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Scientific Evaluation of the Impact of an Increase in the Retirement Age on the Cognitive Functions and Well-Being of Air Traffic Controllers (ATCOs)

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ABSTRACT

In 2020, the Swiss Federal Council made it a strategic objective to encourage Skyguide (Switzerland's private air navigation service provider) and social partners (HelvetiCA) to work together to raise the retirement age from the current 56/59 to at least 60. In this context, HelvetiCA and Skyguide agreed to carry out a scientific study (RAFA study) to assess the possible impact of this increase in age, in particular on the psychological well-being and cognitive performance of ATCOs. Two studies were carried out following a review of the literature. The first study aimed to identify the factors relating to working conditions, individual characteristics and coping strategies that may be affected by ageing and sought to assess whether these factors have an impact on the ability to perform operational tasks according to the demands and conditions of the job carried out by ATCOs. The second study aimed to assess the cognitive functions of ATCOs of different ages using a battery of neuropsychological tests to examine the impact of ageing on cognitive performance, a crucial aspect of air traffic control activity. After a 13-month study period, a final report containing 17 recommendations was submitted to HelvetiCA/Skyguide. Within the context of the Collective Labour Agreement agreed in January 2024, the social partners agreed to implement the recommendations to help HelvetiCA and Skyguide manage this change safely and efficiently, with a transparent programme.

Keywords: Air traffic controllers, Cognitive ageing, Retirement age, Well-being, Fatigue

INTRODUCTION

On the basis of scientific studies (Grandjean, 1968) and a mediation (Dubach, 1975), the retirement age for air traffic controllers (ATCOs) in Switzerland has been set at 55 and 58 years of age, depending on the operational unit (international or regional units). In Switzerland, ATCOs are employed by Skyguide, a private air navigation service provider (ANSP). This company is majority owned by the Swiss Confederation and has been governed by

the Confederation via periodic strategic objectives since 1934. In 2012, following a proposal by Skyguide to strengthen the financial situation of its pension fund, the ATCOs agreed to raise their retirement age to 56 and 59 respectively. In 2020, the Swiss Federal Council set out a strategic goal, urging Skyguide and their social partner, HelvetiCA, to collaborate on raising the retirement age again from its current range of 56/59 to 60. In response, Skyguide and HelvetiCA agreed to conduct a scientific study evaluating the effects of ageing on the psychological well-being and cognitive performance of ATCOs.

The retirement age of controllers is increasingly influenced by the trend in our modern society to have a high proportion of aged individuals and the need to increase globally the retirement age to be able to sustain pension schemes. However, it is well known that ageing is accompanied by a variety of perceptual and cognitive declines (Monge and Madden, 2016; Oschwald et al., 2019; von Krause et al., 2022). Moreover, age has a significant effect on the mechanisms that regulate fatigue and sleep. Circadian rhythms shift by thirty minutes every decade, beginning in middle age (Cooke and Ancoli-Israel, 2011). In addition, synchronisation of the body clock tends to be less efficient (Marquié et al., 2012) and prevalence of sleep disorders increases by 40% with age (Foley et al., 1995). We can assume that these cognitive declines and poorer sleep quality contribute to the difficulties encountered by ATCOs. In the case of air traffic control (ATC), which primarily involves cognitive work, a detailed understanding of the cognitive changes associated with advancing age appears to be essential. Few studies have been initiated on the subject in the area of air traffic management. Skyguide and HelvetiCA were the first to tackle the issue in Europe with a study to assess how a four-year increase in the retirement age (from 56 to 60) could be managed without negatively impacting operational safety and the well-being of ATCOs.

OBJECTIVES

In the context of a global increase in the retirement age, the study aimed to assess the potential impact of ageing on ATCOs, with a particular focus on their ability to perform operational tasks safely and to adapt to the demands of their working environment. It also sought to assess how ageing might affect cognitive functions critical to ATCO tasks. The research was conducted in three phases:

- Phase 1: a literature review on the effects of age on fatigue, stress and cognitive abilities.
- Phase 2: a field data collection on the effects of working conditions, individual specificities and coping strategies for stress and fatigue. This phase also assessed the cognitive performance of volunteer ATCOs in different age groups using a set of neuropsychological tests and ATC simulations.
- Phase 3: development of recommendations based on the results of the literature review and the studies conducted in Phase 2. The extent to which

these recommendations were accepted by ATCOs was also evaluated by means of focus groups.

PHASE 1: LITERATURE REVIEW

The objective of the literature review was to determine whether the interactions between job demands, working conditions and ability to perform operational tasks change with ageing. Based on studies on similar contexts and topics, it was possible to identify the main factors that may have an impact on the ability of air traffic controllers to perform their operational tasks in a safe and sustainable manner with age. The literature review therefore explored the interactions between ageing, sleep, working conditions, fatigue, stress and well-being. Finally, the literature review also helped to identify the cognitive functions that are both crucial for ATC operations and impacted by ageing.

The first step in the literature review was to examine the main scientific basis for the regulation of the sleep-wake cycle. The alternation between sleep and wake is controlled by several physiological processes, in particular the body clock and homeostatic processes (Borbely, 1981). Both processes control sleep-wake regulation and are directly affected by irregular working hours, particularly early shifts and night shifts, which cause circadian disruption and reduced sleep quantity and quality. These processes and the ability to cope with shift work are significantly affected by age, leading to a lower tolerance to shift work in older workers, and may have several health consequences, including cardiovascular disease, psychological disorders and, more recently, degenerative diseases.

Recent works (Loudoun et al., 2014; Saputra et al., 2018) confirm that when it comes to adaptation to working conditions, ageing with the presence of other factors such as work organisation, the absence of control over one's activity or schedule can be an aggravating factor in fatigue. Indeed, older ATCOs tend to be less tolerant to shift work as it further disrupts the workers' normal circadian rhythms. This intolerance can be expressed by indicators such as sleep alteration, persistent fatigue, mood disturbances, depression (Reinberg and Ashkenazi, 2008) or regular use of sleep medications and behavioural changes (Saksvik-Lehouillier et al., 2012). Likewise, older ATCOs may be more affected by night work because they have more difficulty getting deep sleep during the daytime (Pires et al., 2009). Furthermore, the impact of ageing on the internal biological clock leads individuals to be more of the 'morning type'. Therefore, older ATCOs tend to be more sensitive to night shifts and require more recovery time.

This literature review also showed that ageing has a significant effect on stress. Stress tends to increase until 55 and then decrease with age (Stone et al., 2018). The highest levels of stress are found among people aged between their twenties and fifties. As confirmed by Saputra's study (2018) on pilots, ageing, combined with a disruption of the circadian rhythm by shift work and night work, tends to create the conditions for a perceived higher workload that can contribute to increased fatigue.

The work environment significantly influences the health and work capacity of ATCOs. It can contribute to muscular disorders, affecting physical and psychological well-being, and may exacerbate age-related conditions. Given the high sensory demands of the ATCO role, particularly in terms of visual and auditory stimulation, the work environment may potentially lead to ocular and auditory issues in older ATCOs.

The literature review also emphasised that ageing is accompanied by a plethora of cognitive declines including reasoning, processing speed, visuospatial abilities and working memory (Oschwald et al., 2019). Fluid intelligence is much more impacted by ageing than crystallised intelligence (Bugg et al., 2006). Among the cognitive functions associated with fluid intelligence, executive functions and working memory are markedly impacted, while other functions such as vocabulary and verbal knowledge are preserved. The difficulty in adapting can be attributed to the impact of age on cognitive abilities. Cognitive reserve can alleviate ageing effects and is dependent upon a multitude of factors, including genetics, education, occupation and lifestyle (Tucker and Stern, 2011). Some studies that explore how the decline of cognitive functions can be mitigated were also reviewed. These studies can help to find solutions to limit the potential difficulties for older ATCOs in adapting to job demands. Moreover, experience may limit the decline of cognitive functions and allow older ATCOs to have an efficient operational performance during ATC simulations (Nunes and Kramer, 2009). However, these results should be treated with caution: different participants with different ages were assessed and compared between them. In order to properly study the effect of age on performance, ATCOs should be assessed longitudinally during decades.

This literature review identified the main variables that could have an influence on the potential negative effects of ageing. It emphasised the tools and methods that may be relevant to measure these variables such as working conditions, sleep, stress, well-being and health. This review also highlighted the possible limitations of some of the methodologies and tools that have been used to address similar issues in ATM and other industries. For example, some of these tools have been developed for scientific purposes and are not suitable in a real context. More importantly, the literature review showed the importance of combining objective and subjective data collection, using tools and methods based on theoretical models, and the importance of limiting the biases generated by effects such as the 'healthy shift worker effect'.

Finally, this literature review allowed for the identification of possible solutions in order to support older workers in the context of an increase in the retirement age. This identification was made possible by combining knowledge about the effects of age on workers and about the working conditions of ATCOs. The solutions that were reviewed were categorized into two groups: non-organizational and organizational solutions. The effect of experience, individual strategies and collective strategies were part of the non-organisational solutions. The organisational solutions are mostly based on the work of Costa. He considers that there are several levels of action addressed directly to the workers, the work organisation or the company. He also adapted the ergonomic principles developed by Knauth for older shift

workers, aiming in particular to give older shift workers more control over their choice of job or to reduce their workload. These recommendations could lead to potential ways of improvement but should not be considered as prescriptions to be implemented as they are. Indeed, the rigour of this study and the process it involves made it possible to highlight the most relevant factors on which to act in order to obtain the best results by taking into account the specificities of the ATCO population and their activity.

PHASE 2: FIELD DATA COLLECTION

The aim of Phase 2 was to identify the impact of ageing on individual characteristics and adaptation to working conditions and to evaluate the impact of age on cognitive functions and physiological parameters. The method used in this phase combines quantitative and qualitative data collection.

For the quantitative data collection, a survey questionnaire on working conditions and well-being was addressed to all ATCOs within Skyguide, and a neuropsychological experiment was carried out. Following the questionnaire, daily data on fatigue and stress were collected using a dedicated application. For 30 ATCOs over 45 who took part in this survey, this data collection was completed by the use of an actigraph in order to obtain objective sleep measurements. Regarding the study on the effect of ageing on cognitive functions, we thoroughly evaluated the impact of age on 64 ATCOs distributed in four groups (28–36, 37–44, 45–54 and 55–59 years old). Our study is one of the very few in the literature to comprehensively measure the effects of age on so many different cognitive abilities and physiological parameters. We examined changes in cognitive performance through neuropsychological tests and a simulation of ATC (Imbert et al., 2014). We also investigated the relationship between age and physiological parameters, such as resting heart rate, and their impact on cognitive performance. To our knowledge, no study has been carried out to explore the effect of ageing on physiological measures and the cognitive abilities of ATCOs. For example, Nunes and Kramer (2009) used no physiological measures, and participants were not from the same ANSP (Canada vs Switzerland) and were thus not working under the same conditions.

As for the qualitative aspect of this research, the study consisted of interviews and observations of fieldwork sessions. A total of 38 interviews and 9 observations took place in seven different centres, considering the different work units within Skyguide. They were conducted on a sample of ATCOs aged between 30 and 54. These interviews and observations were analysed and used to complete and further explain the quantitative data. The analyses focused primarily on identifying age effects and interactions between ageing and age-related working conditions. The effects of individual specificities were also explored.

Interaction With Fatigue and Work Organisation Factors

Statistical analyses have shown significant interactions between age and specific work organisation factors, such as the number of early shifts. There is a positive effect of satisfaction with the number of early shifts as age increases. The interviews confirmed that among ATCOs, satisfaction and control over

the schedule were linked: the more control ATCOs had over their schedule, the more satisfied they were. This result confirms the hypothesis that control over scheduling has a positive effect on fatigue, particularly for older workers.

In addition, when duty types interact with age, there are higher levels of fatigue at the beginning of duty. In general, night shifts induce higher levels of fatigue at the start of duty than early shifts. This effect becomes more pronounced as ATCOs age. The 50+ age group therefore has a higher level of fatigue at the start of duty than ATCOs under 50. This result is in line with the hypothesis from the literature review that older workers who tend to be more of the morning type are much less tolerant to night work than younger workers.

On the contrary, we note that age, in interaction with the consecutive duty factor, seems to have a slightly more protective effect on fatigue at the beginning of the duty. The increase in fatigue levels during the week was less rapid for those aged over 50 and, after the third consecutive day, fatigue levels were lower for them. The level of fatigue at the start of duty is therefore less significant for older ATCOs. Here, it seems that experience has an impact on fatigue management and allows older ATCOs to cope with fatigue from the third consecutive day of work. However, age is an aggravating factor in fatigue when it interacts with workload during peak traffic hours. In this case, it accentuates the effects of workload on fatigue. Those in the 50+ age group were the only ones to rate workload during peak traffic hours as 'not manageable at all'. As workload increased, their fatigue increased rapidly, too.

Age also interacts with sleep quality before duty. In general, an increase in sleep quality before duty leads to a decrease in fatigue at the end of duty. This protective effect of sleep quality is even more significant for older ATCOs. This result suggests that ageing increases sensitivity to sleep quality. However, the results within the sample are not consistent with studies that report a deterioration of sleep quality for older people.

Effect on Adaptability to Working Conditions

Results show that age itself has no significant effect on the well-being of ATCOs. When the effects of workload on stress are examined, ageing has a slight exacerbating effect. However, the relative weight of this factor remains low. Although the role of age in stress remains moderate, ageing leads to an increase in stress, as showed by our model. This was also confirmed during the interviews where the respondents explained that their stress levels tend to increase with age.

Interaction With Individual Specificities

Age in interaction with chronotype has a significant effect on fatigue levels at the start of duty: lower levels of fatigue were observed for older 'morning type' ATCOs. The protective effect of being a morning type is therefore greater with age. The results of the study also show that within the sample, as age increases, the number of morning people also increases. These results

are therefore in line with studies that show that the older an ATCO is, the more likely they are to be a morning person. Apart from age, the results of the study show the significance of the effect of individual characteristics. Thus, daytime sleepiness alone accounts for 15% of fatigue, regardless of age. Also, an individual's tendency to be more or less stressed solely accounts for 38% of variance in the ATCOs stress levels.

Effect on Reaction Times During Cognitive Tests

A wide variety of cognitive abilities were measured, including vigilance, attention, mental flexibility, fluid reasoning, inhibition, processing speed, short-term memory and working memory. Interestingly, none of these abilities were significantly impacted by age in terms of accuracy. However, in the older ATCO group, reaction times were slower for a variety of abilities: attention, mental flexibility, inhibition, and working memory. Even if older adults have been consistently reported to be slower, they also seem to focus on minimising errors at the cost of being slower (Salthouse, 1979). Several studies have shown that cognitive decline is already visible in middle age, with executive functioning and processing speed being the most affected functions (Salthouse, 2010). This is consistent with our results since mental flexibility, working memory and inhibition are important executive functions. Interestingly, a large set of cognitive abilities were unchanged by ageing: vigilance, fluid reasoning, processing speed, visuo-spatial working memory and short-term memory. Contrary to the results during the cognitive tests, both accuracy and reaction times were affected by age during the ATC simulation. Older ATCOs were slower and had lower performance than young ATCOs.

Physiological Activity at Rest and During Tests

An exploratory approach was employed in this study to assess the impact of age on several physiological measures of mental workload: heart rate, eye movements, and pupil diameter were continuously recorded during task performance. Overall, physiological measurements taken during task completion were impacted by the level of difficulty. For instance, heart rate was lower when carrying out most of the tasks in easier conditions. This effect of task difficulty on physiological parameters is well established (Causse et al., 2016) and reflects an increase in energy mobilisation to meet the demands of the task. However, no marked effect of age group was found. It suggests that energy mobilisation did not significantly differ between the age groups, contrary to the predictions of the CRUNCH model (Schneider-Garces et al., 2010).

Towards Monitoring the Cognitive Performance of Older ATCOs

Our results suggest that older ATCOs generally maintained accuracy during the cognitive tests, despite a decline in efficiency, as response times increased in several tests. It should be remembered that age-related declines in processing speed are thought to underlie widespread changes in cognitive performance in older adults (Eckert et al., 2010). It is complex to establish a target cognitive performance that might represent a reasonable range for

ATC activity. Ideally, it would be interesting to be able to establish a diagnostic cut-off, as we do when diagnosing a fever in an individual. Without being alarmist, the slowing down of reaction times in several cognitive tests and the decline in accuracy in the ATC simulation call for caution with regard to ATCOs aged 55 and over, both in terms of work organisation and cognitive screening.

The results from the cognitive evaluation are consistent with those found during the study on working conditions. Indeed, the workload during peak traffic hours interacts significantly and positively with age. Contrary of the 50+ age group, none of the ATCOs under 50 considered the workload to be unmanageable during peak traffic hours, so it is noticeable that the effect of workload is even stronger with age. Workload is an important contributor to fatigue. ATCOs report having sometimes "the impression of being behind the traffic". The effect of age on reaction time is a factor that could explain the difficulties in coping with high workload during peak traffic hours. Altogether, the results support the idea of creating a global individual follow-up process throughout the ATCO's career that would take into account cognitive performance, questionnaires on fatigue, stress and the well-being of the ATCO.

Overall, these results, with age itself having a minimal effect, tend to be consistent with the 'healthy shift worker effect' hypothesis (Knutsson and Akerstedt, 1992). This effect refers to the fact that in studies on the impact of shift work, the older participants are individuals who have remained in shift work and who are therefore more tolerant to these working hours. This may be due to many different factors that may be related to their behaviour, strategies or sleep patterns that facilitate their adaptation to shift work and could explain why there are few effects of age. Two factors may explain this healthy worker effect. The first would be associated with a natural selection process that would exclude workers who were unable to adapt to the conditions and demands of the job carried out by ATCOs. The second would be due to the positive effect of the work organisation which, at Skyguide, already takes into account numerous factors which do not exacerbate fatigue and stress inherent to the job and which contribute to the well-being of ATCOs.

PHASE 3 : RECOMMANDATIONS

From the literature review and the results of the projects, a set of recommendations have been developed to support ATCOs throughout their career, thus enabling them to work longer in a safe and sustainable manner. 13 focus groups involving 4 to 6 volunteer ATCOs were done to test the acceptability of these recommendations among ATCOs and unit managers before considering their feasibility. Based on the results of the focus groups, the recommendations were improved to consider the various feedback from the participants. The recommendations are organised in three levels: prevention actions for all ATCOs regardless of their age, an individual follow-up process based on a predefined age, and support for those reaching the end of their career.

The first level is the prevention level, which is applicable to all ATCOs whatever their age. It aims to enable early prevention of the effects of working conditions and mainly covers the work schedule organisations. For example, it includes the integration of individual preferences in ATCO rosters and, if necessary, an increase in roster predictability according to ATCO age.

The second level introduces an individual follow-up process that begins after the age of 35 and continues throughout the ATCO's career. This follow-up process would provide a periodic evaluation of the effects of the work organisation on various indicators such as sleep quality, work-related stress and various cognitive abilities.

The third level provides support for those reaching the end of their career, therefore only involving senior ATCOs aged 50 and above. These recommendations would make it possible to identify ATCOs who might have increasing difficulty tolerating the conditions and demands of their job and possibly propose adaptations to compensate for these difficulties. It would include the implementation of a reinforced longitudinal cognitive screening process for all ATCOs. Based on scientific principles, ATCO preferences and this individual follow-up process, ATCOs would have the possibility to change working conditions, e.g. by means of regular scheduling, reduced working time, fewer night shifts, or by keeping only one licence.

CONCLUSION

HelvetiCA and Skyguide agreed to transpose the 17 recommendations over the next decade to ensure that they could be implemented in 2034 when the first ATCOs will work beyond the age of 56 or 59. The newly agreed Collective Labour Agreement (1.1.2024) includes elements of the recommendations and sets the framework for a transition period of ten years (grandfather rights), where ATCOs wishing to stay beyond the official retirement age of 56/59 can continue to work as an ATCO on a voluntary basis and under certain conditions. The social partners agreed to address the recommendations as a high priority. A mandate was provided to the core team who accompanied the study to turn the first recommendations into reality.

The first recommendation to carry out a cognitive screening test for all ATCOs eligible to continue working beyond 56/59 is currently being actioned. The first nine ATCOs who wish to extend their career have taken a cognitive screening test. Combined with the internal quality management peer-based review system, recommendations for a career prolongation are formulated by the core team.

The second recommendation to establish a body overseeing the whole process is being implemented since April 2024. This body, known as Skyfit, is composed of line management, union representatives, human factors specialists and, if necessary, occupational doctors and HR representatives. This body will manage the process of putting in place the rest of the recommendations.

The third recommendation involves the monitoring of soft rules for rostering, taking into account chronobiological type rosters. Work has kicked off to

establish rules and regulations on how to build working rosters while taking into account chronobiological criteria and balanced roster distribution.

Further work is ongoing to extend the tests to various age groups and create a longitudinal observation of the neuropsychological evolution of ATCOs.

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