Spatial Disorientation Training Scenarios within a High-Fidelity Simulator Environment

Steven Gaydos[1], Alaistair Bushby[2], Claire Goldie[1]

[1]HQ Army Air Corps, Aviation Centre, Middle Wallop, Hampshire, UK

[2]Royal Air Force Centre of Aviation Medicine, RAF Henlow, Bedfordshire, UK

Disclaimer

The views, opinions, and/or findings contained herewith are those of the authors and should not be construed as an official UK Ministry of Defence or US Department of Defense position, policy, or decision, unless so designated by other official documentation.

The authors have no financial interests or other relationships that may be perceived as a conflict of interest related to this body of work.

Disclaimer *part deux*

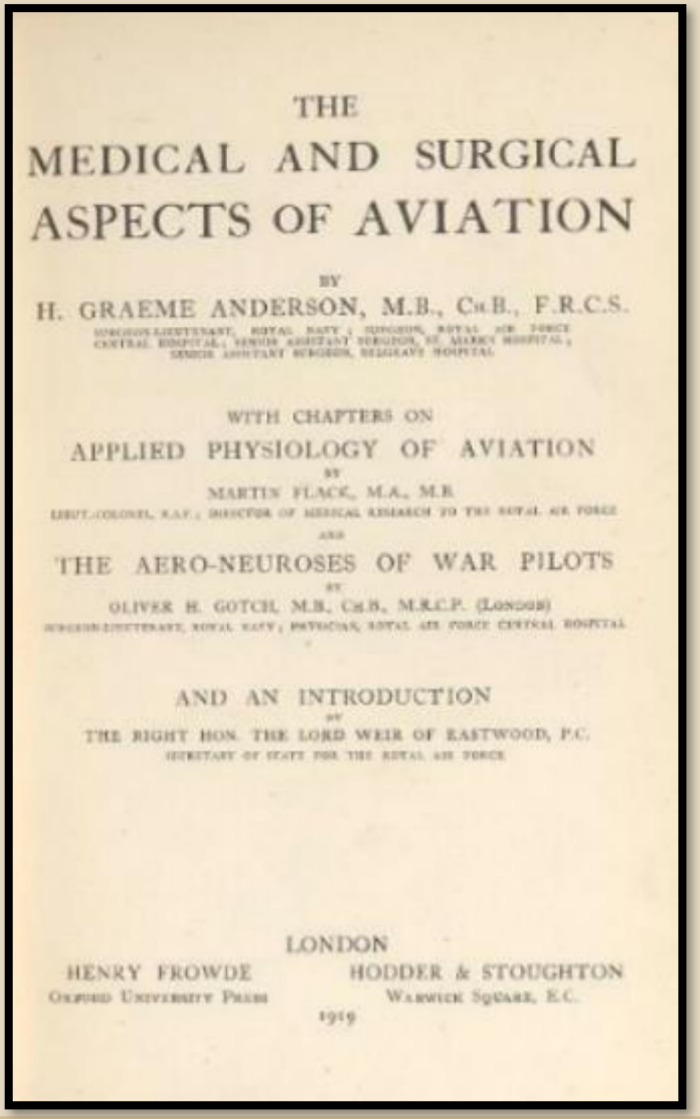
The Problem

- Spatial Disorientation (SD) may result from improper sense of aircraft position, motion, or attitude with respect to the fixed coordinate system of the earth's surface and the gravitational vertical.
- SD has remained a significant cause of military RW aviation mishaps.

The Problem

"…it has even been recorded that some have flown upside down without knowing it."

(Anderson, 1919)



THE
MEDICAL AND SURGICAL
ASPECTS OF AVIATION

BY
H. GRAEME ANDERSON, M.B., Ch.B., F.R.C.S.

WITH CHAPTERS ON
APPLIED PHYSIOLOGY OF AVIATION
BY
MARTIN FLACK, M.A., M.B.

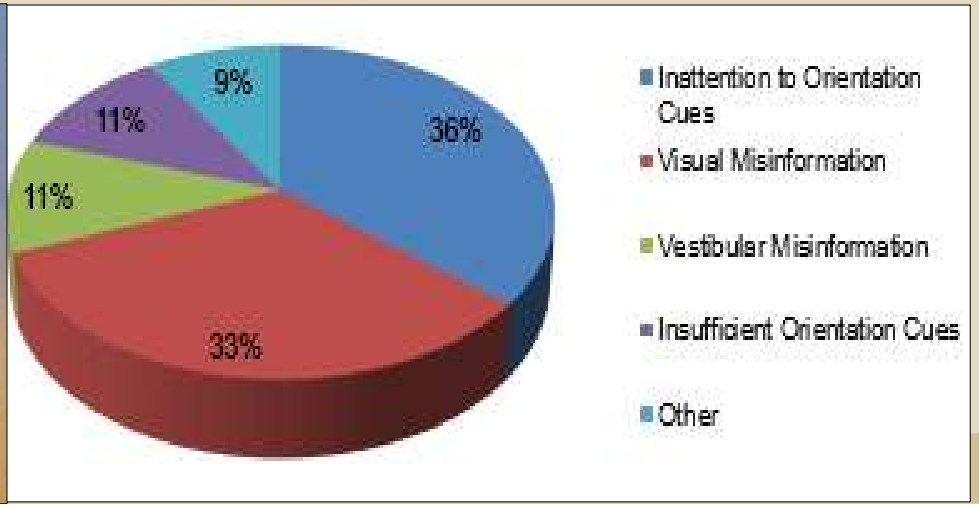
AND
THE AERO-NEUROSES OF WAR PILOTS
BY
OLIVER H. GOTCH, M.B., Ch.B., M.R.C.P. (London)

AND AN INTRODUCTION
BY
THE RIGHT HON. THE LORD WEIR OF EASTWOOD, P.C.

LONDON
HENRY FROWDE
Oxford University Press
HODDER & STOUGHTON
Warwick Square, E.C.
1919

The Problem

- British military RW community, SD remains a causal or contributory factor in about **one-third** of serious accidents
- SD carries a **disproportionate penalty** with respect to fatality rates when compared to non-SD accidents
- UK military SD **incident rate** per flying hours was **higher for RW** than other aircraft types (2x fast jet); greatest numbers among Apache and Wildcat airframes



SD Training

"The practical problem remains as to how the subject should be taught and demonstrated to each successive generation of pilots to forewarn them and maintain their awareness of the potential dangers of disorientation in flight." *(Stott, 2013)*

- **Instruction (teaching, education):** "…provision of systematic (methodological—according to a plan) information about a subject or skill."
- **Demonstration:** "…showing evidence of, or provoking the working of…"
- **Training:** "…to bring or come to a desired state of efficiency or condition of behavior…"

Oxford English Reference Dictionary, 2nd Ed.

Overview

- Focus limited training resources toward areas of highest risk including recognizing incipient SD at times of **high workload** or **deceptive visual cues**
- Employment of **contextual and interactive learning** ("training space" incorporating workload, CRM, and relevant environments)
- AvMed **tri-Service, layered approach** in instruction for RW pilots

1. Classroom academics and disorientation trainer

2. In-flight SD demonstration is provided within basic flying training

3. Refresher training using **interactive synthetics** or in-flight sorties then provided at least every 5 years

Development

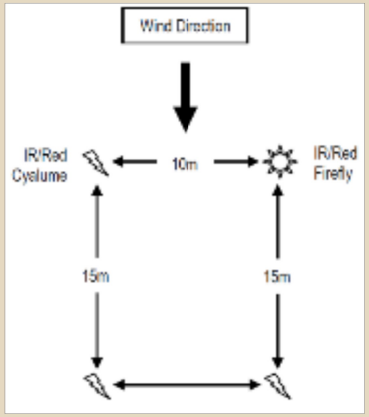
- Ten SD bespoke training scenarios jointly developed
- **Multidisciplinary input** (aviation medicine, QHIs, and simulation technicians)
- Scenarios are **embedded within other routine simulator periods focused on non-SD training objectives**
- Brevity, simplicity, and minimal training interruption key

ARMY

Example Scenarios

SCENARIO	COMMENTS
Dust departure	Out of ground effect take-off with obstacles in DVE* dust recirculation, false cueing, and high operating power limits; considerably increased workload leading to saturation.
Snow-laden valley	Lack of visual horizon and homogeneous scene with blowing snow and misleading attitude cues; increased urgency with immediate casualty evacuation.
Deck departure	Maritime scenario with lateral hover to take-off; low ambient light, limited altitude cues and featureless overwater terrain; minor malfunction increases workload and distraction.
Brownout approach	Approach to hover over dust-laden unfamiliar landing zone, reduced visual references, recirculation, and false cueing; high workload and limited altitude cues.
NATO† T approach	Incorrectly positioned NATO-T on sloping ground causing poor assessment of approach angle; crosswind component increases workload; low ambient and environmental lighting with terrain create black hole conditions.
Deck landing	Combination of poor ambient light and lack of discernible horizon; wake turbulence and high workload conditions with featureless overwater terrain.
NVD‡ low level transit	Nap-of-earth NVD flight; combination of poor ambient light conditions, lack of discernible horizon and snow-covered terrain leading to hidden ridges and late warning of terrain.
NVD formation	Low level NVD join formation task converging with lead aircraft; clear skies overwater with environmental lighting on horizon causing loss of visual with lead.
Desert Box	Landing Desert Box laid out to incorrect size (inexperienced ground troops) resulting in a high closure rate and late identification of the issue; poor ambient lighting and increased urgency with immediate casualty evacuation.
Deck recovery	Low ambient light conditions with lack of discernible horizon to join downwind; wake turbulence and high workload conditions with featureless overwater terrain.

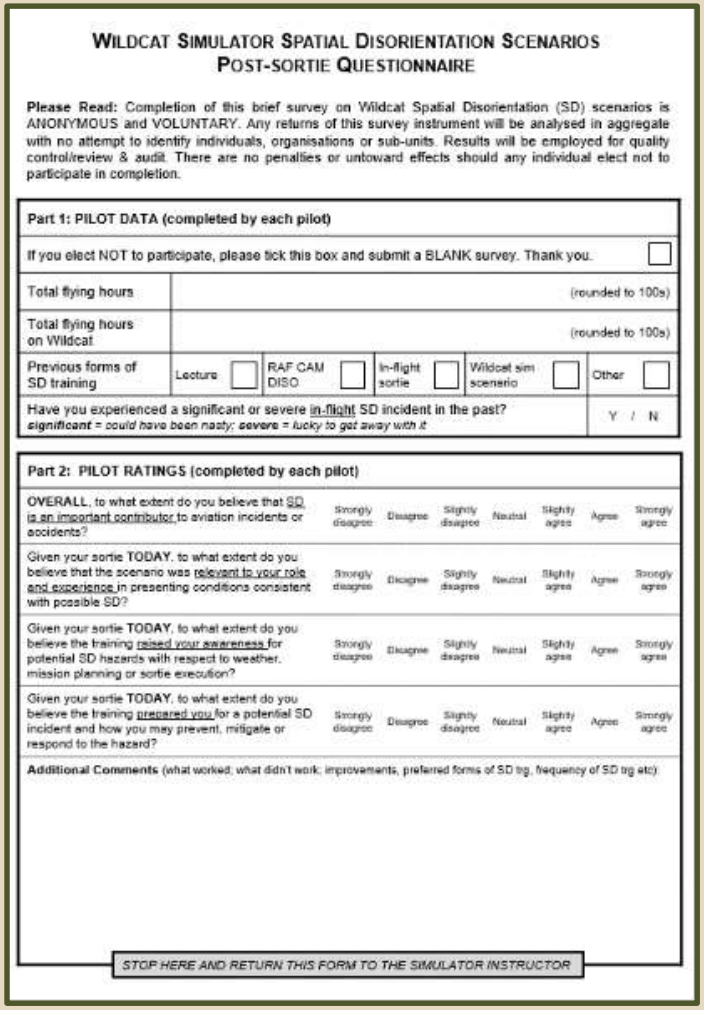
Example Scenarios



Scenario	Comments
Brownout Approach	Based on an approach to the hover in a dust-laden atmosphere. With reduced visual references and recirculation, the crew receive false cueing. High workload and limited visual cues increase likelihood of orientation error.
NATO T Approach	Incorrectly positioned NATO T on sloping ground causing incorrect approach angle. Compounding the issue is low environmental lighting, poor light levels and terrain. Black hole conditions with wind make the assessment of approach angle and closing difficult.
NVG Low Level	Combination of poor ambient light conditions, lack of discernible horizon and snow-covered terrain leading to hidden ridges and late warning of terrain.
Desert Box	Landing Desert Box is laid out incorrect size by inexperienced ground troops resulting in high a closure rate and late identification of the issue. Poor ambient lighting and increased urgency with immediate casualty evacuation.

Methods

- Standard **survey instrument** construct
- Basic demographics
- Self-reported SD-related training & historical experience
- 7-point **Likert-scale** assessment scales
- Free-form comment area
- Separate/associated assessment by instructor with **independent determination of SD**



WILDCAT SIMULATOR SPATIAL DISORIENTATION SCENARIOS
POST-SORTIE QUESTIONNAIRE

Please Read: Completion of this brief survey on Wildcat Spatial Disorientation (SD) scenarios is ANONYMOUS and VOLUNTARY. Any returns of this survey instrument will be analysed in aggregate with no attempt to identify individuals, organisations or sub-units. Results will be employed for quality control/review & audit. There are no penalties or untoward effects should any individual elect not to participate in completion.

Part 1: PILOT DATA (completed by each pilot)

If you elect NOT to participate, please tick this box and submit a BLANK survey. Thank you.	☐					
Total flying hours	(rounded to 100s)					
Total flying hours on Wildcat	(rounded to 100s)					
Previous forms of SD training	Lecture ☐	RAF CAM DISO ☐	In-flight sortie ☐	Wildcat sim scenario ☐	Other ☐	
Have you experienced a significant or severe in-flight SD incident in the past? *significant = could have been nasty; severe = lucky to get away with it*	Y / N					

Part 2: PILOT RATINGS (completed by each pilot)

	Strongly disagree	Disagree	Slightly disagree	Neutral	Slightly agree	Agree	Strongly agree
OVERALL, to what extent do you believe that SD is an important contributor to aviation incidents or accidents?							
Given your sortie **TODAY**, to what extent do you believe that the scenario was relevant to your role and experience in presenting conditions consistent with possible SD?							
Given your sortie **TODAY**, to what extent do you believe the training raised your awareness for potential SD hazards with respect to weather, mission planning or sortie execution?							
Given your sortie **TODAY**, to what extent do you believe the training prepared you for a potential SD incident and how you may prevent, mitigate or respond to the hazard?							

Additional Comments (what worked; what didn't work; improvements; preferred forms of SD trg; frequency of SD trg etc):

STOP HERE AND RETURN THIS FORM TO THE SIMULATOR INSTRUCTOR

Assessment

POST SD SORTIE PILOT RATINGS						
Strongly Disagree	Disagree	Slightly Disagree	Neutral	Slightly Agree	Agree	Strongly Agree
1	2	3	4	5	6	7
Q1. **OVERALL**, to what extent do you believe that SD is an important contributor to aviation incidents or accidents?						
Q2. Given your sortie **TODAY**, to what extent do you believe the scenario was relevant to your role and experience in presenting conditions consistent with possible SD?						
Q3. Given your sortie **TODAY**, to what extent do you believe the training raised your awareness for potential SD hazards with respect to weather, mission planning or sortie execution?						
Q4. Given your sortie **TODAY**, to what extent do you believe the training prepared you for a potential SD incident and how you may prevent, mitigate or respond to the hazard?						

1. SD important contributor to accidents? (overall)
2. Relevant to role & experience? (sortie)
3. Raised SD awareness? (sortie)
4. Prepared you to prevent, mitigate or respond to SD? (sortie)

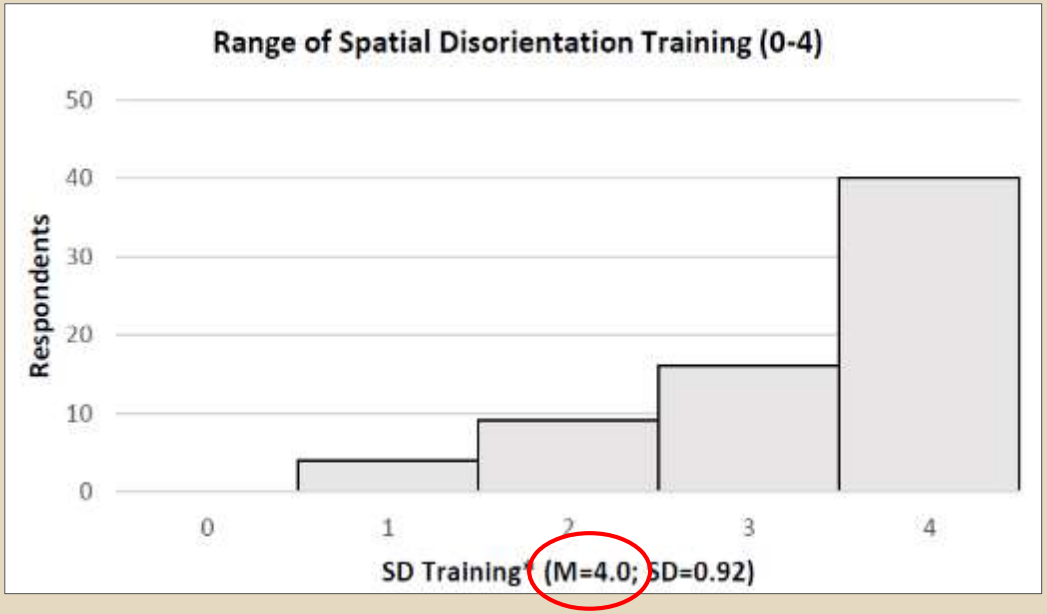
Results

- **69 surveys** were completed over a six-month training cycle
- 7-point Likert-scale assessments: **elevated median scores** (6.0, respectively) across all four categories
- Elevated scoring of range of previous SD training received: **good penetrance**
- Of all sorties flown, the **majority of aircrew** (68%) became **disoriented** at some point during the sortie

Results

- **Experience**
  - Median Total Flying Hours (TFH): 1300 (range: 300, 6700, SD = 1423.7)
  - Median Flying Hours on Type: 500 (range: 100, 2000, SD = 508.5)
- **Previous SD instruction/training**
  - Lecture (90%)
  - Disorientation trainer (90%)
  - In-flight SD demonstration (81%)
  - Previous simulator scenario-based training (74%)

Results



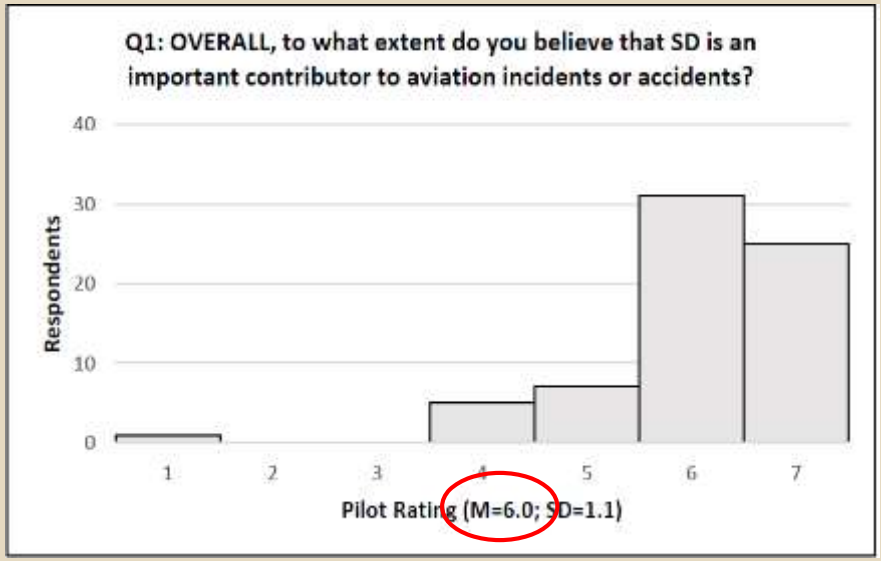
Comments
None
Lecture/academics
Disorientation trainer
In-flight sortie/demonstration
Simulator training
*1-point per category

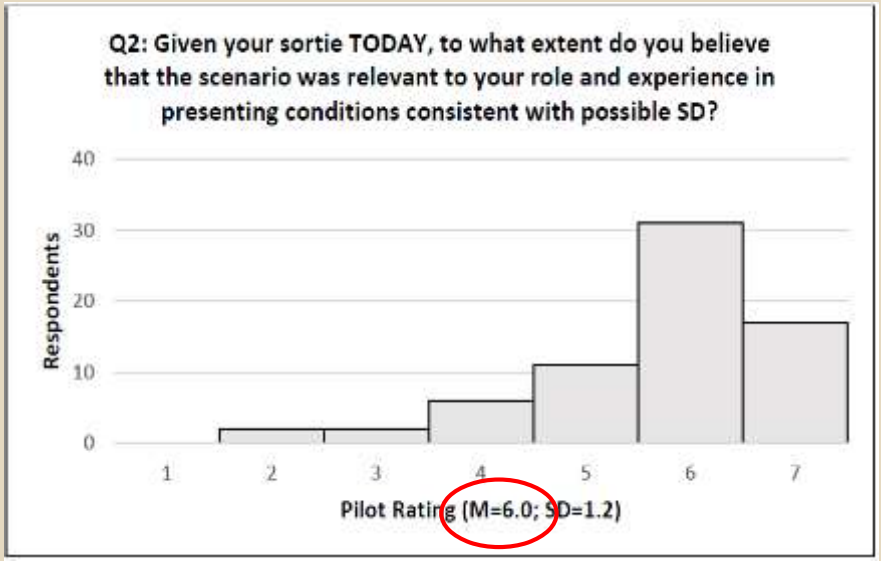
Results

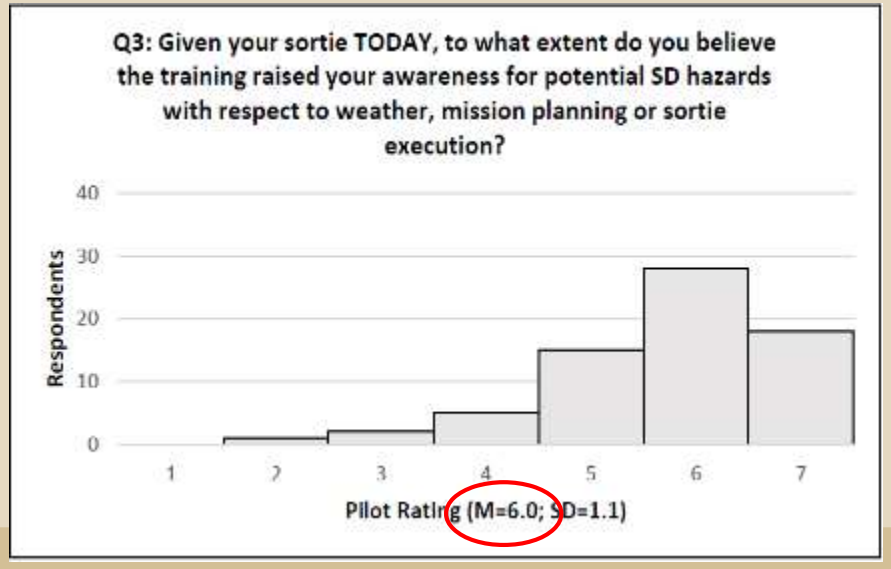
- **Historical SD incident experience (31%)**
  - *Significant* (“could have been nasty”) or *severe* (“lucky to get away with it”)
  - NS relationship between high/low experience cohorts ($\chi 2(1,65) = 2.34$, $P = 0.12$)
- **SD experienced during training sortie (68%)**
  - NS TFH [$\chi 2(1,66) = 0.29$, $P = 0.59$]
  - NS FHOT [$\chi 2\ (1,66) = 0.76$, $P = 0.38$]

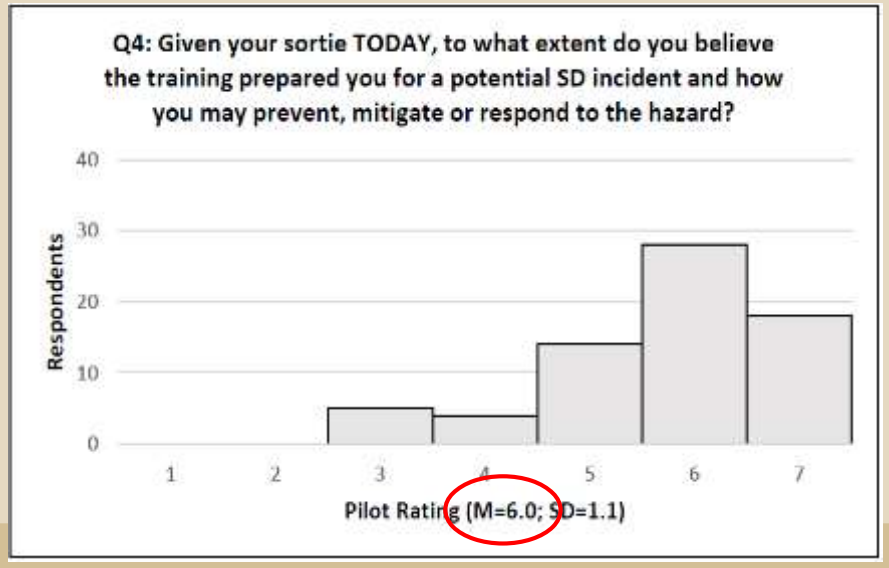
“Most of the scenarios I would not put myself in that situation. However, this is a good opportunity to raise awareness to pilots that all can go wrong quickly and horribly if your choices/decisions are questionable.”

Results


Q1: OVERALL, to what extent do you believe that SD is an important contributor to aviation incidents or accidents?
Respondents
40
30
20
10
0
1
2
3
4
5
6
7
Pilot Rating (M=6.0; SD=1.1)


Q2: Given your sortie TODAY, to what extent do you believe that the scenario was relevant to your role and experience in presenting conditions consistent with possible SD?
Respondents
40
30
20
10
0
1
2
3
4
5
6
7
Pilot Rating (M=6.0; SD=1.2)


Q3: Given your sortie TODAY, to what extent do you believe the training raised your awareness for potential SD hazards with respect to weather, mission planning or sortie execution?
Respondents
40
30
20
10
0
1
2
3
4
5
6
7
Pilot Rating (M=6.0; SD=1.1)


Q4: Given your sortie TODAY, to what extent do you believe the training prepared you for a potential SD incident and how you may prevent, mitigate or respond to the hazard?
Respondents
40
30
20
10
0
1
2
3
4
5
6
7
Pilot Rating (M=6.0; SD=1.1)

Results

		Pearson Correlations								
		M	SD	1	2	3	4	5	6	7
1	Total flying hours**	1300.0	1423.7	--						
2	Hours on type**	500.0	508.5	0.77*	--					
3	Range of previous SD training†	4.0	0.92	0.20	0.22	--				
4	SD important contributor to mishaps (Q1)‡	6.0	1.1	-0.16	-0.18	-0.11	--			
5	SD training relevant to role or experience (Q2)‡	6.0	1.2	-0.17	-0.14	-0.02	0.36*	--		
6	SD training increased awareness of hazards (Q3)‡	6.0	1.1	-0.16	-0.14	0.04	0.18	0.66*	--	
7	SD training prepared you for potential SD incident (Q4)‡	6.0	1.1	-0.13	-0.10	0.02	0.31*	0.75*	0.77*	--

Column numbers correspond to numbered variables in rows.
M = median; SD = standard deviation
* $P < 0.05$
** Self-reported flying experience (requested to round to 100s).
† Scored 0-4 including none, lecture, disorientation trainer, in-flight sortie, or simulator training.
‡ Likert scale 1-7.

Limitations

- **Self-reported**
- **Bias**
  - Social desirability (self-portrayal within a favorable light)
  - Central tendency (avoidance of extremes in ratings)
  - Acquiescence (desire to agree)
- **Survey length was intentionally kept short** (minimize training intrusion/effort of attention)
- **Careless response and response inconsistency**
- **Others**

Discussion

- Differences between instruction, demonstration, and training: *training* brings not only information and the provision of evidence but "…a **desired state of efficiency or condition of behavior**..."
- **Favorable aircrew perceptions** of training objective success
  - Overall SD hazard awareness
  - Relevance to role and experience
  - Awareness of preconditions and contributing elements
  - Prevent, mitigate, and respond
- Good penetrance of changes to **multi-modal training paradigm**

Discussion

- True **multidisciplinary input**: “whole-of-team effort”
- **Training scenarios embedded** within other routine extant simulator periods
- Integrate and flex:
  - Urgency/stress mission imperative (e.g., pickup of deteriorating casualty)
  - Workload (e.g., operating at edges of aircraft performance)
  - Distraction (e.g., aircraft system malfunction)

“Many pilots have commented on how quickly a flight trajectory can go from safe to unsafe when attention is diverted away from the flying task. This is particularly true when the aircraft is maneuvering at low level.” (Stott, 2013)

Discussion

- Evidence (limited) in support of bespoke SD training scenarios within a synthetic training environment
- Merits of the synthetic environment include:
  - *Flexible ability to address root causes*
  - *Provision of an interactive and immersive environment*
  - *Compatibility with extant tactics and mission configurations*
- **SD simulator-based training can serve as an important component of a layered, multimodal approach**

References (abbreviated)

Adams MS, Curry IP, Gaydos SJ. British Army Air Corps Accidents, 1991-2010: Review of Contrasting Decades. Aviat Space Environ Med. 2014; 85(8):852–856.

Anderson HG. The medical and surgical aspects of aviation. London (UK): Oxford University Press; 1919.

Bles W, editor. Spatial disorientation training—demonstration and avoidance. Final report, Task Group TG-039 (TR-HFM-118). Soesterberg (Netherlands): RTO/NATO, 2018.

Bushby A, Holmes SR, McGowan A, Bunting A, Panchal R, Stott J. An assessment of the influence of spatial disorientation upon military aircraft accidents from 1983 to 2002. Farnborough (Hampshire, UK): QinetiQ, 2005. Report No. QinetiQ/05/00474.

Cheung B. Spatial disorientation: more than just illusion. Aviat Space Environ Med. 2013; 84(11):1211–1214.

Estrada A, Adam GE, Leduc PA. Use of simulator spatial disorientation awareness training scenarios by the U.S. Army and National Guard. NATO RTO HFM Symposium on Spatial Disorientation in Military Vehicles: Causes, Consequences and Cures (RTO-MP-086). La Coruna (Spain): RTO/NATO, 2002.

Gaydos SJ, Harrigan MJ, Bushby AJ. Ten years of spatial disorientation in U.S. Army rotary-wing operations. Aviat Space Environ Med. 2012; 83(8):739–745.

Grimshaw T, Boyd J, Bushby AU. Tri-Service spatial disorientation incidents 2018-2021. Farnborough (Hampshire, UK): QinetiQ; 2022. Report No. QinetiQ/21/04058.

Grimshaw T, Stott R. Integrating spatial disorientation training into rotary wing flight simulators: focus on refresher training [abstract]. Aviat Space Environ Med. 2010; 81(3):319.

North Atlantic Treaty Organization Standardization Office. Aeromedical training of flight personnel, 5th ed. Brussels (Belgium): NATO; 2018. Standardization Agreement (STANAG) 3114.

Pennings HJM, Oprins EAPB, Wittenberg H, Houben MMJ, Groen EL. Spatial disorientation survey among military pilots. Aerosp Med Hum Perform. 2020; 91(1):4–10.

Previc FH, Ercoline WR, editors. Spatial disorientation in aviation. Progress in aeronautics and astronautics, vol. 203. Reston (VA): American Institute of Aeronautics and Astronautics; 2004.

Stott JR. Orientation and disorientation in aviation. Extrem Physiol Med. 2013; 2(1):1–11.

ARMY

Questions