Performance Factors Associated with a Penalty Scoring System as used at the Precision World Flying Championships

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MBChB (Pretoria) BSc.Honns Aerospace Medicine (Pretoria)

Submitted in partial fulfilment of the requirements for the award of degree of

MASTERS OF SCIENCE

(With specialization in Aerospace Medicine)

in the

Faculty of Medicine

School of Health Systems and Public Health

University of Pretoria

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Abstract

The performance of pilots in the aerospace environment is a critical factor in the success of modern air and space travel. Various methods of evaluating performances of pilots have been implemented and the search for improved means of evaluation is an ongoing process. Multiple factors influencing performance have been identified in the past.

However, as the demands on the pilot's performances varies with changing technology, so does the need to identify new risk factors, as well as ranking old and new factors in order of effect on performance.

Aim

The descriptive study aims to identify and rank risk factors affecting the performance of pilots as assessed by the Penalty Scoring System at a Precision World Flying Championship.

Methods and materials

Pilots participating at the 2008 World Precision Championship in Ried-Kircheim in Austria were requested to complete questionnaires regarding possible factors that could affect performance stress factors. Each questionnaire required the subject to answer 14 questions, relating to 17 possible factors. These questionnaires were linked to the participant's individual score as per the official competition results.

Results

Out of a total number (n = 178) of pilot performances during a week period, 88 % (n=157) completed questionnaires. Only 57% (n=89) of these performances were included in the study, due to administrative difficulties preventing the accurate linking of performances to penalty scores. Out of the 17 possible risk factors, 4 factors (23 %) were identified as being significantly associated with the Penalty Scoring System.

Age proved the most consistent factor, the younger pilots (youngest aged 21) performing consistently better than the older ones (oldest aged 67), even if the older pilots may have had more experience. Experience also proved reliable as a factor predicting outcome, as the performances of the moderate experienced group (having competed in 3 or less previous World championships) was associated with a lower penalty score.

The mood of the pilots on the day of competing proved to be an effective way of predicting outcome, with a good mood associated with a lower penalty score. Any medical condition or medication used, were associated with a higher penalty score.

The remaining factors (n=13) showed no association, although some (n=5) factors, like sleep deprivation and alcohol are known risk factors.

Conclusions

The study succeeds in showing an association between the Penalty Scoring System and 4 factors (Age, Experience, Mood and Medical conditions) affecting the performance of pilots.

Although not the aim of this study, the conclusion can be made that the Penalty Scoring System may be a valuable tool in identifying risk factors affecting pilot's performance.

DECLARATION

I, Dr BH Koster hereby declare that the work on which this dissertation is based is original and that neither the whole work or any part of it has been, is being, or shall be submitted for another degree at this or any other university, institution for tertiary education or examining body.

Signed…………………………..   Date……………………………….

Dr. Henk Koster

ACKNOWLEDGEMENTS

I wish to express my heartfelt gratitude to the following people and institutions without whose help this research would not have been completed.

My heartfelt thanks go to my supervisor, Professor. Paul Rheeder, Head of the Division of Clinical Epidemiology at the University of Pretoria, without whose valuable guidance, support, encouragement and thoughtfulness, I would never have achieved my goal.

A special thanks to Dr Chris Le Roux who has introduced me to the interesting field of Aerospace medicine many years ago, and Dr Wynand Murray, whose knowledge and expertise in the field proved invaluable in the collection of data and interpretation of information. The same thanks to all staff at the Institute for Aviation Medicine at Centurion, who assisted me greatly.

I wish to convey my gratitude to the entire academic and administrative staff of the School of Health Systems and Public Health for their support that helped to make this work a success, especially to Loveness Dzikiti whose statistical advice and input proved invaluable. I wish to thank my fellow students for their assistance, constructive criticism and encouragement.

My special thanks go to the Austrian Flying Community and Sport Flying association, who with the Federation Aeronautique Internationale and South African Power Flying Association granted me the privilege and assistance to conduct the survey while they were hosting a World Championship.

Lastly a warm thank you to fellow aviators and competitors who found the time to complete questionnaires while they were focused on giving their best performances at a World Championship.

ABBREVIATIONS

WPFC	World Precision Flying Championships
GPS	Global Positioning System
FAI	Federation Aeronautiqe Internationale
SAPFA	South African Power Flying Association

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CHAPTER 1

Introduction and background

1.1 Introduction

Air and space travel forms a vital part of living in the 20^{th} century, and safety will always form an integral part of aerospace transport. Although flight safety has dramatically improved since the first recognized manned flight in 1903; continuous improvement and reassessment of safety measures and procedures are essential for the present aerospace industry to maintain and improve its viability.

The aviation industry relies heavily on the performance of their pilots to perform their duties effectively and safely. Demands made on the pilot in the modern air – and spacecrafts are strenuous and complicated, although vast technological progress have been made in assisting the pilot. As technology improves, it does change the nature and level of the demands being made on the pilot's performances.

A multitude of factors are known to affect the performance of pilots and other aviation personnel, although the need exists to identify new (previously unknown) factors.

Much of the commercial airline pilot's duties are routine and borders on boredom, except for the instance when something "goes wrong". The pilot then has to switch from boredom mode to the uppermost levels of performance (mentally and actual physical handling of the aircraft), often within a very short time span. The ability to have a sudden "change of mode" on all levels is what effectively saves many lives each year, not to mention the financial implications of having avoided or prevented a disaster.

1.2 Background

The performances of the pilot under routine and abnormal conditions, and the ability to "switch mode" effectively, are extremely difficult to evaluate or measure. Each pilot has to do a practical test flight in either an airplane or flight simulator, while being evaluated by a test officer. These tests are being done on a regular basis, from 6 monthly to 4 yearly, depending on the type of license held by the subject.

The cognitive skills requirements are perhaps increasing, while the manual and actual ability to fly an aircraft is getting less and less important, due to autopilots and other electronic atomization equipment. This is more so for the commercial aviation industry than for the private industry.

Performances of pilots are generally measured by the ability of the pilot to complete his/her flying duties effectively. Routine tests do not evaluate the factors affecting the pilot's performance; it just evaluates the performance itself. In case a problem is detected with the pilot's performance, some attention is given to the factors affecting the performance, and these factors are addressed. But it is done only once an inadequate performance has been detected. Up to date, no routine test focuses on all the factors affecting performance.

These tests or evaluation flights consist of a variety of tasks to be done, from routine duties to unexpected emergency scenarios. The pilot should be prepared for most of the scenarios, since it may happen on any regular scheduled flight. Continuous evaluations of known factors affecting pilot's performances are essential to maintain and improve the performance qualities of all involved in the aerospace industry, as well as the identification of new factors.

1.3 Literature review

Quite often the pilots describe most of their duties as being "boring",[1] in stark contrast to the hectic cockpit environment in case of an emergency.[2]

Pilot's attention to tasks at hand is crucial to the effective management of the multitasking cockpit requirements of the modern air- or spacecraft. Cognitive input come from a variety of sources and provide a noisy, visually complex, distracting environment for the pilot, especially in an emergency situation, when things "do not go according to plan" and he/she has to immediately adjust the "mental framework" and function with accurate efficiency while receiving input from various stimuli.[5]

Various studies have been done trying to evaluate pilot's performances as well as trying to identify and eliminate factors which may negatively influence pilot's performance. No test is 100% effective as a stand-alone test, because of the complex nature of the aviation environment.

It is not within the realms of this study to go into detail regarding aircraft accidents, but since pilot's performance is linked to accidents, some aircraft accident causes are mentioned.

Table 1: Causes of aircraft accidents

HUMAN	PHYSICAL	ENVIRONMENTAL
Mishandling wind/runway	Aircraft-design Maintenance	Turbulence
Sleep deprivation	Aircraft structure	Radiation
Diet	Equipment failure	Poor visibility
Alcohol		Lack of oxygen
Drugs		High levels of CO and CO_2
Circadian rhythm disturbance		
Lack of concentration (inattentiveness)		
Medical conditions/illnesses Cardiac, gastro, neuro, metabolic, infection)		
Inexperience		
Mishandling aircraft kinetics		
Flawed decision making		

1.3.1 Performance of pilots

It has been claimed that up to 80% of all aviation accidents and incidents are caused by the sometimes ill-defined "human error" factor[6] and the rest by other factors, such as aircraft design, manufacturing, maintenance, equipment failure and environmental effect.[7] Some studies suggest that this figure is produced by an over-emphasis on the "human error" factor and that wider systemic causes (such as organizational factors) should not be defined as "human error" .[8]

For a pilot to be able to function efficiently, he/she needs to possess specific physical and mental attributes.[16] Airlines and space institutions have developed various means and methods selecting suitable crew who have the ability to cope with the routine operations as well as performing efficiently under pressure. These selection processes and methods are also continuously re-evaluated and improved.

Apart from a complete and in-depth physical examination, prospective pilots undergo mental and psychological evaluations upon application. While the physical standards and measurements are easy to define, the mental capabilities are more difficult to define and measure.[17] Mental attributes like situation awareness[18], higher judgment skills and decision making capabilities[19] are notoriously difficult to evaluate.[20].

1.3.2 Factors influencing performance

Research has demonstrated that monotonous vigilance tasks decrease alertness by 80% in 1 hour.[3] This phenomenon has been described as "boredom fatigue". Flying a commercial aircraft has been described as "98% boredom and 2% sheer terror".

These contrasting demands being made on the pilots have lead to a move to minimize or eliminate the "human touch" Shalin[4]. Even if we live in a "computerized" environment, the "human factor" still forms the core of the operation of manned flight.[5]

Nevertheless, the individual pilot forms an integral and essential part of the process of aerospace travel.[9] Even in unmanned aerial vehicle flight, the "hidden human factor" has lead to loss of aircraft.[10]

Table 2 Factors affecting performance

PHYSICAL/PHYSIOLOGICAL	PSYCHOLOGICAL	ENVIRONMENTAL
Hypoxia	Boredom	Temperature
Sleep deprivation	Anxiety	Noise
Diet	Stress	Radiation (sunlight)
Alcohol	Time pressure	Cockpit layout Ergonomics
Drugs	Mood	
Circadian rhythm disturbance		
Visual “clutter”		
Clothing		

Even with all of these tests being passed successfully and being trained continuously, pilots still err. The effect of external stressors on the cause of these “errors” is a well-known fact.[9] A multitude of stressors have been identified as influencing the cognitive function, such as noise, fatigue, anxiety, mood, sleep deprivation, disturbance of circadian rhythm, time pressure, hypoxia, diet, alcohol and over-the-counter drugs (caffeine).[2,4,27, 28,29,30,31].

1.3.3 Current methods of measuring performance

In an effort to improve the “human factor” performance, the aerospace industries continuously work at improvements in the field of aviation, both on systems and individual pilot performance. Physical system include flight display systems, attempting to minimize the effect visual “clutter” has on the pilot’s concentration [11], and cognitive avionics development.[12] Presently a software system of “transcribing languages (e.g. Japanese into English)” are being developed and tested, in an effort to minimize the “human error” factor.[13] Individual pilot performance are improved by physical programs Rosekind[14] and displays improving attention.[15]

These skills are closely linked to concentration, since if a pilot cannot concentrate on multiple tasks at hand, while under different stressors simultaneously, all of these "higher mental skills" may be compromised.[21] One of the widely recognized methods of measuring pilot skills, is the CogScreen test, which was developed by Dr Gary Kay and his colleagues in 1986 and is still in worldwide use today.[22] Its was designed to evaluate pilot's neurocognitive and neuropsychological functions, namely deficits or changes in attention, immediate and working memory, visual perception functions, sequencing functions, logical problem solving, calculation skills, reaction time, simultaneous information processing abilities, and executive functions. It consists of a battery of tests, designed for repeated testing.[23] To name a few of the 28 CogScreen tests: "Visual sequence comparison test, symbol digit coding, matching to sample test, Manikin test, Divided attention test, auditory sequence comparison, shifting attention and dual task test."[24]

Table 3: Some Skills evaluated by CogScreen test

NEUROCOGNITIVE SKILLS	NEUROPHYSIOLOGICAL SKILLS
Attention changes	Sequencing function
Attention deficit	Logical problem solving
Immediate memory	Calculation skills
Working memory speed	Reaction time
Divided attention test	Simultaneous information processing ability
	Motor coordination

The results of the test are then displayed by means of physical measurements, specifically parameters of speed, accuracy, throughput and process. These are then combined to give an objective opinion of the applicant's skills.[25] Specifically 4 CogScreen variables account for 45% of variance in other flight summary scores: Speed/working memory, Visual associative memory, Motor coordination, and tracking.[22]

In analysis of data Flight recorders in cases of flight violations, the flight performance were found to be significantly correlated with 11 CogScreen variables.[26]

Psychometric tests are used to evaluate the applicant's psychological status and whether he/she has the applicable capabilities to handle the stressors of modern flight appropriately. These tests are well-defined and have been proven to be reliable for the selection process.

1.4 Rationale of study

All aircraft management systems are however, still dependent on the pilot to combine it all in a synchronized way to operate the aircraft efficiently and safely, be it an airliner, fighter jet or spacecraft.

The aerospace industry is continuously looking for ways to evaluate[32]the pilot's performance under the effect of external stressors.[33] Performance is indeed closely linked to concentration, or at least the ability to concentrate for extended periods of time. Concentration can be evaluated under normal and stressful conditions, although each subject is aware that the simulator test conditions are not "the real thing". None of the above tests can accurately evaluate or measure the function of sustained concentration as a sole parameter. What is yet to be researched is the capability of pilots to concentrate for extended periods, under real extreme pressure, during the international flight competition (WPFC) as opposed to simulator induced stress alone.

Using the penalty scores obtained by the pilots participating in the WPFC may indeed render a useful instrument to research pilot performance and hence sustained pilot concentration ability over a period of time.

CHAPTER 2

Aim and objectives

2.1 Aim

The aim is to establish whether a relationship (if any) exists between the behavioural/concentration factors and the penalty score during the World Precision Flying Championships.

2.2 Objectives

2.2.1 Primary

The primary objective is to establish the correlation between the performance of pilots, and their "score" as measured by the penalty points scoring system.

2.2.2 Secondary

The secondary objective was to identify possible new (unknown) factors affecting performance of pilots.

2.3 Null Hypothesis

The null hypothesis states that there are no correlation between the known performance- affecting factors and the penalty score as being used at the Precision World Championships.

CHAPTER 3

Methods and Materials

3.1 Study site

The 18th WPFC was held at the Ried/Kircheim airfield, near the town of Ried, in Austria. The competition dateline was 17 – 24 July 2008.

3.2 Study population

All pilots competing at the PWC were invited to join as subjects, on a complete voluntarily basis. The team managers and coaches were briefed on the possible objections some participants may have, and they were given assurance of the confidentiality nature of the study.

3.3 Terminology

Participants – all participants competing at the World Precision Flying Championships.

Subjects – participants who volunteered to participate in the study.

Competitors – same as participants

3.4 Sampling frame

Of the possible total number (348) of measurable performances, 152 (43.7%) were recorded for this study purposes.

3.5 Study design

The study type was a descriptive cross-sectional study.

3.6 Measurement

GPS Loggers: Electronic Global Positioning System Loggers, which record the position of the aircraft each second. These digital instruments are extremely accurate in their measurements, plotting the position and altitude of the aircraft to within a 1 meter accuracy, each second, for the duration of the flight.

Landing penalties: The landing spot was measured by electronic landing device (much like a gatsometer), as well as video and visual observation by a panel of international landing judges. All 3 these observations had to concur in order for a landing penalty to be awarded.

En-route penalties: Missed, misplaced or accurate en-route pictures and markers were manually evaluated by international judge, in the presence of the competitor. The distances on the map are measured by a ruler, to the nearest millimetre. In case of an unclear pen mark, the competitor makes a pinprick on the map and measurements are taken from the pinprick.

A scale of 1 – 10 was used to measure exposure factors, marked by the subject with a clear mark, and measured by the researcher to the nearest millimetre. These were then transferred to electronic media by the researcher.

3.7 Sample size

Of the total number (n=116) of pilots participating at the WPFC of which all were invited to participate, 43% (n=50) returned completed questionnaires.

3.8 Data Collection and management

All ethical considerations were strictly maintained and adhered to. The questionnaires were collected by the researcher, by means of 3 secure collection boxes which were placed at the mess hall, the mail room and the briefing room. Any subject could place the completed questionnaire in any of these boxes, without fear of having his/her information exposed to anyone but the researcher.

The researcher collected these boxes at the end of each day and moved it to his hotel room, and locked it away securely.

Each questionnaire was completed by each subject in his/her own handwriting. The questionnaires were collected on a daily basis and the linking of questionnaire was done once the final competition results were made public. These results take a few days to be finalized, since some pilots may protest a penalty which they think they received unfairly. The protests are managed by a jury panel. Final results are published once the protests were finalized.

3.9 Analysis strategies

Descriptive statistics were done with statistical software programs. The penalty score was not normally distributed; according to the Shapiro-wilk test for normality indicated that penalty score was not normally distributed, hence analyses were carried out using logged values. Univariate regression for survey data was used to identify variables associated with log penalty score. Regression for survey data was used because there were some individuals with more than one measurement. Variables found to be associated with log penalty score, that is, variables with a ttest p-value less than or equal to 0.25, were used in stepwise backward regression to build a model for predicting log penalty score. Thus the penalty score was logged and projected as a log base 10 function.

A linearized standard error adjustment was made for each variable due to the fact that some subjects had more than one measurement. Analysis was done by means of a linear regression analysis.

For ease of interpretation, the t-statistic was converted to a p-value, with the interpretation of a p-value of <0.05 as being significant.

A 95% confidence interval was established for each variable.

3.10 Ethical aspects of study

The protocol for this study was presented to the Ethics Committee of the Faculty of Human Health Sciences of the University of Pretoria for assessment. Full approval was granted.

Since this study required examination of competition scores and results, initial consent from the FIA and SAPFA and Austrian flying association were obtained before the study was undertaken. The researcher collected data anonymously so that confidentiality could be ensured.

Chapter 4

Results

This chapter seeks to outline the results of the research report.

Although most of the competitors were keen to participate in the study, 42% (n=64) of the returned questionnaires were spoiled due to various reasons, which include language barrier, incompleteness of questionnaires and reluctance in providing identifiable information.

4.1 Baseline Sociodemographic results

The youngest pilot was 21 years of age, the oldest 68 years, with a mean value of 44 years. A total of 12 countries were represented in the study, with Austria (being the host nation) represented best and Sweden the worst.

Female participants were 4, the rest were male. Competitors stayed in different accommodation facilities at different distances from the competition venue, so different countries were exposed to different stressors at their place of accommodation.

4.2 Data analysis

4.2.1 Measuring performance

Measurement of outcome was done by the competition organizers, by means of 2 GPS's (Global Positioning System) Loggers in each aircraft. The organizers provide these measurements (results) to each competitor after each day's flight.

All penalty points are awarded to each competitor in his/her presence, and each competitor gets the opportunity to dispute any penalty. Since each competitor wants as little penalties as possible, everyone scrutinizes any possible mistake in measurement, and recheck each measurement. Outcome measurement was very accurate indeed.

The outcome results were published on the competition site, on the competition website, as well as on the various countries flying federation websites.

Table 4: Competition results as published by organizers.

PLACE	PILOTS	AIRCRAFT	CODE	FP & NAV*	OBSER *	LANDING PENALTIES	TOTAL
1	Pilot A	C-152	OK-NAV	18	70	22	110
2	Pilot B	C-152	SP-AKP	78	40	55	173
3	Pilot C	C-152	S5-DMI	89	40	61	190
4	Pilot D	C-152	OK-IKH	60	140	27	227
5	Pilot E	C-152	SP-KWW	157	80	17	254
6	Pilot F	C-152	OK-NAV	93	160	22	275
7	Pilot G	C-152	SP-KCH	96	120	68	284
8	Pilot H	C-152	OK-IKC	132	140	42	314

*FP & Nav is combined penalty score for accuracy of flight plan theory and time penalties incurred.

*Obser is the penalties incurred by observing en route pictures and ground markers.

4.2.2 Measuring exposure factors

Exposure factors were measured by means of a Visual Analogue Scale (100 mm in length) representing the factor on a scale of 1 – 10, where the participant had to mark the appropriate distance from zero. The researcher measured this distance in mm and transposed it into the statistical database as a definite number.

Factors which could not be measured as such, were measured by subjective opinion of the participant, on a scale of little, moderate or severe options to be marked.

4.3 Significant factors

All of these factors were statistically proven to be significant in affecting performance.

4.3.1 Age

Pilots consists of various age groups, the youngest (n=1) being 21 and the oldest (n=1) 67 years of age, with a mean of 44.8 years. The pilot with the best performance chose not to participate in the study. The pilots in the younger age group, 18 – 29 years (n=6) performed consistently better with an average penalty score of 195. (Lowest 110 highest 354.). The older age group (older than 45 years) fared consistently poorer with a mean penalty score of 830 (lowest 20 highest 3510). Comparing these 2 groups the younger group fared 87 % better than the older group.

The middle age group (n=.21.) aged 30 – 45 years of age, performed average, with a mean penalty score of 532 (highest 1583 lowest124)

Age was found to be a significant predictor of penalty score (r^2=0.1564; $p < 0.01$) with the younger group consistently better than the other groups.

4.3.2 Moderate experience

The moderate experienced group were considered the pilots who had previously competed in 1 – 3 WPFC.

Most pilots 66% (n=30) participating in the competition were included in the very experienced group, since only a few pilots 22% (n=10) included in the study were considered to have moderate experience (having competed in more than 1 but less than 4 WPFC).

The moderate experienced group fared consistently better than the group with little experience as well as the very experienced group, with a mean penalty score of 1052 (lowest 134 highest 4116) compared to the very experienced group's mean score of 1344 and the little experience group's mean score of 2288.

When applying the study model, the moderate experienced group was a reliable predictor of outcome (r^2= 0.0568 $p < 0.004$)

4.3.3 Little experience

The group with little experience was those who have not participated in a WPFC previously, although they do have some experience, since to make it to the World Championship, one has to do really well at National level in their respective country's

National Championships. In this group there may thus have been some very experienced pilots, but because they have not participated in a WPFC they were classed as having little experience.

Penalty scores of this group (n=5) was consistently higher than the other groups, with a mean penalty score of 2288 (lowest 205 highest 6948). With a p value of 0.001 the little experienced group was found to be a reliable predictor of penalty score, indicating that the least experience the higher the score.

4.3.4 Emotional state (Mood)

Emotions do play a vital role in performance, and each participant completed the questionnaire as soon as comfortable for him/her, after the flight. By this time the pilot is aware of his/her performance and had a pretty good idea of the expected penalty score. These perceptions may not be entirely correct, since the pilot may be unaware of a missed checkpoint (high penalty score) or he may be under the impression that he did miss a checkpoint only to realize later that he did not miss it. So even if the mood of the pilot at the time of completing the questionnaire is a true emotion, his/her perception at the time may not be an accurate one.

The mood was scored on a scale of 0 -10, measured in mm by the researcher, and it was shown that the worse the mood of the pilot, the worse the penalty score was. With a p value of 0.023 this is considered to be of significance.

4.3.5 Medical conditions

No differentiation was made between various medical conditions; any medical condition whatsoever classified the pilot to be in this group. This group (n=22) fared consistently poorer with a mean penalty score of 928 than the “healthy” group’s (n= 89) mean penalty score of 473.

A complicating factor may be the fact that many of the participants who suffer from some medical condition, also fall in the older age group. The correlation between the medical condition group and the older age group was not investigated.

4.3.6 Sleep environment

Competitors at the WPFC were accommodated in hotels around town, which provided a quiet and calm environment to sleep in. The group (n= 102) whose sleeping environment was considered to be near dark fared consistently better (mean penalty score 381) than the other groups who were sleeping in a near light (n=11) or totally dark (n=33) environment.

Table 5: Summary of Significant factors effecting performance

FACTOR	SIGNIFICANCE
Age	The younger the better performance
Experience Moderate	Affects score positively
Experience Little	Effects score negatively
Mood about today's flight	The worse the mood the worse the score
Medical	Medical condition affects score negatively
Sleep - near dark	Affects score positively

Table 6: Summary of statistical model

PENALTY_SC~X	COEFF	LINEARISED STD ERROR	t	P>|t|	95 % CONF INTERVAL	
age	.03011	.0059807	5.03	0.000	.0180405	.0421795
mood	-.0122427	.0038893	-3.15	0.003	-.0200916	-.0043938
Experience mod	.6223313	.1713731	3.63	0.001	.2764865	.9681761
Experience little	.4400572	.2080922	-2.11	0.040	-.8600043	-.02011
Sleep environment	-.300423	.2230986	-1.35	0.185	-.7506541	.1498082
Medical condition	.6147657	.385842	2.66	0.011	.148746	1.080785

4.4 Insignificant factors

The factors in table 7 could not be proven as being significant by this study. No consistent correlation between these factors and the penalty score could be demonstrated.

Table 7

1. Gender
2. Sleep - hours of sleep
3. Sleep - noise during sleep
4. Awake hours before take-off
5. Stress before take-off
6. Alcohol amount
7. Coffee amount
8. Coffee time before take-off
9. Hours flown previous 24 hours
10. Landings previous 24 hours
11. Stress at home
12. Stress at work
13. Stress - financial
14. Stress before today's flight
15. Stress during today's flight
16. Fitness level

Some of these factors have been proven by other studies to significantly affect performance.

4.5 Bias

Pilots participating at the World Championship, are not the average recreational, commercial or military pilot, nor are they space astronauts. They are mostly pilots who have a passion for flying, who like to do it as a sport, and most may not have come through a strict initial selection process, regarding performance capabilities. Therefore the subjects studied at the WPFC provide a fair representation of the average aviator.

Selection bias may have been introduced to the study, by the competitors themselves, since less than 60% of competitors responded to the questionnaires. Some of the reasons for not participating in the study are listed in table 9. The information used for this study, may thus not be statistically accurate, since some of the more experienced competitors elected not to participate in the study. It is possible that the very experienced group may not be well represented in the study.

Chapter 5

Discussion, Conclusion and Recommendations

5.1 This study

This study is a retrospective study of the performances of precision pilots as measured by a penalty scoring system, while participating at the WPFC during July 2008. Initially the study aimed to use data from more than one world championship, but due to various reasons (Table 8) the data from only the 2008 competition was used. The data of the pilot studies done in South Africa were not included in the study.

Table 8: Logistical difficulty in collecting data

Logistical difficulty of getting to various countries (visa, travel, etc)
Permission to conduct research at a world championship
Language difficulties
Time span – competition held over 2 -3 week period
Co-operation between researcher and competition director (organizers).
Data collection at championships – researcher needs assistance

Although the study originally aimed to collect data from each and every competing pilot, the data collected were from 43% of competitors. Most competitors and team managers were very keen on participating in the study, but various factors caused some competitors not to participate. Various obstacles had to be overcome to collect these data; the major difficulties are listed in table 8.

Even with all these complicating factors, some easier to overcome than others, the researcher managed to collect enough data to be of statistical significance. Of 116 competitors most of them indicated that they are keen and willing to participate, and in the end 152 questionnaires were collected, of which 42% were spoilt because of various reasons, mostly because of lack of information provided by the pilot, for fear of revealing his identity.

This study is unique in the sense that in the literature no other studies could be found which have been done while pilots are participating in a competition, let alone a world championship.

The data reflects some factors to be significant in improving or affecting performance, although other factors which have been proven to affect performance could not be proven to reflect in the penalty score.

5.2 This study in relation to other studies

This study aims to investigate the possibility of using it as an adjunct to other proven means of measuring pilot's performances and thus concentration. As such, it supports the study of Taylor et al [23] in 2000 whereby younger pilots seem to perform better in flight simulator conditions. In this study, the CogScreen test was used to evaluate pilots and their performances in relation to their ages, and it proved to be a useful test correlating these factors.

Yakimovich et al[26] showed in 1994 that the CogScreen test is a fairly reliable predictor of flight performance in Russian pilots, although it was focused on the measuring of the physical performances and not so much on the mental/psychological performances. The penalty scoring system attempts to focus more on the psychological side of the performances and may support what Yakimovich have found.

It is indeed very difficult to evaluate or distinguish between the effects of age and experience, it is a grey area which is notoriously difficult to evaluate. The penalty scoring system is perhaps the closest one has ever come to distinguish between the 2 factors, and it seems to prove that age is more reliable than experience as a predictor of performance, although the 2 factors are so closely interlinked that it is difficult to differentiate between the 2. Both the younger (less than 26 years) and older (more than 55 years) age groups have similar experience levels and the younger group consistently performed better.

Emotions, subjective feelings and perceptions about stress do play an important role in performance, and it proved to be a fairly constant predictor of performance, as measured by the mood as experienced by the pilot. Singer et al[17] (1991), De Hart[28] (2000) and Johnston et [34] (2001) showed that although stress is difficult to measure, it does have a substantial influence on performance. Perhaps this study may assist in proving that in measuring the mood of the pilot, the researcher may interpret the results of the test (e.g. Cog Screen) different.

As other studies by De Hart [28] (2000) Davenport et al [29] (1992) have proven extensively, the fact that any medical condition and/or medication Paul et al [31] (2005) have a negative effect on performance have been supported by this study. Alcohol as a detrimental effecter as proven by Petros et al[27] (2003) could not be confirmed by this study, (although the alcohol consumption question was included in the questionnaire) perhaps more due to the fact that the pilots tend to stick firmly to the “8 hours between bottle and throttle” rule and it was not within the realms of this study to transgress that rule.

As with the Cogscreen test, the cognitive function of the pilots could not be tested 100%, and as Simons[25] (1998) has shown that cognitive impairment does occur with age, it does not necessarily means poorer performance form pilots. This study is in line with these findings, since cognitive functions (identifying photographs, ground markers, and map reading skills) do make up a major part of the penalty scoring system. Thus a pilot with poorer cognitive skills will accumulate more penalties than those with excellent cognition.

AS shown by Rebok[4] there appear to be no significant age differences in the pilot performance factors contributing to aviation crashes. The authors also concludes that the role of cognition and other causative factors in the flight performance of older pilots needs further empirical study, and that may be an area where this study can provide valuable information regarding the performance of older pilots.

5.3 Limitations of Study

Most tests attempting to evaluate pilot's performances consists of individual skill testing, since it suffers from the complexity of the nature of the performances, when trying to evaluate simultaneous multi-tasking skills. This study suffers from the same limitations and although certain factors could be linked to the penalty score, it is impossible to link all the factors to a predicted penalty score.

The study was further limited as to the participation of the pilots, naturally some participants at the championship chose not to participate in the study, for various reasons, as shown in table 9.

Table 9: Complicating factors in data collection

- Language difficulty
- Fear of research interfering with performance
- Fear of research revealing some obscure/hidden factor
- Forgetfulness – pilots may be so focused on the competition they forget to complete the questionnaire, or forget to post it in the collection box.
- Anxiety/Stress – pilots may be so stressed that they do not want to complete the questionnaire immediately post-flight.
- Lack of belief- some pilots did not take it seriously and made a mockery of the questionnaire.
- Scepticism that the research results may benefit certain countries (i.e. that of the researcher) only.
- Scepticism about the confidentiality of the information requested on the questionnaire.

5.4 Conclusions

The null hypothesis could not be proven; therefore the study proves that a correlation between factors affecting performance and the penalty scoring system as used during the World Precision Flying Championships does exist. The primary objective has been accomplished, with evidence that the penalty points scoring system may be effectively used to measure performance, and thus concentration.

The secondary objective has not been obtained, since no new factors affecting performance could be identified. This may be due to a number of factors, including the fact that the number of factors in the research questionnaire may have been too many, not well-defined and perhaps too wide of nature.

5.5 Recommendations

It is recommended that further studies be done to use this fertile ground of pilot's concentration efforts.

5.6 Future studies

The researcher is convinced that there is a close link between performance and concentration in Precision Flying, due to the nature of the competition. Each competitor can vouch that penalties are accumulated as soon as the concentration level on the various tasks at hand, drops.

The researcher recommends further study in this field; the biggest hurdle to overcome was to gain the confidence of the organizers and competitors alike and prove to them that research could be done at a World Championship without interfering with the running of the event or influencing performances. That has been accomplished, and the suggestion exist that each future World Championship may be used for future research

The possibility to use the penalty scoring system in a modified way (allocate a statistical "loading factor" to each penalty discipline, or even exclusion of some penalties), could also be investigated.

It is unfortunate that this performance measuring tool can only be used to measure the performances of already qualified pilots, and is unable to measure performances of recruits or non-pilots. The possibility to use the penalty scoring system on non-pilots may be examined by researchers, in the world of simulator flying – already there is a "Reality Flying" competition for non-qualified persons (pilots and non-pilots) where Precision competitions are flown on computers only. This holds some promise since no actual flying takes place and lives, property and equipment will not be endangered as in an actual flying competition. This offers the option to evaluate performance while the subject is on “unsafe” medication (e.g. alcohol, motion sickness tablets, etc)

Perhaps the most promising outcome of this study, lies in the opportunity to identify (and perhaps quantify) previously unknown factors affecting concentration and it is recommended that the World Championships be used for future research.

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Appendix A

VOLUNTARY PILOT QUESTIONNAIRE

Date:_______ Aircraft competition number:_________ Take-off Time________

Please cross/tick the applicable box and/or write the accurate numeric answers in the appropriate box.

Personal information

Age	
Gender (Sex)	
Position attained at previous World championships	

1. How many hours quality sleep did you have last night?

3 or less	
3 – 5	
5 or more	

2. Mark the appropriate squares describing your sleep environment most accurately.

Background noise		Light/dark environment	
Total quietness		Total darkness	
Very little noise		Near dark	
Noisy		Light	
Very noisy		Very light	

3. How many hours between waking up and take-off for today's flight?

4. Were these hours spent relaxing or stressful, on a scale of 0 to 10? 0 is totally relaxed and 10 is very stressful

0 Relaxed ________________________________ 10 Stressed

5. What type and how much alcohol have you had during the previous 72 hours?

TYPE	QUANTITY	DATE	START TIME	STOP TIME	DATE
Beer per glass					
Wine per glass					
Spirits per single					

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6. What type and quantity coffee have you had during the 12 hours before take-off?

TYPE	AMOUNT IN CUPS	TIME LAST CONSUMED
Caffeinated		
Caffeine free		

7. State number of hours flown in the 24 hours preceding today's flight.

8. State total number of landings you have done in the 24 hours preceding today's flight.

9. What amount of stress do you perceive presently?
Please mark it on a scale of 0 to 10. (0 is no stress, 10 is severe). Draw a vertical line at your mark.

	None		Severe
At work:	0		10
At home:	0		10
Financial:	0		10
Before today's flight:	0		10
During today's flight:	0		10

10. Mark your present mood level about today's flight, on a scale of 0 to 10.

Very upset 0 —————————— 10 Very Happy

11. What is your present fitness level?

Fit (Athlete, exercise 5 or more times per week)	
Moderately fit (Exercise 3 - 4 times per week)	
Unfit (Exercise 2 times or less per week)	

12. Do you have any medical condition, even if it does not require any medical treatment? Please provide details/diagnosis in the space below.

13. Are you on any medication presently, even for flu or air-sickness?

YES	NO

If yes, please provide the name and the time you last took it before take-off.

____

____

14. Please state any other factor(s) which you perceive as influencing your concentration, including comments about today's flight. Use flipside of this page if necessary.

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