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Understanding military pilot selection

Insights from cognitive, personality and experimental studies in Sweden

Malcolm Sehlström

Department of Psychology

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Seven years ago – on my first day at the flight school – a pilot joked that airplanes run primarily on coffee and on jet fuel secondarily.

I suppose that makes two ways that coffee was essential for producing this thesis.

The doctoral research project resulting in this thesis has been a collaboration between the Umeå University Industrial Doctoral School (IDS), SAAB and the Swedish Air Force, with financial support from the UmU IDS and SAAB.

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Abstract

This thesis investigates the critical issue of military pilot selection. To understand and optimize selection, much research has been conducted on factors predicting educational outcomes. While assessment testing remains central to selection and understanding pilots, studying ability requirements for pilot in modern-day educational and professional settings can help make sure that our understanding is up to date. This thesis includes both approaches through the two distinct but interconnected measures of (1) successful completion of Swedish military pilot education, and (2) the ability to perform effectively as a professional military pilot**.** By adopting this holistic approach and focusing on the historically underexamined Swedish military pilot education context, this work provides unique insights into selection criteria.

Studies I and II were conducted based on a data registry of assessment tests provided by the Swedish Armed Forces and examined the role of common predictors such as personality and cognition in completing the Swedish military pilot education. Using a qualitative, interview-based approach, Study III examined instead what qualities that active military pilot cadets themselves perceive as required for their profession. In a stress experiment in a laboratory setting, Study IV begun examinations on whether a unique type of stress that can occur in flight, startle, could deserve attention during selection.

It was found through Studies I and II that personality traits, as assessed by specialist psychologists, are associated with success in the Swedish military pilot education. In particular being energetic, professionally motivated, studious and having leadership potential. In addition, interview-based suitability judgements by senior pilots appear the strongest predictor of success in the Swedish system, while typically observed cognitive predictors did not appear related to success. Study III informed about professional demands for pilots and found through thematic analysis that Swedish pilot cadets value being a team player, having drive, being stress tolerant and being in good shape, in some overlap with Studies I and II. Startling events, carried out in a controlled laboratory environment in study IV, did negatively affect basic human performance – this was unrelated to individual personality and stress levels however, providing a first indication about this professional ability requirement for pilots.

Taken together, the thesis findings provide valuable insights for military pilot selection. A key takeaway is the importance of personality factors in predicting educational success within the Swedish system. Historically, personality has been considered less predictive than cognitive ability in pilot selection. The lack of predictive validity for traditionally emphasized cognitive measures may be attributed to a restriction of range, likely due to Sweden's highly rigorous selection process. In this system, most candidates have demonstrated strong cognitive aptitude before entering training, reducing variability in those measures and maybe allowing for a shifting of focus to personality traits. The personality traits found significant for education have conceptual overlap with previous aviation research profiles based in the Five-Factor Model, and overlap with the professional demands identified by pilot cadets in study III. This highlights the potential importance of these variables, the requirement for further research.

List of papers

I. Sehlström, M., Ljungberg, J. K., Nyström, M. B., & Claeson, A. S. (2025). Relations of personality factors and suitability ratings to Swedish military pilot education completion. *International Journal of Selection and Assessment*, *33*(1), e12492. https://doi.org/10.1111/ijsa.12492

II. Sehlström, M., Ljungberg, J. K., Nyström, M. B., & Claeson, A. S. (Submitted). Cognitive and personal assessment in the Swedish military pilot selection process and its impact on education completion.
Under review

III. Sehlström, M., Nyström, M. B., Ljungberg, J. K., & Claeson, A. S. Pilots profiling piloting—What do military aviation cadets believe is important for piloting?
Manuscript

IV. Sehlström, M., Ljungberg, J. K., Claeson, A. S., & Nyström, M. B. (2022). The relation of neuroticism to physiological and behavioral stress responses induced by auditory startle. *Brain and Behavior*, *12*(5), e2554. https://doi.org/10.1002/brb3.2554

Introduction

A fighter jet slices through the sky at supersonic speeds, weaving through clouds with precision. The roar of engines resonates throughout the cockpit. Inside, the pilot is strapped into her confined seat, surrounded by an array of screens and instruments—every single one vying for the pilot's attention. Hands grip the control stick as eyes rapidly scan the horizon, sensors and radar displays, processing information at lightning speed. At this kind of velocity, every decision must be measured, every reaction appropriate—and the tactical landscape is constantly changing. The margin for error is thinner than a hair. Beneath a mask providing oxygen and a high-tech helmet is a pilot, whose performance determines not only her survival, but potentially that of her colleagues and any of those depending on her mission.

It becomes instantly clear that in a scenario such as that above, it is extremely important that the person flying the plane is right for the situation. Military pilot selection, or the identification of individuals with the potential to succeed in this role, is the focus of this thesis.

The stakes of selection are immense. Poor understanding of pilot characteristics can not only jeopardize the safety of lives but also military operational efficiency, and resource investment of the organization (Hunter, 1989). In order to understand what makes the best pilot, pilots are now among the most studied modern professions (Martinussen, 2016) and specific assessment tests have been abundantly studied (e.g., Hunter & Burke, 1994; Martinussen, 1996; Broach & Schroeder, 2019; ALMamari, 2019). However, studies often narrow their scope to identifying factors of training success, with less attention paid to how factors interact across a pilot's career. Even if one has the natural aptitude to learn to fly, are they necessarily suited to being a pilot? Do they have the temperament for the long run, making the training worthwhile? Are they suited for military life? Educating military pilots is expensive in regard to resources for the responsible organization, and in regard to time for the individuals being educated.

One of the key motivations for this thesis is the need for military pilot selection systems to keep pace with technological advancements and modern times. A meta-analysis, drawing on 50 years of data, indicates that the predictiveness of traditional selection factors, while remaining significant, have decreased over time (Hunter & Burke, 1994). While the exact reasons for such changes remain unclear—whether they are due to advancements in aviation technology, changes

in selection procedures, educational methodology, or other factors—it serves as a critical reminder that selection processes require reassessment to remain effective. As military aviation continues to change, the tools and methods used to select pilots must be re-examined to ensure they are equipped to identify appropriate candidates. This thesis, therefore, not only seeks to examine a current selection system, but also to provide insights into the current demands of modern aviation.

This thesis addresses the central issue of military pilot selection by focusing on two key outcome measures: (1) successful completion of military pilot education, and (2) the ability to perform effectively as a professional military pilot. These are distinct but connected goals. The former reflects the immediate challenge of progressing through rigorous training, while the latter involves the long-term demands of the profession. Optimally, these two outcomes should align—where selection methods identify candidates who succeed in both training and professional performance. Thus, this thesis studies predictors of educational success and identifies important professional abilities. Historically, selection research has relied heavily on quantitative methods, particularly psychometric testing, to identify predictors of training success. While this has led to substantial advancements in understanding the characteristics linked to educational performance, it leaves unexamined how variables translate into success in a later active operational context. For example, early research by Sells (1955, 1956) demonstrated that personality traits could predict long-term professional performance, even though their immediate impact on selection outcomes appeared to be limited. However, additional such studies have not been conducted since that time. While assessment tests remain central to selection processes and understanding pilot profiling, the development of pilots throughout education and professional life must also be considered as important in deciding what characteristics truly defines a successful pilot. By considering selection holistically, incorporating traditional and novel approaches to selection and professional ability examinations, this thesis can lay the groundwork for further examinations of the validity of military aviation selection processes.

The concept of validity, particularly criterion validity, frames this work. It is important to continuously evaluate the relevance of tests used towards actual professional task demands. That is, making sure that selection tests, and the constructs that they measure, actually represent what is required of pilots in real-world, operational settings. This criterion validity is essential for selection to not devolve into merely identifying candidates who can make it through a

demanding educational program, rather than those who will actually excel as pilots. This thesis contributes to this by not only studying selection tests in relation to educational outcomes but also by examining the professional ability requirements that extend beyond the educational context. While selection systems aim to predict things such as training outcomes based on assessment tests, one cannot expect to perfectly predict success. Life circumstances, unpredictable events, and the dynamic nature of military aviation all introduce variability with which selection systems must contend. Thus, a key question becomes how much prediction is realistically achievable, and how can selection methods evolve to better reflect the full spectrum of pilot performance?

This thesis is grounded in the Swedish military pilot selection system, which offers a unique framework for studying these questions. Sweden's rigorous selection process emphasizes ensuring that admitted candidates complete their training, in contrast to well-studied systems like the United States Air Force, which employs progressive screening throughout training—essentially making education part of the ongoing selection process. The uniqueness of the Swedish system and population may provide hitherto undiscovered insights.

The following introduction outlines the foundational topics that frame the thesis. It begins with an exploration of the history and evolution of aviation selection, followed by current understandings of relevant pilot characteristics and alternative approaches to profiling pilots.

A history of selection

Understanding what makes a successful pilot, and selecting for these factors, has been an enduring focus of research since the early days of aviation, with the primary interest having been identifying a cognitive aptitude for flying. The high-stakes nature and complexity of piloting demands a nuanced understanding of the traits and abilities that contribute to success.

Selection of pilots in general and selection of military pilots specifically have a considerable overlap in development. Historically, identifying military pilots around the time of the first World War was the initial trigger (Dockeray & Isaacs, 1921). At that time, much of the larger studies relied on to establish general piloting characteristics were conducted specifically in military settings, primarily the US Air Force (see, e.g., Henmon, 1919), and later, commercial aviation would contribute large numbers of studies (Hunter & Burke, 1994).

Aviation selection has undergone an interesting evolution since its inception during the early 20th century. When it first emerged as a response to the requirement for, and risks associated with, aerial warfare in WWI, there was an almost unilateral focus on cognition, with the addition of emotional stability (e.g., Henmon, 1919; Termøhlen, 1986). Primarily tested were factors such as spatial abilities, psychomotor skills, and general intelligence. Between the times of the first and second World Wars, there was little research on pilot profiling and selection (Martinussen & Hunter, 2017). Starting with the second World War and going forward, entities such as the US Air Force (USAF) would begin more systematic approaches to selection, and by the end, test batteries for selection had been developed. Beyond the USA, the Royal Norwegian Air Force (RNoAF) has seen the historical development of their selection strategies published extensively (e.g., Riis, 1986; Martinussen & Torjussen, 1998).

Increased digitalization after the rise of computers lead to the development and wide adaptation of digital tests—up until this point, tests had, to a large extent, been conducted with paper and pencil. The technological advancements would allow for more realistic testing of complex abilities and more closely simulate the demands or tasks of actual flight, and pilot aptitude test batteries were developed (Bartram, 1995; Burke et al., 1997). The USAF selection method developed from this period, the Pilot Candidate Selection Method (PCSM) is the most researched (Carretta, 2011), and includes the computerized Test of Basic Aviation Skills (TBAS) that is supposed to measure an individual's aptitude for flying based on psychomotorics, spatial orientation, and working memory capabilities.

Character was also considered important (Dockeray & Isaacs, 1921; Fitts, 1946), but it was with the rise of trait personality psychology, starting in the 1950s, that more trait-based considerations of pilot personality would be given space and be used concurrently with cognitive measures. During this period, systems like Eysenck's personality theory (Eysenck, 1967) were adopted to evaluate traits thought to predict piloting success. For instance, studies using the Eysenck Personality Inventory (Bartram & Dale, 1982; Jessup & Jessup, 1971) found that being less stable (more neurotic) was negatively associated with training outcomes, while extraversion was linked to better performance. Rorschach's famous ink blot test (Rorschach et al., 1942) was also used to assess the mental health of applicants and active pilots (Moser, 1981), as was Cattel's 16 personality factors (Bartram, 1995).

With the growing popularity of the Five-Factor Model (FFM) (McCrae & Costa, 1987) in the late 20th century, the study of pilot personality has generally adapted the use of this framework. This model posits five primary dimensions of personality: *openness*, *conscientiousness*, *extroversion*, *agreeableness*, and *neuroticism*. Openness is concerned with imagination, wit, and originality. People low on this trait tend to be plain, simple, and uninterested in new things. Conscientiousness includes responsibility, perseverance, goal-orientation, and caution. Low conscientiousness comes with impulsiveness, disorder, and unreliability. Extroversion is concerned with energy, enthusiasm, being talkative, and socializing. Low extroversion is introversion and includes being shy and quiet. Agreeableness encompasses being cooperative, friendly, and warm, and people low on agreeableness are confrontational, unfriendly, and cold. Neuroticism, as also brought up in Eysenck's (1967) work, captures emotional volatility and propensity for stress and worrying. Low neuroticism involves being emotionally stable and includes being content and calm. Researchers began investigating the relevance of traits like conscientiousness, neuroticism, and extroversion, which continue to dominate investigations into pilot profiles today (Breuer et al., 2023). While personality measures appeared to have limited importance in earlier decades (Hunter & Burke, 1994; Martinussen, 1996), recent research has reignited interest in their potential, arguing for their complementary role alongside cognitive assessments (Breuer et al., 2023), suggesting that they may be more useful in understanding retention (Martinussen & Hunter, 2017).

This historical development of pilot selection methodology reflects the dynamic between evolving psychological theory and the practical demands of aviation. From the initial reliance on pure cognitive testing in the early 20th century to the current integrative approaches, the field continues to refine its understanding of what makes a successful pilot.

Selecting the right person for the job

In selecting the right person for the job, one can rely on pilot-specific characteristics as well as general job selection and performance research. Decades of personnel selection research have established key predictors of job performance across various professions. Generally, tests of general mental ability (GMA/g, see next section) and work sample tests have been seen as primarily important, followed by tests of integrity, conscientiousness and

profession-tailored interviews (Hunter & Schmidt, 1998). In recent years, updated meta-analyses have suggested that structured employment interviews may actually be the most effective tool for selection and that employment interview scores or outcome are the main predictor of job performance (Sackett et al., 2022; Sacket et al., 2023), followed by job knowledge-, work sample-, and GMA tests.

What can we infer about important pilot characteristics specifically, based on research up until this point? While the profiling of what is important for pilots has advanced significantly since the 1920s, there is no definite profile. There are, however, a number of robust trends.

Pilot aptitude/cognition

Cognitive ability remains the class of characteristic that is most strongly considered important for piloting, informed by selection testing. Identification of relevant cognitive traits for pilots can concern itself with two perspectives—traits that are generally predictive in higher education/elite professions, and traits that are specifically necessary for the pilot profession. General intelligence, often referred to as the *g factor*, has been repeatedly found as a significant aspect in both regards. The general intelligence factor, g, was first proposed by Spearman (1927). It's been proposed that g could be split into the constructs of *fluid g* and *crystallized g* (Cattel & Horn, 1978), which represent intelligence independent of knowledge and accumulated knowledge, respectively. However, some have argued that g and fluid g may be considered to be practically the same thing (Gustafsson, 1984). Over the years, g has emerged as a central construct in general personnel selection research, with a strong relationship to job performance across a variety of professions (Schmidt & Hunter 1998; Schmidt et al., 2016). The value of g comes from its association with learning ability, problem-solving, and adaptability, qualities that appear to be universally relevant. In pilot profiling, g has been found to be predictive of pilot performance in numerous studies (Ree & Carretta, 1996; Martinussen, 1996). It appears that, beyond being supportive of learning, the ability to deal with demands for rapid information processing, integration of said information, and the decision-making encompassed by flying are correlated with the g factor.

The tasks of flying inform us of the cognitive requirements of pilots, where the topics of *situational awareness* and *workload* become relevant. Situational awareness is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of

their status in the near future" (Endsley, 1995). It is crucial to be situationally aware in all types of piloting, and it informs what constituent cognitive abilities are of importance for pilots. Pilot aptitude tests are often made to mirror these real-world demands, assessing abilities like information processing, spatial reasoning, attention, and psychomotor coordination to gauge a candidate's aptitude for learning (e.g., Martinussen & Torjussen, 2004). When attempting to break the complex construct of situational awareness into cognitive parts, we can argue that it's mainly constituted of some of these demands—information processing, attention, and working memory (Martins, 2016) —highlighting the importance of these faculties. For workload, the amount of data needing to be processed and how fast and accurately a pilot needs to fly informs the workload imposed on aviators (Cardosi & Murphy, 1995), again demanding information processing and working memory capacities.

In relation to the recently mentioned information processing and its integration, psychomotor ability—physical movement in relation to cognitive processing—has been studied since the first cognitive pilot tests (Henmon, 1919), and ever since, has consistently been used and reported as a crucial ability for pilots (Hunter & Burke, 1994; Martinussen, 1996). Indeed, being able to quickly and accurately perform manipulations of controls is a large part of flying. The importance of psychomotor ability is underscored in modern selection batteries such as the USAF TBAF (Carretta & Ree, 2003), which includes multiple psychomotor subtests, designed to assess coordination, reaction time, and precision (Carretta, 2005). Furthermore, Nye et al., (2018) demonstrated that psychomotor ability, in conjunction with the g factor, provides incremental predictive validity for pilot performance in training, highlighting it as a cornerstone of the cognitive capacities necessary for pilots.

Another cognitive faculty that is critical for pilots is spatial ability, the capacity to understand and reason about objects in space. Spatial ability is essential for navigating and orienting during flight, where pilots must maintain an accurate mental model of their position in relation to terrain, other aircraft, or other entities. Spatial ability has also been acknowledged as being of primary interest since the early testing days, with spatial tests being numerous since the early testing processes devised by the USAF and the Norwegian Royal Air Force (Termøhlen, 1986; Martinussen & Torjussen, 2004). In a job analysis, Damos & Schwartz (2011) highlighted spatial ability as well as perceptual speed as the two abilities of primary interest for military pilots. Perceptual speed—the ability

to quickly process, recognize, and compare stimuli—is closely related to information processing, as previously mentioned.

The meta-analyses of relevant pilot characteristics identify that while separate cognitive tests such as these are predictive of pilot performance, composite scores of larger test batteries across the cognitive spectrum provide more predictive validity (Hunter & Burke, 1994; Martinussen, 1996). More recent examinations of cognitive test batteries for pilot selection (King et al., 2013; ALMamari, 2019) confirm that while aspects such as spatial ability or processing speed are of importance, general measures of cognitive ability may be the most informative. Analysis of the interactions of different cognitive aspects indicate that when categorized into perceptual processing, motor abilities, and controlled attention, test battery composites may be the most closely related to what determines a pilot's success (ALMamari, 2019, 2020)

Personality

When profiling military pilots' personalities, one can consider it from three interrelated perspectives. First, regarding the personality appropriate for piloting—what kind of person is suited to specifically managing the flying of a plane and holding the responsibility of lives and significant resources? Second, what makes a person suited for military life in particular, often a higher-ranking position within said military organization. Third, we can consider pilot personality as a reflection of other high-performing populations, such as those in higher education or high-performing professionals. These can be considered when determining whether pilots are suitable for such intensive and demanding education and whether they are a good fit for working, and staying, in a generally demanding profession.

Recent research relies on modern personality theory, particularly the FFM trait approach, and has identified several traits that are relevant for pilots. Primarily observed historically has been, as previously mentioned, the requirement for pilots to be stable individuals—to be a less neurotic individual with less propensity for stress (Bartram & Dale, 1987; Breuer et al., 2023). When comparing pilot populations to normal populations, pilots tend to be more conscientious, openminded, and extroverted while also having lower levels of neuroticism (Martinussen & Hunter, 2017)— that is they are typically disciplined and reliable, curious and adaptable, and sociable and energetic. When looking within the population of pilots, those who succeed in training tend to score higher on conscientiousness and lower on neuroticism than their

classmates, which appears true for both military and commercial aviation (Breuer et al., 2023). Interview studies and job analyses have also had similar findings; when rated for importance by 43 and 100 military pilots respectively, conscientiousness and high emotional stability (low neuroticism) were rated as the most important (Carretta et al., 1993; Siem & Murray, 1994). This is of significant overlap with findings regarding academic performance: more conscientious and open individuals are successful in education (Poropat, 2009), while more neurotic individuals perform worse (Vedel & Poropat, 2017).

Beyond trait studies, other personality factors, such as motivation, grit, and self-discipline are recognized as impactful not only for pilots but for military officers. Motivation, particularly intrinsic—internal—is important for military pilots in particular (Walsh et al., 2017). Grit, defined by the American Psychologist Association as perseverance, working strenuously to overcoming challenges, and maintaining effort over time, has been identified as a factor of importance for military performance for the general private as well as for officer roles such as pilots (Eskreis-Winkler et al., 2014; Kelly et al., 2014).

Despite the magnitude of studies about pilot personality, multiple meta-analyses (e.g., Hunter & Burke, 1994; Martinussen, 1996) show that cognition is more effective than personality in predicting successful outcomes for pilots and that personality is generally a weak predictor. This apparent lack of predictive power from personality traits may be explained by the fact that most of the research has been conducted during pilots' education stage, in which cognitive abilities have consistently been found to predict immediate success (Martinussen & Hunter, 2017). Consideration also needs to be given to the fact that personality is typically incorporated into pilot selection in one of two ways: as a separate scoring variable to be weighed besides other, cognitive variables; or as a basis for producing another scoring variable, such as interview scores produced by psychiatrists (Martinussen, 2016). This would give extra weight to the worth of personality in pilot profiling, but there are, to my knowledge, no studies specifically examining the use of personality as a basis for interviewing, and as such, establishing their contribution is not possible at this time. In addition, personality traits may offer more insight into long-term professional performance. Sells (1955; 1956), provided initial indications in two studies that personality could be more informative regarding sustained work over time, despite the dominance of cognition in training outcomes; i.e., personality might end up being more indicative of professional success in the long term. Despite these findings from over half a century ago, subsequent research has largely

focused on training outcomes, with limited investigation of pilots' long-term performance (Horman & Maschke, 1996).

Methods for identifying important selection factors

Even with the hitherto extensive research into pilot selection, there are avenues to further our understanding of important pilot characteristics that are less utilized. While most of the research identifying relevant pilot characteristics has been based in selection analysis and focused on psychometry, aptitude, and the use of personality inventories, these may be limiting in some respects. Indeed, while selection studies have produced valuable insights, they could be argued to be confined by their reliance on pre-defined assessment constructs. Is it possible to gain a broader understanding of pilot characteristics by using alternative methods that go beyond the selection stage? Would it be feasible to refer back to previous findings to refine the selection process?

Interviews and qualitative studies

While qualitative and interview-based studies in pilot populations are carried out, it could be argued to be historically under-utilized. In selection, as mentioned, interviews are a common tool for judging candidates' suitability (Eaglestone, 2022), but how can they be used to identify what makes a good candidate and to improve selection? Active pilots may be interviewed or included in job analysis studies (Siem & Murray, 1994; Goeters et al., 2004; Kubisiak & Katz, 2006; Harlem, 2016) to identify important characteristics according to their experience. There also exist a limited number of studies examining pilots' lived experiences, often targeting stressors or problems (Engel, 2021; Bosdotter, 2022). I would argue that these kinds of studies have the potential to identify contextual factors influencing pilot performance, such as organizational culture or training methodology/educational pedagogy. By examining how pilots perceive their own development and challenges, it is possible to uncover whether certain characteristics emerge or start mattering later on in training or in professional practice. Additionally, continually evaluating professional requirements with the help of active professionals keeps science up to date with changing professional demands—piloting is constantly affected by technological advancements. Adopting this approach can be used to enrich existing pilot profiling, complementing static measures typically assessed during selection.

Startle

A potential professional ability requirement for pilots that is not covered by current selection is dealing with a unique type of stress, called startle. It is well known that stress, acute as well as chronic, can have physical and psychological effects. As previously mentioned, the need for pilots to be stress resistant has been a throughline since the very first pilot tests (Henmon, 1919), thanks to the mental demands of flying. In addition, individuals more prone to stress tend to perform worse in aviation education (Campbell et al., 2009), as well as education in general (Vedel & Poropat, 2017). In aviation settings with multiple crew members, cooperation or lack thereof can also be a source of stress. Crew resource management (CRM) research has emphasized the importance of simulated or real-life study to understand important characteristics involved in team situations and stressful situations (Kanki et al., 2019).

Startle is a specific type of stress, however, that is particularly relevant for aviation. The startle response is a defense mechanism triggered by sudden and intense stimuli, such as loud sounds or sudden movement (Davis, 1984). The interest in startle in aviation has developed most in the last 10 years, as it was found that a number of catastrophic aviation accidents could be attributed to improper pilot responses following startling situations (Martin et al., 2012). Indeed, Martin and co-authors argue for a real need for the further examination of startle response effects on human performance. There have been suggestions that different people may deal with startling events in different ways, and understanding this could be of importance for both the selective and educational aspects of producing military pilots.

The human startle response appears to not only involve reflexive motions intended to protect the individual, but also includes initiating a stress response intended to prepare for dealing with the threat in some way (LeDoux, 2000). In situations as serious as steering an airplane, becoming startled while realizing that failure might result in catastrophe and/or death, it is fair (according to Martin et al.) to expect to experience serious stress following a startling event. A few studies on startle in simulated flight training have actually been carried out. It was shown that in these simulated situations, where the pilots must be aware of the relative lack of actual threat, their performance in managing their aircraft was still significantly impaired following a startle (Martin et al., 2016). Indeed, in the study by Martin et al. (2016), one third of pilot participants “were so badly affected that their performance following startle resulted in considerable

delay as indicated by lost altitude on a go-around decision, or, worse, with some continuing on very unstable approaches to the point where flight safety was impacted." (Martin et al., 2016, p. 29). In a second study described by Martin et al., as many as 78% of pilots failed to recover from stalling in a correct manner, which is a predominant reason for accidents. It is therefore clear that the startle response can influence complex task performance or higher-order cognitive functions to the point of great impairment, and additional research to help identify how startle responses affect human behavior in this way, has been requested by many authors in the field.

Is understanding the startle response of concern when it comes to pilot selection? While a significantly startling event could be a once-in-a-lifetime happening for one pilot and others may never experience it, the potential catastrophic consequences warrant its inclusion in selection processes, if possible. Whether this is possible or not is unclear at this point and motivates research. Interestingly, early pilot selection designed in Denmark included startling candidates—a surprise gunshot was fired behind the applicant and psychophysiological responses were measured as a measure of emotional stability (Termøhlen, 1986). While a primitive test, and not designed to test specifically startle but rather emotional stability, if we consider the outcomes of aviation accidents, understanding whether different people react in different ways when under startled stress could be of enormous importance. Limited evidence is available, as most research has been conducted on the reflexive movements of the startle effect and not the cognitive effects. It has, however, been found that when startled during an anxious state, participants physically react more strongly (Grillon et al. 1993). It has also been found that individuals displaying higher neuroticism traits may be more prone to startle and its negative effects (Wilson et al., 2000, Szymura & Wodniecka, 2003). A hypothesis of how startle negatively impacts performance is that it affects working memory processing (Blumenthal, 2015), and as such, differences in working memory capacity may correlate with startled performance. Further, simulation studies show that pilots reporting higher self-efficacy in dealing with non-normal events respond more appropriately following startle events (Martin et al., 2015). At face value, it is not unreasonable to assume that different individuals may be differently equipped to deal with startling events, and these characteristics merit study.

The potential of holistic research and this thesis

These approaches—qualitative and behavioral studies—underscore that there are other lenses through which we can view the study of pilot characteristics. A holistic approach can allow for alternative insights, leading to potential improvement in selection processes. The term 'holistic' may be used differently in different circumstances—what is meant by the term throughout this thesis is the perspective of studying military pilot selection not only through the use of already established assessment tests in relation to training outcome, but by also studying the requirements for pilots in the modern day. This broader perspective is particularly valuable for identifying what selection factors are of the most predictive value in the current system, and if these are supported by current ability demands, as well as whether there are demands on ability that go unassessed. In addition, characteristics that begin to show their importance only after the selection or educational stages can be discovered more easily this way. Thus, this thesis utilizes this perspective to understand currently important selection factors in Swedish military pilot education, as well as assessing professional ability requirements for current military pilots. Selection factors are examined based on the unique system used in Sweden, as well as the aforementioned need for the reassessment of selection procedures. Professional ability requirements are studied using qualitative research with currently active pilots, and the relevance of startle response sensitivity as a selection factor is examined.

Also supporting holistic research, Hunter and Burke (1994) stated that at the time of their analysis, the predictiveness of assessment tests had decreased over the 50 years of data collection. The potential reasons for this range between the technological advancements in the aviation field, to applicants today not necessarily being the same population as had been the case in years past. "Back in those days, it was a battle just to keep the plane in the air, and now it's a technological wonder that drives itself", may be heard when speaking to the old guard in respect to planes. How solid are selection profiles based on old examinations today? Interviews, together with observational studies, could potentially elucidate this in today's profession. Behavioral studies will more clearly reveal how individuals interact with their environment under acute stress than assessment stress testing, and this information is important when it comes to improving safety in the industry. Conducting studies throughout education and the later profession can then be recursively included to improve selection criteria and make sure that selection is up to date.

Aims

Understanding how to select military pilots has been an ongoing and constant effort since the first World War. There are various approaches to exploring necessary qualities, including studies conducted at selection and educational levels among military pilots, as well as within the professional domain. Research utilizing the unique, and historically understudied, Swedish system might—in addition to reinforcing previous research—provide fresh insights in understanding characteristics of importance for military pilots.

Against this background, the main aim of this doctoral thesis is to further our understanding of military pilot selection. This is achieved by examining two key aspects: (1) characteristics necessary for completing military pilot education, and (2) the characteristics necessary for performing effectively as an active pilot.

Out of the four conducted studies, the first two approach this on: (1) the educational level (Studies I and II); and the second two from the (2) professional performance (Studies III and IV) angle.

The specific aims of the included studies are:

1. To examine the role of individual characteristics such as personality in successfully completing Swedish military pilot education, contributing to the understanding of selection criteria (Study I)
2. To examine the combined roles of personality and cognition in successfully completing Swedish military pilot education, contributing to the understanding of selection criteria (Study II)
3. To examine active pilot cadets' perceptions of the characteristics required for their profession, providing insight into professional demands (Study III)
4. To examine whether startle negatively affects cognitive performance, and whether personality and stress are related to this effect, providing insight into professional demands (Study IV)

Overview of studies

Here follows a summary of the studies in this thesis. Descriptive information is available in Table 1. Since the studies are situated in the Swedish system for the selection and education of military pilots, I will let a brief summary preface the individual studies. A more in-depth description is available in the thesis appendix, Appendix 1.

The Swedish system for the selection and education of military pilots is unique in comparison to other countries and organizations, in regard to both the selective and educational aspects. First of all, the Swedish system utilizes its own assessment measures in an in-depth selection process of great rigor. Second, the Swedish system relies on a unique pedagogical model, a major aspect of which is not giving out test grades or conducting in-education separations. This can be compared to, e.g., the USAF, which employs a progressive screening model throughout its military education program, in which candidates are assessed based on their performance at each stage of training. This ongoing screening serves as a mechanism for further refinement of the selected pool of cadets. In comparison, the Swedish system focuses on reducing in-program attrition and the development of selected cadets. This Swedish system offers unique opportunities to investigate pilot characteristics in a holistic manner. The rigorous selection process, which is meant to minimize attrition by only selecting individuals who will perform, contrasts with systems in other countries which rely on continuous performance evaluations and terminations—what could be considered ‘ongoing screening’ throughout the education. Swedish military pilot cadets can, in this way, be argued to be a closer representation of professionally active military pilots, in that the Swedish system assumes that (and assures the cadets) they will make it to become pilots. While, on the other hand, they still have limited experience of active life in a flight division, it could be argued to be a step closer to active professional life than those in an educational system in which ongoing separation might make cadets feel more like students. Together, all of this makes the Swedish system a novel context for studying the traits and abilities that contribute to military pilot success; both in education and in professional practice. By understanding how selection and education align with professional requirements, insights gained from this system can provide a fresh perspective on how to best select for pilots.

Table 1. *Description of included studies*

Study	Sample	Data collection type	Variables	Analysis method
I	182	Data registry	Education completion status, personality traits, suitability ratings	Discriminant analysis
II	182	Data registry	Education completion status, personality traits, suitability ratings, general intelligence, pilot aptitude, working memory	Logistic regression, ROC
III	10	Interviews	Cadets' perceptions of required qualities	Thematic analysis
IV	38	Laboratory	Reaction time, accuracy, biophysiological stress levels, trait personality	Repeated-measures ANOVA, linear regression

Study I—Relations of Personality Factors and Suitability Ratings to Swedish Military Pilot Education Completion

Background

In deciphering what characteristics are important for pilots, it is common to employ psychological test scores from the cadet selection processes (Martinussen & Hunter, 2017). While there has been an ongoing debate on the relative relevance of personality-based versus cognitive measures, meta-analytic research has historically suggested that cognitive abilities may be more strongly related to completing pilot education and may therefore be more important (Hunter & Burke, 1994; Martinussen, 1996). Newer efforts have, however, reinforced the relevance of trait personality in selection (Breuer et al., 2023) and suggests that it should be studied in more depth, as its inclusion can produce incremental selection validity. In addition to Swedish pilots being a relatively unstudied population, the selection process for Swedish military pilot education includes unique personality trait assessments and suitability ratings, which motivated this study.

Research Question

Do personality variables and suitability ratings relate to pilot cadets completing military pilot education?

Methods

Participants

The study was conducted based on a registry data set of 4991 applicants, provided by the Special Selection Department at the Swedish Armed Forces HR Centre. Applicants accepted for military pilot training who had records of education completion or termination between the years 2004 and 2021 were included in the study, leading to the extracted sample comprising 182 individuals (mean age =24, SD ±4.2; 96% men, 4% women) who had trained in the Swedish Air Force. Note that this is not the complete dataset of all individuals who had trained within Sweden for the time period. Of the 182

cadets, 36 did not complete their education, meaning the termination rate in this sample was 19.7%.

Materials

Commander Trait Inventory (CTI)

The CTI is a personality inventory meant to assess the responder's officer qualities (Carlstedt & Widén, 1998), since all Swedish military pilots have to acquire officer status as part of their training. The inventory has 11 scales, out of which 6 are concerned with cognitive style—the way in which the world is perceived and interacted with—and are based in Messickian-style theory and Jungian-type theory (Messick, 2021; Jung, 1971). The remaining five scales are concerned with positive and negative aspects of leadership. Scores are normalized into stanine-scores based on a 1997 population of 1176 test-takers (Carlstedt & Widén, 1998). The CTI scales and sample items are displayed in Table 2.

Table 2. *CTI Subscales, number of Items and Sample Items*

Scale	Number of items	Sample item
Sensation orientation	15	I seldom miss an opportunity that provides a challenge
Intuitive decision-making	12	I often see possibilities where others see difficulties
Concrete thinking	12	Concrete facts are the only things that matter
Abstract thinking	16	I spend quite a lot of time thinking and reflecting over different things
Superficial value orientation	14	I keep up with all new trends
Ideological value orientation	11	It is important to formulate your own ideals and to live by them
Empathy	15	I often comfort colleagues who have problems
Leader motivation	15	I am suited for leading positions
Egocentrism	14	My main purpose in life is to get as many goodies as a I can
Impulsiveness	14	I quickly lose interest in tasks that I initiate
Ethnocentrism	9	There will be problems if immigrants to a greater extent come to command Swedes

Note. CTI—Commander Trait Inventory (Carlstedt & Widén, 1998).

Psychologist-assessed traits

Licensed psychologists with extensive training and experience in assessing applicants conduct semi-structured interviews, each lasting around 90 minutes. Participants are rated on a set of personality traits, identified internally over time in the Swedish system. The following traits are included: *social ability, energy, emotional stability, maturity, leadership potential, professional motivation,* and *study forecast* (Wolgers, 2016).

Social ability involves basic socialization skills, communication, and the ability to maintain relationships. *Energy* includes drive, initiative-taking, perseverance, and stress tolerance. *Emotional stability* is concerned with impulsivity and propensity for aggressive behavior. *Maturity* encompasses responsibility, humility, reflection, and lack of prestige. *Leadership potential* covers the will to lead, teach, and develop other individuals while being a motivating and diplomatic presence. *Professional motivation* involves motivation, regarding both work in a military context and flying specifically. Finally, the *study forecast* could be called 'studiousness' and is an assessment of conscientiousness, enjoying learning, and understanding of the context of military pilot education and military work. Ratings are stanine-transformed into a 1–9 scale.

Suitability assessment

Suitability ratings are given by the psychologists during the psychologist assessment interview and comprise a single scaled number of applicant suitability. Senior pilots, having been instructed and trained for assessment, conduct their own separate interview and report their suitability rating in the same manner (Wolgers, 2016). Suitability ratings are also stanine-transformed into a 1–9 scale.

Analysis

Exploratory discriminant analysis (EDA) was used to analyze the relationship of the selection measures to the binary outcome variable of completion or termination, through attempting to establish a predictive discriminant model. Controls for EDA assumptions were carried out, including approximating the normality of distributions and controlling for correlation and multicollinearity.

Results

A significant discriminant model was produced, (Λ =0.808, [20] =32.817, *p* =.035) with a squared canonical correlation of 0.19, indicating an approximate 20% of variance explained. Significant factors were senior pilot suitability rating (factor weight (FW) =.598), energy (FW =.551), professional motivation (FW =.428), study forecast (FW =.338), leader potential (FW =.376) and psychologist suitability rating (FW =.337). The model was able to predict the original completion/termination groups with 74.1% accuracy, indicating low-to-moderate effectiveness.

Conclusion

The results indicated that the traits of being more energetic, professionally motivated, being given a good study forecast, and having high potential for leadership were associated with completing training. Also, cadets who were seen to be generally suitable by primarily senior pilots, but also by the interviewing psychologists, were more likely to complete their education rather than have their training terminated.

Study II—Cognitive and Personal Assessment in the Swedish Military Pilot Selection Process and its Impact on Education Completion

Background

In Study I, it was found that senior pilots' judgements of suitability and some of the psychologists' trait assessments were related to completing military pilot education. Historically, different tests of cognitive abilities such as attention, intelligence, and psychomotor ability have been more strongly related to educational success within aviation (Martinussen, 1996; ALMamari, 2019). To offer a more comprehensive view on factors influencing education success, this study examined the elements from Study I alongside cognitive measures from the Swedish selection process.

Research Question

How do cognitive abilities, pilot aptitude, personality traits, and expert suitability ratings relate to completion of Swedish military pilot education?

Methods

Participants

Study II relied on the same dataset as Study I, provided by the Special Selection Department at the Armed Forces HR Centre. This led to the sample used for Study II, comprised of 182 individuals (mean age =24, SD = 4.2; 96% men, 4% women) who had trained in the Swedish Air Force. Of the 182 cadets, 36 did not complete their education, meaning the termination rate was 19.7%.

Materials

Pilot aptitude

Several cognitive tests are utilized to test for applicant suitability—a test battery and two separate cognitive tests. Firstly, the test battery consists of six tests from the PilApt test battery (Kokorian, 2015), with the addition of three additional subtests provided by the RNoAF. The included tests measure the previously

observed significant pilot-relevant domains of psychomotor ability, spatial ability, information processing and attention in different ways. The pilot aptitude battery is displayed in Table 3.

Test scores were aggregated into categories of cognitive ability, based on previous research (ALMamari, 2019). This yielded cognitive performance scores on the categories of perceptual processing, motor abilities, and controlled attention. Patterns, hands, planes, and number tests were grouped as perceptual processing; deviation and trax were grouped as motor abilities; and concentration, capacity, and attention were grouped as controlled attention.

Table 3. *Pilot Aptitude Subtests, Origins, and Their Attributes*

Test	Origin	Attributes
Deviation	PilApt	Psychomotor, tracking
Pattern	PilApt	Spatial perception, selective attention
Hands	PilApt	Spatial perception, information processing
Concentration	PilApt	Information processing, divided attention
Capacity	PilApt	Divided attention, psychomotor, tracking
Trax	PilApt	Psychomotor, tracking
Planes	RNoAF	Spatial perception, psychomotor
Numbers	RNoAF	Perceptual speed, tracking
Attention	RNoAF	Information processing

Note. PilApt—Pilot aptitude battery tests (Kokorian, 2015). RNoAF—Royal Norwegian Air Force tests.

General intelligence

The Militära högskoleprovet (MHS) is a general intelligence test, carried out to make sure that applicants are of officer quality (Carlstedt & Widén, 1999). The test is normalized against the officer applicant population of 1998 and is designed to measure g via three subtests measuring spatial, inductive, and verbal ability. Spatial ability is measured through a number of shape-, geometric rotational-, and pattern-recognizing tasks. Inductive reasoning is measured by tasks concerned with things like rule-finding, number series, and finding common elements. Verbal intelligence is measured by word knowledge tests and association tests. The tasks used for establishing a general intelligence score and

the spatial, inductive, and verbal intelligence subtypes have been extensively studied through factor analysis (Carlstedt & Widén, 1999).

Working memory

Simultaneous capacity (SIMKAP) test and The Paced Auditory Serial Addition Test (PASAT) are tests designed to assess working memory and sustained as well as divided attention under pressure (Bratfisch & Hagman, 2008; Groenwall, 1977). Both tests are considered stress tests of working memory capacity.

Psychologist-assessed traits

The traits observed as significant in Study I, energy, professional motivation, study forecast, and leadership potential were aggregated into a grouped psychologist assessment variable for Study II.

Suitability assessment

As in Study I, suitability ratings given by the interviewing psychologists and senior pilots based on their understanding of the individual, were used. All scores were rated on a scale of 1–9.

Analysis

Descriptive statistics were calculated and logistic regression modeling was used to assess the relationship between pilot aptitude, general intelligence, working memory, personality traits, and suitability ratings to education completion. Post-hoc ROC analysis was conducted to assess whether significant variables were more predictive under any specific segment of the scoring interval.

Results

Mean test scores on cognitive factors were similar across completion and termination groups. Logistic regression modeling (Chi^2 =19.396, df =5, p =.02) revealed that only senior pilot suitability ratings were significantly related to completing pilot education (p =.025). G, perceptual processing, motor abilities, controlled attention, and working memory tests were all insignificant. Post-hoc ROC analysis indicated that senior pilot ratings are particularly sensitive when it comes to termination, with predictive power being concentrated in the lower scores.

Conclusion

Cognitive test scores do not appear to be able to predict the outcome of the Swedish military pilot education. Senior pilots' judgements of whether the cadet has a suitable personality is related to education outcome, and they appear to be better at identifying potential dropouts than identifying successful cadets.

Study III—Pilots profiling piloting—What do military aviation cadets believe is important for piloting?

Background

While the majority of research on pilot characteristics has been conducted in relation to selection (Martinussen, 2016), there might be much to gain from considering other perspectives—researchers have suggested that factors other than assessment tests scores may be more relevant in predicting long-term professional performance (Martinussen & Hunter, 2017). Utilizing the perspective and input of active pilots, studies such as job analysis (Goeters et al., 2004; Harlem, 2016) have helped rank the order of importance of different skills and requirements. It is possible that the lived experiences of active pilots and pilot cadets are an untapped font of insight into professional requirements for aviation in general, motivating this qualitative study.

Research Question

What qualities do active Swedish military pilot cadets believe are the most important for being a military pilot?

Method

Participants

The study was based on interviews conducted with 10 male cadets active in the military pilot education at the Flying Training School at time of interviewing.

Material

The interviews were semi-structured and were conducted during a broader qualitative examination of cadet experiences, ordered by the Air Force. Study III focused on material produced under the question of “What do you believe is what it takes to be a military pilot?” and subsequent follow-up questions.

Analysis

Data were transcribed verbatim. Reflexive thematic analysis was used as the approach for the study, informed by the suggested phases of Braun and Clarke (Braun & Clarke, 2006). Initially, familiarization with the data was established by reading and re-reading the transcripts while re-listening to the audio recordings of the interviews, while taking general notes on the individual transcripts. Material from the larger interviews relevant to the research question was extracted. General coding of the content was then conducted before the coded content was used to produce initial themes. The coding process was inductive, not constraining interpretation to any pre-existing theoretical framework. A research journal was kept during analysis. Themes were identified based on their recurrence across multiple participants, as well as their relevance to the research question. Because of the limited number of interviews and the amount of data from each interviewee, a reflexive weighing of representing broad patterns as well as valuing individual voices was attempted. Unique or critical insights that provided depth were considered, even those with a less patterned presence. The initial themes were then reviewed, reconsidered, discussed between the authors ,and further reviewed and redefined before the final reporting.

Results

The thematic analysis produced four main themes: ‘being a team player’, ‘having drive’, ‘being stress-tolerant’ and ‘being in good shape’. Subthemes brought out underlying aspects, such as that teamwork was bound by cooperative spirit, humility, and social skills, where team spirit is valued based on collaboration and support being necessary throughout education and professional life. The willpower and desire to improve were sub-thematic aspects of drive; while being calm, dealing with pressure and being able to adapt is what embodies stress tolerance. Being in good shape was divided into the profession being physically demanding but not demanding superhuman performance.

Conclusion

Swedish military pilot cadets believe that having qualities such as team spirit, personal drive, stress resilience, and physical fitness are of primary importance when it comes to being a pilot in the Swedish military.

Study IV—The Relationship of Neuroticism to Physiological and Behavioral Stress Responses Induced by Auditory Startle

Background

Sudden and intense events can cause startle, a protective stress response (Koch, 1999). In cases of severe threat, the response can become exacerbated (LeDoux, 2000) and has been found to be the cause in a number of catastrophic aviation accidents (Martin et al., 2015). While the reflexive movements of being startled are well studied (Davis, 1984; Dawson et al., 1993; Wilson et al., 2000), exactly how the stress response affects human performance is not well understood. Understanding the performance effects following startling events, and whether personal characteristics affect how individuals react, could be useful in understanding how to select and train pilots—this motivated Study IV. Neuroticism was proposed as a factor worth examination, based on findings that neurotic individuals move more when startled (Wilson et al., 2000), and tend to be more bothered by interruptions (Szymura & Wodniecka, 2003).

Research Question(s)

1. Do unpredictable startling acoustic stimuli affect performance on a simple choice reaction time (CRT) task and physiological stress responses?

    a. If so, does this effect persist over time?

2. Is there a relationship between startle-affected performance, neuroticism, and stress responses?

Method

Participants

The sample consisted of 38 participants (16 male, 22 female), who were university students and recruited on campus. Participants mean age was 27 (SD =6.9).

Material

Physiological stress response
Electrocardiographical (ECG) and skin conductance response (SCR) measurements were used to assess physiological stress during testing. The modules used were developed by BioPac and data were managed using AckKnowledge software.

Personality
Neuroticism was assessed using the Mini-IPIP (Donellan et al., 2006), a 20-item short-form survey of the International Personality Item Pool (Goldberg, 1999).

Procedure

Participants conducted a choice reaction time (CRT) task, which consisted of deciding in which of four possible target areas on a computer screen a target appeared (Deary-Liewald, 2011). The CRT task was repeated for 300 trials over 3 blocks, for a total of 900 trials. One second passed between each trial, and there was a 2500ms window to respond to an appearing target on the screen. A startling stimulus of 105db of white noise was occasionally deployed 300ms before an upcoming trial, in quasi-randomized order. A total of 12 startling stimuli were presented for every participant. Participants were told to ignore any sounds and solely focus on the task at hand.

Analysis

Trials were divided into three types: standard trials, startle trials (trials accompanying the startling stimuli) and post-startle trials (trials one step removed from a startling stimuli). Repeated measures ANOVA for test block and trial type were carried out for both accuracy and reaction times. ANOVA was also used to assess physiological stress responses following startling stimuli and for the duration of participation. Finally, linear multiple regression was used to

examine the relationships between performance, stress response, and neuroticism.

Results

ANOVA results indicated that the type of trial affected reaction time (Wilks's Lambda =.794, F(2, 36) =4.676, p =.016, ηp^2 =.093,), which was confirmed post-hoc to be a significant difference between standard- and post-startle trials (t(37) = −2.667, p =.011).

There was no significant effect of trial type on accuracy (Wilks's Lambda =.955, F(2, 36) =847, p >.05, ηp^2 =.091), suggesting similar accuracy for the different trial types.

Startle-induced stress as measured by both SCR and HR-based measures: SCR when startled was significantly higher than spontaneous fluctuations (t(29) = −5.96, p <.00) and heart rate went up (t(32) = −2.135, p =.041.). ANOVA indicated that stress, as measured by SCR, decreased over time (Wilks's Lambda =.643, F(2, 28) =7.782, p =.002, ηp^2 = .304), while HRV did not improve and remained heightened (Wilks's Lambda = .867, F(2, 30) =2.305, p >.05, ηp^2 =.066).

Regression analysis over the individual levels of reaction time degradation versus both types of stress measure and trait neuroticism did not display any prediction from the variables (F(3, 22) =1.550, p >.05.

Conclusion

The results showed that participants appear to be equally affected by startle, independent of personality and/or levels of stress. Participants were significantly slower following startle, but they did not make more mistakes. The effect was not instantaneous but rather delayed due to processing time. Participants displayed stress responses, but these were unrelated to the level of effect on reaction time, as was neuroticism.

Discussion

The overarching aim of this thesis was to further the understanding of military pilot selection through the lenses of factors involved in educational completion as well as required professional abilities. The main findings can be summarized as follows:

Being energetic, professionally motivated, studious, and having leadership potential is associated with success in the Swedish military pilot education. Being judged to have a suitable personality by a senior pilot is the factor most strongly related to completion. Pilot aptitude tests and other cognitive measures appear to not be related to success in the Swedish system (Studies I and II).

Active Swedish pilot cadets value being a team player, having drive, being stress-tolerant, and being in good physical form as professional abilities (Study III).

Startling events, carried out on a student sample in a controlled laboratory setting, negatively affects basic cognitive tasks. This is unrelated to personality and individual stress levels, providing initial insights about the professional ability requirement to deal with this kind of stress (Study IV).

In the following sections, the results of the studies are discussed, together with methodological considerations and suggestions for future research.

Characteristics for completing education (Studies I and II)

Study I found that some of the personality traits measured by the Special Selection Department relate to completing Swedish military aviation education. In addition, senior pilot suitability assessments were the strongest predictor, in what seems to be the first observance of this trend thus far. While some recent aviation studies have studied ratings from senior officers, these have mainly been in regard to active performance ratings post-admission (Barron et al., 2016; Skoglund et al., 2021). Selection interviews are commonly carried out when selecting pilot candidates (Broach & Schroeder, 2019; Eaglestone et al., 2022), although their validity and documentation have been questioned (Walters et al., 1993; Broach & Schroeder, 2019). In some studies, it is not completely clear what the exact qualifications of the interviewers are—whether they are an officer, psychologist, pilot, or something else. In any case, this finding of senior

pilot suitability judgements being the strongest predictor appears to be unique so far, and highlights senior pilots' proficiency in understanding the demands and expectations of pilot students. These findings are in line with the importance of interviews according to Sacket et al. (2022; 2023).

On the other hand, the Commander Trait Inventory, measuring traits related to an individual's suitability in becoming a military officer, did not relate to success. It is important to realize that the insignificance of this, or any variable in the analysis, does not necessarily signify the insignificance of its use in selection—this may simply indicate the utility of this instrument is located in the screening stage of selection. Indeed, it is possible that that as long as an applicant is suitably officer-like, it doesn't matter whether they have more of those qualities. However, this contrasts somewhat with the ideas of Retzlaff and Gibertini (1987), who suggest that a general suitability for military life and the role in particular is of importance for military pilots.

The personality traits relevant to success were energy, professional motivation, study forecast, and leader potential. For these traits, there is extensive conceptual overlap with previous findings carried out within the FFM. Indeed, 'energy' is defined as encompassing initiative, perseverance, and stress tolerance, and could be argued to be similar to the low neuroticism and high conscientiousness traits that have been observed in successful pilots in American studies (Campbell et al., 2009; King et al., 2012). Professional motivation, defined as the motivation to fly and the motivation to work in a military context, also relates to the goal-orientedness and perseverance of conscientious individuals (Campbell et al., 2009), and to successful military pilot cadets generally being highly motivated (Walsh et al., 2017). Of primary interest among insignificant trait measures may be emotional stability, as this has been a predictor for pilots historically (Breuer et al., 2023). The primary explanation for this remains restriction of range: no outliers of high instability participants are even admitted to pilot education, based on the selection process, as can be seen in the similar group trait distributions (see Study I).

While these connections are purely speculative at this point and would require a separate, large-scale correlative study to establish the level of congruity, there is a conceptual overlap that should be considered of interest to the research field and merits further examination.

The decreased reliability of trait personality as a predictor when aggregated from Study I to Study II suggests that its predictive strength may be weaker than

initially assumed based on the results of Study I. While the relational aspect of the traits and psychology assessment being used in discriminant analysis may be brought up as a potential reason for these results, it should be noted that multicollinearity between these variables was pre-assessed and found to be nonproblematic (See full Study I for details) and general correlation levels were ranging within strong but acceptable levels, and therefore I argue that the methodology should not be considered the issue, but rather the strength of the predictors. However, there is a variance in SD for the trait aggregate variable between cadets who completed their training and those who were terminated, indicating that some value might have been lost in aggregation. Further research should examine these traits separately.

Together, the results of Studies I and II stand in some contrast to general findings on selection assessment scores and education outcome: different ways of measuring cognitive abilities are generally significant predictors of pilot education success (Martinussen, 1998; King et al., 2013; ALMamari, 2019), and most of the time are also more significant than personality measures (Hunter & Burke, 1994; Martinussen, 1996). With perhaps the exception of general intelligence, which has a predictive strength that can prove spurious (Martinussen, 1996), this may be considered a surprising finding. Neither perceptual processing, motor abilities, nor attention—all essential abilities in piloting—were predictive of completing pilot education in Sweden. The current results' failure to confirm previous research does not contradict it—there are two reasonable explanations at hand to explain these findings. First, if the rigor of the Swedish military pilot selection process only selects a very similar top percentage of applicants, this would imply a restriction of range. Then, the primary explanatory pathway is that the population is so highly selected that failure to complete training is unlikely to occur purely based on an inability to progress based on cognitive faculties. This is a preliminarily reasonable explanation, as Study II shows a near perfect convergence of means and standard deviations of cognitive test scores across completion and termination groups. A secondary explanatory factor may lie in the Swedish educational system. Since the Swedish model is to not post open test scores and, if possible, not carry out in-term separations based on failures, it is not unlikely that difficulties in advancing due to cognitive faculties may be ameliorated by the grace allowed by this pedagogical model. This assumption is purely speculative at this point however and would require further research.

Qualities according to pilot cadets (Study III)

The results from the interview study (Study III) indicate that, according to Swedish cadets, teamwork, personal drive, stress tolerance, and physical fitness are the most important requirements for being a military pilot. Even with the study being an early foray into the experiences in the Swedish system, the observed themes may nonetheless be argued to conceptually overlap with both the findings from Study I, and to previously established personality profiling according to the FFM. Indeed, if we observe the themes of being a team player, having drive, and being stress-resilient, it is easy to draw lines to the observed traits of Study I. Teamwork, being valued by active cadets—particularly the cooperative spirit and social skills requirements—overlaps with the leadership potential trait from Study I, as leader potential is defined as will to lead, teach, and develop other individuals while being diplomatic and motivating. This is in line with the findings of previous research that identifies extroversion (Campbell, 2009) as being related to educational outcomes. Drive, with its subthemes of willpower and desire to improve, can be related to conscientiousness being a significant predictor of pilot training (Breuer et al., 2023), as well as the Swedish model trait of energy, encompassing the concepts of drive and perseverance. The reported importance of stress tolerance can be related to the fact that the most frequently reported FFM factor affecting piloting outcomes is neuroticism (negatively), and that highly conscientious individuals are more successful (Breuer et al., 2023). For the findings in Study I, this also relates to the trait of energy, which also encompasses perseverance and stress tolerance.

This conceptual overlap between what pilot cadets identify as important, according to their lived experience, and the findings of our data study assessment is interesting. Applicants are not informed of the trait framework on which the interview questions are based during selection, nor about which traits are preferable for candidates. Even so, after becoming active pilot cadets, they start valuing the traits upon which their admittance was based. While a preliminary finding at this stage, cadets experiencing the selection traits as being important in their professional life may be taken as being supportive of the traits used in the Swedish model. It is, however, worth noting that this could also reflect cadets' learning regarding what is expected of them during education, whether consciously or subconsciously, from exposure to educational culture.

Startle response and individual characteristics (Study IV)

Study IV found that that task performance—reaction time—was impaired by startling stimuli, while none of the individual markers such as physiological stress levels or trait neuroticism were related to the level of performance effect. Accordingly, it appears that being startled affected participants similarly, independent of individual variations. This is an important finding, as if this can be confirmed in future research, it would enable us to say that startle is of no concern when selecting for military pilots or piloting in general. However, the findings related to this in this thesis must be considered to be both early and preliminary. The current results were obtained in a laboratory environment with a highly artificial task of low cognitive demand. The studied sample were also not clearly representative of pilots, being university students—although some similarities, such as age range and being enrolled in higher level education, are present. The small significant delayed-onset negative effect on reaction time that was observed with the utilized setup is informative regarding startle effects on base cognition, while not being directly applicable in the aviation setting at this time. While it is the same startle pathway that has been studied in the lab as that is triggered in real-life threatening situations, the level of threat carries the cascading of the stress reaction (LeDoux, 2000). Indeed, current research on what exacerbates startle response into severe effects includes perceived threat and self-efficacy in dealing with issues (Martin et al., 2015). Momentarily hearing a frightening sound in front of a computer screen cannot be compared to the experience of a stressed pilot in flight. The natural line of further research into this, in order to arrive at ecologically applicable knowledge, would be to first conduct further laboratory behavioral studies on more demanding tasks, such as the study recently undertaken by Deniel et al. (2024), which examined startled performance on a more memory-intensive n-back task. Once cognition under pressure in relation to startle is better understood, addition of ecological assessment in simulated or real scenarios which can induce more realistic stress responses would follow as the logical next step. Current startle research suggests that beyond individual propensity for stress reaction, self-efficacy in the situation where an individual is startled can affect recovery and enforce correct behavior (Martin et al., 2015; Martin et al., 2016), and including measures of this in a simulated study will be of importance.

Implications for selection

Personality traits and senior pilot suitability assessments are predictors of cadet potential and provide valuable insight for pilot selection in general. The potential for the senior pilot assessment method is highlighted, and it may be possible to add incremental validity to selection processes by including this. In general job selection research, structured interviews—a method conceptually akin to the senior pilot judgements studied here—have been shown in recently re-worked meta-analyses to offer greater predictive value than previously stated (Sackett et al., 2022; Sackett et al., 2023) This suggests that that expert-based qualitative evaluations, such as those conducted by the senior pilots, could meaningfully complement existing selection tools. Greater integration of this kind of assessments into pilot selection systems that do not already rely on such, and refinement of such assessments where they are already in use, could improve selection.

The findings regarding energy, professional motivation, study forecast, and leadership potential are important on their own, but also reinforce established personality profiling work done under the FFM, although complementary research would be beneficial. Notably, these traits also conceptually overlap with the professional abilities identified as critical by active cadets in the interview study. This alignment may be interpreted as a sign of validity: the traits that predict educational success appear to resonate with what is valued in the professional domain by cadets. However, it is also possible that cadets' views reflect a process of cultural learning upon beginning their education, based on the unique setting of the Swedish educational model. Future research could explore this.

The absence of significant cognitive predictors in the Swedish system, while not indicating any unimportance of cognition in general, poses interesting implications for selection. While cognitive abilities are well-established as reliable predictors globally (Hunter & Burke, 1994; Martinussen, 1996), the Swedish system, effective truncation of the range of scores through their rigorous selection process could be taken to suggest that these predictors may be less effective in highly selective contexts; this restricted range could mask the predictive value of cognitive abilities. However, if the selected population consistently meets this high threshold, does this limitation matter? Specifically, if all candidates possess sufficient cognitive ability, gains in educational success prediction based on cognitive ability may be marginal. This could be allowing

other abilities such as personality, stress tolerance, or social skills to play more of a role in differentiating successful cadets—it is possibly these traditionally less-valued predictors would be more informative in other educational models as well, provided that cognitive scores were high enough. Again, this does not negate the importance of cognition as a foundational requirement; all previous research indicates that these abilities are essential for success. However, not finding any relationships in our study indicates that there is likely a ceiling effect to cognition—once you're good enough, you're good enough. The findings highlight the importance of tailoring the selection system to the specific population and goals of the educational program—this insight may be less applicable in systems that conduct less rigorous initial assessments and run ongoing screening throughout the education.

It is important to note that while factors—such as those observed in this research—may be significant predictors of success even after they have served their purpose in selection may be informative, it is also a complex topic. A variable such as motivation or energy being a significant predictor of completion in the admitted sample could be interpreted to mean that it is an important quality in a successful pilot. It could also indicate that the variable may be more important than it is currently considered to be in the Swedish selection process. If it is important, could retention of students be improved if it is given more weight in selection? At the same time, the selection phase may be considered to have the main purpose of deselecting or screening those who will definitively not pass training, rather than selecting only those that will make it through 100% of the time. Until the hypothetical point in which the profile of a successful pilot is absolutely complete, overly stringent selection will reduce the number of educated pilots. The fact that observed variables are indefinite predictors of educational outcome does not necessarily translate easily into adjusting selection cutoffs. Indeed, this is particularly the case for the Swedish model, granted that it aims to make sure all admitted students pass training. While not being able to directly adjust selection processes based on this, the findings of this thesis could be the basis for beginning further internal evaluation at the Special Selection Department. When evaluating military pilot selection, and selection processes in general, it is important, however, to maintain a realistic expectation with regards to the predictability of success. While some level of predictive validity is crucial, no system will be able to account for every factor influencing training outcome or long-term professional performance—a significant portion of the explained variance may lie beyond the reach of selection tools. It is hard or even impossible to account for how cadets' lives may be affected by personal circumstances, health issues, or other external factors. Even if some of the value of personality as an assessment may be argued to relate to how different individuals will deal with such happenings throughout their professional lives, some events will fall outside this scope. Contextual factors such as variations in educational quality, leadership, or group dynamics in education can also be feasibly imagined to influence outcomes.

Limitations

The work in the current thesis takes a wide approach and initiates research branchingly: the startle study provides an initial steppingstone for further examinations of this matter, while the selection registry and interview studies comprise early forays into Swedish military pilot education that can now be set in relationship to international counterparts. With this being said, the studies of the current thesis work do suffer some limitations, some of which were just mentioned—this initial endeavor is not as narrowly focused, and therefore provides less directly actionable information. This is by no means a bad thing, but it is the other side of that particular coin.

For Studies I, II and IV, some methodological limitations may be considered. Both Study I and Study II rely on the same sample of 182 participants, with the termination group only making up 20% of the sample. Uneven groupings are undesirable, as they limit statistical power and can interfere with methodology. While this might raise concerns and should be rectified in additional research to ensure robustness and generalizability (if possible), the current studies' sampling can be argued to be sound, based on the similarity of variable profiles between completion and termination groups, for both mean values and standard deviations. While it is possible that differences between completion and termination groups may be missed based on the small number of terminations, both groups being so close in test scores is in line with what could be argued to be expected based on the selection processes. Of concern is also that the data are concerned with all types of military piloting tracks—helicopter, transport, and fighter pilots. This should be taken into consideration, given the different requirements for fighter pilots and transport pilots—transport pilots' cognitive demands are closer to those of commercial airline pilots than to fighters (Glicksohn & Naor-Ziv, 2016), who must be considered to have a unique profile of requirements (e.g., Harlem, 2016). Helicopter pilots are also argued to have more of a specific type than other pilots (Dickens & Farrel, 2019). It is possible that by grouping cadets into general military piloting, this thesis misses some nuances, however the number of individuals terminating their training is already so small that this manner of analysis has not been possible. Individual appropriateness for the different tracks is considered by the commissions in the late admission stages of the Swedish selection process—it is then interesting that the studied group is still so heterogenous in regard to mean values and deviations.

Some validity concerns regarding the assessment variables in the registry studies also need to be discussed. The operationalization of the psychologist-assessed characteristics as 'traits' is not entirely without limitations. While traits are traditionally understood to be stable, enduring qualities of individuals, it is not completely out of place to suggest that psychologist assessments can be considered measures of an individuals' current attitudes rather than lasting characteristics. This is particularly relevant for professional motivation, which is not classically considered a trait. It would have been interesting to see data on cadets' type of motivation according to typical theories such as internal and external motivation (Ryan & Deci, 2000). However, the definition of these psychologist assessed 'traits', as discussed in Study I, reflect lasting characteristics. Further research will want to consider examining the overlap between FFM and the psychologist assessments in the Swedish model, and its categorization may merit reconsideration. I argue that for the purposes of this initial foray, such an operationalization is still useful for understanding the data at hand.

Study IV could also have benefitted from a larger sample size, and from the studied sample consisting of pilot cadets or similar individuals. Although the major point of the debate remains the startling stimuli and their frequency; limiting the startling stimuli to 12 exposures was decided in order to minimize habituation to, and the expectation of, the startles. Statistically, limiting the exposure condition to 1.3% of the base condition is not praxis, and does allow for fluctuations in means and standard deviations that could even out with significantly more trials. In the current study, this was weighed against keeping the stimuli novel. Future research will want to try to further counterbalance both sides.

In qualitative interview studies, it is common practice to utilize multiple coders to ensure reliability and to minimize bias in the interpretation of the data, ensuring balanced analysis in the case of thematic analysis. For Study III, this was foregone for practical reasons.

Future research

As recently mentioned, I believe that ecologically valid assessment of stress reactions and startle reflexes are required if we are to understand this phenomenon in any practical way. Startle research has been concerned with what abilities are affected and for how. Study IV was a good starting point, but

conducting a study with startle paradigms for pilot students or active military pilots would be informative in an ecological sense, compared to studying students or other non-pilot populations. The natural line of inquiry would be another laboratory study with a more demanding cognitive test—such as has been studied by Deniel et al. (2024)—as well as including a more stressful startling stimulus. After establishing effects under higher demand but in a relatively safe scenario, I would like the opportunity to study startle in simulated flight with pilot cadets or active pilots. Since startle in simulated tasks has already been found to significantly impair pilot performance (Martin et al., 2016), simulated tasks supported by roleplay, to ensure maximal realism, may be the closest we can get to ethically studying startle in an ecological manner. In this way, stress levels and performance could be studied in relation to the extensive cognitive assessment tests from the selection, perhaps providing clear elucidation on whether, e.g., working memory has a protective effect when it comes to recovering from startle (Espenan, 2020; Deniel et al., 2024), or if self-efficacy or other more personal characteristics are relevant (Martin et al., 2015).

On the educational level, where enforcing strict ecological validity may be considered less important, I believe that the aim of future research should be to study longitudinal data, if possible, to build on the current findings. I would like to highlight again that simply studying who is successful as a cadet disregards the whole of the professional life of pilots post-education. There may very well be something in what was suggested by Sells (1955, 1956), in that cognition may be more relevant for education, and personality may be more pertinent in assessing ongoing professional performance, as also mentioned by Martinussen & Hunter (2017) more recently. A longitudinal perspective would account for this, in addition to potentially solving some other methodological issues. This was impossible to carry out for the work in this dissertation because of the strict levels of secrecy around active military pilots in the Swedish system. Had it been possible, I believe that being able to follow pilots over time, based on selection assessments, psychologist follow ups during active duty, work performance measures, and eventual retirement data would yield a much clearer picture of the impact of different factors over a long-term perspective. I would encourage future research endeavors to attempt longitudinal approaches, although this may not be feasible in the Swedish system.

However, an interactionist or holistic perspective would suggest that even if we are able to carry out better, longitudinal statistical analysis, these analyses could still be lacking specificity and context. In the real world, situations and

contextual factors arise for some people and not for others. With enough of a sample and enough included factors, this may be minimized, but I would argue that it will be hard to capture the complete, living picture. In this way, purely quantitative methods may not be appropriate for fully understanding dropout rates, completion of military pilot educations, or long-term professional aviator performance, and there may be much to learn from conducting more targeted qualitative studies.

Conclusion

This thesis work has produced insights about selection that can be added to the existing body of knowledge which may act as steppingstones for further endeavors. Important selection factors in the Swedish military pilot education were identified, including the personality traits of energy, motivation, leadership, and studiousness, which mirror findings of a similar nature in other populations (Campbell et al., 2009; Breuer et al., 2023). Active Swedish pilot cadets expressed the importance of conceptually overlapping traits in their own words, identifying important professional qualities and adding validity to the idea of their importance in selection. It was found that senior pilots were good judges of character for Swedish cadets, particularly in identifying potential dropouts—this is supportive of the use of expert judgements in selection as well as following most recent research identifying interviews as important in general job selection (Sacket et al., 2023). Instead of overlapping with established research, it was found that cognitive measures were not predictive in the Swedish military pilot education. This does not indicate the unimportance of such measures, and the results could be dependent on a number of things. Whether this reflects a restriction of range because of the rigorous selection process or cognitive measures being less important in the Swedish pedagogical model will remain a question for future research to examine. However, it can be argued to be the first indication of a ceiling effect in the use of cognitive factors for military pilot selection. In sum, these findings of this thesis provide a basis for a number of important selection factors, and the insight that selection factor importance may vary based on selection model and educational approach. While preliminary, obtaining these findings in assessment testing but also seeing them confirmed in the study of professional requirements suggests importance.

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It's many years ago now, nearer to a decade than not, that I decided to challenge my comfort zone and consider a masters thesis in cooperation with the Lund University School of Aviation. I did not know much about aviation psychology or even aviation in general. If someone had told me at that point that not only would I continue on to develop both a personal and scientific interest in aviation psychology and military aviation, getting the privilege to continue on to this PhD, but also that my supervisors from that thesis would remain my supervisors and become valued mentors and friends – I do not think I would believe it. But here we are, it did happen and I'm so very thankful for it.

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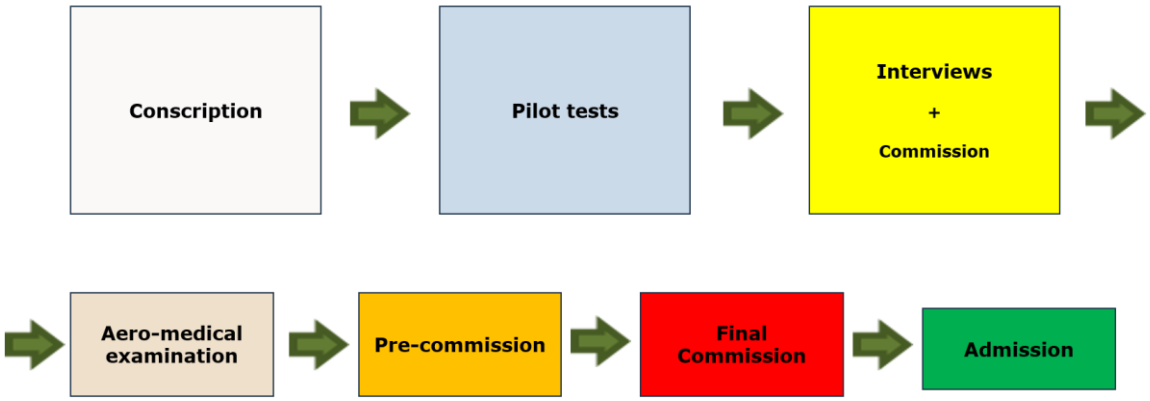
Appendix

Selection in the Swedish system

Figure 1. *Selection of military pilot applicants*



Note. Each selection phase is conducted on a separate day.

The Swedish military pilot selection process is a multi-phase process that is conducted over several separate days, designed to continuously screen for the most qualified candidates. It includes conscription testing, pilot tests, interviews, medical examination, and commisionary sessions, culminating in admission for a select few.

Using numbers from a sample year, the process may begin with approximately 4700 applicants having shown interest in applying for military pilot education and having to pass conscription testing. Despite the term, in Sweden this involves voluntary testing for entry into the military's basic education program, (*Grundläggande militärutbildning*, GMU), which is a prerequisite for officer education and pilot training. During this phase, applicants undergo standard medical examinations, physical fitness tests, are subject to psychologist interviews, and have to take a national aptitude test for conscripts (I-prov, Carlstedt & Annell, 2010). Out of 4700, only around 300 participants will score high enough on intelligence and the other tests to be allowed to proceed to pilot testing. The pilot tests phase includes a more advanced intelligence test, the *Militära Högskoleprovet* (MHS), developed for officer-level candidates (Carlstedt & Widén, 1999), as well as a personality inventory—the Commander

Trait Inventory (Carlstedt & Widén, 1998). Furthermore, informed by the knowledge of important abilities such as spatial ability, psychomotorics, and working memory, a battery of pilot aptitude tests is also administered. Out of 300 tested, around 90 meet the cutoffs and proceed to the interview day of testing. Here, psychologists and senior pilots conduct separate interviews to assess each candidate's potential, assigning a suitability rating based on their evaluations. The psychologists also assign applicants scores on an internally developed personality trait system.

In the final stage, the final commission, the selected and ranked participants are divided into the flying tracks of transport-, fighter-, or helicopter pilots based on the scores, requirements for that year, as well as the applicants' wishes. In this sample year, 22 candidates were selected as cadets.

Education in the Swedish system

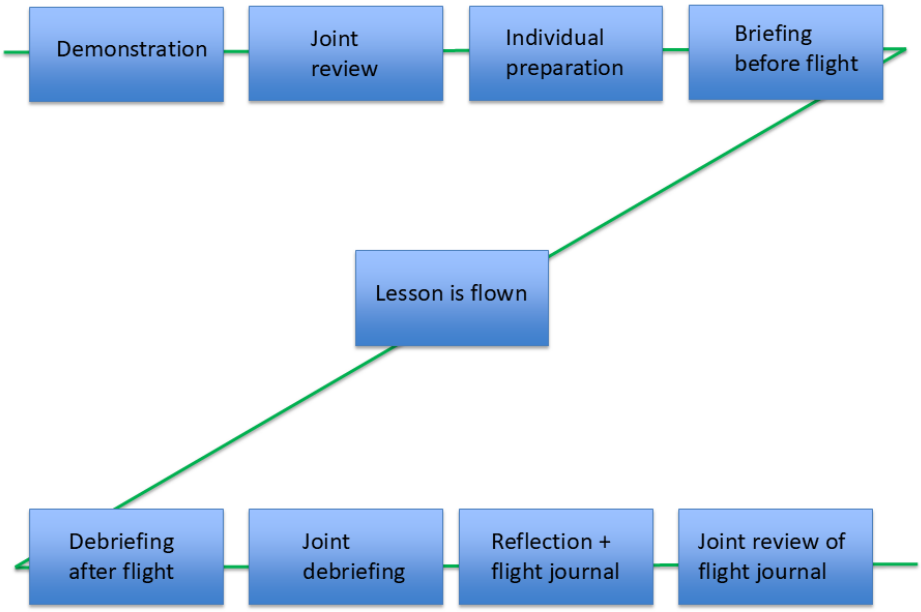
All Swedish military pilots must be army officers, which means that most begin their time by spending two years at the officer education at Karlberg military college in Stockholm, Sweden. This would be the case unless the applicant has already completed or began officer education at the time of application. The primary aviation training is then carried out at the Flight School, the primary flight school of the Air Force, organized under the Air Warfare Centre. Fighter pilots will then complete their education out in active flight divisions, helicopter pilots participate in further education at the German army flight school of Bückeburg, and transport pilots complete their education with the US Navy.

The Swedish military pilot education challenges the traditional military education hallmarks of strong hierarchy and authoritarian leadership. The pedagogical model aims for student-centered learning with a collegial relationship between students and teachers (Flygskolan, 2011). This is based on Brunerian notions of motivation in learning (Ozdem-Yilmaz & Bilican, 2020). The pedagogical approach suggests that learning occurs primarily via student initiative and that this can be helped by fostering curiosity and reciprocity between students and teachers, while providing appropriate levels of challenge. In addition, a particularly developed pedagogical layout to teaching is relied upon throughout the education: the Z model (Figure 2).

A primary part of the Z model brings with it another major deviation from other pilot educations and education in general: Swedish military pilot education does

not give out open grades on lessons or course segments. This relates back to the selection goal of stringently selecting cadets who are expected to complete training: if cadets are expected to have a good chance of completing training and there is a desire to foster a student-initiated learning, the threat of separation becomes primarily a detriment, a distraction. (Flygskolan, 2011). As such, no open grades are given. However, students are given clear summaries and verbal feedback on the outcomes of training during the stages of the Z model lessons. Swedish Flight School teachers argue that the connection between occasional educational performance and final educational grading is very weak: performance on individual flight training sessions can vary depending on how a student is feeling on one day, chemistry with the day's teacher, or their natural skill at the particular aspect being trained on the current day. Based on this, they're supportive of the grade-less system that encourages student engagement and learning rather than trying to keep grades up in order to not be terminated (Swedish Armed Forces, 2022).

Figure 2. *The Z model for education.*



Note. Adapted from Flygskolan (2011).