

Post-Treatment Effects of Multiple Sclerosis (MS) on the Executive and Memory Functions of Commercial Pilots in the UAE

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Abstract:- Individuals with MS often face challenges in cognitive functioning, particularly in demanding occupations such as commercial flying. This study investigates the post-treatment impact of MS on the memory and executive functions of commercial pilots while working under a busy flying roster. The research aims to understand cognitive changes over time and their implications for onboard safety. Data was collected over two and a half years from a single pilot. Standard assessments were used to evaluate the pilot's executive and memory functions. A two-way ANOVA table was used for statistical analysis. The analysis indicates that there is no significant decline in performance over time for the pilot ($p = 0.106447$, $df = 3$). However, there are notable variations among memory and executive function tasks ($p < 0.001$, $df = 7$), highlighting specific areas of strength. The null hypothesis there is no decline in pilots' neurocognitive functions, has been accepted. Additionally, the case study outcomes showed improvement in the pilot's executive and memory functions over two and a half years while maintaining stressful long-haul flight rosters. Future research should focus on understanding the factors driving these variations and exploring interventions to address cognitive weaknesses.

Keywords:- Multiple Sclerosis, Cognitive Function, Memory, Executive Function, Commercial Pilots, Aviation Safety.

I. INTRODUCTION

Individuals with Multiple Sclerosis (MS) face unique challenges in various aspects of their lives, including commercial pilots who work in the demanding field of aviation. Due to the complex cognitive demands needed for flying, it is crucial to understand the trajectory of cognitive functions among people diagnosed with MS. This study aims to investigate how MS impacts memory and executive functions on long-term neuropsychological profiles post-treatment, specifically within commercial pilots. Initial post-treatment results show that the pilot's executive and memory functions were working within the normal range of his age group. However, researchers do not have baseline data for the pilot to prove the trends if there is any decline, and how unpredictable and dynamic disease progression can be over time. Moreover, the aviation industry requires maximum performance under high-pressure situations, so understanding if there are any progressive or new implications from these

conditions could significantly contribute valuable insights towards promoting safety when navigating through challenging skies. Therefore, the researcher considered assessing the pilot on the aspects of memory and executive functions on a biannual basis. This research seeks four reassessment intervals at various times throughout those two years, wherein psychometric assessments will provide more information about possible trends or declines that shed light on this intersection between multiple sclerosis's impact upon both occupational roles as well as airspace security concerns related to it.

A. Research Questions

- How do memory and executive functions change over time in a commercial pilot with a history of Multiple Sclerosis after undergoing treatment?
- Are there observable trends or declines in specific cognitive domains relevant to the demands of flying.

B. Objectives:

- To examine the post-treatment impact of Multiple Sclerosis MS on pilots' memory and executive functions
- To find any potential trends or declines in specific cognitive domains crucial for the pilot's job responsibilities.

C. Problem Statement:

Despite receiving treatment, commercial pilots with a history of Multiple Sclerosis may face persistent challenges in memory and executive functions, potentially impacting their performance and safety on board. Understanding the lasting effects of the disease on cognitive abilities is essential for developing proper interventions and ensuring continued safety.

II. LITERATURE REVIEW

MS is a multifaceted autoimmune illness that specifically impacts the central nervous system and creates an array of neurological symptoms. The current study will explore the impact of MS on commercial pilots' cognitive functions. In multiple sclerosis, the immune system wrongly targets myelin - which safeguards the nerve fibers. Consequently, this disrupts communication between the brain and other body parts, resulting in varied symptoms that range from tiredness and mobility complications to cognitive difficulties, as well as

sensory disturbances. Despite the well-documented physical symptoms of MS, cognitive difficulties play a significant role in this disease and are often overlooked. Those living with MS often struggle with aspects such as memory retention, attention span, processing speed of information intake, and executive functions. These challenges can vary greatly from person to person, which contributes significantly to their individual experiences dealing with multiple sclerosis. In the case of pilots, flying requires technical knowledge but also needs sharp cognitive skills to deal with complex and challenging situations on board. This review delves into the extensive literature on the cognitive demands of the aviation industry, emphasizing the significant findings from studies that investigate pilots' mental workload, attentional requirements, and cognitive processing capabilities. These insights provide a foundational understanding of the intricate and multifaceted challenges within the cockpit. This study investigates how environmental factors, such as task complexity and rapidly advancing technology, impact cognitive functioning in aviation. Understanding these intricate demands on cognition is essential for fully appreciating the potential implications for safe flying, especially concerning conditions such as Multiple Sclerosis.

A. Relevant Studies

Initial studies were conducted on MS by Feinstein on clinically isolated lesions associated with MS and detected attention deficits during the first assessment that persisted in individuals classified as having such a lesion status. The research also highlighted how patients who progressed to clinically definite MS developed memory impairments while those with chronic progressive symptoms experienced significant declines specifically in auditory attention tasks. The outcomes showed the interplay of organic, psychological, and social factors behind intellectual and emotional deterioration related to this disease (Feinstein et al., 1992). Similarly, the study was conducted by Piras and colleagues (2003) on cognitive dysfunction in individuals with MS. The findings showed mild impairment of attention as well as short-term and long-term visuospatial memory at the beginning of the study. All these impairments persisted longitudinally without change. According to this research, disease peculiarity might play a more significant role than the time course of cognitive dysfunction in MS patients since increased MRI lesions did not correlate with either clinical outcomes or the progression of cognitive deficits (Piras et al., 2003). Moreover, Macallister et al. (2007) conducted a study on cognitive decline in pediatric MS patients over time and found that several experienced further deterioration. The severity of neurologic disability at the start was significantly related to changes seen in cognition, emphasizing its importance during assessments (Macallister et al., 2007). In 2008, Denney and his colleagues conducted a longitudinal investigation spanning three years that explored cognitive impairment within primary progressive MS patients. Their findings suggested that over the course of those three years, MS sufferers experienced far greater declines in processing speed performance compared to control participants. This evidence substantiated earlier claims suggesting information processing velocity was the domain most susceptible to long-term detrimental effects from this neurological condition

(Denney et al., 2008). Amato et al. research also provided similar outcomes over the course of three years. They predicted that around one-third of patients with relatively short disease duration would experience such deterioration in this time and found SDMT as the best tool for measuring longitudinal changes in cognition related to MS. Furthermore, their findings showed that initial moderate impairment was predictive of further decrease and T2 lesion volume had limited correlation with certain cognitive tasks (Amato et al., 2010).

However, Glanz et al. (2011) examined individuals who had early onset MS and discovered that their working memory as well as visual spatial memory diminished while verbal memory remained unaffected. Additionally, more serious cognitive impairments were linked to heightened disease severity and an augmented possibility of relapse according to the same study by Glanz et al. (2011). In their 2014 research, Parisi and colleagues analyzed the effects of cognitive rehabilitation on resting-state functional connectivity in multiple sclerosis (MS) patients. The study revealed that such therapy led to notable enhancements in attention, executive function, quality of life, and depression levels among participants. Furthermore, changes in resting-state functional connectivity were identified as significant predictors for improved mental health outcomes and cognitive performance post-rehabilitation according to Parisi et al. Borghi and colleagues (2016) conducted longitudinal research for two years on neuropsychological abilities among sizeable groups of people with MS, finding tasks such as SDMT, PASAT, and WLG particularly sensitive to this disease's implications while presenting general mental impairment among sufferers significantly worse than healthy controls who showed less drastic deterioration over time.

B. Cognitive Reserve Theory in the Context of Multiple Sclerosis and Aviation

The application of Cognitive Reserve Theory is crucial to understanding how cognitive functioning in professions like commercial pilots is affected by multiple sclerosis (MS). According to this theory, disparities among individuals' cognitive reserves decide their ability to endure neurological damage. The literature review on cognitive challenges in MS highlights the significance of several aspects such as memory retention, attention span, processing speed, and executive functions. This theory is notable for considering individual differences in cognitive abilities by emphasizing the impact of cognitive reserve beyond physical symptoms caused due to multiple sclerosis. Moreover, Cognitive Reserve Theory's paradigms prove useful when dealing with commercial pilots' unique mental abilities required for safe flight operations that conform to established standards. In addition, our comprehensive research examines mental workload demands on a pilot's focus levels and information-processing ability which are integral while illuminating complex requirements within airline cockpits. The concept of cognitive reserve plays a key role in how individuals with multiple sclerosis (MS) cope with their cognitive limitations. Individuals who have higher levels of this reserve show a greater ability to adapt and overcome MS-related obstacles, using various coping strategies that can explain differences

between experiences among people such as pilots. Understanding the level of cognitive reserve had by those affected by MS is vital for predicting potential outcomes related to advancing symptoms, particularly for professions requiring challenging mental tasks like commercial pilots. Through synthesizing Cognitive Reserve Theory and existing literature on this topic, it becomes clear that these challenges are unique based on individual factors experienced by persons living with MS - offering key insights into onboard safety measures around brain-intensive duties involving cockpit-related complications where pilot performance may be affected overall. Ultimately though we see here The Cognitive Reserve Theory offers us a valuable framework towards understanding better how both neurological difficulties caused from illness interact alongside demanding careers within commercial pilots.

C. Significance of the Current Study

Although the current research provides valuable knowledge on how Multiple Sclerosis (MS) affects cognition, there remains a clear gap in the literature when it comes to commercial pilots. Even though several studies have examined the cognitive implications of MS, very few focus specifically on memory and executive functions among this group over extended periods. The skill set needed for commercial piloting is distinct; therefore, exploring the details of cognitive decline as related to occupational context has been under-investigated thus far. Additionally, the current studies often neglect to investigate memory and executive functions in MS patients longitudinally. Despite some informative findings, there is a shortage of research that comprehensively examines the enduring effects on cognitive abilities such as memory and executive functions. These void underlines the necessity for investigations that track cognitive variations over a prolonged duration thereby offering more intricate insights into the progression of MS-linked mental deterioration among commercial pilots. In

addition, there is a gap in knowledge due to conflicting findings on the impact of MS treatment on cognitive function. While some research shows minimal effects, little attention has been paid to investigating the post-treatment period for commercial pilots with MS. Understanding how treatment affects their cognitive decline is vital for developing interventions and keeping safety standards within this demanding occupation. In addition, the field of commercial aviation has a significant research gap that needs to be addressed - specifically regarding pilots with Multiple Sclerosis (MS). While cognitive decline can affect job performance, limited studies have been conducted on the challenges faced by MS-diagnosed pilots. Researchers must fill this void and develop interventions tailored towards meeting their unique needs. Doing so will promote better cognitive health among commercial pilots and ensure safety in aviation operations. Furthermore, there is a deficiency in the existing literature about the investigation of memory and executive functions simultaneously. Despite individual studies focusing on these cognitive aspects, there is an absence of comprehensive research that considers both components concurrently. The proposed research question specifically addresses this gap by emphasizing the simultaneous examination of memory and executive functions among commercial pilots with MS. By taking this approach, the researcher aims to provide a more well-rounded comprehension of cognitive decline within this population. In brief, while earlier research has made important paces in understanding cognitive decline associated with MS, the found gaps highlight the need for added investigation - particularly when it comes to commercial pilots. Filling these gaps is not only crucial for improving our knowledge of how MS affects cognition but also offers essential insights into developing targeted interventions and maintaining safety standards within demanding occupations such as commercial flying.

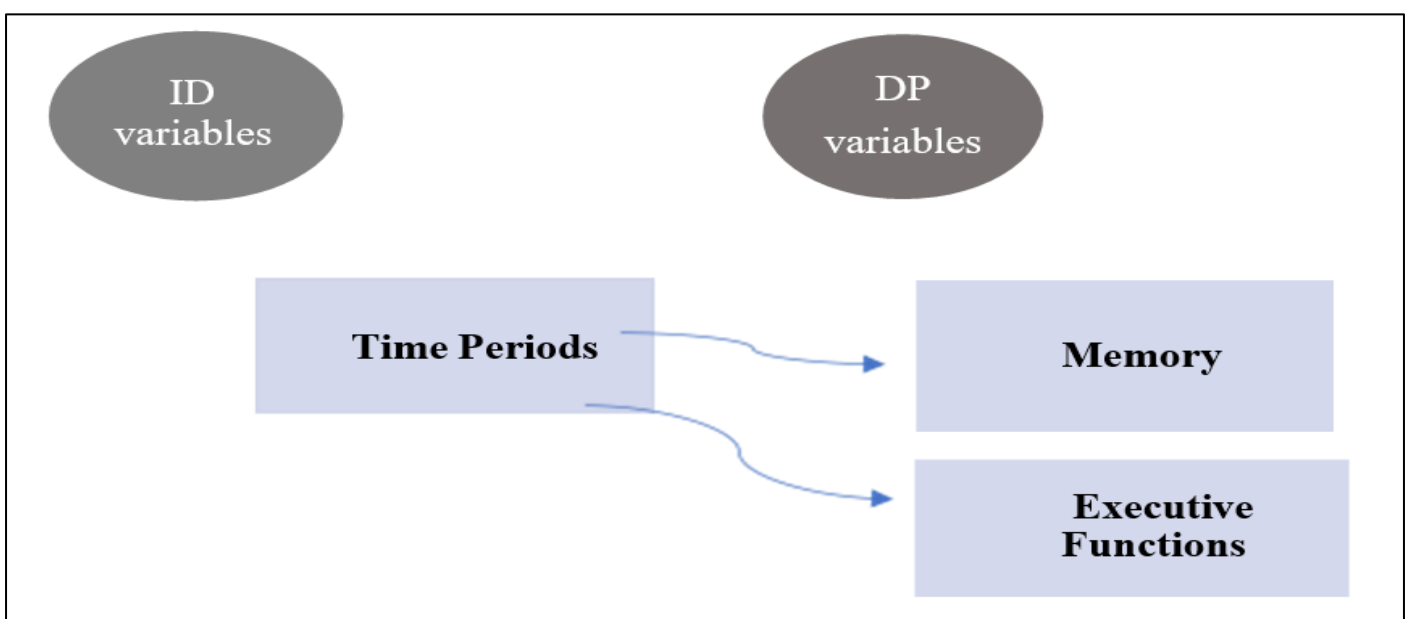


Fig 1: Theoretical Framework

III. RESEARCH METHODOLOGY

In this chapter, the researcher will discuss the research method, including hypotheses, variables, population, sample size, data collecting tools, and data analysis methods.

A. Research Hypothesis:

- H0: There is no significant decline in either memory or executive functions in commercial pilots with a history of MS after undergoing treatment.
- H1: There is a significant decline in both memory and executive functions in commercial pilots with a history of MS after undergoing treatment.

B. Variables and Definitions

➤ Independent Variables:

- *Time Definition:*
- ✓ The duration elapsed since the pilots' completion of Multiple Sclerosis treatment.
- ✓ Measured in months from the completion of treatment.

➤ Dependent Variables:

- *Memory Function:*
- *Anova*

✓ Definition:

- The cognitive ability related to the retention and recall of information.
- Assessed through standardized memory tests.

- *Executive Function*

✓ Definition

- Cognitive processes responsible for planning, organizing, starting, and completing tasks.
- Assessed through standardized executive function tests.

C. Procedure:

The study aimed to investigate how post-treatment affects commercial pilots with a history of Multiple Sclerosis. They selected one pilot on purpose, choosing someone with specific characteristics important to the study. They used standardized tests like the D-KEFS and WMS to measure memory and thinking skills. These tests were done every 6 months after treatment. A certified psychologist conducted each assessment.

D. Data Analysis:

The data was collected in quantitative form. For statistical analysis, ANOVA Table repeated measure was used.

Table 1: Two-Factor without Replication Post Treatment MS

ANOVA: Two-Factor Without Replication				
SUMMARY	Count	Sum	Average	Variance
1	8	527	65.875	1876.125
2	8	524	65.5	1855.714286
3	8	539	67.375	1905.410714
4	8	540	67.5	1890.285714
AM	4	377	94.25	31.58333333
VM	4	396	99	0
VWM	4	396	99	0
DM	4	394	98.5	0.333333333
IM	4	396	99	0
VS	4	60	15	1.333333333
IH	4	57	14.25	0.25
MS	4	54	13.5	0.333333333

E. Description of Abbreviation in Table

Auditory Memory (AM), Visual Memory (VM), Visual Working Memory (VWM), Delayed Memory (DM), Immediate Memory (IM), Visual Scanning (VS), Inhibition (IH), Motor Speed (MS).

In a series of four evaluations, a single patient diagnosed with Multiple Sclerosis (MS) consistently showed stable performance in memory and executive function tasks. The patient's average scores ranged from 65.875 to 67.5 across all

assessments. There was an improvement from the first to the third evaluation followed by a slight decline in the fourth assessment, but overall, the results remained stable. The variability of each score fluctuated significantly, peaking during the third examination session. During the evaluation of various memory and executive function tasks, differences in the patient's performance were observed. They showed higher ability in completing AM (average score of 94.25) compared to MS (average score of 13.5). However, within each task category, the patient's performance showed low

variability overall.

Overall pilot with MS showed consistent cognitive performance across the different evaluations with some fluctuations in specific tasks. Overall stability was observed

within each task category, although certain tasks showed superior results compared to others. Further comprehensive examination alongside control groups could provide a deeper understanding of the patient's cognitive abilities.

➤ *Anova*

Table 2: Results of Post Treatment MS Pilots on Multiple Assessments

ANOVA						
Source of Variation	SS	Df	MS	F	P-value	F crit
Rows	25.125	3	8.375	2.302782324	0.106447	3.072467
Columns	52616.38	7	7516.625	2066.764321	0	2.487578
Error	76.375	21	3.636904762			
Total	52717.88	31				

The ANOVA table presents the results of a statistical analysis comparing the performance of post-treatment pilots with Multiple Sclerosis (MS) across multiple assessments. The table includes the sum of squares (SS), degrees of freedom (Df), mean squares (MS), F-statistic (F), p-value, and critical F-value (F crit) for the rows and columns factors. For the rows factor, the p-value is 0.1064, which is greater than the typical significance level of 0.05. This suggests that there is no significant difference between the groups represented by the rows factor. For the columns factor, the p-value is 0, indicating a significant difference between the groups represented by the columns factor. In conclusion, the results indicate that there is a significant difference between the groups represented by the columns factor, but not the rows factor.

IV. CONCLUSION

Analyzing the ANOVA results for a single patient across four assessments provides valuable insights into their cognitive performance. The variability observed among the assessments (rows) showed a p-value of 0.106447, indicating that there is not enough evidence to reject the null hypothesis. This suggests that there is no significant difference in performance between the assessments, and thus, the null hypothesis (H0) stating "There is no significant decline in either memory or executive functions in commercial pilots with a history of MS after undergoing treatment" is accepted.

In contrast, when examining the variance among different memory types and executive function tasks (columns), a p-value of zero was obtained, indicating statistical significance. This suggests that there are notable differences in task types that affect the patient's overall cognition level, and therefore, the null hypothesis (H0) for the columns factor is rejected. Overall, the patient's performance remains stable across all four assessments. However, there are noticeable differences between various memory and executive function tasks. Based on the data presented, we confirm that there is no significant decline in either memory or executive functions in commercial pilots with a history of MS after undergoing treatment, supporting the acceptance of the null hypothesis (H0).

LIMITATIONS OF THE STUDY

- **Single-Participant Design:** The study's narrow scope which involved a single pilot for two and a half years could constrain the applicability of its results. A broader representation of pilots with Multiple Sclerosis (MS) encompassing greater diversity in numbers and demographics would yield more correct insights into cognitive patterns within this group.
- **Duration of Study:** Although the study covered two and a half years this may not have fully captured the diverse range of cognitive changes in MS patients due to infrequent assessments and limited time points. To gain a more detailed comprehension of cognitive trajectories over extended periods, conducting a longer-term study with increased assessment frequency would be beneficial.
- **Potential Confounding Factors:** Future studies should aim to control for all potential confounding variables that could affect cognitive function, like medication use, comorbidities, or lifestyle choices, since this study may have overlooked some of them. Doing so will improve the reliability and validity of any findings in future research.

FURTHER RESEARCH

- **Longitudinal Studies with Larger Samples:** To enhance comprehension of the developmental pattern of cognitive impairment in pilots with MS, future investigations must undertake longitudinal research using bigger pilot populations. Analyzing diverse subjects will help an inspection of distinctive variances and subdivision evaluations.
- **Diverse Participant Populations:** By studying pilots with MS from diverse backgrounds and demographics, researchers could gain a more complete understanding of the effects that this disease has on cognitive function. A thorough investigation would entail enlisting participants who show varied levels of illness severity, time afflicted by the condition, as well as their past treatment histories.
- **Comprehensive Cognitive Assessments:** An extensive array of cognitive assessments that encompasses a range of cognitive domains would yield a more comprehensive evaluation of the pilots' cognitive abilities who suffer from

MS. Such evaluations may form tests centered on memory, attention, processing speed, and executive function.

- Exploration of Protective Factors: Valuable research would investigate potential protective factors or interventions that can reduce cognitive decline among pilots with MS. This could include assessing the benefits of lifestyle changes, cognitive training programs, and pharmacological treatments focused on maintaining mental function.
- Validation Studies: To increase the dependability and applicability of results, it is recommended to confirm outcomes from pilot studies with bigger cohorts or replication research. Joint endeavors between aviation organizations and analysis establishments could aid in enlisting larger samples as well as executing multicenter investigation.

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