Better performance on the psychomotor vigilance task is associated with longer sleep duration and lower self-reported sleep need in the real world

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Introduction: The psychomotor vigilance task (PVT) is sensitive measure of performance impairment arising from sleep loss and circadian misalignment. Some individuals are able to maintain stable, good performance during laboratory-imposed sleep restriction. It is unclear whether such individuals need less sleep or whether they are more resilient to the effects of sleep loss. We aimed to characterize the relationship between sleep duration and perceived sleep need with PVT performance under real-world conditions.

Methods: We collected actigraphy (MotionWatch 8, CamNtech), daily sleep logs, and the PVT (3-10 times/day) from airline pilots over a 34-day fixed work schedule that began with a baseline (mid-morning start) and then varied between early and late shifts. We split the participants into quartiles by mean baseline PVT performance and calculated sleep duration, self-reported sleep need, and percentage of sleep obtained relative to perceived need. We used analysis of variance to compare sleep outcomes between PVT quartiles.

Results: Thirty-seven participants completed the study (3F). The mean PVT scores over the entire study varied according to the baseline quartile split (quartile 1 [Q1] = 229.1 ms ±84.9 SD; Q2 = 245.2 ms ±79.9; quartile 3 [Q3] = 267.8 ms ±65.2; quartile 4 [q4] = 331.9 ms ±146.2) and remained stable irrespective of work schedule (e.g. those in Q1 had the best performance throughout). Actigraphy-derived sleep duration was significantly shorter among those in Q3 (6.4 h ±1.4; $p = 0.01$) and Q4 (6.4 ±1.5; $p = 0.01$) compared to Q1 (6.8 h ±1.3). Participants in Q1 reported needing less sleep (7.7 h ± 0.7), but obtained a higher percentage of their self-reported sleep need (90%) on average compared to those in the other quartile categories (Q2 = 7.9 h ±0.6, 86%; Q3 = 8.0 h ±0.8, 81%; Q4 = 8.1 h ±0.7, 79%).

Conclusion: We found that participants with the best performance on the PVT reported needing less sleep, but obtained more sleep on average than those in the poorer performing groups. Our findings confirm that longer sleep duration is associated with better PVT performance and suggest that sleep need may differ between individuals who are defined resilient and vulnerable according to the PVT.

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INTRODUCTION

- Group average performance on the psychomotor vigilance task (PVT) changes according to sleep loss and circadian misalignment (Lim and Dinges 2010)
- Some individuals are able to maintain stable, good PVT performance even during sleep restriction (Van Dongen et al. 2012; Dennis et al. 2017)
- It is unclear whether the phenotypic differences in performance observed in consistent high performers is due to lower sleep need or resiliency against the effects of sleep loss
- We aimed to characterize the relationship between sleep duration and perceived sleep need with PVT performance under real-world conditions

METHOD

Participants and Protocol

- Short-haul airline pilots recruited from a single airline
- Pre-study questionnaires including demographics, Epworth Sleepiness Score, Checklist of Individual Strength
- 34-day fixed daytime work schedule (Figure 1)
- Sleep measures: actigraphy (MontionWatch 8, CamNtech), daily sleep logs
- Performance measure: 5-minute PVT 3-10 times daily depending on work schedule

Statistical Methods

- Participants split by quartile of overall PVT performance
- Calculation of actual sleep obtained, proportion of sleep obtained relative to need

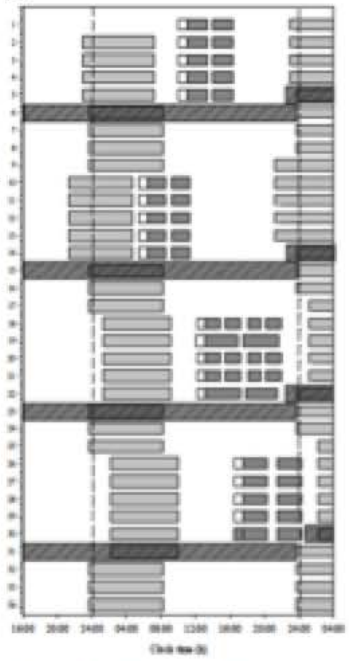

Figure 1. Study protocol for pilots participating in the study. Dark gray = flights, light gray = approximate sleep.

RESULTS

Participants

- n = 37 pilots (3 female), mean age 30.8 ± 7.1 (mean ± SD)

Table 1. Demographic characteristics by baseline PVT performance.

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Age	28.6 (5.4)	33.1 (10.8)	27.7 (4.1)	34.2 (4.4)
Height (cm)	178.3 (5.3)	180.7 (6.4)	181.1 (4.9)	180.5 (5.1)
Weight (kg)	75.2 (6.3)	80.5 (11.0)	79.9 (10.5)	76.7 (7.9)
Self-reported sleep need (h)	7.7 (0.7)	7.9 (0.6)	8.0 (0.8)	8.1 (0.7)
Commute time (m)	40.8 (22.2)	32.4 (17.4)	45.0 (24.0)	40.2 (20.4)
Epworth Sleepiness Score	7.0 (5.3)	5.7 (3.4)	5.2 (5.3)	6.1 (3.1)
Checklist of Individual Strength Score	52.1 (17.4)	59.8 (7.5)	57.3 (19.1)	53.1 (10.8)
	n (%)	n (%)	n (%)	n (%)
Female	1 (10)	1 (13)	0 (0)	1 (11)
Marital Status				
Single	8 (80)	5 (63)	7 (70)	4 (44)
Married	2 (20)	3 (38)	3 (30)	5 (56)
Current smokers	0 (0)	1 (13)	0 (0)	0 (0)
UK citizens	8 (80)	6 (75)	7 (70)	6 (67)
Shared housing	6 (60)	5 (63)	4 (40)	3 (38)
Morning types	2 (20)	1 (13)	2 (20)	0 (0)
Evening types	1 (10)	0 (0)	2 (25)	1 (11)

cm = centimeters; kg = kilograms; h = hours; m = minutes

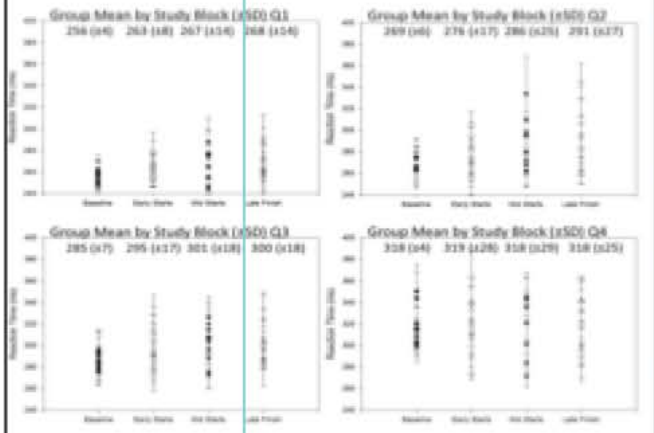

Figure 2. PVT reaction time by study block for each individual in each of the quartile groups

- PVT mean and variability for those in Q1 (early: $p < 0.01$; midday: $p < 0.01$; late: $p < 0.01$), Q2 (early: $p = 0.02$; midday: $p < 0.01$; late: $p < 0.0001$), and Q3 (early: $p < 0.01$; midday: $p < 0.01$; late: $p < 0.01$) increased in each of the duty blocks relative to baseline
- Participants in Q4 increased in variability for each duty block relative to baseline, but the mean PVT score did not change (early: $p = 0.23$; midday: $p = 0.32$; late: $p = 0.46$)

RESULTS

Table 2. Hours of sleep by duty type and by quartile of PVT performance.

	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Rest	7.1 (1.5)	6.9 (1.4)	6.8 (2.0)	6.6 (1.4)
Baseline	6.8 (1.2)	7.1 (0.9)	6.8 (1.5)	6.8 (0.9)
Early duty	5.9 (1.0)	5.8 (1.0)	5.5 (1.0)	5.8 (1.1)
Midday duty	7.3 (1.1)	7.1 (1.0)	6.6 (1.4)	6.5 (1.5)
Late duty	6.8 (1.2)	6.8 (1.3)	6.5 (1.4)	6.7 (1.3)
All Mean	**6.9 (1.4)**	**6.7 (1.4)**	**6.4 (1.5)**	**6.5 (1.4)**

Table 3. Average proportion of sleep obtained relative to self-reported sleep need by PVT performance quartile.

	% of Sleep Need
Quartile 1	90 (13)
Quartile 2	86 (07)
Quartile 3	81 (13)
Quartile 4	79 (13)

CONCLUSIONS

Preliminary analysis suggests:

- Participants in the quartile of best performance appeared to maintain stable performance during each work schedule manipulation, consistent with the trait-like resiliency observed in prior studies
- Participants in the quartile of poorest performance had more variable PVT performance at baseline and throughout the study
- Participants in the best quartile of performance reported needing less sleep on average, but achieved the most sleep across study conditions
- Participants in the worst quartile of performance reported needing more sleep, but achieved a less sleep relative to the other quartiles
- These findings suggest that individuals who show resilient performance on the PVT may need less sleep than average
- Additional data is needed to validate these findings

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REFERENCES

Lim J and Dinges DF. A meta-analysis of the impact of short-term sleep deprivation on cognitive variables. Psychol Bull; May 2010; 136:375-89.

Dennis LE, Wohl RJ, Selame LA, Goel N. Healthy adults display long-term trait-like neurobehavioral resilience and vulnerability to sleep loss. Scientific Reports; Nov. 2, 2017; 7:14889.

Van Dongen, HPA, Bender AM, Dinges DF. Systematic individual differences in sleep homeostatic and circadian rhythm Contributions to neurobehavioral impairment during sleep deprivation. Accid Anal and Prev; Mar2012, 45:11-16