Review Article

European and US Aeromedical Authority Guidance for Neurocognitive Evaluation of Airline Pilots With Mental Disorders

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Abstract: Commercial airline pilots must exhibit specific neurocognitive skills and aptitudes to perform their safety-critical roles. This review addresses neuropsychological assessment in mental disorders derived from guidance developed by European and US aviation authorities as well as indications in the current literature in relation to major depression and suicidality, self-harm, attention-deficit/hyperactivity disorder, posttraumatic stress disorder, and bipolar disorder in aeromedical evaluations. Several studies show that cognitive functioning may be impaired during major depression. The results of neurocognitive assessments provide useful information about a pilot's performance. Obstacles to referring crew for neuropsychological testing are the paucity of neuropsychological specialists to undertake assessments and aeromedical examiners' varied training and experience in assessing mental health problems of pilots in general.

Keywords: Neurocognition, airline pilots, major depression, attention-deficit/hyperactivity disorder, suicide, self-harm, posttraumatic disorder, bipolar disorder

Commercial airline pilots must exhibit specific neurocognitive skills and aptitudes in addition to a measure of psychological stability that is necessary to perform their safety-critical roles. Psychological stability includes demonstratable, measurable, and high standards in perception, memory, decision-making, problem-solving, and psychomotor coordination (European Union Aviation Safety Agency [EASA], 2022). However, these skills can degrade due to a range of work-related, mental health, and physiological challenges (Bor, Eriksen, Georgemiller, et al., 2024). The aim of neuropsychological evaluations of commercial pilots is to gauge whether there are cognitive and emotional limitations that may cause a risk to the safety of pilots, passengers, or third parties (Front, 2017). This evaluation is important because cognitive and psychological interaction can be a crucial factor in aircraft accidents (Nidos et al., 2018; Bor, Eriksen, & Vuorio, 2025). Maintaining mental stability in stressful and irregular aviation work is in itself very demanding, and sustaining a healthy lifestyle including physical activity and a regular healthy diet is important to prevent or mitigate against the effects of symptoms of major depression (Contreras-Osorio et al., 2022; Gorham et al., 2019; Hills et al., 2015; Li et al., 2019).

In transport medicine, in general, the majority of published studies focus on assessments of drivers who have suffered brain injury or who have aging-related cognitive problems (Egeto et al., 2019; Khan et al., 2018; Marcotte & Scott, 2009). In aviation, perhaps most commonly, neurocognitive evaluation has been used when selecting commercial pilots (Kay, 2013; Yesavage et al., 2011) and assessing aging in pilots (Causse et al., 2011; Kennedy et al., 2013; Van Benthem et al., 2015). Neuropsychological evaluation among pilots is complicated because the performance of pilots cannot readily be compared with results of assessments obtained from the general population (Thompson, 2004). Specifications for aeromedical neuropsychological evaluation are listed in Table 1.

While it is well recognized in aeromedical assessments that sleep deprivation can have a negative effect on cognitive processing (Lowe et al., 2017; Maki et al., 2022; Rosa

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Table 1. Specifications for aeromedical neuropsychological evaluation according to the Federal Aviation Authority (FAA, 2023d)

- A review of all available records, including academic records, records of prior psychiatric hospitalizations (e.g., psychiatrist, psychologist, or pediatric neuropsychiatrist treatment notes)
- A thorough clinical interview regarding psychosocial or developmental problems; academic and employment performance; legal issues; substance use/abuse; aviation background; medical conditions, and all medication use; and behavioral observations during the interview
- A mental status examination
- Interpretation of a full battery of neuropsychological and psychological tests including but not limited to the core test battery
- Summary of findings with diagnostic statement, and the neuropsychologist's opinion(s) regarding clinically or aeromedically significant findings and the potential impact on aviation safety

et al., 2017), aeromedical examiners (AMEs) may overlook mental disorders, such as moderate depression, which not only affects mood but also often impairs cognitive performance (Hammar et al., 2022; Wang et al, 2022). Chavez-Baldini et al. (2023, p. 476) stated that "cognitive functioning and psychopathology are independent but related dimensions, which interact in a transdiagnostic manner." Research has shown that in the acute phase, processing speed, learning, and memory may be impaired during episodes of depression (Kriesche et al., 2022). An aeromedical evaluation solely based on mood disorders can reflect an overly optimistic impression of a pilot's potential for performing on the flight deck. A pilot's cognitive performance may still be impaired, but without a neuropsychological evaluation, negative impact may be overlooked. While it is possible to assess performance to fly regarding mental disorders with an emphasis on psychiatric evaluations, European and US aeromedical guidance suggests carrying out additional neuropsychological tests especially for certain mental disorders. In this clinical review, we discuss neuropsychological assessment derived from guidance by aviation authorities and regulators and the reflection of the current literature in relation to major depression and suicidality, self-harm, attention-deficit/hyperactivity disorder (ADHD), posttraumatic stress disorder (PTSD), and bipolar disorder in aeromedical evaluations (Table 2).

The purpose of this clinical review is to give insight into the guidance offered by aviation authorities in Europe and US in the neuropsychological assessment of commercial pilots with mental disorders. Symptomatic pilots are not addressed in selection assessment herein. There is currently no aviation mental health validated instrument that assesses all aspects of mental disorders related to incapacitation risk (EASA, 2022). The use of brief cognitive and mental health screening tests by an AME or aviation psychologist is not recommended in the aviation setting due to poor levels of sensitivity and specificity associated with brief screening questionnaires and also the risk of positive or negative impression management when a career may be at stake (Bor et al., 2017; Bor et al., 2020). Comprehensive neuropsychological evaluation, including a battery of standardized tests, should instead be carried out (Klekociuk et al., 2014). Utilizing a neuropsychological perspective provides additional opportunities for analyzing mental health problems in terms of flight work, and very recently in medicine the intertwined nature of mental and brain health and disease has been highlighted (Ibanez & Zimmer, 2023). Additionally, some mental states or related conditions may affect neuropsychological functioning even in the absence of obvious symptoms. It is recognized, for example, that major depression can lead to cognitive impairment, which can persist even when in remission (Rhee et al., 2024). There are other challenges to the neuropsychological assessment. Neuropsychological examination covers a detailed medical history, and pilots may fear that a history of some previously undisclosed mental disorders could emerge. To this end, the US Federal Aviation Authority (FAA) has recommended a nonpunitive pathway for reporting previously undisclosed mental health issues (FAA, 2024). Additionally, at least in Europe, availability of neuropsychologists is insufficient (Hokkanen et al., 2021).

According to our clinical experience and discussion with aviation authorities, neuropsychological testing is used quite sparingly in most jurisdictions, even when available. It is also possible that AMEs are not trained regarding situations in which a referral to a neuropsychologist could be beneficial (Schaefer et al., 2023). It also has been noted in the EASA MESAFE Report that some AMEs may have insufficient experience regarding psychological and psychiatric assessments (EASA, 2022). This survey revealed that (a) more than half of the respondents find it very difficult to assess the mental incapacitation risk level, based on medical records; (b) only 20% of the respondents find it easy to collect information about mental health during an aeromedical examination; and (c) almost half of the respondents do not have consistent and effective criteria to decide whether to refer a pilot to a mental health specialist.

European (EASA, 2023) and US (FAA, 2023a, 2023b) aeromedical guidance provides a good overview of recommendations for the use of neuropsychological testing as part of the assessment of mental health problems in pilots. Additionally, there are several national aeromedical guidelines worldwide that compare well with these two guidelines. Furthermore, the military aviation of different

Table 2. US FAA and EASA guidance related to psychiatric disorders and their neuropsychological testing (FAA, 2023a; EASA, 2023).

Disorder	Guidance by aviation authority
Major depression	The US FAA asserts that major depression may produce cognitive deficits degrading a pilot's performance. An eligible neuropsychologist is required to carry out an evaluation.
Self-harm	EASA recommends when evaluating self-harm that detailed individual-based risk analysis is undertaken and mentions the possibility of conducting a neuropsychological assessment.
ADHD	According to US FAA, HIMS neuropsychologists[a] need to review all the available psychological reports, review the documents according to a checklist, perform testing according to guidance, and create a detailed report.
Bipolar disorder	Bipolar disorder in general is not compatible with flying because of neurocognitive dysfunction and due to depressive, hypomanic and manic episodes, and elevated risks of suicide.
PTSD	Many aviation authorities do not give any specific instructions to consider neuropsychological evaluation as a part of PTSD assessment. EASA advises that neuropsychological assessment could complement at least the assessments of pilots' more serious PTSD cases

Note. FAA = Federal Aviation Authority; EASA = European Union Aviation Safety Agency; ADHD = attention-deficit/hyperactivity disorder. [a]Human Intervention Motivational Study (HIMS) neurospsychologists have special training to test the cognition of pilots. FAA ADHD guidance is currently under revision.

countries will have their own aeromedical guidelines related to neuropsychological assessment practice (Graver et al., 2021). To the best of our knowledge, this article is the first to (a) examine the importance of neuropsychological assessment as a whole in the European and American aviation medical recommendations for the assessment of mental health problems in pilots and to (b) compare European and US guidance.

Neurocognition Performance and Major Depression

Several studies show that cognitive functioning may be impaired during an episode of major depression (Kriesche et al., 2022; Raghavendra et al., 2022; Sankar et al., 2023; Wood-Ross et al., 2023). As stated previously, meta-analysis has shown that cognitive impairment of major depression can persist in remission (Rhee et al., 2024). In addition to well-known clinical symptoms of major depression, there are several less well understood neurocognitive symptoms in many depressive individuals (Hammar et al., 2022). Examples are processing speed, learning, and memory, which are impaired in the acute phase (Kriesche et al., 2022). An additional challenge is that some of these defects may persist after depressive symptoms disappear (Hammar et al., 2022). Interestingly, lack of insight into neurocognitive function has been shown very recently to be associated with impaired cognitive flexibility and risk of recurrence in patients with major depression (Wang et al., 2023). There often are significant delays in seeking treatment for pilots with depression, which may be due to perceived stigma, barriers to accessing assessment and treatment, and also a fear of the consequences of a diagnosis or grounding. In 2023, the US FAA Mental Health and Aviation Medical Clearances Rulemaking Committee (ARC) began investigating barriers that discourage pilots from seeking care for mental disorders (FAA, 2023a). The preliminary report has been published, and among its several recommendations, one is to improve mental health training among AMEs and revise and evaluate requirements for certification for depression/anxiety, ADHD, and PTSD (FAA, 2024).

These specific neurocognitive deficits have relevance especially for airline pilots. The US FAA is an aviation regulator that requires a neuropsychological evaluation of pilots with major depression (FAA, 2023c). They also require neuropsychological evaluation of pilots treated with specific serotonin reuptake inhibitor (SSRI) medications (FAA, 2023c). The US FAA asserts that major depression may produce cognitive deficits degrading a pilot's performance. An eligible neuropsychologist is required to carry out an evaluation and must be board certified with the American Board of Clinical Neuropsychology (FAA, 2023b). Furthermore, the evaluation includes the neuropsychologist's opinion(s) and recommendation(s) regarding clinically or aeromedically significant findings and the potential impact on aviation safety.

Antidepressant treatment, in itself, may have a positive effect on cognitive functions (Di Nicola et al., 2023). Treatment with vortioxetine after major depression caused by COVID-19 significantly improved cognitive function (Di Nicola et al., 2023). A retrospective study evaluated the effects of vortioxetine after 1 month and 3 months of treatment in 80 patients (44.4% males, 54±17.2 years) with post-COVID-19 major depression. Cognitive symptoms were measured using the Hamilton Depression Rating Scale (HDRS) and Hamilton Anxiety Rating Scale (HARS), Short Form-36 Health Survey Questionnaire (SF-36), Digit Symbol Substitution Test (DSST), and Perceived Deficits Questionnaire for Depression (PDQ-D5). Results showed that, alongside a reduction in depressive symptoms (HDRS, $p < .001$), vortioxetine (mean dose: 10.1±4.1 mg/day) significantly improved cognitive functioning (DDST, $p = .02$; PDQ-D5, $p < .001$). While the results are interesting, the study has limitations including that it was relatively small, open-labeled, and retrospective. However, a recent systematic review supports that vortioxetine can improve neurocognition, although more studies are clearly needed (Huang et al., 2022). Vortioxetine is pharmacologically different than other SSRIs and works by modulation of various serotonin receptors (D'Agostino et al., 2015). However, it seems that the positive neurocognition-improving effect of antidepressant treatment has limitations in some patients with major depression. In a recent secondary analysis of randomized trials, a total of 1,008 patients (mean [SD] age, 37.8 [12.6] years) participated in the overall trial and 96 patients participated in the imaging substudy (mean [SD] age, 34.5 [13.5] years; Hack et al., 2023). In this study there were 27% of patients with depression who had prominent behavioral impairment in executive function and response inhibition domains of cognitive control. These patients had significant pretreatment depressive symptoms such as worse psychosocial functioning ($d = -0.25$; 95% CI [-0.39, -0.11]; $p < .001$) and reduced activation of the cognitive control circuit (right dorsolateral prefrontal cortex: $d = -0.78$; 95% CI [-1.28, -0.27]; $p = .003$). Remission was comparatively lower in the cognitive dysfunction subgroup ($p = .04$) and cognitive impairments persisted regardless of symptom change ($p < .001$). This finding is supported by a recent follow-up study among patients with major depression, in which about 24% of patients with major depression had at least one type of persistent cognitive impairment (Liu et al., 2023).

The aforementioned analysis shows that it would be useful to assess the cognitive findings of a pilot with major depression in addition to monitoring clinical symptoms and recognize that neurocognitive recovery from major depression may be worse among some pilots even when clinical symptoms decrease. It remains to be studied whether some antidepressants are more favorable in this respect. Currently, antidepressants under prescribed treatment protocols are approved by most regulators (EASA, 2023; FAA, 2023b). Antidepressants were first accepted among air crew, subject to certain assessment and surveillance protocols, in Australia in 2002 (Vuorio et al., 2012). At that time, there was concern that the use of antidepressants may increase accidents in aviation (Ross et al., 2007). The aforementioned preliminary finding that antidepressants may have a beneficial effect on neurocognition should be welcomed especially in light of the history of the introduction of antidepressants into aeromedical use. Increasing attention should be given to the use of SSRIs and their neurocognition-improving effects.

A recent meta-analysis also shows that cognitive rehabilitation may help improve cognitive functions in individuals with major depression (Mokhtari et al., 2023). In depression, the concentration of tryptophan is reduced. Tryptophan is an essential exogenous amino acid serving, among other things, as a substrate for production of neuroactive substances. One substance is serotonin (5-hydroxytryptamine), which is an important neurotransmitter involved in the control of processes in the central nervous system directly related to mood, anxiety, and cognitive processes (Baranyi et al., 2017; Beis et al., 2015). The use of drugs together with physical exercise (Ren et al., 2024) and diet seems to be supported as an adjunct treatment of depression.

Neurocognition and Suicidal Major Depression

A suicidal attempt can be triggered by complex pathological processes, impulsively or over a longer time (Swann et al., 2020). Expressing suicidal thoughts is a relatively common behavior in patients with depression, without ideation necessarily leading to suicide (Klonsky et al., 2016). It has been estimated that approximately one out of two patients with a mood disorder may have suicidal thoughts (Kessler et al., 1999), but ideation of suicide is a relatively poor predictor of attempt to die by suicide (Nock et al., 2022). In an anonymous questionnaire-based study among nearly 2,000 airline pilots, 4.1% of these pilots had suicidal thoughts during the previous 2 weeks (Wu et al., 2016).

An understanding of cognitive processing involved in suicidal behavior is the subject of recent research (Rutter et al., 2020). Cognitive processing has been studied among people with depression who have made suicide attempts (Keilp et al., 2001). This study showed that patients with depression and a history of suicide attempts had significantly worse general intellectual functioning, attention, and memory, and these observed differences were not associated with education or occupation. Interestingly, there was an association with prefrontal cortical dysfunction. This kind of dysfunction may contribute to suicide risk by impairing decision-making. In a controlled comparison study of 106 patients, who had psychiatric diagnoses without suicidal ideation, with suicidal ideation, or with suicide attempts, the neurocognitive profiles were compared between the groups (Comparelli et al., 2022). Social cognition impairment was present among those patients who had either suicidal ideation or suicidal attempts, possibly reflecting a diminution or absence of the recognition of one's own or other people's emotions. It also is possible that among these patients emotional regulation may be impaired or compromised. Neurocognitive profiling has been shown to screen for and assess risk in suicidal behavior among those with mood disorders. Furthermore, specific cognitive therapeutic interventions aimed at improving social cognitive functions may possibly be used clinically in suicide prevention. In a recent small study of 15- to 29-year-old patients with major depressive disorder, severe suicidal symptoms were associated with higher serum levels of proinflammatory cytokines (p = .050) and worse cognitive function (p = .021; Chen et al., 2024). It seems that our understanding of factors influencing suicidality is deepening.

Neuropsychological tests can be compared with modern functional neuroimaging findings, such as in a recent study by Kamimura et al. (2022). Patients who had a history of suicide attempts were significantly more impulsive. The functional neuroimaging findings during an emotional recognition test in these patients were associated with increased activity in specific parts of the frontal cortex (Aupperle et al., 2024). One of the functions of the frontal cortex is to control responses to emotions.

Suicidal behavior risk seems to be modified by cognitive traits (Mann et al., 2022). But the challenge in understanding brain neuropsychology is more complex than understanding an association between different parts of the brain and suicidality. Healthcare assessors need to be aware of complex dysfunctions between brain networks. A meta-analysis has shown that in patients with depression there is hypoconnectivity between the frontal cortex (responsible for controlling emotions) and other functions in different parts of the brain responsible for cognitive control (Friedman & Robbins, 2022).

Preventing aircraft-assisted suicide is one of the most critical yet challenging aims in aviation medicine (Vuorio et al., 2014). In part, accident investigation has increased information about suicides by airplanes, but prevention can be seen to consist of several different types of preventive measures, of which, however, knowing the pilot's history of psychiatric symptoms is one of the most important (Bor, Eriksen, & Vuorio, 2025; Vuorio et al., 2023). There is a clear need to understand more deeply suicidal behavior, and possibly neuropsychological and neuroimaging methodology may give additional insight. Current EASA regulations advise that applicants with a documented history of a single or repeated acts of attempted suicide shall be assessed as "medically unfit." However, they may be assessed as "fit" after satisfactory psychiatric evaluation (EASA, 2023). The FAA has similar guidance (FAA, 2023c). Neither of these authorities mention neuropsychological assessment separately.

Neurocognition and Self-Harm

Self-harm is associated with several mental health problems such as borderline personality, depression, bipolar disorder, schizophrenia, and drug and alcohol use disorders (Skegg, 2005). Typical examples of self-harm are tension-triggered impulsive self-poisoning and superficial cutting. Self-harm is associated with a highly elevated risk of suicide and more than 5% of patients visiting a hospital after self-harm die by suicide within 9 years (Skegg, 2005). Risk-assessment scales have not proved to be very useful in predicting the risk of future suicide (Chan et al., 2016). The MESAFE report by EASA notes that individuals with autism spectrum disorder are at greater risk for suicide death (EASA, 2022; Giannouchos et al., 2023). This finding is supported by a recent review (Newell et al., 2024). Another recent study identified a biological phenotype associated with nonsuicidal self-harm (Mürner-Lavanchy et al., 2024). In this study the highest positive predictive powers were associated with low oxytocin (OR = 0.55; p = .002), low pain sensitivity (OR = 1.15; p = .021), and high leukocyte levels (OR = 1.67; p = .015).

In comprehensive reviews of self-harm, several specific brain regions have been shown to be associated with neurocognitive functions in patients who self-harm (de Cates & Broome, 2016; de Cates et al., 2017). Decision-making and activation of the anterior cingulate cortex (ACC) were found to be different when comparing patients with depression with patients having depression and having carried out self-harm (Pan et al., 2011). An impaired processing of emotional feedback was found to be associated with self-harm behavior (Cox et al., 2014). Self-harming patients with mood disorders have impaired memory compared with patients only having mood disorder (Rohrer et al., 2006). Combining the aforementioned neurocognitive variables may help in enhanced risk assessments of self-harm and in targeted treatment of individual neurocognitive deficits (de Cates & Broome, 2016).

There are limited data on self-harm among commercial pilots. In an opportunistic, web-based survey carried out between April and December 2015, 75 participants (4.1%) reported having thoughts of being better off dead or inflicting self-harm during the past 2 weeks (pilots working during the past month 49, 3.5% vs. not 26, 6.4%, p = .008; Wu et al., 2016). The EASA recommends when evaluating self-harm that detailed individual-based risk analysis is undertaken and mentions the possibility of conducting a neuropsychological assessment (EASA, 2022). The evaluation of self-harm-related aviation performance risk is complex (Vuorio & Bor, 2021) as self-harm itself increases risk, and self-harm in many cases that may be related to mental disorder may render the pilot's capacity to reflect upon and have insight into his/her fragile mental state. Against this background, it is highly probable that neuropsychological research can provide additional opportunities for higher predictive risk analysis.

Neurocognition and ADHD, PTSD, and Bipolar Disorder

ADHD is a neurodevelopmental disorder leading to hyperactive/impulse symptoms (Faraone et al., 2015). However, evidence for the clinical predictive value of neurocognitive assessments in this context has been in part controversial. In a recent large study of over 10,000 youth (ages 9–10 at baseline) across the United States, with the aid of machine-learning models, ADHD symptoms were predicted based on neurocognitive abilities, demographics, and child and family characteristics (Weigard et al., 2023). Neurocognitive indices such as reasoning, memory, verbal ability, processing speed, and the Diffiusion Decision Model's (DDM) cognitive efficiency ("drift rate") parameter were negatively associated with ADHD symptoms. In addition to neurocognitive factors, child self-report features indicated that greater impulsivity, greater screen time, lower parental monitoring, greater family conflict, and lower involvement/engagement in school were also predictive of symptoms. One meta-analysis showed that ADHD is associated with substantial deficits across neurocognitive domains (Pievsky & McGrath, 2018). These domains include working memory, reaction time variability, response inhibition, intelligence/planning, and planning/organization (Bhullar et al., 2023). Common to the cause of these functional disturbances is that the brain has difficulty in switching from the rest mode to an active mode.

ADHD and bipolar disorder practically are currently incompatible with commercial flying. The aviation health guidelines, however, give instructions on how a neuropsychological assessment can be made in these cases. One of the reasons why ADHD is considered a medically excluding condition in aviation is due to an increased accident risk (Laukkala et al., 2017). However, in a few cases, ADHD may be acceptable for recreational pilots. In these cases, a very comprehensive evaluation neurocognitive testing needs to be carried out, with a drug test within 24 hr of testing.

Interestingly in the new and revised US FAA Statement on Mental Health and Aviation Medical Clearances Rulemaking Committee initial report there is a recommendation that "FAA should evaluate the feasibility of permitting pilots with ADHD to use acceptable medications while on duty" (FAA, 2024). The rationale behind this recommendation is the concern that untreated ADHD is fairly common, is not always easy to assess or screen out, causes safety risks, and there are likely to be pilots operating who have ADHD. Based on US national representative data, the estimated ADHD recent prevalence among 4- to 17-year-old children is about 10.5% and has slightly increased (Li et al., 2023). In a recent meta-analysis, the global prevalence of adults with ADHD was estimated to be 3.10% (95% CI [2.60, 3.60]; Ayano et al., 2023). Some psychostimulants are reported to improve several aspects of cognition in patients with ADHD (Mckenzie et al., 2022), and the US FAA will likely re-examine its ADHD certification policies (FAA, 2024). While it is too early to predict whether this evidence-based re-analysis will lead to new policy, it is likely that neuropsychological evaluation will be a core part of the new evaluation policy. Determining potential comorbidities as well as substance use will be a challenge (Barbuti et al., 2023; Woo et al., 2023). Additionally, the neuropsychological assessment will need to be carried out on participants in two different conditions, namely, without and with medication to be sure that performance is acceptable if a pilot forgets to take medication.

PTSD is a psychiatric disorder that may arise after exposure to a traumatic event (Bryant, 2019). Studies show that there are neural changes following exposure to trauma in the amygdala, prefrontal cortex, and hippocampus, indicating fear conditioning (Koopowitz et al., 2021). It has been shown in neurocognitive assessments that patients with PTSD may exhibit neurocognitive dysfunction such as intrusion errors (incorrectly recalled words; Jacob et al., 2017). Koopowitz et al. (2021) speculate that this dysfunction could lead to incorrectly recalled instructions by the patient. In a review by Jacob et al. (2019), PTSD was found to be associated with the neurocognitive domains of learning and memory, attention, working memory, and executive functioning. The authors of this review assert that there is still a lack of knowledge related to the direction of causality between PTSD and dysfunctions in neurocognition. In the recent cross-sectional study among 274 women (mean [SD] age, 59.03 [4.34] years), associations of PTSD symptoms with neurocognitive outcomes significantly varied by APOE4 status (Thurston et al., 2023). There is a growing body of research linking PTSD to altered neurocognition, thus supporting neurocognitive assessment when evaluating pilots with PTSD.

The US FAA does not provide any specific instructions to consider neuropsychological evaluation as a part of a PTSD assessment (Laukkala et al., 2018) although neuropsychological assessment could complement at least the assessments of pilots' more serious PTSD cases (EASA, 2023). In the recent US FAA Statement on Mental Health and Aviation Medical Clearances Rulemaking Committee initial report there is a recommendation that "the FAA should re-evaluate its decision grid on PTSD to liberalize the criteria for issuing a medical certificate" (FAA, 2024). Currently there is no requirement related to neuropsychological assessment, and the need for it is not discussed in the recommendation mentioned above. Based on current literature, it could be helpful to consider neuropsychological assessment among pilots with PTSD.

Current opinion is that cognitive dysfunction in bipolar disorder is caused by the combination of neurodevelopmental and neurodegenerative processes (Goodwin et al., 2008). Results of a recent study showed that biomarkers related to oxidative stress promoted impairments in frontal cognitive functions highlighting the pathological mechanisms behind neurocognitive impairment (Lima et al., 2022). The cognitive defects worsen in bipolar disorder over the course of time, and it is challenging to know whether illness progression causes worse neurocognition or vice versa (Balanzá-Martinez et al., 2010). Inter-episodic cognitive and affective symptoms especially may harm bipolar disorder patients in their social and work life (Brissos et al., 2008). Neuropsychological test results can also predict the prognosis for the tested individual. Both attention/psychomotor speed and attentional functions have clinical value when evaluating the prognosis of bipolar disorder (Jaeger et al., 2007; Martino et al., 2009). Bipolar disorder in general is not compatible with flying because of neurocognitive dysfunction due to depressive, hypomanic, and manic episodes and elevated risks of suicide (Vuorio et al., 2017).

Conclusion

There are several studies showing that cognitive functioning may be impaired during episodes of clinical depression (Kriesche et al., 2022; Raghavendra et al., 2022; Sankar et al., 2023; Wood-Ross et al., 2023). These neurocognitive deficits have relevance to the abilities and performance of a pilot. The guidance given by the FAA and the EASA is summarized in Table 1 (EASA, 2023; FAA, 2023b). Only the US FAA currently requires a neuropsychological evaluation of pilots with major depression (FAA, 2023b). We propose that neuropsychological testing should be more widely available in the assessment of pilots' fitness to fly without depressive symptoms, as the potential limitations in their performance may not be immediately discernable through their day-to-day performance or standard AME or clinical assessment.

Another interesting issue is how a neuropsychological evaluation can assist in the estimation of risk of suicidal behavior or self-harm. There is increasing literature on cognitive processing in suicidal behavior and self-harm (de Cates & Broome, 2016; de Cates et al., 2017; Rutter et al., 2020). While there is still a long way to go from current knowledge to clinical applications, the preliminary results of assessments applied to risk estimation are encouraging. The usefulness of neuropsychologic tests regarding ADHD, PTSD, and bipolar disorder in aeromedical evaluations is better understood.

In our practical experience, neuropsychological testing is used quite sparingly in most jurisdictions, even when available. One reason, obviously, is the limited availability of neuropsychological services in both resource-rich and resource-limited countries, which is a justified concern (Hokkanen et al., 2021). Also, there is a need to harmonize qualifications of aviation neuropsychologists (Bor et al., 2024; Bor, Eriksen, Georgemiller et al., 2024; FAA, 2023b; Kay, 2013).

Most commonly, neuropsychological testing is carried out using a battery of tests involving several cognitive ability areas such as memory, attention, processing speed, reasoning, judgment, problem-solving, and spatial and language skills (Harvey, 2012). A normative comparison is needed to evaluate the neuropsychological test results obtained (Anastasi & Urbina, 1997). When a pilot needs neuropsychological evaluation, it is appropriate to compare and interpret the results in relation to those obtained from other pilots as well as from the general population (Thompson, 2004). An aeromedical evaluation needs to be in-depth and based on understanding a pilot's specific working circumstances in relation to neuropsychological findings (Mackenzie Ross, 2017). It also should be recognized that cognitive tests alone are insufficient to capture the dynamism of the cognitive skills involved with flying (Hardy & Parasuraman, 1997).

Medical advances and insights into the functioning of the brain and dysfunctions in psychiatric diseases have increased significantly in recent years. Neuropsychological assessments provide significant additional information that can be linked to aeromedical assessments. There already are preliminary examples that neuropsychological examination can be combined with neuroimaging regarding specific performance-related disorders, although this type of assessment still requires further development (Petersen et al., 2023).

We encourage AEMs to increase the use of neurocognitive testing especially regarding evaluation of performance of pilots with major depression. Neurocognitive tests do not provide absolute "yes" or "no" answers, but they do provide additional information about a pilot's performance. The main obstacles to adding neuropsychological assessments to AME evaluations are training in assessing mental health problems of pilots in general as well as a paucity of specialist neuropsychologists to conduct these assessments with the knowledge and experience to apply their findings to the aeromedical work and safety context.

References

Anastasi, A., & Urbina, S. (1997). *Psychological testing* (7th ed). Prentice-Hall.

Aupperle, R. L., Kuplicki, R., Tsuchiyagaito, A., Akeman, E., Sturycz-Taylor, C. A., DeVille, D., Lasswell, T., Misaki, M., Berg, H., McDermott, T. J., Touthang, J., Ballard, E. D., Cha, C., Schacter, D. L., & Paulus, M. P. (2024). Ventromedial prefrontal cortex activation and neurofeedback modulation during episodic future thinking for individuals with suicidal thoughts and behaviors. *Behaviour Research and Therapy, 176*, Article 104522. https://doi.org/10.1016/j.brat.2024.104522

Ayano, G., Tsegay, L., Gizachew, Y., Necho, M., Yohannes, K., Abraha, M., Demelash, S., Anbesaw, T., & Alati, R. (2023). Prevalence of attention deficit hyperactivity disorder in adults: Umbrella review of evidence generated across the globe. *Psychiatry Research, 328*, Article 115449. https://doi.org/10.1016/j.psychres.2023.115449

Balanzá-Martínez, V., Selva, G., Martínez-Arán, A., Prickaerts, J., Salazar, J., González-Pinto, A., Vieta, E., & Tabarés-Seisdedos, R. (2010). Neurocognition in bipolar disorders–a closer look at comorbidities and medications. *European Journal of Pharmacology, 626*, 87–96. https://doi.org/10.1016/j.ejphar.2009.10.018

Baranyi, A., Amouzadeh-Ghadikolai, O., Lewinskivon, D., Breitenecker, R. J., Rothenhäusler, H.-B., & Robier, C. (2017). Revisiting the tryptophan-serotonin deficiency and the inflammatory hypotheses of major depression in a biopsychosocial approach. *Peer Journal, 5*, Article e3968. https://doi.org/10.7717/peerj.3968

Barbuti, M., Maiello, M., Spera, V., Pallucchini, A., Brancati, G. E., Maremmani, A. G. I., Perugi, G., & Maremmani, I. (2023). Challenges of treating ADHD with comorbid substance use disorder: Considerations for the clinician. *Journal of Clinical Medicine, 12*, Article 3096. https://doi.org/10.3390/jcm12093096

Beis, D., Holzwarth, K., Flinders, M., Bader, M., Wohr, M., & Alenina, N. (2015). Brain serotonin deficiency leads to social communication deficits in mice. *Biology Letters, 11*, Article 20150057. https://doi.org/10.1098/rsbl.2015.0057

Bhullar, A., Kumar, K., & Anand, A. (2023). ADHD and neuropsychology: Developmental perspective, assessment, and interventions. *Annals of Neuroscience, 30*, 5–7. https://doi.org/10.1177/09727531231171765

Bor, R., Eriksen, C., Georgemiller, R., & Gray, A. (Eds.). (2024). *Handbook of Aviation Neuropsychology*. Hogrefe.

Bor, R., Eriksen, C., Hubbard, T., & King, R. (Eds.). (2020). *Pilot selection: Psychological principles and practice*. CRC Press.

Bor, R., Eriksen, C., Oakes, M., & Scragg, P. (2017). *Pilot mental health assessment and support*. Routledge.

Bor, R., Eriksen, C., & Vuorio, A. (2025). Air accident investigation with a focus on relevant neuropsychological factors. In R. Bor, C. Eriksen, R. Georgemiller, & A. Gray (Eds.), *Handbook of aviation neuropsychology* (pp. 323–336). Hogrefe.

Brissos, S., Dias, V. V., Carita, A. I., & Martinez-Aràn, A. (2008). Quality of life in bipolar type I disorder and schizophrenia in remission: Clinical and neurocognitive correlates. *Psychology Research, 160*, 55–62. https://doi.org/10.1016/j.psychres.2007.04.010

Bryant, R. A. (2019). Post-traumatic stress disorder: A state-of-the-art review of evidence and challenges. *World Psychiatry, 18*, 259–269. https://doi.org/10.1002/wps.20656

Causse, M., Dehais, F., Arexis, M., & Pastor, J. (2011). Cognitive aging and flight performances in general aviation pilots. *Aging, Neuropsychology and Cognition, 18*, 544–561. https://doi.org/10.1080/13825585.2011.58601

Chan, M. K., Bhatti, H., Meader, N., Stockton, S., Evans, J., O'Connor, R. C., Kapur, N., & Kendall, T. (2016). Predicting suicide following self-harm: Systematic review of risk factors and risk scales. *British Journal of Psychiatry, 209*, 277–283. https://doi.org/10.1192/bjp.bp.115.170050

Chavez-Baldini, U., Nieman, D. H., Keestra, A., Lok, A., Mocking, R. J. T., de Koning, P., Krzhizhanovskaya, V. V., Bockting, C. L. H., van Rooijen, G., Smit, D. J. A., Sutterland, A. L., Verweij, K. J. H., van Wingen, G., Wigman, J. T. W., Vulink, N. C., & Denys, D. (2023). The relationship between cognitive functioning and psychopathology in patients with psychiatric disorders: A transdiagnostic network analysis. *Psychological Medicine, 53*, 476–485. https://doi.org/10.1017/S0033291721001781

Chen, M. H., Bai, Y. M., Hsu, J. W., Huang, K. L., & Tsai, S. J. (2024). Proinflammatory cytokine levels, cognitive function, and suicidal symptoms of adolescents and young adults with major depressive disorder. *European Archives of Psychiatry and Clinical Neuroscience*. Advance online publication. https://doi.org10.1007/s00406–024-01780–5

Comparelli, A., Corigliano, V., Montalbani, B., Nardella, A., De Carolis, A., Stampatore, L., Bargagna, P., Forcina, F., Lamis, D., & Pompili, M. (2022). Building a neurocognitive profile of suicidal risk in severe mental disorders. *BMC Psychiatry, 22*, Article 628. https://doi.org/10.1186/s12888-022-04240-3

Contreras-Osorio, F., Ramirez-Campillo, R., Cerda-Vega, E., Campos-Jara, R., Martínez-Salazar, C., Reigal, R. E., Hernández-Mendo, A., Carneiro, L., & Campos-Jara, C. (2022). Effects of physical exercise on executive function in adults with depression: A systematic review and meta-analysis. *International Journal of Environmental Research and Public Health, 19*, Article 15270. https://doi.org/10.3390/ijerph192215270

D'Agostino, A., English, C. D., & Rey, J. A. (2015). Vortioxetine (brintellix): A new serotonergic antidepressant. *P & T: A Peer-Reviewed Journal for Formulary Nanagement, 40*, 36–40.

de Cates, A. N., & Broome, M. R. (2016). Can we use neurocognition to predict repetition of self-harm, and why might this be clinically useful? A perspective. *Frontiers in Psychiatry, 7*, Article 7. https://doi.org/10.3389/fpsyt.2016.00007

de Cates, A. N., Rees, K., Jollant, F., Perry, B., Bennett, K., Joyce, K., Leyden, E., Harmer, C., Hawton, K., van Heeringen, K., & Broome, M. R. (2017). Are neurocognitive factors associated with repetition of self-harm? A systematic review. *Neuroscience and Biobehavioral Reviews, 72*, 261–277. https://doi.org/10.1016/j.neubiorev.2016.10.032

Cox Lippard, E. T., Johnston, J. A., & Blumberg, H. P. (2014). Neurobiological risk factors for suicide: Insights from brain imaging. *American Journal of Preventive Medicine, 47*(3 Suppl. 2), S152–162. https://doi.org/10.1016/j.amepre.2014.06.009

Di Nicola, M., Pepe, M., Montanari, S., Spera, M. C., Panaccione, I., Simonetti, A., & Sani, G. (2023). Vortioxetine improves physical and cognitive symptoms in patients with post-COVID-19 major depressive episodes. *European Neuropsychopharmacology, 8*, 21–28.

Egeto, P., Badovinac, S. D., Hutchison, M. G., Ornstein, T. J., & Schweizer, T. A. (2019). A systematic review and meta-analysis on the association between driving ability and neuropsychological test performances after moderate to severe traumatic brain injury. *Journal of International Neuropsychological Society, 25*, 868–877. https://doi.org/10.1017/S1355617719000456

European Aviation Safety Agency. (2022). *MESAFE (Mental health for aviation SAFEty). D-1.1: Report on the review of diagnostic measures*. https://www.easa.europa.eu

European Aviation Safety Authority. (2023). https://www.easa.europa.eu/document-library/easy-access-rules

Faraone, S. V., Asherson, P., Banaschewski, T., Biederman, J., Buitelaar, J. K., Ramos-Quiroga, J. A., Rohde, L. A., Sonuga-Barke, E. J., Tannock, R., & Franke, B. (2015). Attention-deficit/hyperactivity disorder. *Nature Reviews in Disease Primers, 1*, Article 15020. https://doi.org/10.1038/nrdp.2015.20

Federal Aviation Authority. (2023a). *FAA statement on Mental Health and Aviation Medical Clearances Rulemaking Committee*. https://www.faa.gov/newsroom/faa-statement-mental-health-and-aviation-medical-clearances-rulemaking-committee

Federal Aviation Authority. (2023b). *Guide for aviation medical examiners. Decision considerations – disease protocols – neurocognitive impairment*. https://www.faa.gov/ame_guide/dec_cons/disease_prot/neurocog

Federal Aviation Authority. (2023c). *Guide for aviation medical examiners. Decision considerations – aerospace medical dispositions Item 47. Psychiatric conditions – use of antidepressant medications*. https://www.faa.gov/ame_guide/app_process/exam_tech/item47/amd/antidepressants

Federal Aviation Authority. (2023d). *Decision considerations disease protocols – neurocognitive impairment*. https://www.faa.gov/ame_guide/dec_cons/disease_prot/neurocog

Federal Aviation Authority. (2024). *Mental health & aviation medical clearances aviation rulemaking committee. Recommendation report April 1, 2024*. https://www.faa.gov/sites/faa.gov/files/Mental_Health_ARC_Final_Report_RELEASED.pdf

Friedman, N. P., & Robbins, T. W. (2022). The role of prefrontal cortex in cognitive control and executive function. *Neuropsychopharmacology, 47*, 72–89. https://doi.org/10.1038/s41386-021-01132-0

Front, C. M. (2017). *Neurocognitive assessment of pilots: The FAA perspective* [Conference session]. CAMA Sunda, ASMA Annual Scientific Meeting, Denver, Colorado. https://www.pilotsofamerica.com/community/attachments/neurocognitive-assessment-the-faa-perspective_cama-sunday-at-asma-2017-pdf.84176/

Giannouchos, T. V., Beverly, J., Christodoulou, I., & Callaghan, T. (2023). Suicide and non-fatal self-injury-related emergency department visits among individuals with autism spectrum disorder. *autism, 27*, 1983–1996. https://doi.org/10.1177/13623613221150089

Goodwin, G. M., Martinez-Aran, A., Glahn, D. C., & Vieta, E. (2008). Cognitive impairment in bipolar disorder: neurodevelopment or neurodegeneration? An ECNP expert meeting report. *European Neuropsychopharmacology, 18*, 787–793. https://doi.org/10.1016/j.euroneuro.2008.07.005

Gorham, L. S., Jernigan, T., Hudziak, J., & Barch, D. M. (2019). Involvement in sports, hippocampal volume, and depressive symptoms in children. *Biological Psychiatry Cognitive Neuroscience and Neuroimaging, 4*, 484–492. https://doi.org/10.1016/j.bpsc.2019.01.011

Graver, C. J., Armistead-Jehle, P., & Fritch, A. M. (2021). Neuropsychologist's guide to aeromedical examinations in the military. *Military Behavioral Health, 9*, 89–100. https://doi.org/10.1080/21635781.2020.1742823

Hack, L. M., Tozzi, L., Zenteno, S., Olmsted, A. M., Hilton, R., Jubeir, J., & Williams, L. M. (2023). A cognitive biotype of depression and symptoms, behavior measures, neural circuits, and differential treatment outcomes: A prespecified secondary analysis of a randomized clinical trial. *JAMA Network Open, 6*, e2318411. https://doi.org/10.1001/jamanetworkopen.2023.18411

Hammar, Å., Ronold, E. H., & Rekkedal, G. Å. (2022). Cognitive impairment and neurocognitive profiles in major depression-A clinical perspective. *Frontiers in Psychiatry, 13*, Article 76437. https://doi.org/10.3389/fpsyt.2022.764374

Hardy, D. J., & Parasuraman, R. (1997). Cognition and flight performance in older pilots. *Journal of Experimental Psychology, 3*, 313–348.

Harvey, P. D. (2012). Clinical applications of neuropsychological assessment. *Dialogues Clinical Neuroscience, 14*, 91–99. https://doi.org/10.31887/DCNS.2012.14.1/pharvey

Hills, A. P., Street, S. J., & Byrne, N. M. (2015). Physical activity and health: "What is old is new again". *Advances in Food Nutrition Research, 75*, 77–95. https://doi.org/10.1016/bs.afnr.2015.06.001

Hokkanen, L., Ponchel, A., Mondini, S., Jonsdottir, M. K., Varako, N., Nikolai, T., & Hessen, E. (2021). European clinical neuropsychology: Role in healthcare and access to neuropsychological services. *healthcare, 9*, 734

Huang, I. C., Chang, T. S., Chen, C., & Sung, J. Y. (2022). Effect of vortioxetine on cognitive impairment in patients with major depressive disorder: A systematic review and meta-analysis of randomized controlled trials. *The International Journal of Neuropsychopharmacology, 25*, 969–978. https://doi.org/10.1093/ijnp/pyac054

Ibanez, A., & Zimmer, E. R. (2023). Time to synergize mental health with brain health. *Nature Mental Health, 1*(7), 441–443. https://doi.org/10.1038/s44220-023-00086-0

Jacob, S. N., Dodge, C. P., & Vasterling, J. J. (2019). Posttraumatic stress disorder and neurocognition: A bidirectional relationship? *Clinical Psychology Reviews, 72*, 101747. https://doi.org/10.1016/j.cpr.2019.101747

Jaeger, J., Berns, S., Loftus, S., Gonzalez, C., & Czobor, P. (2007). Neurocognitive test performance predicts functional recovery from acute exacerbation leading to hospitalization in bipolar disorder. *Bipolar Disorder, 9*, 93–102. https://doi.org/10.1111/j.1399-5618.2007.00427.x

Kamimura, H., Matsuoka, T., Okai, H., Shimizu, N., Harada, S., & Matsuo, K. (2022). The associations between suicide-related behaviors, prefrontal dysfunction in emotional cognition, and personality traits in mood disorders. *Science Reports, 12*, 17377. https://doi.org/10.1038/s41598-022-22345-3

Kasten, E., Barbosa, F., Kosmidis, M. H., Persson, B. A., Constantinou, M., Baker, G. A., Lettner, S., Hokkanen, L., Ponchel, A., Mondini, S., Jonsdottir, M. K., Varako, N., Nikolai, T., Pranckeviciene, A., Harper, L., & Hessen, E. (2021). European Clinical Neuropsychology: Role in Healthcare and Access to Neuropsychological Services. *Healthcare (Basel, Switzerland), 9*(6), Article 734. https://doi.org/10.3390/healthcare9060734

Kay, G. G. (2013). Aviation neuropsychology. In C. H. Kennedy & G. G. Kay (Eds.), *Aeromedical psychology* (pp. 239–268). Routledge.

Keilp, J. G., Sackeim, H. A., Brodsky, B. S., Oquendo, M. A., Malone, K. M., & Mann, J. J. (2001). Neuropsychological dysfunction in depressed suicide attempters. *American Journal of Psychiatry, 158*, 735–741. https://doi.org/10.1176/appi.ajp.158.5.735

Kennedy, Q., Taylor, J., Heraldez, D., Noda, A., Lazzeroni, L. C., & Yesavage, J. (2013). Intraindividual variability in basic reaction time predicts middle-aged and older pilots' flight simulator performance. *The Journals of Gerontology Series B, 68*, 487–494. https://doi.org/10.1093/geronb/gbs090

Kessler, R. C., Borges, G., & Walters, E. E. (1999). Prevalence of and risk factors for lifetime suicide attempts in the National Comorbidity Survey. *Archives of Genetic Psychiatry, 56*, 617–626. https://doi.org/10.1001/archpsyc.56.7.617a

Khan, R., Khan, M. T., & Alam, B. (2018). The use of neuropsychological tests to study the effects of aging on driving performance in the UK. *European Transportation Research Review, 10*, Article 15. https://doi.org/10.1007/s12544-018-0287-7

Klekociuk, S. Z., Summers, J. J., Vickers, J. C., & Summers, M. J. (2014). Reducing false positive diagnoses in mild cognitive impairment: The importance of comprehensive neuropsychological assessment. *European Journal of Neurology, 21*(10), 1330–e83. https://doi.org/10.1111/ene.12488

Klonsky, E. D., May, A. M., & Saffer, B. Y. (2016). Suicide, suicide attempts, and suicidal ideation. *Annual Reviews in Clinical Psychology, 12*, 307–30. https://doi.org/10.1146/annurev-clinpsy-021815-093204

Koopowitz, S. M., Maré, K. T., Zar, H. J., Stein, D. J., & Ipser, J. C. (2021). The neurocognitive profile of post-traumatic stress disorder (PTSD), major depressive disorder (MDD), and PTSD with comorbid MDD. *Brain and Behavior, 11*, Article e01950. https://doi.org/10.1002/brb3.1950

Kriesche, D., Woll, C. F. J., Tschentscher, N., Engel, R. R., & Karch, S. (2022). Neurocognitive deficits in depression: A systematic review of cognitive impairment in the acute and remitted state. *European Archives of Psychiatry and Clinical Neuroscience, 273*, 1105–1128. https://doi.org/10.1007/s00406-022-01479-5

Laukkala, T., Bor, R., Budowle, B., Navathe, P., Sajantila, A., Sainio, M., & Vuorio, A. (2018). Pilot posttraumatic stress disorder and fatal aviation accidents: A descriptive study. *Aviation Psychology and Applied Human Factors, 8*, 93–99. https://doi.org/10.1027/2192-0923/a000144

Laukkala, T., Bor, R., Budowle, B., Sajantila, A., Navathe, P., Sainio, M., & Vuorio, A. (2017). Attention-deficit/hyperactivity disorder and fatal accidents in aviation medicine. *Aerospace Medicine and Human Performance, 88*, 871–875. https://doi.org/10.3357/AMHP.4919.2017

Li, A., Yau, S. Y., Machado, S., Wang, P., Yuan, T. F., & So, K. F. (2019). Enhancement of hippocampal plasticity by physical exercise as a polypill for stress and depression: A review. *CNS Neurological Disorders–Drug Targets, 18*, 294–306. https://doi.org/10.2174/1871527318666190308102804

Li, Y., Yan, X., Li, Q., Li, Q., Xu, G., Lu, J., & Yang, W. (2023). Prevalence and trends in diagnosed ADHD among US children and adolescents, 2017–2022. *JAMA Network Open, 6*(10), e2336872. https://doi.org/10.1001/jamanetworkopen.2023.36872

Lima, D. D., Cyrino, L. A. R., Ferreira, G. K., Magro, D. D. D., Calegari, C. R., Cabral, H., & Fiamoncini, H. (2022). Neuroinflammation and neuroprogression produced by oxidative stress in euthymic bipolar patients with different onset disease times. *Scientific Reports, 12*, 16742. https://doi.org/10.1038/s41598-022-21170-y

Liu, J., Chen, Y., Xie, X., Liu, B., Ju, Y., Wang, M., & Zhang, Y. (2023). The percentage of cognitive impairment in patients with major depressive disorder over the course of the depression: A longitudinal study. *Journal of Affective Disorders, 329*, 511–518. https://doi.org/10.1016/j.jad.2023.02.133

Lowe, C. J., Safati, A., & Hall, P. A. (2017). The neurocognitive consequences of sleep restriction: A meta-analytic review. *Neuroscience and Biobehavioral Reviews, 80*, 586–604. https://doi.org/0.1016/j.neubiorev.2017.07.010

Mackenzie Ross, S. (2017). Assessing cognitive function in airline pilots. In R. Bor, R. Eriksen, C. Oakes, & P. Scragg (Eds.), *Pilot mental health screening and assessment a practitioners guide (Chap. 7)*. Routledge, Taylor & Francis Group.

Maki, K. A., Fink, A. M., & Weaver, T. E. (2022). Sleep, time, and space-fatigue and performance deficits in pilots, commercial truck drivers, and astronauts. *Sleep Advances, 3*, zpac033. https://doi.org/10.1093/sleepadvances/zpac033

Mckenzie, A., Meshkat, S., Lui, L. M. W., Ho, R., Di Vincenzo, J. D., Ceban, F., Cao, B., & McIntyre, R. S. (2022). The effects of psychostimulants on cognitive functions in individuals with attention-deficit hyperactivity disorder: A systematic review. *Journal of Psychiatric Research, 149*, 252–259. https://doi.org/10.1016/j.jpsychires.2022.03.018

Mann, J. J., & Rizk, M. M. (2020). A Brain-Centric Model of Suicidal Behavior. *The American Journal of Psychiatry, 177*, 902–916. https://doi.org/10.1176/appi.ajp.2020.20081224

Marcotte, T. D., & Scott, J. C. (2009). Neuropsychological performance and the assessment of driving behavior. In I. Grant & K. M. Adams (Eds.), *Neuropsychological assessment of neuropsychiatric and neuromedical disorders* (pp. 652–687). Oxford University Press.

Martino, D. J., Marengo, E., Igoa, A., Sca´pola, M., Ais, E. D., Perinot, L., & Strejilevich, S. A. (2009). Neurocognitive and symptomatic predictors of functional outcome in bipolar disorders: A prospective 1 year follow-up study. *Journal of Affective Disorders, 116*, 37–42. https://doi.org/10.1016/j.jad.2008.10.023

Mokhtari, S., Mokhtari, A., Bakizadeh, F., Moradi, A., & Shalbafan, M. (2023). Cognitive rehabilitation for improving cognitive functions and reducing the severity of depressive symptoms in adult patients with Major Depressive Disorder: A systematic review and meta-analysis of randomized controlled clinical trials. *BMC Psychiatry, 23*, Article 77. https://doi.org/10.1186/s12888-023-04554-w

Mürner-Lavanchy, I., Koenig, J., Reichl, C., Josi, J., Cavelti, M., & Kaess, M. (2024). The quest for a biological phenotype of adolescent non-suicidal self-injury: A machine-learning approach. *Translational Psychiatry, 14*, 56. https://doi.org/10.1038/s41398-024-02776-4

Newell, V., Townsend, E., Richards, C., & Cassidy, S. (2024). Measurement properties of tools used to assess self-harm in autistic and general population adults. *Clinical Psychology Review, 109*, Article 102412. https://doi.org/10.1016/j.cpr.2024.102412

Nidos, A., Stavrakis Kontostavlos, S., Roussos, P., & Mylonas, K. (2018). Aerospace neuropsychology: Exploring the construct of psychological and cognitive interaction in the 100 most fatal civil aviation accidents through multidimensional scaling. In C. Baldwin (Ed.), *Advances in neuroergonomics and cognitive engineering* (pp. 235–245). AHFE.

Nock, M. K., Millner, A. J., Ross, E. L., Kennedy, C. J., Al-Suwaidi, M., Barak-Corren, Y., Castro, V. M., Castro-Ramirez, F., Lauricella, T., Murman, N., Petukhova, M., Bird, S. A., Reis, B., Smoller, J. W., & Kessler, R. C. (2022). Prediction of suicide attempts using clinician assessment, patient self-report, and electronic health records. *JAMA Network Open, 5*, Article e2144373. https://doi.org/10.1001/jamanetworkopen.2021.44373

Pan, L. A., Batezati-Alves, S. C., Almeida, J. R., Segreti, A., Akkal, D., Hassel, S., Lakdawala, S., Brent, D. A., & Phillips, M. L. (2011). Dissociable patterns of neural activity during response inhibition in depressed adolescents with and without suicidal behavior. *Journal of American Academy of Child and Adolescence Psychiatry, 50*, 602–611.e3. https://doi.org/10.1016/j.jaac.2011.03.018

Petersen, M., Nägele, F. L., Mayer, C., Schell, M., Petersen, E., Kühn, S., Gallinat, J., Fiehler, J., Pasternak, O., Matschke, J., Glatzel, M., Twerenbold, R., Gerloff, C., Thomalla, G., & Cheng, B. (2023). Brain imaging and neuropsychological assessment of individuals recovered from a mild to moderate SARS-CoV-2 infection. *Proceedings National Academy of Sciences, 120*, Article e2217232120. https://doi.org/10.1073/pnas.2217232120

Pievsky, M. A., & McGrath, R. E. (2018). The neurocognitive profile of attention-deficit/hyperactivity disorder: A review of meta-analyses. *Archives of Clinical Neuropsychology, 33*, 143–157. https://doi.org/10.1093/arclin/acx055

Raghavendra, P. A., Hegde, S., Philip, M., & Kesavan, M. (2022). Music and neuro-cognitive deficits in depression. *Frontiers in Psychology, 13*, Article 959169. https://doi.org/10.3389/fpsyg.2022.959169

Ren, F. F., Hillman, C. H., Wang, W. G., Li, R. H., Zhou, W. S., Liang, W. M., Yang, Y., Chen, F. T., & Chang, Y. K. (2024). Effects of aerobic exercise on cognitive function in adults with major depressive disorder: A systematic review and meta-analysis. *International Journal of Clinical and Health Psychology, 24*, Article 100447. https://doi.org/10.1016/j.ijchp.2024.100447

Rhee, T. G., Shim, S. R., Manning, K. J., Tennen, H. A., Kaster, T. S., d'Andrea, G., Forester, B. P., Nierenberg, A. A., McIntyre, R. S., & Steffens, D. C. (2024). Neuropsychological assessments of cognitive impairment in major depressive disorder: A systematic review and meta-analysis with meta-regression. *Psychotherapy and Psychosomatics, 93*, 8–23. https://doi.org/10.1159/000535665

Rohrer, R. R., Mackinger, H. F., Fartacek, R. R., & Leibetseder, M. M. (2006). Suicide attempts: Patients with and without an affective disorder show impaired autobiographical memory specificity. *Cognition and Emotion*, *20*, 516–526. https://doi.org/10.1080/02699930500342449.

Rosa, E., Gronkvist, M., Kolegard, R., Dahlstrom, N., Knez, I., Ljung, R., & Willander, J. (2021). Fatigue, emotion, and cognitive performance in simulated long-duration, single-piloted flight missions. *Aerospace Medicine and Human Performance, 92*, 710–719. https://doi.org/10.3357/AMHP.5798.2021

Ross, J., Griffiths, K., Dear, K., Emonson, D., & Lambeth, L. (2007). Antidepressant use and safety in civil aviation: A case-control study of 10 years of Australian data. *Aviation, Space, and Environmental Medicine*, *78*, 749–755.

Rutter, S. B., Cipriani, N., Smith, E. C., Ramjas, E., Vaccaro, D. H., Martin Lopez, M., Calabrese, W. R., Torres, D., Campos-Abraham, P., Llaguno, M., Soto, E., Ghavami, M., & Perez-Rodriguez, M. M. (2020). Neurocognition and the suicidal process. *Current Topics in Behavioral Neuroscience, 46*, 117–153. https://doi.org/10.1007/7854_2020_162

Sankar, A., Ziersen, S. C., Ozenne, B., Beaman, E. E., Dam, V. H., Fisher, P. M., Knudsen, G. M., Kessing, L. V., Frokjaer, V., & Miskowiak, K. W. (2023). Association of neurocognitive function with psychiatric hospitalization and socio-demographic conditions in individuals with bipolar and major depressive disorders. *EClinical Medicine, 58*, Article 101927. https://doi.org/10.1016/j.eclinm.2023.101927

Schaefer, L. A., Thakur, T., Meager, M. R. (2023). *Neuropsychological assessment*. StatPearls [Internet]. https://www.ncbi.nlm.nih.gov/books/NBK513310/

Skegg, K. (2005). Self-harm. *Lancet, 366*, 1471–1483. https://doi.org/10.1016/S0140-6736(05)67600-3

Swann, A. C., Lijffijt, M., O'Brien, B., & Mathew, S. J. (2020). Impulsivity and suicidal behavior. *Current Topics in Behavioral Neuroscience, 47*, 179–195. https://doi.org/10.1007/7854_2020_144

Thompson, W. T. (2004). *Neuropsychological evaluation of aviators: Need for aviator-specific norms?* United-States Air Force School of Aerospace-Medicine. SAM-FE-TR-2004–0001. https://apps.dtic.mil/sti/tr/pdf/ADA434386.pdf

Thurston, R. C., Jakubowski, K., Chang, Y., Wu, M., Barinas Mitchell, E., Aizenstein, H., Koenen, K. C., & Maki, P. M. (2023). Posttraumatic stress disorder symptoms and cardiovascular and brain health in women. *JAMA Network Open, 6*, Article e2341388. https://doi.org/10.1001/jamanetworkopen.2023.41388

Van Benthem, K. D., Herdman, C. M., Tolton, R. G., & LeFevre, J. A. (2015). Prospective memory failures in aviation: Effects of cue salience, workload, and individual differences. *Aerospace Medicine and Human Performance, 86*, 366–373. https://doi.org/10.3357/AMHP.3428.2015

Vuorio, A., & Bor, R. (2021). Self-harm in aviation medicine–a complex challenge during a pandemic. *Frontiers in Public Health*. *9*, Article 681618. https://doi.org/10.3389/fpubh.2021.681618

Vuorio, A., Bor, R., Sajantila, A., Suhonen-Malm, A.-S., & Budowle, B. (2023). Commercial aircraft-assisted suicide accident investigations re-visited–agreeing to disagree? *Safety, 9*, Article 17. https://doi.org/10.3390/safety9010017

Vuorio, A., Laukkala, T., & Navathe, P. (2012). Major depression and fitness to fly by different aviation authorities. *Aviation, Space, and Environmental Medicine, 83*, 909–911. https://doi.org/10.3357/asem.3363.2012

Vuorio, A., Laukkala, T., Navathe, P., Budowle, B., Bor, R., & Sajantila, A. (2017). Bipolar disorder in aviation medicine. *Aerospace Medicine and Human Performance, 88*, 42–47. https://doi.org/10.3357/AMHP.4620.2017

Vuorio, A., Laukkala, T., Navathe, P., Budowle, B., Eyre, A., & Sajantila, A. (2014). Aircraft-assisted pilot suicides: Lessons to be learned. *Aviation, Space, and Environmental Medicine, 85*, 841–846. https://doi.org/10.3357/ASEM.4000.2014

Wang, Y., Meng, W., Liu, Z., An, Q., & Hu, X. (2022). Cognitive impairment in psychiatric diseases: Biomarkers of diagnosis, treatment, and prevention. *Frontiers in Cell Neuroscience, 16*, Article 1046692. https://doi.org/10.3389/fncel.2022.1046692

Wang, M., Liu, Q., Yang, X., Dou, Y., Wang, Y., Zhang, Z., Luo, R., Ma, Y., Wang, Q., Li, T., & Ma, X. (2023). Relationship of insight to neurocognitive function and risk of recurrence in depression: A naturalistic follow-up study. *Frontiers in Psychiatry, 14*, Article 1084993. https://doi.org/10.3389/fpsyt.2023.1084993

Weigard, A., McCurry, K. L., Shapiro, Z., Martz, M. E., Angstadt, M., Heitzeg, M. M., Dinov, I. D., & Sripada, C. (2023). Generalizable prediction of childhood ADHD symptoms from neurocognitive testing and youth characteristics. *Translational Psychiatry, 13*, 225. https://doi.org/10.1038/s41398-023-02502-6

Woo, Y. S., Hong, J. W., Shim, S. H., Sung, H. M., Seo, J. S., Park, S. Y., Lee, J. G., Yoon, B. H., & Bahk, W. M. (2023). Prevalence and comorbidities of adult attention-deficit/hyperactivity disorder in a community sample from Korea. *Clinical Psychopharmacology and Neuroscience, 21*, 798–807. https://doi.org/10.9758/cpn.23.1112

Wood-Ross, C., Tran, T., Milanovic, M., Jokic, R., Milev, R., & Bowie, C. R. (2023). Neurocognition and depressive symptoms have unique pathways to predicting different domains of functioning in major depressive disorder. *Canadian Journal of Psychiatry, 68*, 241–248. https://doi.org/10.1177/07067437221133375

Wu, A. C., Donnelly-McLay, D., Weisskopf, M. G., McNeely, E., Betancourt, T. S., & Allen, J. G. (2016). Airplane pilot mental health and suicidal thoughts: A cross-sectional descriptive study via anonymous web-based survey. *Environmental Health, 15*, 121. https://doi.org/10.1186/s12940-016-0200-6

Yesavage, J. A., Jo, B., Adamson, M. M., Kennedy, Q., Noda, A., Hernandez, B., Zeitzer, J. M., Friedman, L. F., Fairchild, K., Scanlon, B. K., Murphy, G. M. Jr, & Taylor, J. L. (2011). Initial cognitive performance predicts longitudinal aviator performance. *Journals of Gerontology Series B*, *66*, 444–453. https://doi.org/10.1093/geronb/gbr031

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