“Aging-and-Tech Job Vulnerability” : A proposed framework on the dual impact of aging and AI, robotics, and automation among older workers

"Aging-and-Tech Job Vulnerability": A proposed framework on the dual impact of aging and AI, robotics, and automation among older workers*

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Abstract

As the aging population and workforce constitute a worldwide concern, it is becoming necessary to predict how the dual-threat of aging and technology at work increase job vulnerability of older workers and jeopardizes their employability and permanence in the labor market. The objective of this paper is twofold: (1) to analyze perceptions of artificial intelligence, robotics, and automation in work settings and the expected impact of these technologies on the employment of older workers to contextualize this emergent phenomenon; and (2) to propose a general model related to "Aging-and-Tech

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Job Vulnerability" to explain and predict the combined effect of aging and AI/robotics/automation on job insecurity and further outcomes among older workers. The propositions of the Age-and-Tech Job Vulnerability model developed in this paper seek to present a first approach for the conceptual advance and research on this emerging phenomenon and entails several theoretical and practical implications for organizational psychology.

Keywords: older workers, vulnerability, aging, technology, job insecurity.

Nowadays, news in the media that disseminates the results of reports and surveys about the millions of workers who may lose or fear to lose their job because machines can replace them is increasingly frequent (e.g., IBA Global Employment Institute, 2017: Nedelkoska & Quintini, 2018; McKinsey & Company, 2017a). The main difference between the current Fourth Industrial Revolution (4IR) (Schwab, 2017) –or the Second Machine Age (Brynjolfsson & McAfee, 2014)– and previous industrial revolutions focuses on the range and type of tasks that machines are capable of performing today, and predictably in the near future (Brynjolfsson & McAfee, 2014; Schwab, 2017).

Machines and technologies no longer only replace low-skilled and unskilled human work in mechanical and routine tasks. At present, algorithms for big data based on pattern recognition are capable of replacing human work in an increasingly wide range of higher-order skills in non-routine cognitive tasks (Frey & Osborn, 2017). To what extent human work will be complemented or replaced by computerization is the subject of analysis and debate. For instance, recent statistical projections state that about 47% of total US employment faces the risk of being automatized (Frey & Osborn, 2017). In Japan, about 55% of jobs are susceptible to being replaced by computer

technology in the next decade. However, non-regular jobs (temporary and part-time workers) are more vulnerable to computer technology diffusion than standard work arrangements (David, 2017). However, job replacement effects will be different depending on the type of work-related skills. A survey carried out by Morikawa (2017) on the perceived risk of job loss found that about 30% of Japanese workers are afraid of their jobs being replaced by technology, but results also suggest that adaptable complex skills acquired by higher education graduates, particularly STEM (Science, Technology, Engineering, Mathematics) knowledge and skills, are complementary with artificial intelligence (AI) and robotics at work.

At the same time, job insecurity has become a structural phenomenon in the labor market since the beginning of the 21st century due to economic, technological and geopolitical influences – effects of globalization – and the dominance of neoliberal ideology and a market-driven economy (Bal & Dóci, 2018; Sverke & Hellgren, 2002). Job insecurity refers to "the perceived threat of job loss and the worries related to that threat" (De Witte, 2005, p. 1). While conflicting results have been found concerning the relationship between workers' age and perceived job insecurity (Keim et al., 2014; Lübke, 2019), data from different countries support the high vulnerability of older workers to job insecurity (Flynn, 2010). Specialized literature usually defines older workers as people over 50 years of age (Caines et al., 2020), a criterion we adopt in this paper. For instance, American older workers tend to experience distress associated with perceived job insecurity due to organizational policies that generate age discrimination, the anticipation of health problems related to age, and/or fear about the possible obsolescence of their skills and expertise (Burgard & Seelye, 2016). Furthermore, older workers are more vulnerable to the negative consequences of job insecurity, in particular in relation to psychological distress (Glavin, 2015), risk of clinical depression

(Gutierrez & Michaud, 2019; Mandal et al., 2011), decreased psychological well-being and reduced physical and general health (De Witte et al., 2015).

Further, the combined effect of AI/robotics/automation and age tends to increase job insecurity for older workers significantly. According to data from the Survey of Adult Skills (PIACC; OECD, 2016), about 55% of adults aged 55–65 lack basic ICT skills (such as the ability to use, solve problems with and collaborate using a computer or tablet or a new software), and only 10% of adults aged 55–65 are able to complete new multiple-step ICT tasks, compared with 42% of adults aged 25–54 (see also Marsh & McLennan Companies, 2018). While the risk of job loss or being pushed into early retirement is higher for older low-skilled workers, high-skilled older workers can also be vulnerable because they "tend to face unique difficulties in the labor market – such as high long-term unemployment and age discrimination – and so are prone to particularly harsh fallouts from displacement by new technologies" (Marsh & McLennan Companies, 2018, p. 3). Consequently, we introduce the term "Aging-and-Tech Job Vulnerability" to predict the risk of an older worker losing his/her job, or decreasing the quality of his/her job due to the interactive effect of age and the automation of their job tasks. This double threat is an unprecedented phenomenon that can reach a new dimension by adding the consequences of the COVID-19 pandemic and its potential effects on older workers, who are exposed to additional health risks and can be the target of workplace discrimination. Hence the relevance of identifying, evaluating, tackling and preventing these new forms of vulnerability is the main goal of this paper.

In the context of an aging population and low birth rates, especially in more developed countries, the sustainability of pension and social protection systems requires maintaining and prolonging the working life of older workers. However, the dual threat

of aging and AI/robotics/automation can increase their vulnerability and put their employment and careers at risk, with negative consequences for older workers, their families, and also for the human capital of organizations and societies as a whole.

The aim of this paper is twofold. First, to analyze perceptions of AI, robotics, and automation in work settings and the expected impact of these technologies on the employment of older workers, in order to contextualize this emergent phenomenon. Second, to propose a broad model related to "Aging-and-Tech Job Vulnerability" to explain and predict the combined effect of age and AI/robotics/automation on job insecurity and their consequences for older workers. A further contribution of this paper is to develop a coherent set of empirically testable propositions that allow the measurement of this dual vulnerability. From this, in addition to getting a model that will enable knowing and dimensioning the phenomenon, it will be possible to design further organizational interventions aimed at the prevention of "Aging-and-Tech Job Vulnerability".

Perceptions and Prospects of AI, Robotics and Automation at Work

Although AI, robotics, and digitalization are exponentially growing in work settings over the past two decades, “there is surprisingly little research on how [they are] altering work systems or the work that people do” (Cascio & Montealegre, 2016, p. 350). Recently, Brougham and Haar (2018) have proposed the acronym STARA (Smart Technology, Artificial Intelligence, Robotics, and Algorithms) to refer to the technologies that are changing the world of work. Researchers cluster these technologies into three main categories: (1) artificial intelligence, including machine learning and cognitive computing; (2) robots, comprising service robots, robot-assisted procedures, and robotic process automation; and (3) automation technologies (Coombs,

Hislop, Barnard, & Taneva, 2017). Given the growing accumulation of estimates and forecasts, it is important to assess the impact of STARA's implementation at work and identify the older workers' perceptions of these technological changes in their daily activities.

Data and Prospects on STARA's Effects

Studies on the effects of STARA at work show divergent results. This is not surprising in light of the debates in previous Industrial Revolutions about the different impacts of implementing successive technologies in the destruction/creation of employment (Autor et al., 2003; Frey & Osborn, 2017; Nübler, 2016). Experts wonder if technology will bring a fearsome jobless future or a hopeful golden age of job creation (Nübler, 2016), or if the effect of STARA on jobs is a process of creative destruction (Montealegre & Cascio, 2017) using Schumpeter's concept of capitalism dynamics. For instance, the econometric modeling develops by Oxford Economics (2019) estimates that by 2030, as many as 20 million manufacturing jobs worldwide could be displaced due to robotization, representing 8.5% of the global manufacturing workforce. However, the net loss of jobs is not a criterion that allows a very accurate estimation.

Given the current state of knowledge about tasks and jobs that can be totally or partially automated, it seems that a small percentage (7%) may be completely lost, and the main impact refers to the jobs likely to be significantly disrupted or suffer a significant change in their execution, about 33% (OECD 2018). Thus this recent study (Nedelkoska & Quintini, 2018) estimates for the 32 OECD countries the risk of automation for individual jobs based on the Survey of Adult Skills (PIAAC). Across all countries, almost one in two jobs is likely to be significantly affected by automation.

However, the degree of risk varies. About 14% of jobs in OECD countries are highly automatable (i.e., more than 70% probability of automation), a percentage equivalent to over 66 million workers in the 32 countries. But more important is the data related to 32% of jobs at risk of significant change (between 50 and 70% probability), reflecting the possibility of a substantial change in the way these jobs are executed due to STARA.

The data from the OECD study (Nedelkoska & Quintini, 2018) also indicate that the relationship between automation and age is U-shaped, although the effect is much more pronounced in younger than in older workers. In this sense, as Nedelkoska and Quintini (2018) noted, “automation is much more likely to result in youth unemployment than in early retirements” (p. 8). However, it is clear that young workers, in general, have a better educational level and are better skilled than older, so their capacity to adapt to new job requirements will be greater, especially (as “digital natives” vs. “digital immigrants”) in those new positions and professions created around STARA technologies (Nedelkoska and Quintini, 2018). In addition, older workers face job insecurity mentioned above due to organizational policies that "sacrifice" (mainly for economic reasons) workers over 50. This factor amplifies their risk of job loss and leaving the workforce due to the STARA effect.

With regard to older employees, at high levels of STARA awareness they have little difference in job outcomes (organizational commitment, career satisfaction, and turnover intentions) compared to employees with low STARA awareness. Brougham and Haar (2018) suggest that this might reflect a blissful unawareness on the part of older employees about the potential impact of STARA on their working conditions, or it might reflect their awareness of being at the end of their careers (“that won't affect me anymore”), their STARA awareness causing lower levels of stress and strain.

In sum, the small amount of research shows the existence of a relatively low STARA awareness among workers and ambivalent perceptions about its effects. Meanwhile, the European Parliament and the governments of several countries have already proposed forcing companies to pay taxes for the robots used as a “labor force” to sustain social security and pensions systems. The differences in both macro estimates and perceptions of workers and employers show that the working world faces a phenomenon of uncertain proportions, but whose existence and impact are real. Every year an increasing number of baby boomers will reach retirement ages, which will have a strong impact on organizations, current and future pension systems, and society as a whole. Social media and policymakers warn with growing concern about the so-called "Baby boomer retirement crisis", and potential skills shortages looming over organizations. Hence, a priority in this emerging field remains the need to propose a model to evaluate and prevent the vulnerability of (baby boomers) older workers due to aging and technologies to guide future research and interventions. In the next section, this model is developed and structured in the subsequent propositions linked to each element of the process.

Impact of AI, Robotics and Automation on the Employment of Older Workers: Aging-and-Tech Job Vulnerability Proposed Framework

In this section, we begin by analyzing the scarce data available so far and future projections on the impact that AI, robotics, and automation can have specifically on the work and jobs of older employees. Then we present the proposed model on Aging-and-Tech Job Vulnerability and develop propositions formulated to test the model empirically.

Estimates and Projections on the Size of the Impact

In general, many workers perceive their mid-to-late working life as a period of uncertainty and considerable vulnerability (Hofäcker, 2010; Lyon & Pollard, 1997) and this perception can be accentuated by technological or organizational changes (mergers, downsizing, automation, etc.). Recent prospective studies indicate that while computerization will affect workers of all ages, the older ones are at higher risk. A recent study found relationships between estimated automation risks in different countries and their performance in labor market indices related to young people, women, and older workers. For instance, Slovakia, Slovenia, Czech Republic, and Italy (with percentages of potential jobs at high risk of automation of 44%, 42%, 39%, and 38%, respectively) show "relatively higher NEET (not in education, employment or training) rates for younger people and lower engagement of women and older people in the workforce" (PwC, 2018, p. 11).

In particular, the projections of one of the most significant studies (Marsh & McLennan Companies, 2018) estimates that “older low-skill workers will face some of the harshest fallouts from workplace automation due to the age-associated difficulties they face in the labor market” (p. 15). In general terms, these difficulties focus on the fact that older workers face higher long-term unemployment than their younger counterparts and often find fewer new opportunities. Data also show that older workers have difficulties maintaining or finding regular employment (stable and full-time jobs), re-entering employment after a period of unemployment, sickness or disability, and tend to have part-time and non-standard or alternative work arrangements, including independent contractors, as they get older (Appelbaum et al., 2019; Marsh & McLennan Companies, 2018; Posthuma & Campion, 2009; Visser et al., 2018).

Drawing on several statistical data sources and the nine categories of "probability of computerization" values from Frey and Osborne (2017), weighted-average scores for the automation risk to older workers for each country (Marsh & McLennan Companies, 2018) ranged from 76% for China to 42% for Australia. Recent data from the US (Muro et al., 2019) show that jobs at risk of automation for young workers between the ages of 16 and 24 are 49%, workers aged 55 to 64 face an average automation potential for current tasks of 41%, those 65 and older 40%, and workers age 25 to 54 40%. However, older workers displaced by technology will generally have more difficulty with retraining since they have not had formal schooling in many years, or most of them never completed any higher education, and they may have negative attitudes towards the technology or lack of self-efficacy related to it. For instance, limited skills in using digital technology preclude older adults from connecting online, excluding them from social interaction and the further facets of society online (Hill et al., 2015). Nonetheless, digital and social media might enable social connection and inclusion among older adults by overcoming the physical boundaries inevitably associated with aging (Caidi et al., 2020).

According to studies from several countries (Carlstedt et al., 2018), a better educational level is strongly associated with lower retirement intentions and higher motivation for bridge employment. For instance, data from Finland show that the higher the level of education, the higher the probability of a late exit from working life (Järnefelt, 2010), and that workers with higher occupational classes (a correlate of higher education) were two times more likely to continue working when they reached retirement age compared to those in lower occupational classes (Virtanen et al., 2017).

Meanwhile, an Australian study (Taylor et al., 2014) show that more highly educated older workers are more likely to continue to work part-time or never to retire.

Therefore, there are differences between high- and low-skilled older workers in terms of their ability and readiness for learning and requalification and their subsequent possibility of continuing to work. Thus, an additional obstacle to the retraining of low-skilled older workers is that the marginal income difference between a retraining program and entering a new job and unemployment or disability benefits or early retirement pension may be minimal (Muro et al., 2019).

Of course, older workers are a diverse group regarding their educational levels. However, it is necessary to consider two factors when comparing the effects of changes caused by STARA at work according to age groups. On the one hand, according to data from the Survey of Adult Skills (PIACC; OECD, 2016), although the age-proficiency profiles in information-processing skills vary considerably across countries, on average and in the majority of OECD countries, proficiency tends to peak at around age 30, and then gradually declines with age. In addition, proficiency in problem solving in technology-rich environments peaks at around age 25. This depreciation over time can be increased and even accelerated due to a lack of investment in training and lifelong learning activities (PIACC; OECD, 2016). Furthermore, current research emphasizes the high level of complexity in implementing training activities which cannot disregard a thorough examination of participants' skill levels and previous experiences (Tyler et al., 2020). Therefore, these initiatives should rely on the costly and challenging tailoring of training that cannot effectively cover the gap of needs between experienced and reluctant users among older workers. Reduced investment in skills training/updating, both by organizations and individuals, is especially sensitive in times of economic recession such as the current and expected one, where the negative effects of the COVID-19 pandemic on the labor market may extend over many years.

These facts may result in a limitation for reskilling and training of workers over 50. On the other hand, reskilling and upskilling opportunities for older workers at work are comparatively lower than for their young and core age counterparts. These lower learning and training opportunities can be experiment implicitly or explicitly (Beck, 2012). Still, both research on career development (e.g., Bown-Wilson, 2011) and professional surveys (e.g., LinkedIn, 2020) have revealed that age is their biggest opportunity gap for older workers training and career development when seniority is not exclusively prioritized. For instance, a study on 3,638 organizations in six European countries about human resource policies of European employers concerning older workers (Van Dalen et al., 2015) showed that the employers clearly use exit policies (i.e., exit through retirement) more intensively than they use development measures; only when organizations face recruitment problems, more emphasis is placed on accommodation and investment.

In short, the dual effect of aging and risk of work automation –which affects lower educational levels and lower occupational classes to a greater extent, but also higher-skilled jobs– leads to an increase in personal and structural vulnerability faced by workers 50 years and over.

Aging-and-Tech Job Vulnerability Model and Propositions

General Overview

In order to characterize the phenomenon of the combined impact of aging and work automation described in the previous sections, we propose the term "Aging-and-Tech Job Vulnerability" to predict the risk of an aged worker losing his/her job, or decreasing the quality of his/her job, due to the interactive effect of his/her age and the automation of their job tasks.

Drawing on vulnerability models used in social science disciplines, we assume that vulnerability refers to "the characteristics of a person or group and their situation that influence their capacity to anticipate, cope with, resist and recover from the impact of…an event or process," which has a potential traumatic effect with negative consequences for the person or the group (Wisner et al., 2004, p. 11). This definition of vulnerability has a temporal dimension since it not only refers to the damage or the negative consequences that are suffered when the event occurs but also to the probability of damage in the immediate or near future (Wisner et al., 2004). A central element in the concept of vulnerability is a threat since it generates risk and places people exposed to it in a position of vulnerability (Alwang et al., 2001; McLaughlin & Dietz, 2008; Wisner et al., 2004). The threat is, therefore, related to a specific danger or risk, which is different from the threat of uncertainty in general (Calvo & Dercon, 2005). And the threat is "a relational property reflecting the match between perceived coping capabilities and potentially hurtful aspects of the environment" (Bandura, 1988, p. 77).

The label "vulnerable workers" has gained acceptance in recent research (e.g., Burgess et al., 2013; Sargeant & Giovannone, 2016; Saunders, 2003, 2006) as it reflects the risk of negative work consequences due to both working conditions (non-standard work arrangements, precarious jobs, part-time and temporary jobs, or low wage jobs) as to the characteristics of individuals or groups, including significantly, workers over 50 (Bisom-Rapp et al., 2011; Jones et al., 2013; Visser et al., 2018).

We propose an integrated framework on Aging-and-Tech Job Vulnerability rooted in several well-established and widely used theoretical models in vulnerability research in situations of hazards, natural disasters, poverty and social exclusion (e.g., Alwang et al., 2001; Hufschmidt, 2011), adapted to work contexts, and models from

OH&S vulnerability (e.g., Sargeant, 2009; Smith et al., 2015). Our model on Aging-and-Tech Job Vulnerability includes four components: antecedents, mediators, moderators, and outcomes, and two types of Aging-and-Tech Job Vulnerability: vulnerability related to the combined risk of age and technology ("Aging-and-Tech Job Risk Vulnerability"), and vulnerability related to outcomes or consequences ("Aging-and-Tech Outcomes Vulnerability"), and include recursive cycles of feedback (see Figure 1 for a view of the general model proposed).

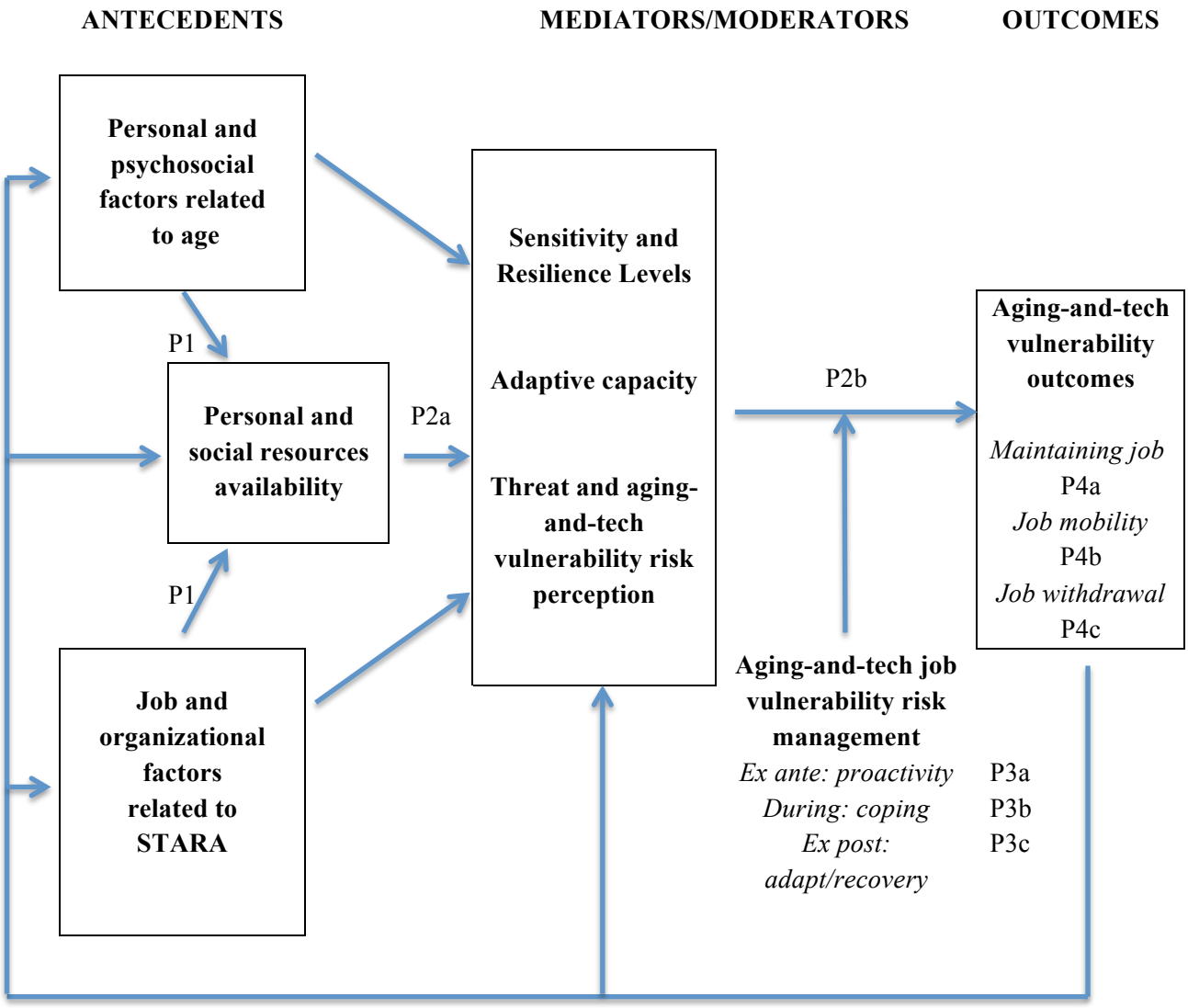

Figure 1. Aging-and-Tech Job Vulnerability: Proposed general model and propositions

Antecedent factors

The interaction of individual and contextual factors involve adjustment at work (Dawis & Lofquist, 1984), employability (Van der Heijde & Van der Heijden, 2006), sustainable workability (Kira, Van Eijnatten, & Balkin, 2010), or sustainable career (Stuer, De Vos, Van der Heijden, & Akkermans, 2019) among other processes relevant for older workers. In particular, the conceptual framework proposed by Yeatts et al. (2000) on older workers' adaptation to a changing workplace identifies these two key factors: personal and organizational. Further analysis should be done on environmental factors (socio-economic, political, cultural) or *frame* (Hufschimdt, 2011), but they exceed the psychosocial scope adopted in this article.

Related to personal antecedents, aging can lead to changes or decreases in their physical, cognitive and socio-emotional abilities, although not necessarily or with the same intensity for all people (Cjaza et al., 2015; Peng & Chan, 2019; Truxillo et al., 2015). These potential losses can reduce their skills and competencies and influence their workability, both objective and perceived (Bohle et al., 2010; Cadiz et al., 2019). But it is also possible for physical deficits and any cognitive losses to be compensated by the greater experience of older workers and more efficient use of resources (Bohle et al., 2010), as well as better emotional regulation and higher emotional well-being (Truxillo et al., 2015).

Meanwhile, prior research has shown that chronological age can itself be a risk factor for discrimination of employees aged 50 and over (Dordoni & Argentero, 2015; Griffin et al., 2016). Age, and age stereotypes – especially those related to their technological competence – are significant barriers for assessing, appraising, retaining and recruiting older workers (Fisher et al., 2017; Harris et al., 2017; Van Dalen et al., 2009). Moreover, they can negatively affect objective and subjective workability,

employability, motivation to train, work engagement (Chiesa et al., 2019; Boone James et al., 2013), job satisfaction (Griffin et al., 2016), occupational well-being (Sutin, Stephan, Carretta, & Terracciano, 2015) and desired retirement age (Zaniboni, 2015). It is important to note that these consequences are not the result of the real state and capacity of the older workers, but rather the result of perceptions and attributions that are made about them due to their age (Snape & Redman, 2003). To this are added decisions based on economic criteria to dispense with older workers as they are more "expensive" and make them the priority objectives of downsizing processes (Armstrong-Stassen & Cattaneo, 2010).

Competency and skill levels of older workers can be challenged by new demands imposed by technology (design constraints, microminiaturization, usability, etc.) and weak or insufficient training related to STARA implementation (Brougham & Haar, 2018; Cascio & Montealegre, 2016; Cjaza et al., 2015). The anxiety and impotence experimented by these challenges can contribute to attitudinal barriers to technological change and to perceive it as a high risk for performance, employability, and even maintaining a job. Difficulties in accessing required training to cope with technological changes can be perceived as discrimination (Lee et al., 2009) and accelerate early retirement decisions (Magnani, 2006). Meanwhile, a disruptive change or an unexpected change in the rate of technological change can induce older workers to retire early because they perceive the required amount of retraining or new skills acquisition as a toilsome and unattractive investment (Bartel & Sicherman, 1993).

Consequently, functional factors associated with aging, psychosocial factors related to age stereotypes and prejudices, and factors related to competency, skills and adequate training will influence the objective and perceived workability (Brooke, 2009; Cadiz et al., 2019) and the workers' fragility level, that is, their physical and mental

health, well-being and disability levels (Sutin et al., 2015). And these personal factors will directly influence older worker's individual disposition – i.e., their ability and desire to successfully adapt to a technologically changing work environment (Yeatts et al., 2000) – as well as reducing his/her availability of resources (see Figure 1).

Regarding job and organizational factors, potential effects on threat and risk, and subsequent older workers' vulnerability are primarily related to two categories of factors: structural and socio-cultural. Structural factors refer to STARA implementation and job characteristics and job status involved in a given technological change. And socio-cultural factors refer to organizational culture, organizational climate for successful aging, and organizational age norms. A first relevant aspect is related to the reasons argued by top management for the need for technological change, that is, transparently explain why the change is necessary, what will change and who will be affected (Yeatts et al., 2000). Workers' attitudes and responses to organizational change can differ depending on whether they perceive the smart side or the dark side of technology at work (Holland & Bardoel, 2016). A second aspect is related to the scope and rate of STARA implementation, that is, whether the technology that partially modifies jobs and tasks will be more disruptive (Brougham & Haar, 2018).

The effects of STARA implementation can result in the elimination of jobs, the displacing of jobs, the transformation of jobs, and the creation of jobs (Roos & Shroff, 2017). Elimination can affect older workers in the ways already mentioned in the previous section. Job displacement, which refers to externalization or migration of jobs instead of being performed directly or via platforms from locations outside the organization, can affect the jobs of workers of any age. The transformation of jobs requires, by definition, the acquisition of new skills or retraining, which can represent significant barriers for the elderly, as discussed above. And job creation, being mostly

associated with technological developments and the new occupations it generates, seems less accessible to older workers, who may be forced to late job mobility or career change, as well as choosing bridge employment (Alcover & Topa, 2018). In short, the transparency of the organization in the communication and justification of technological change and the range of this change will affect threat and risk perception for older workers

Finally, leaders' styles, experiences, values, and ideas about age norms can determine HR policies and practices (Moen et al., 2017; Mulders et al., 2017) and generate a trickledown effect influencing the decisions adopted by other managers at the various organizational levels, facilitating or hindering older workers' possibility of adaptation to technological change. In a similar vein, organizational culture, HR practices, and age-related workplace norms shape the organizational climate for successful aging, which refers to employees' shared perceptions of the extent to which organizational policies and practices enable and facilitate successful aging (Zacher & Yang, 2016). This climate is a buffer of the negative relationship between employee age and the beliefs about future goals and opportunities at work, which in turn, are positively associated with job satisfaction, organizational commitment, and motivation to continue working until or beyond normal retirement age (Mulders et al., 2017; Zacher & Yang, 2016). In addition, an age-diversity climate affects HR policies, practices, and procedures directly associated with collective perceptions of social exchange and indirectly with organizational performance and employees' collective turnover intentions (Böhm et al., 2014), consequences that can be crucial when addressing a technological change.

In short, the combination of personal factors related to age and job and organizational factors associated with STARA implementation will condition the

availability of resources for older workers to deal with the dual threat of age and technology. These resources mainly refer to personal resources, such as self-efficacy levels and self-determination motivation (Kanfer & Ackerman, 2004; Paggi & Joop, 2015) or voice and agency (Spreitzer, 1995); social resources, such as social support from supervisor and coworkers (Brougham & Haar, 2018); and organizational resources, such as opportunities to learn (Cjaza et al., 2015; Raemdonck et al., 2015), or opportunities to participate / empowerment (Schermuly et al., 2017; Smith et al., 2015).

Based on these rationales, we offer the following proposition:

Proposition 1: Personal factors related to age and task and organizational factors related to STARA implementation are associated with resource availability to face aging-and-tech job vulnerability.

Mediator factors

In turn, this amount of resources and accessibility to them will determine sensitivity and resilience levels. According to a central corollary of Conservation of Resources Theory (COR), the possession and lack of resources are directly related to people's vulnerability and resilience. Mainly, "those with greater resources are less vulnerable to resource loss and more capable of resource gain. Conversely, individuals, and organizations that lack resources are more vulnerable to resource loss and less capable of resource gain" (Hobfoll et al., 2018, p. 107).

Drawing from vulnerability concepts and vulnerability research (Alwang et al., 2001; Davis, 1996) in our model sensitivity refers to the degree to which a given individual or group can undergo change due to external forces, in this case STARA changes at work. And resilience refers to the individual’s or group’s ability to absorb

and utilize (or even benefit from) technological change. Both sensitivity and resilience are associated with adaptive capacity (awareness and willingness to adapt; Hufschmidt, 2011) and the perception of STARA threat and risk. Prior research has shown (Brougham & Haar, 2018; Maurer, 2001; Piasna et al., 2013; Smith et al., 2015) the positive effects of these resources for dealing with and adapt to technological changes at work. And as Yeatts et al. (2000) noted, older worker participation in adaptation to change processes "can promote feelings of personal investment in the outcome and greatly reduce the perceived insecurity that can be brought about by change" (p. 574). In short, levels of sensitivity and resilience will be associated with the risk levels of older workers and their vulnerability to ageing and technology.

Extant research and theory on Occupational Health and Safety (OH&S) suggest that job characteristics, work environments, and risk factors workers are exposed to are perceived and interpreted differently by individuals (McLain, 1995). This evidence allows verifying the distinction between perceived or subjective risk and objective risk (Hansson, 2010). Concerning the subjective perception of threat and risk, the model predicts that the combination of age over 50 and performing tasks/occupying a job likely to be automated or STARA affected will increase perceived threats, both *person-at-risk threats* and *job-at-risk threats* (Shoss, 2017). As mentioned above, tasks, jobs, and/or occupations at risk increase job insecurity, especially in the case of older workers (Flynn, 2010; Marsh & McLennan Companies, 2018; Nedelkoska & Quintini, 2018). When older workers perceive tasks at risk in their jobs, they will experience qualitative insecurity or fear to decrease quality of working conditions (Gallie et al., 2017; Hellgren et al., 1999; Shoss, 2017), whereas when they perceive their job and/or occupation is at risk, they will experience quantitative insecurity, or fear of job loss (Hellgren et al., 1999; Sverke & Hellgren, 2002; Shoss, 2017). The perception of job insecurity and

vulnerability can increase when they feel low protection and the threat of age discrimination (Griffin et al., 2016; Lee et al., 2009). Experiences of job insecurity depend on three characteristics (Shoss, 2017): perceived situational control (the extent to which older workers view the technological threat as controllable), threat duration (from acute to chronic technological threat), and volition (the extent to which older worker enter insecure job situations voluntarily). Consequently (Shoss, 2017), lower control, longer duration, and lower volition will cause increased stress in older workers, with detrimental effects to physical and psychological health and well-being (De Cuyper et al., 2019; De Witte et al., 2015; Lübke, 2019), a greater perceived risk, and greater subjective vulnerability.

Regarding objective threat and risk exposure, the main factors are real organizational plans for STARA implementation and subsequent jobs and positions at risk. As the available data and forecasts show, although low-paid jobs and low-skilled tasks and jobs are at higher risk to be transformed or lost (Acemoglu & Autor, 2011; Brougham & Haar, 2018), complex tasks and highly qualified jobs may also be at risk (Frey & Osborn, 2017; Nedelkoska & Quintini, 2018). Consequently, the objective risk will be contingent on each production sector, type and size of the company, job type, and characteristics of the tasks and functions, as well as contingent on the socioeconomic characteristics of each country and region.

Based on these rationales, we offer the following propositions:

Proposition 2a: Personal and social resources availability is associated with sensitivity and resilience levels, adaptive capacity (awareness and willingness to adapt), and threat and aging-and-tech risk perception

Proposition 2b: Sensitivity and resilience levels, adaptive capacity, and threat and aging-and-tech risk perception will mediate the relationships between personal and job/organizational antecedents and aging-and-tech outcomes vulnerability

Risk Responses as moderators

In the face of Aging-and-Tech Job Vulnerability, older workers can employ *ex-ante* or proactive adaptive actions and risk management responses. If these responses have not been made or have not been effective when experiencing Aging-and-Tech Job Vulnerability, adaptive actions, and risk management behaviors occur. And if these actions and behaviors have not been able to avoid Aging-and-Tech Job Vulnerability, older workers make *ex-post* or adaptive/recovery responses to alleviate the adverse effects experienced. The reaction of older workers and the effectiveness of one or more of the three types of adaptive actions and risk management responses will have a different impact concerning Aging-and-Tech Job Risk Vulnerability and Aging-and-Tech Outcomes Vulnerability.

Ex-ante or proactive responses are directly related to resource availability that results from the individual disposition and organizational dispositions analyzed above (Figure 1). Theses pre-impact responses, initiated to neutralize the expected result (i.e., vulnerability) (Heitzmann et al., 2002), include learning, anticipating, modifying, preparing or planning (Hufschmidt, 2011), so that the older worker is in a position to deal with a STARA change in the workplace successfully. Proactive behaviors are facilitated when organizations implement primary interventions aimed at risk prevention (Truxillo et al., 2015), so that older workers have the necessary resources to deal effectively with technological change. The availability of personal and organizational resources that facilitate proactive behaviors is beneficial to reduce anxiety and increase

self-efficacy for learning and development. In addition, older workers' self-efficacy can be enhanced by organizational interventions aimed at managing mastery experiences, vicarious influences, persuasion, and physiological influences (Maurer, 2001). Self-efficacy is directly related to competence, a core dimension of psychological empowerment mentioned above (Spreitzer, 1995), which in turn enhances self-confidence in one's skills and abilities to avoid or minimize undesirable results in the workplace. If adaptive actions and risk management responses are effective in addressing the threat and job risk, both Job Risk Vulnerability and Outcomes Vulnerability of older workers will be reduced. This expected relationship is formulated in the following proposition:

> Proposition 3a: Ex ante, proactive actions, and risk responses are associated with Aging-and-Tech Job Risk Vulnerability and Aging-and-Tech Outcomes Vulnerability.

In addition to proactive behaviors –or when these are not fully effective– older workers may need to use coping behaviors during the implementation of STARA changes. As is well known, three basic coping strategies can be effective in stress management: problem-centered, emotion-centered, and meaning-centered (Lazarus & Folkman, 1984; Folkman, 2008). In the coping process, in addition to these strategies, two dimensions of psychological empowerment are especially relevant: self-determination and impact (Spreitzer, 1995). Self-determination refers to the personal sense of having the capacity to initiate and regulate adaptive and constructive actions in the work- place, while impact refers to the sense of being able to significantly influence valued work results (Spreitzer, 1995). As Schermuly et al. (2017) argue, competence beliefs might help older workers to perceive more coping resources and coping options

in their work settings, and workers with high competence beliefs tend to use problem-focused more than emotion-focused coping strategies.

On the other hand, they also found (Schermuly et al., 2017) that the self-determination and impact of psychological empowerment provide workers with more favorable cognitive, affective, and motivational resources. And as Self-Determination Theory postulates (Deci et al., 2017), when basic psychological needs such as autonomy, competence, and relatedness are satisfied, people's motivation improves, whether autonomous or controlled. According to the stress model by Lazarus (2006), these cognitive, affective and motivational resources can enhance older workers' ability to perceive coping resources and coping options more positively, and thus increase their effectiveness in dealing with difficult work situations with more self-protecting reappraisals and a more relaxed handling of threats and strain (Schermuly et al., 2017). In addition, when older workers have high levels of coping efficacy or perceived controllability, they do not engage in apprehensive thinking, controlling dysfunctional apprehensive cognitions, and experiencing low levels of anxiety arousal (Bandura, 1988). In a similar vein to adaptive actions, if coping behaviors and risk management responses during a technological change process effectively address the threat and job risk, both Job Risk Vulnerability and Outcomes Vulnerability of older workers will be reduced. This expected relationship is formulated in the following proposition:

> Proposition 3b: During, coping behaviors and risk management responses are associated with Aging-and-Tech Job Risk Vulnerability and Aging-and-Tech Outcomes Vulnerability.

If the ex-ante/proactive and coping responses during the STARA implementation process has not been effective, or the objective factors mentioned above have made job destruction inevitable and the older worker is likely to lose his/her job,

the most functional responses are those related to adaptation/recovery. The main goals of these responses are to reduce or mitigate the potential negative effects on physical and psychological health and implement fragility mitigation actions and preparedness activities to reduce future vulnerability (Hufschmidt, 2011). For instance, workers who perceive a job loss as a transition and not as an "unemployment" event may deal with the loss experience with less stress and perceive it as a career growth opportunity (Latack & Dozier, 1986), like older workers with a proactive personality (Zacher, 2013). In addition to activity level, and consistent with Latack and Dozier's model, the opportunity to leave or be removed from a dissatisfying job can also promote career growth (Eby & Buch, 1995), facilitating adaptation/recovery responses.

However, career stage and older workers' self-perceptions can affect adaptation and recovery from involuntary job loss. It seems that adverse reactions are more frequent among those who view themselves as old enough to have difficulty re-entering the workforce and getting hired but too young to retire (Schlossberg & Liebowitz, 1980). In a similar vein, older workers that perceive lower remaining time left in the occupational context – a dimension of Future Occupational Time Perspective (Zacher, 2013) – tend to reduce job search intensity and adaptation/recovery responses. Meanwhile, older workers' adaptation to changes and starting of new jobs will be facilitated when alternative workplaces are designed so that older workers have the ability and desire to adapt (Yeatts et al., 2000), and as long as the obstacles to re-employment are not too great to be overcome (Klehen et al., 2012). From these arguments, we propose the following proposition:

> Proposition 3c: Ex post, adapting, and recovery risk responses are associated with lower-adverse effects for well-being and physical and mental health.

Outcomes

The Aging-and-Tech Outcomes Vulnerability is associated with potential changes in the mid and late career paths of older workers. On the one hand, the organization can force a modification of their working conditions, for instance, reducing working hours or their workload, or via demotion (Van Dalen et al., 2009; Visser et al., 2018). And on the other hand, the threat or effective job loss can significantly alter career paths because the vulnerability fragments, interrupts, or redirects the mid and late careers of older workers (Brooke, 2009; Fournier et al., 2011; Tempest & Coupland, 2017).

When older workers face lower subjective and objective job risk and have the ability to effectively adapt to technological changes implemented in the workplace (Cjaza et al., 2015; Yeatts et al., 2000), they will experience a lower Aging-and-Tech Outcomes Vulnerability. As noted above, this adaptive capacity is based on personal resources and disposition, resource accessibility, self-efficacy, and learning and training opportunities (Kanfer & Ackerman, 2004; Maurer, 2001; Schermuly et al., 2017). This ability can be enhanced by adequate organizational and coworker support (Ng & Law, 2015; Truxillo et al., 2015) and an organizational disposition to facilitate retraining opportunities (Brooke, 2009; Magnani, 2006) so that older workers can compensate for potential resource losses and maintain optimal performance and work outcomes (Hobfoll et al., 2018; Ng & Law, 2015; Paggi & Joop, 2015) as well as higher well-being and health at work (Hedge, 2008). From these arguments and research results, we propose the following proposition:

> Proposition 4a: Lower Aging-and-Tech Outcomes Vulnerability is associated with maintaining job performance, well-being, and health.

As a corollary of the proposition, lower Aging-and-Tech Outcomes Vulnerability and subsequent older worker's ability to maintain a job in the face of

technological change will have a positive feedback effect on the system, so that (1) personal and organizational factors will be enhanced; (2) resource availability will be maintained or increased; (3) subjective and objective threat and risk perceptions will be reduced; and (4) Aging-and-Tech Job Risk Vulnerability will be reduced.

Regarding the second outcome, a medium level of Aging-and-Tech Outcome Vulnerability may result from different factors. First, since the worker does not have enough personal disposition, motivation, perceived ability, or interest in investing effort and time in a retraining process (Bartel & Sicherman, 1993; Cadiz et al., 2019; Kanfer & Ackerman, 2004). Second, because while the older worker could face a process of change, he/she considers that the technological threat may be the opportunity for labor mobility and thus positively change his/her career path (Alcover & Topa, 2018; Latack & Dozier, 1986), especially when he/she perceives could the opportunity of leaving a highly demanding job (Brougham & Haar, 2018; Cjaza et al., 2015), or a dissatisfying or demotivating job (Eby & Buch, 1995). And third, a medium level of Aging-and-Tech Outcome Vulnerability may result because the older worker clearly perceives that the threat and objective risk of job loss in the current or short/medium term are very high and does not find compensation for the anxiety and distress experienced until the inevitable organizational exit arrives.

Prior research shows how older workers in situations facing current job threats, especially those who perceive their job loss as completely involuntary (Van Solinge, 2014), opt to start entrepreneurial projects or move towards bridge employment opportunities (Alcover, 2017; Kerr & Armstrong-Stassen, 2011). Bridge jobs can be chosen in the same or another organization but in the same occupation (career bridge jobs) or another occupation, either other-employed or self-employed (non-career bridge jobs; Beehr & Bennett, 2015), and any of these options can be an alternative to reduce

vulnerability, although high-skilled and higher employability older workers will have more capacity to find and adapt to bridge jobs (Wang et al., 2008). Based on these rationales and research results, we propose the following proposition:

> Proposition 4b: Medium Aging-and-Tech Outcome Vulnerability is associated with job mobility (entrepreneurship and bridge employment).

As a corollary of this proposition, medium Aging-and-Tech Outcome Vulnerability achieved by older worker job mobility will have a feedback effect on the system, such that (1) personal factors will be modified; (2) resource availability will be reoriented towards new career paths; (3) subjective and objective threat and risk perceptions will be reduced if job mobility is successful; and consequently (4) Aging-and-Tech Job Risk Vulnerability will be reduced.

Third, older workers who experience high Aging-and-Tech Outcome Vulnerability face a deteriorated and adverse work setting characterized by worsening working conditions (Van Dalen et al., 2009; Visser et al., 2018), higher OH&S vulnerability (Smith et al., 2015), poorer well-being and occupational health (Munnell & Rutledge, 2013), and job loss, unemployment, or involuntary early retirement threats. For instance, research results show that a greater fragility caused by lack of control at work was a risk factor for disability pension, unemployment, and early retirement (Robroek et al., 2013). Prior research (e.g., Gallo et al., 2000) provides evidence of a causal relationship between involuntary job loss and both worse physical functioning and worse mental health among older workers. Among vulnerable older workers with limited wealth, the potential effect of unintentional job loss in the years preceding retirement is associated with depressive symptoms and enduring adverse mental health (Gallo et al., 2006). In sum, older workers who lost a job can expect lower earnings,

higher unemployment periods, and more instability and, potentially, higher vulnerability associated with worse physical and mental health (Munnell & Rutledge, 2013).

A last negative factor that adds to job loss due to aging-and-tech job vulnerability is the aforementioned difficulty of reentering the workforce. Studies indicate (Lassus et al., 2015) that these experiences of impotence associated with the challenge of finding a new job have far-reaching social-psychological consequences for older workers, such as the loss of belief in organizational meritocracy, questioning of self-esteem and self-image, and feelings of isolation, hopelessness, and depression; in short, feelings of learned helplessness. However, at an older age, the importance of the STARA effect may diminish because older workers over 63 or 65 already self-perceive being close to the end of their professional career and full retirement (Brougham & Haar, 2018), so the consequences of vulnerability will be limited to a voluntary or resigned job withdrawal. Based on these rationales and research results, we propose this proposition:

> Proposition 4c: Higher Aging-and-Tech Outcome Vulnerability is associated with avoidance response (job withdrawal), job deterioration (worsening working conditions, well-being, and health), or exit (layoff, unemployment, early retirement).

As a corollary of this proposition, higher Aging-and-Tech Outcome Vulnerability will have a negative feedback effect on the system, such that (1) personal and organizational factors will be reduced; (2) resource availability will be limited or eliminated; (3) subjective and objective threat and risk perceptions will be increased to a maximum level; and consequently (4) Aging-and-Tech Job Risk Vulnerability will also be increased, or the exit of organizational/labor market will become effective.

Discussion

As the aging population and the aging workforce constitutes a worldwide concern, it is becoming necessary to analyze and predict how the dual-threat of aging and technology increase job vulnerability of older workers and jeopardizes their employability and permanence in the labor market, as well as their well-being and health. The Aging-and-Tech Job Vulnerability model developed in this paper seeks to present a first approach to this emerging phenomenon and has a series of theoretical and practical implications, summarized in the following sections.

Implications for Theory and Research

In the organizational literature, the analysis of the vulnerability of older workers is relatively scarce, and has basically focused on OH&S (e.g., Burgess et al., 2013; Sargeant & Giovannone, 2016). The model presented offers a comprehensive and integrative perspective and, consequently, contributes to the progress of the understanding and future research of this emerging phenomenon by combining constructs and conceptual frameworks from the literature on social vulnerability with theories and processes of work and organizational psychology.

The consideration of personal and organizational factors as antecedents of resource availability that allow older workers to face the dual-threat directly link the model with the sustainable employability approach. From this perspective, it is considered that it is not only the individual responsible for maintaining their work capacity but also that the work setting is also important (Van der Klink et al., 2016). In a similar vein, a sustainable career perspective approaches the career from a dynamic and systemic perspective, postulating that multiple agents play a key role in its development over one's lifespan (Stuer et al., 2019). In line with these approaches, in the proposed model, both the coping capacity and the perception and exposure to the

dual risks of age and technology will depend on the interaction of factors related to the older worker as well as the organization. And three critical dimensions are considered when analyzing Aging-and-Tech Job Vulnerability: the person, the organizational context, and time, also used to analyze the sustainability of careers (De Vos et al., 2018). Vulnerability is a process (Heitzmann et al., 2002; Hufschmidt, 2011), and therefore research in this area should consider its temporal dimension. This means that future research devoted to empirically testing the formulated propositions will be necessary to use longitudinal designs that allow checking causal relationships between variables.

Although job vulnerability due to STARA factors can affect workers of all age groups, the focus on aging in our model is justified by the existence of psychosocial processes that operate relatively independently of the actual competence of older workers. Previous research has identified the existence of stereotypical beliefs, positive and negative, related to older workers, which tend to coexist together (Bal et al., 2011; Fiske et al., 2018). However, the weight of negative stereotypes is greater, leading to discriminatory treatment by organizations (e.g., lack of advancement opportunities, or forced early retirement) (Bal et al., 2011; Harris et al., 2017). Age stereotypes are acquired in the early stages of socialization and become so deeply rooted that they can be automatically activated by the mere perception of an older person (Carstersen & Hartel, 2006). For instance, a common age stereotype is related with the "correct age" for a job position (Posthuma & Campion, 2009), and the subsequent "correct age" for being technologically competent. Despite evidence that contradicts these miscategorizations, the activation of negative age stereotypes in the workplaces tends to be automatic (Posthuma & Campion, 2009). This implicit stereotype activation help to establish strong associations that technology is incompatible with old age. And it helps

to create and reproduce a pervasive mantra: *Technology is an Unsuitable Job for an Older*.

This bias towards negative perceptions of older workers, and in particular towards their alleged technological incompetence and aversion to learning how to utilise new technology (Von Hippel et al., 2019), may be motivated because this age group represent a 'risky investment' in relation to anticipated future training capacity and work performance that reduces expectations on potential return on investment (Petery et al., 2020). Therefore, positive stereotypes also attributed to older workers fail to avoid discrimination associated with age and technology.

From the temporal perspective mentioned above, another key point of the model is that it foresees possible paths for older workers depending on the effectiveness of adaptive actions and risk management, as well as the Aging-and-Tech Outcome Vulnerability. These paths can be positive when there is low vulnerability (maintaining one's job, performance, well-being, and health) and medium vulnerability (job mobility, entrepreneurship, and bridge employment), which can be analyzed from the perspective of mid and late career management (Alcover, 2017; Fournier et al., 2011; Kerr & Armstrong-Stassen, 2011). On the other hand, when the vulnerability is high, less positive alternatives go through unemployment or early retirement, which would link Aging-and-Tech Job Vulnerability to research on the effects of age discrimination at work (Dordoni & Argentero, 2015; Fisher et al., 2017). Consequently, the proposed model complements and expands the explanatory frameworks on the barriers faced by older workers based on the combination of their age and factors related to work and organizational context (e.g., Griffin et al., 2016; Lee et al., 2009).

Finally, a central characteristic of the model is the consideration of agency, that is, the assumption that the older worker is an active agent of his/her employability and

his/her mid and late career, who in interaction with organizational agents and workplace factors defines their contingent capacity to adapt to age-and-tech changes in their job (Yeatts et al. 2000). Consequently, the model has the capacity to generate research results that can be integrated into well-established literature in the field of organizational behavior, such as self-efficacy and work motivational orientations (Kanfer & Ackerman, 2004; Maurer, 2001; Paggi & Joop, 2015), self-determination theory (Deci et al., 2017), or psychological empowerment (Schermuly et al., 2017; Spreitzer, 1995). In short, a new model proposal, but strongly anchored in theories and consolidated research results, both in WOP and specifically in older workers and aging research.

Implications for Practice

As technologies are changing – and will change even more in the future – work and organizations (Cascio & Montealegre, 2016; Holland & Bardoel, 2016), interventions aimed at preventing and reducing older workers' vulnerability need guidance for an effective design. Although there are already proposals for interventions supporting the aging workforce (e.g., Truxillo et al., 2015) until now there was no framework for specific interventions related to the dual threat of age and technologies. In this sense, the proposed model can serve to guide practitioners and HR managers in designing and implementing prevention interventions, as well as secondary and tertiary interventions, aimed at reducing or alleviating Aging-and-Tech Job Vulnerability.

At an individual level, the success of future interventions with a focus on Aging-and-Tech Job Vulnerability will serve to maintain and improve older workers' health and well-being, increase their work capacity (both perceived and objective), contribute to their motivation, strengthen their psychological empowerment, increase

organizational commitment and work engagement, and facilitate the achievement of adequate performance. As a result, the maintenance of older workers in the workforce can be ensured, and the risk of unemployment and early retirement will be reduced, at least in the absence of the adverse effects of other personal factors (e.g., poor health, eldercare requirements) or organizational factors (e.g., downsizing, mergers). Further, these organizational interventions can serve to avoid other undesired outcomes. For instance, when the increase in Aging-and-Tech Job Vulnerability leads to an early exit that is perceived as involuntary, the consequences for health and well-being can be very harmful, as research on early retirement has extensively shown (Gallo et al., 2000, 2006; Van Solinge, 2014). On the other hand, an involuntary and unplanned retirement well in advance of withdrawal can cause elderly people and their families' financial difficulties in the medium and long term. Therefore, reducing the vulnerability of older workers can also contribute to reducing the vulnerability of their relatives and dependents.

At an organizational level, reducing the vulnerability of older workers and the risk of job loss can avoid the loss not only of intellectual capital due to the brain drain by the early withdrawal of workers over 50 years (Rau & Adams, 2013), but especially the loss of the valuable social and tacit relational capital of experienced employees with extensive professional networks. Prior research had found (Massingham, 2008) that lost social capital may reduce organizational memory, while lost relational capital may produce disrupted knowledge flows with the external organization. These organizational losses of intangible resources seem difficult to replace by robots or automated processes, at least for now.

As for the structural consequences, the proposed model also has practical implications. On the one hand, in the next decade, Aging-and-Tech Job Vulnerability

can accelerate the exit of voluminous cohorts of baby boomers from the labor market, with the consequent financial overload of pension systems and social protection welfare programs. It is an overload that will have repercussions not only in the present but especially in the future since the expected years of retirement will continue to increase both for men and women. On the other hand, in a socio-demographic context also characterized by low or stagnant birth rates, the early exit from work of a significant number of older workers can lead to growth in the old-age dependency ratio, as well as significant labor shortages and a reduction in generational replacement, especially in certain professions and sectors. Consequently, the prevention, early detection, or reduction of Aging-and-Tech Job Vulnerability of older workers can contribute to delaying the retirement of cohorts of baby boomers and reduce or mitigate the structural effects mentioned. Workers, families, organizations, and societies as a whole can benefit from these policies and practices, without prejudice to the fact that companies and individuals would also benefit from the advantages and advances provided by STARA technologies.

Limitations and future prospects

Despite the original contribution of the proposed model, certain limitations and future prospects need to be considered.

Firstly, although, as has already been analyzed, the effects of STARA do not only affect current workers over 50, but will also foreseeably affect the following generations when they reach these ages, the proposed model will nevertheless have to adapt to the changes that the development of technologies will impose on the types of jobs and organizational structures. Secondly, the turbulence of the present times does not allow for an accurate prediction of changes in the labor market and in the required

working skills, and consequently, neither does it allow assess their impact on workers and age groups, which may limit the validity of our model. For example, the current need for teleworking, remote working and hybrid work arrangements may extend over time with effects that are not yet well known, so future research should check whether Aging-and-Tech Job Vulnerability is maintained, increased or how it will be affected. Finally, the proposed model may also be sensitive to the socio-demographic changes resulting from the current pandemic or future worldwide events (e.g., reduced life expectancy, declining birth rates, changes in generational ratios), so its formulation and the factors included will have to be updated according to these potential transformations. In short, and despite these limitations, what cannot be denied is that in the current context and in the scenarios that are predicted, the vulnerabilities of all groups of workers have increased, and that Aging-and-Tech Job Vulnerability is at the core of the multiple concerns we face.

Declaration of Conflicting Interests

The Authors declare that there is no conflict of interest.

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