Efficacy of Naps as a Fatigue Countermeasure: A Meta-Analytic Integration

James E. Driscoll & Brian Mullen, 2005

Human Factors, Vol. 47 No. 2

Presented by: Kevin Riley

Advanced Human Factors

"The effect is too much, sleep is winning, my whole body argues dully that nothing, nothing life can attain is quite so desirable as sleep. **My mind is losing resolution and control**." – Charles Lindbergh

Key Concepts & 3 Stated Goals of the Study

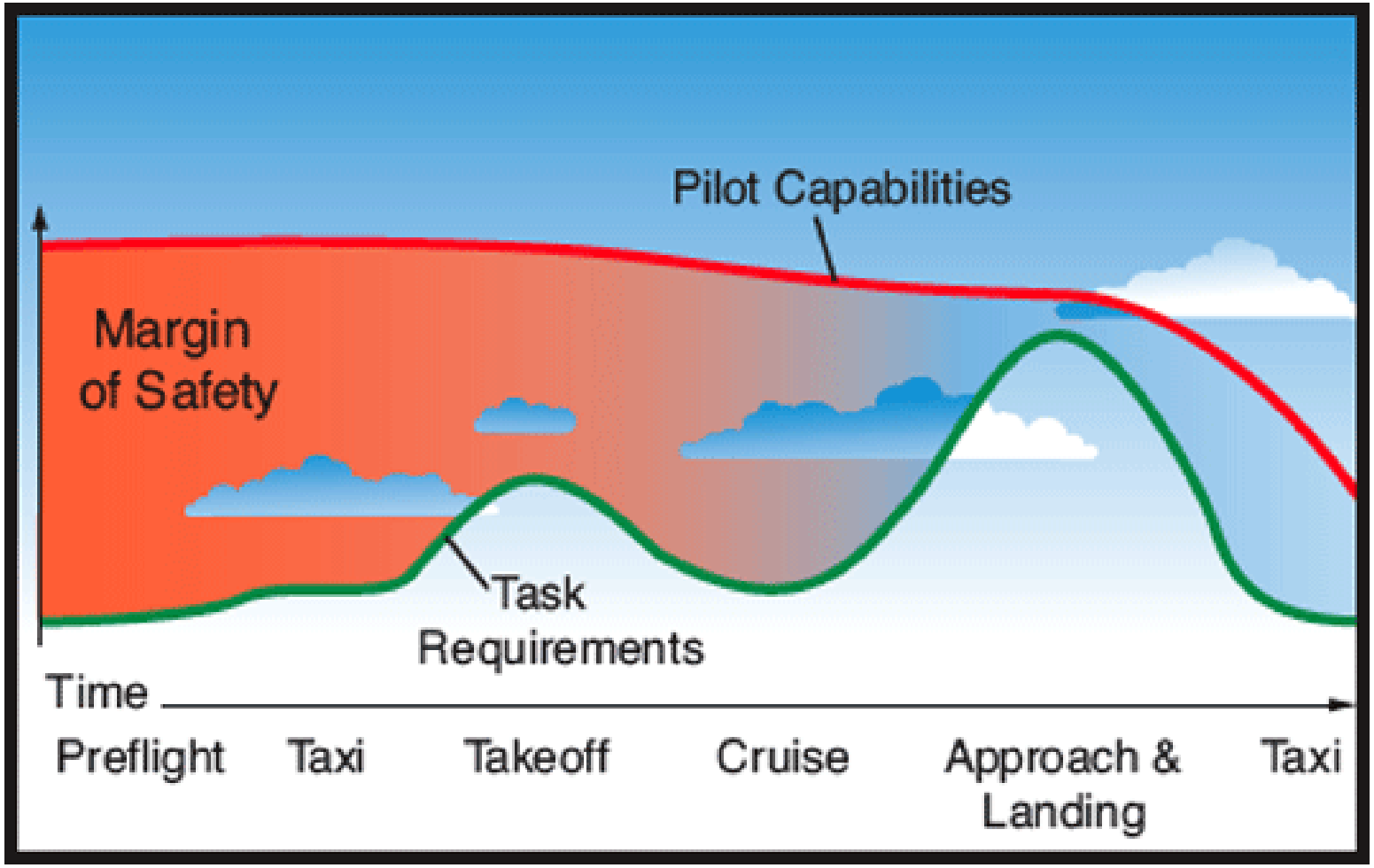
- Countermeasures can help sustain “safety” and performance over time (extended maritime transit, aircraft flight time/operator duty day)
- Minimizing risk or costs (lives, property) in high demand, high consequence environments that have low error tolerance
- Previous research had largely focused on environmental lighting, caffeine, rest breaks and napping

3 Goals:

- Summarize existing (at the time) fatigue research in a meta-analysis
- ID strength and significance of naps on performance and the perception of fatigue
- ID factors that moderate the effect of napping on fatigue

Seminal Research & Findings:

Effects of planned cockpit rest on crew performance and alertness in long-haul operations. Rosekind, Graeber, et al. (1994)



- N=21, control & rest group
- Found significance in improved alertness and task performance w/ rest group
- NSD of *perceptions* of fatigue
- Sleep Inertia concept

Follow on study focus areas from Rosekind 1994 Study

Nap effectiveness depended on implementation. Often thought of as **duration**, and **timing**.

Napping effects on separate but related ideas of **performance**, and **perception of fatigue**.

Postnap interval (deteriorating effects vs long term benefits)

Circadian rhythm effects on napping

Sleep inertia (15-30 minutes, or not observable)

Meta-analysis Example (Driscoll & Mullen 2005)

- 12 studies 1985-2001
- Avg N= 26
- Avg participant age= 20
- 10 min to 8-hour naps
- Postnap interval= 0 hrs. to 4 days

Study/Measure	Statistic (*df*)	*N*	DOE	Effect Size	Nap Duration	Postnap Interval	Time of Day
Aud Vigil (P)	$t(54) = 0.125$	10	+	+0.017	0.33	4.33	17:00
Sleepiness (F)	$t(54) = 2.534$	10	+	+0.338	0.33	0.33	13:00
Sleepiness (F)	$t(54) = 1.164$	10	+	+0.158	0.33	1.33	14:00
Sleepiness (F)	$t(54) = 0.137$	10	–	–0.019	0.33	2.33	15:00
Sleepiness (F)	$t(54) = 0.323$	10	+	+0.044	0.33	3.33	16:00
Sleepiness (F)	$t(54) = 0.128$	10	+	+0.017	0.33	4.33	17:00
Fatigue (F)	$t(54) = 1.252$	10	+	+0.170	0.33	0.33	13:00
Fatigue (F)	$t(54) = 1.548$	10	–	–0.209	0.33	1.33	14:00
Fatigue (F)	$t(54) = 3.958$	10	–	–0.515	0.33	2.33	15:00
Fatigue (F)	$t(54) = 5.474$	10	–	–0.689	0.33	3.33	16:00
Fatigue (F)	$t(54) = 5.209$	10	–	–0.660	0.33	4.33	17:00
Hayashi, Watanabe et al. (1999)							
Logical (P)	$t(36) = 1.440$	7	+	+0.238	0.33	0.67	15:00
Logical (P)	$t(36) = 0.507$	7	+	+0.084	0.33	1.67	16:00
Logical (P)	$t(36) = 0.621$	7	+	+0.103	0.33	2.67	17:00
Calc (P)	$t(36) = 1.131$	7	+	+0.187	0.33	0.67	15:00
Calc (P)	$t(36) = 2.008$	7	+	+0.329	0.33	1.67	16:00
Calc (P)	$t(36) = 1.864$	7	+	+0.306	0.33	2.67	17:00
Visual Det (P)	$t(36) = 1.070$	7	+	+0.177	0.33	0.67	15:00
Visual Det (P)	$t(36) = 0.876$	7	+	+0.145	0.33	1.67	16:00
Visual Det (P)	$t(36) = 0.564$	7	+	+0.094	0.33	2.67	17:00
Aud Vigil (P)	$t(36) = 1.266$	7	+	+0.209	0.33	0.67	15:00
Aud Vigil (P)	$t(36) = 1.331$	7	+	+0.220	0.33	1.67	16:00
Aud Vigil (P)	$t(36) = 0.839$	7	+	+0.139	0.33	2.67	17:00
Sleepiness (F)	$t(36) = 2.726$	7	+	+0.440	0.33	0.67	15:00
Sleepiness (F)	$t(36) = 2.025$	7	+	+0.331	0.33	1.67	16:00
Sleepiness (F)	$t(36) = 1.469$	7	+	+0.242	0.33	2.67	17:00
Fatigue (F)	$t(36) = 0.206$	7	–	–0.034	0.33	0.67	15:00
Fatigue (F)	$t(36) = 2.311$	7	–	–0.376	0.33	1.67	16:00
Fatigue (F)	$t(36) = 2.689$	7	–	–0.434	0.33	2.67	17:00
Horne & Reyner (1996)							
KSS (F)	$t(18) = 3.920$	10	+	+0.827	0.25	0.50	15:45
Takahashi & Arito (2000)							
Logical (P)	$t(55) = 1.094$	12	+	+0.147	0.25	0.50	13:15
Logical (P)	$t(55) = 1.824$	12	+	+0.244	0.25	2.00	14:45
Logical (P)	$t(55) = 0.608$	12	+	+0.082	0.25	3.50	16:15
Logical (P)	$t(55) = 2.797$	12	+	+0.369	0.25	5.00	17:45
RT (P)	$t(55) = 1.882$	12	+	+0.251	0.25	0.50	13:15
RT (P)	$t(55) = 2.425$	12	+	+0.321	0.25	2.00	14:45
RT (P)	$t(55) = 1.951$	12	+	+0.260	0.25	3.50	16:15
RT (P)	$t(55) = 2.563$	12	+	+0.339	0.25	5.00	17:45
Digit Span (P)	$t(55) = 1.319$	12	+	+0.177	0.25	0.50	13:15

Surprising General Results?

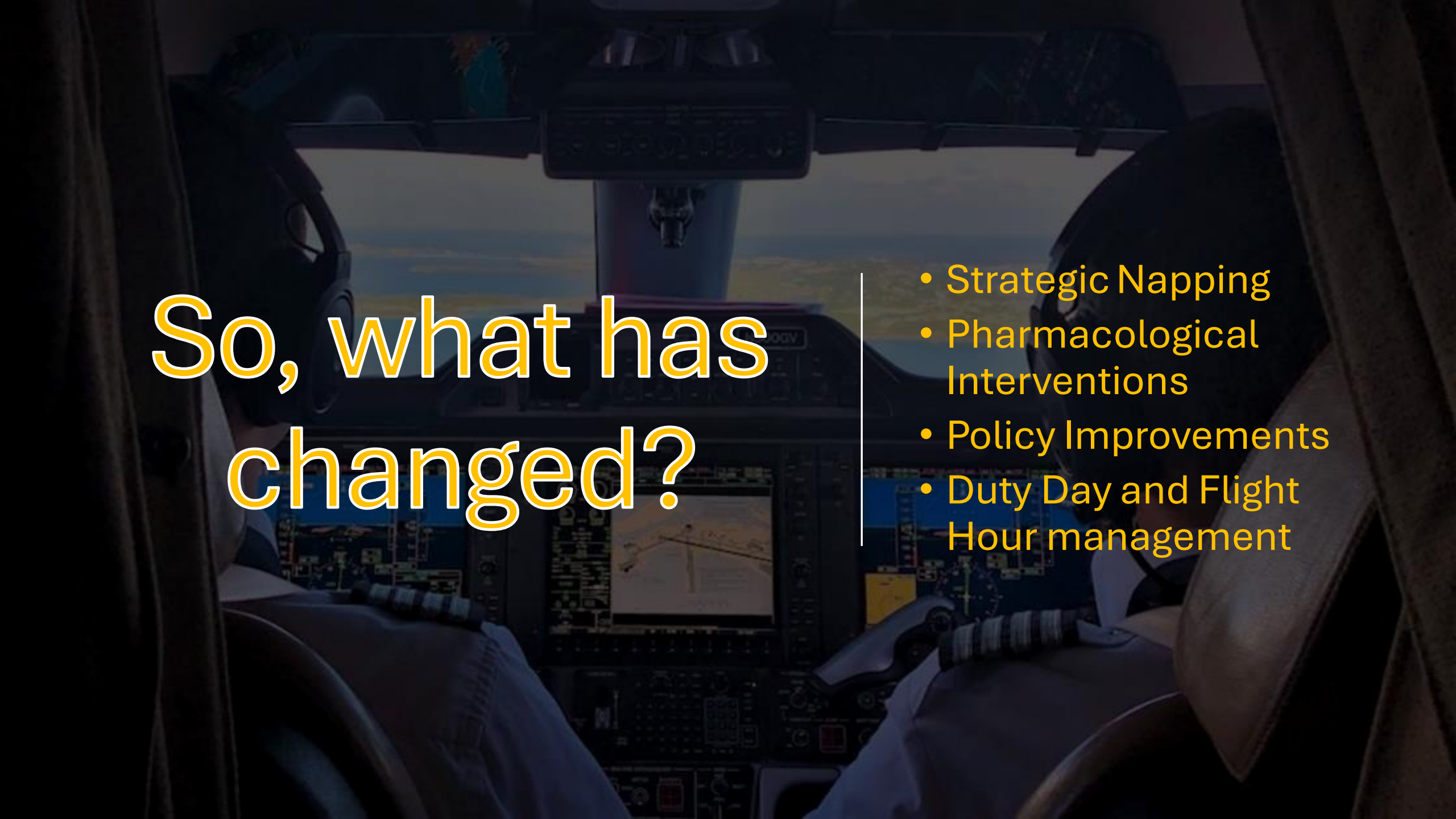
- Overall naps resulted in significant differences between groups with extremely small **negative** effect sizes for experimental (nap) vs control groups (baseline).
- A deeper dive is required to see that this is not true in all instances

Example:

Test Type	DF	N	Corr.	Effect Size	Nap Dur	Interval	TOD
Sleepiness (F)	t(55) = 4.534	12	+	+0.579	0.25	0.50	13:15
Sleepiness (F)	t(55) = 5.069	12	+	+0.639	0.25	2.00	14:45
Sleepiness (F)	t(55) = 3.480	12	+	+0.454	0.25	3.50	16:15
Sleepiness (F)	t(55) = 5.258	12	+	+0.660	0.25	5.00	17:45

Surprising General Results? (cont.)

- Naps & Performance: significant but negligible positive correlation with improved performance (Z fisher = 0.00007)
- Naps & Fatigue: significant but negligible negative correlation (Z fisher= -0.048) compared to baseline
- Nap duration: Longer naps led to significantly reduced benefits of naps (r= -0.286)
- Post nap intervals: Longer PNI significantly correlated with reduced beneficial effects (r= -0.404)



So, what has changed?

- Strategic Napping
- Pharmacological Interventions
- Policy Improvements
- Duty Day and Flight Hour management

Further Reading

- Caldwell, J. A., & Caldwell, J. L. (2005). Fatigue in military aviation: an overview of US military-approved pharmacological countermeasures. *Aviation, space, and environmental medicine*, *76*(7 Suppl), C39–C51.

- Wingelaar-Jagt, Y. Q., Wingelaar, T. T., Riedel, W. J., & Ramaekers, J. G. (2021). Fatigue in Aviation: Safety Risks, Preventive Strategies and Pharmacological Interventions. *Frontiers in physiology*, *12*, 712628.

- Zhang, P., Zhao, W., Shi, L., Wang, Y., Sun, H., & Sun, Z. (2022). Study on Fatigue Coefficient of Airline Pilots. *Frontiers in psychology*, *13*, 865342.