenges, including an aging work force, this demographic change should be seen, instead, as an opportunity rethink and innovate workplace health and take advantage of the experience of older workers. The Quantified-Self and Wearables can leverage interventions to improve employees' health, safety and well-being.

Keywords: Aging, Health and Safety, Monitoring, Personalized intervention, Big Data.

Hacer frente a los desafíos de una fuerza laboral que envejece con el uso de tecnologías usables y la auto-cuantificación

Resumen
La población mundial está envejeciendo a un ritmo sin precedentes. El envejecimiento y un mayor porcentaje de trabajadores que trabajan más allá de los años de jubilación presentan importantes desafíos y oportunidades. Los trabajadores mayores son un recurso valioso, pero a fin de garantizar que permanezcan en buen estado de salud, la prevención será la clave. Tecnologías portátiles, ó wearables, están proporcionando un medio para hacer frente a el envejecimiento mediante la creación de un amplio espectro de oportunidades para intervenir y para prolongar la vida laboral de los colaboradores, mantenendoles seguros y saludables. El objetivo de este trabajo es exponer las implicaciones de este tipo de intervenciones con wearables (Control de salud, vigilancia, seguridad, y formación) y los desafíos (privacidad, aceptabilidad y escalabilidad). Los wearables pueden aprovechar y fortalecer las intervenciones para mejorar la salud, seguridad y el bienestar de los empleados.

Palabras clave: Envejecimiento, salud y seguridad, supervisión, intervención personalizada, big data

1. Introduction

The graying of the Baby Boomer generation, combined with a decrease in birth rates, has resulted in a dramatic shift in worldwide demographics. In 1950, a large percentage of the population fell in the working age range of 18-64 years. This segment, of work aged adults supported the small population of individuals in their retirement years and the

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large demographic of children. In comparison, the U.S. Census estimates that the year 2050 presents a very different picture to the past, the demographic of people age 65 and over is projected to reach as high as 20.2% [1]. This shift, often referred to as the squaring of the demographic curve, shows a shrinking percentage of the population of children and those of working age, along with an expanding percentage of the population surviving into what has traditionally been considered the retirement years. Aditionally, workers in the U.S. are working longer [2].

The aging of the workforce is a considerable issue worldwide. In Europe, the demographic of 55–64 year olds is predicted to increase by 16.2 % from 2010 to 2030 [3]. In the U.S., 9.9 % of the workforce was over the age of 55 in 2000, and it is expected that this number will increase to 15.3 % of the workforce by 2020 [4]. Such a demographic change has begun to affect many industries, including healthcare, finance, insurance, food, durable goods, electronics, the automotive industry, etc. Despite markets having recognized this demographic shift as an opportunity for products and services for an aging demographic also known as the "longevity economy" [5], less is known about how this will impact the future workforce. Industries need to react to changes not only in their consumer base to maintain market share, but perhaps more importantly, in their own workforce. In the discipline of human factors and ergonomics aging is considered a risk factor rather than an opportunity to retain skilled employees [6].

A review of epidemiological literature on the causes, and types of injuries and their related costs for the construction industry by age showed that workers age 50 and over, in fact, had a lower frequency of workplace injuries than younger workers, although the older workers had higher injury costs [7]. Similarly, the rate of injuries for 2012 with paid disability leave from work due to injuries by age range [8] showed that workers age 65 and over have a much lower rate of injuries with paid leave from work than the rest of the workforce. However, the length of disability leave for older workers tended to be longer, and they experienced a much higher fatality rate than younger workers [8].

On top of a leave of absence due to injuries or an accident in the workplace, it has been shown that health limitations appear to increase the likelihood of all types of retirement, suggesting that the beginnings of poor health are present before the decision to retire is made [9,10]. Therefore, it is of utmost importance to maintain or augment employees' health to keep them healthy and safe and, as such, able to keep working. In a literature review, physical activity has been shown to help alleviate the negative impact of age on the body and the mind [11]. On the way to old age, there are landmark birthdays, which mandate certain screenings and tests for preventive purposes (e.g., the aviation and the trucking industry). The workforce may need to adopt similar practices in terms of health monitoring, be it checkups in real time or at intervals like the medical model in order to keep their older workforces healthy and working.

The technological developments in the portability (i.e., miniaturization), precision and accuracy of different types of health related sensors (e.g., heart rate monitors) and other sensors have transformed the realm of everyday calculability. These changes have come with an increased capacity to gather data about one's performance and the capacity to track one's personal responses (i.e., emotional, physiological, etc.) to the environment. This movement known as the Quantified-Self can be characterized as self-monitoring or self-sensing using diverse types of Wearable sensors combined with the use of computing [12]. The Pew Research Center [13] showed that 60% of individuals surveyed recorded some type of information about their health (e.g., weight, diet, exercise routines or sleep patterns). For those who keep records of this information, methods vary considerably. Some people use electronic forms, while others use a pen and paper. The Wearables and Quantified-Self movement have enabled individuals to understand their personal life better through their health data, and such an approach could allow different industries to obtain a clearer picture of their employees through their lifespan [14].

Even though many ethical questions remain regarding their place in work settings [15], the use of Wearables technologies and Quantified-Self data represents an interesting opportunity to tackle the challenges associated with the aging of the workforce, both in terms of protecting and improving the health of employees and capturing information on working procedures to prevent the loss of knowledge due to retirement.

The aim of this work is to lay out the implications of using Wearable technologies and Quantified-Self data in the workplace to tackle the challenges of an aging workforce.

2. Methods

This work aims to expand an initial review that was conducted on the use of Quantified-Self and Wearable technologies in the workplace (for more details see Lavallière et al. [16]). The implications (Monitoring Health and Well-Being, Oversight and Safety, and Mentoring and Training) and challenges (Privacy and Acceptability, Scalability, Creativity) were addressed for a broader audience of health and safety practitioners, workers and industries. To extend this previous work and its relevance to the aging of the workforce, a similar structure will be used that will emphasize specific topics of these particular areas that would benefit the older employee. A narrative literature review was conducted to identify the main aspects that companies should take into consideration on how Wearables technologies can help to improve employees' health, safety and well-being.

3. Implications

3.1. Monitoring health, safety, and well-being

In line with one's ability to complete work, numerous reports have been made on the importance of health in the workplace [17]. The use of Wearables and Quantified-Self in such a setting allows for two types of interventions: identification of tasks that may involve risks for older employees and interventions in the workplace aimed at improving or maintaining employee health.

3.1.1. Identification of at risk situations for older employees

Based on the recent advances in technology development to collect multiple types of signals, all this new data can now be gathered, recorded and tracked during work to gather information such as the level of physical or cognitive fatigue. Such physiological indicators include heart rate, electromyography [18] and stress level.

An example of such an application would be the mining industry. An investigation of the most common type of accident recorded in subsurface and surface mining in Spain throughout the 2003–2008 period showed "Physical over-exertion on the muscular-skeletal system" as the primary reason for accidents at work [19]. This result showed that over-exertion was the main descriptor for 21.7% (out of 25,362 accidents) and 28.3% (out of 28,094 accidents) in sub-surface and surface mining, respectively.

Recent technological development has allowed for smaller and smarter devices to detect specific events or levels of fatigue. Some have used a Smart Safety Helmet (SSH), which combines inertial measurement units (IMU) and electroencephalography (EEG) sensors to detect an operator's level of fatigue [20]. The SSH sends a warning signal using a haptic device to alert the operator when a computed risk level (i.e., fatigue, high stress, or error) has reached a certain threshold.

Instantaneous measurement of physiological variables and environmental characteristics (e.g., light, noise, temperature, vibration) would enable decisions based on someone's physical state and, enable employers to identify risk factors such as particular working conditions or fatigue onset among employees prior to reaching a state of over-exertion. Moreover, gathering information over time with such devices would enable industries to better evaluate the procedures involved in job requirements.

3.1.2. Interventions in the workplace aimed at improving employees' health.

3.1.2.1. Modifying the work environment

As one ages, loss of physical strength and endurance can indicate potential declines in physical capacity [1]. There is also evidence that cognitive performance does not generally show any marked decrease until after 70 years of age [21]. Therefore, it is important to verify that the possible interventions implemented in the workplace are efficient at reducing the physical and cognitive burden of one's job. By allowing individualized data collection using Wearables, information regarding workplaces adaptations and/or the use of mechanically efficient techniques to compensate for age decline can be gathered and analyzed to evaluate their efficacy and efficiency.

3.1.2.2. Health interventions in the workplace

Workplace health and wellness interventions have received a considerable amount of attention (for more details consult The NIOSH Total Worker Health™ Program [17]). These approaches integrate occupational safety, workplace health protection and promotion initiatives through ergonomics to prevent worker injury and illness and to promote worker health and well-being [22,23]. It has been recognized that to be successful and beneficial, these approaches require the full participation of the employee [24]. Factors, such as higher attendance (i.e., greater participation in terms of number of employees) and better assessment of the level of involvement (i.e., intensity of one's activity measured by a physiological value such as heart rate) with improved recording over time is needed to achieve significant results in augmenting worker productivity. Self-monitoring has been found to improve chronic conditions such as high blood pressure, excessive weight, and diabetes [25]. Moreover, two behaviors—healthful food consumption [26] and restful sleep patterns—which can be improved with Wearables and the Quantified-Self-concept, [27,28] have also been shown to greatly influence health. Since chronic health problems have been associated with decreased work ability and, to lower productivity at work, it is beneficial for employers to prevent chronic health conditions among their staff [29]. It is important to note that these programs benefit employee health throughout workers' lifespans and not only once they are senior workers [30]. In sum, the use of Wearables, when embedded in a health promotion program, can help to improve employees' health by reducing the prevalence of chronic conditions among employees and helping them to adopt and/or maintain a healthier lifestyle.

3.1.2.2. Return to work

In the case where all these interventions would have been insufficient in preventing employee's injury, Wearables, and their associated data can be used to facilitate the employee's return to work after sick leave. Results have shown that the longer an employee remains away from work due to disability or work related injuries, the less chance they have of returning [31,32]. Therefore, efforts should be made to guarantee the best treatment possible during sick leave. It has been shown that a formal follow-up with employees while on disability leave [33,34] and a proper rehabilitation program, on-site or using tele-rehabilitation [35] can greatly influence return to work programs and, as such, prevent prolonged disability. The integration of Wearable and ambient sensors has been suggested for home monitoring while undergoing treatment [14,36] and would increase accessibility to rehabilitation programs.

Overall, there are definite benefits to the inclusion of Wearables in health interventions aimed at either preventing risky situations in the workplace, improving employee health care through health promotion programs, or by improving the rehabilitation process if one is injured on the job.

3.2. Oversight and Safety

Different approaches have been used to monitor workers in the workplace in the past. Some have even made the assumption that we are transitioning from a world of surveillance to sousveillance [37]. Sousveillance has been described as the recording of an activity by an individual using a small Wearable or portable personal technology [38]. Such approaches allow for a direct monitoring of the working environment from an employee's perspective (i.e., recording from first person perspectives - sousveillance), instead of the entire working environment (surveillance).

Systems can also be introduced to allow for remote monitoring of employees using an approach similar to sousveillance in combination with a GPS and personal emergency response system (PERS) to allow them to call for assistance at the push of a button or automatic emergency response.

The above mentioned the application of Wearables, and Quantified-Self data focused on tracking information regarding the health status of employees at work or while in recovery. With the aging of the population and the baby boomer generation quickly approaching retirement, multiple industries and job sectors are not only facing a shortage of workers, they are also at high risk of knowledge loss when these highly experienced and knowledgeable employees leave (e.g., oil, gas, and nuclear power facilities)[39].

3.3. Mentoring and training

While employers should assist their older employees in having long and healthy working lives, they do eventually leave. Employee knowledge can be captured and passed on by tapping into the underlying theme of human dynamics research. Pentland et al. [40-42] have suggested that people are social learners, so arranging work to increase productive face-to-face communication yields measurable benefits.

Wearble devices can be utilized to show a less experienced employee how a task should be performed. For example, recording devices such as smart glasses or a miniaturized video that gives a first person perspective (head, chest or shoulder mounted) would allow more experienced employees to gather information on how they navigate and interact in a work environment. Combining this video collection with a voice-over procedure of their execution of a task will not only enable the collection of precious information from experienced employees but also, help to identify whther there are disruptions in procedures that should be fixed. These procedures—used to gather employee knowledge—should serve all individuals as communicating vessels so older employees can also learn from younger colleagues. This type of approach aligns with Naegele & Walker's [43] work suggesting that when it comes to training employees, an age-neutral approach is particularly appropriate.

4. Challenges

4.1. Privacy and Acceptability

The use of more moment-to-moment information to improve the workplace would ideally lead to better management, and improved workplace conditions. All the information gathered by Wearables should be available for all parties involved—the employee as well as the employer—in order to be meaningful and prevent the stigma of technology as something that restricts autonomy.

4.1.1. Technology adoption among older workers

There is clear evidence that sensory abilities, such as visual [44] and auditory acuity [45,46], generally deteriorate with age. These declines can generally be compensated for by corrective technology, for example the use of personal aids such as corrective lenses or a hearing aid, or by adaptations to the environment such as improved lighting, reduced glare or reduced background noise. Therefore, Wearable technologies have to be designed to be inclusive without raising a flag as a device for an older or impaired individual. As reported by Coughlin [47], the baby boomers represent a new generation of consumers. They have experienced mobility, new technology, and a growing trend in improvements in every field in their lives [48]. They therefore expect to continue this type of lifestyle and will demand more of industries [49]. They will not be drawn to what could be considered an "older worker Wearable." Although the hope is that monitoring technologies will allow older adults to live independently and age in place, some may feel embarrassed and see technology as an admission of dependence on others. For example, patients, particularly older adults, are concerned about privacy, unfamiliarity with technology, and a potential decrease in social contact [50]. Therefore, great efforts and research should be undertaken in the domain of privacy concerns and willingness to use these devices among older individuals.

Sensors are becoming amazingly accurate, but Wearable products continue to be clunky and provide a poor user experience. In fact, studies have found that 40 percent of consumers who purchase a Wearable fitness tracker leave it sitting on their bedside after a month or two of wearing it. It is of utmost importance to overcome the barriers to the adoption of such technologies and recognize the potential benefits that they can deliver to older and younger adults alike.

4.2. Scalability

Such devices and quantified data have to provide insightful and accessible information to the user for an agreeable and compelling experience. Charts, graphs, and statistics can automatically be compiled, transforming what is essentially a large database of meaningless numbers into something that users can quickly parse and understand. This type of data translation is necessary to pass from a continuous data collection paradigm to information that is understandable and actionable [51,52].

4.2.1. Oligarchy

Implementations will have to rely on widespread distribution and usage among their industries to be successful. Moreover, great care should be taken that these tools are not only accessible to the wealthy. Open source code and the Internet of Things should alleviate such hurdles since cloud computing and crowdsourcing platforms will benefit us all by allowing the use of developments and tools created by others for free.

5. Conclusions

Instead of being viewed as a challenge, this upcoming aging workforce should be seen as an opportunity to review, rethink and reinvent how we cope with the aging workforce. The use of Quantified-Self information and Wearables represents a new way to tackle the challenges associated with an aging workforce by creating a wide spectrum of opportunities to intervene with aging employees to extend their working lives by keeping them safe and healthy. However, to be effective, products and/or programs have to engage workers and have a meaningful impact on one's life in order to be successful.

The creation of an organization with a reputation for being an ethical, trustworthy, and a good place to work is likely to deliver additional benefits across all generations of employees [53].

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