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Daily sleep quality and naval work performance: the role of leadership

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ABSTRACT

Background: Poor sleep is a growing concern in naval settings. Previous research has demonstrated that both civilian and military naval work strains sleep quality as well as a negative relationship between sleep quality and crew work performance. Variables moderating this relationship, such as leadership are of interest.
Materials and methods: The present paper investigates how sailors' daily variations in sleep quality influence self-rated naval work-performance and interacts with perceived daily transformational leadership during a 30-day naval training mission.
Results: Using multi-level analysis, we found significant positive main effects of sleep quality and transformational leadership on naval work performance. Transformational leadership moderated the sleep quality-work performance link. Individuals who experienced higher levels of leadership were less prone to reductions in performance after poor sleep.
Conclusions: Overall, the results suggest that leadership can partly negate some of the reduction in performance that often accompanies poor sleep, and that leadership becomes more important as the crew becomes sleepier.

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Key words: naval work performance, sleep quality, transformational leadership

INTRODUCTION

The last decades have seen an increase in focus on sleep in naval settings [1]. Both military and civilian naval operations consist of continued wakefulness, decreased sleep quality and partial sleep deprivation [1, 2]. These developments have raised two concerns, firstly that reduced sleep impairs the health and well-being of sailors and seamen. Secondly, that poor sleep causes a decrease in human functioning and subsequent naval work performance. Research indicates that directly increasing time available to sleep and taking measures to ensure sleep quality bring both tangible health and work performance benefits [3]. However, the naval work situation is characterised by situations where the option to decrease workload and increase

crew sleep duration is impossible. In these work situations, sometimes referred to as continuous operations, measures that keep performance high in spite of increasing crew fatigue are of interest. The purpose of the current study is to investigate the relationships between sleep quality, naval work performance and leadership during a real-world naval training scenario. It aims to test the role of leadership as a moderator of the sleep quality-work performance link. A large number of laboratory studies find a positive relationship between sleep quality and human performance [4], and some studies have workplace effects. These include positive relationships with job satisfaction [5], organisational citizenship behaviour [6], and work engagement [7]. Unfavourable effects of poor sleep include unethical behaviour [8, 9],

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workplace deviance [10], risk for injuries [11], and abusive supervision [8]. However, fewer studies have investigated the real-world effects in naval settings, and the effects do not necessarily carry over to the maritime workplace. The naval workplace periodically consists of sustained operations to meet extraordinary demands and often includes shift and night work, disrupting the sleep wake cycle [1]. Leaders of naval personnel may not be able to directly influence the amount or quality of sleep onboard, but their leadership still arguably have an important role. Especially, when crew fatigue and sleepiness increases. Naval leaders are in the position to use social and motivational processes to activate and stimulate otherwise sleepy sailors to increase their naval work-performance. Experiencing high quality naval leadership may thus decrease the impact of poor sleep quality on naval work performance.

SLEEP AND NAVAL WORK PERFORMANCE

Both civilian and military naval work is multi-faceted and tasks range from complex to simple and very brief to continuous. Some works duties include the entire crew, and some are relegated to the individual sailor. The overall performance of each individual sailor is determined by a complex interaction of self and organisational variables, including the level of fatigue. Given the role of poor sleep quality as a strong predictor of fatigue, it is likely to influence the individual's work-performance [1]. This notion is supported by a large body of empirical evidence [12–14]. Reductions in sleep have a number of predictable and well-known effects on cognition and mood [15] and reviews of experimental research using both simple and complex works find reductions in human functioning and performance at most levels of sleep deprivation [16]. Sleep theories postulate that long periods of wakefulness increase lapses in attention and unresponsiveness due to episodes of micro sleep [17]. Periods of unresponsiveness lead to increased errors, especially in tasks that require sustained vigilance [18]. Other proposed mechanisms include the role of motivation, disruptions of the circadian rhythm, and situational factors [19, 20]. The "state instability" hypothesis posits that human performance becomes more variable during sustained wakefulness because sleep initiation processes reduce the capacity to maintain alertness and attention [19]. Another explanation to the performance impairing effects of poor sleep is that the latter causes a general reduced work motivation, as the motive for sleeping increases and compete with work motivation [20]. Based on the research cited here, we propose that sailors experiencing poor sleep quality show a reduction in naval work performance. Formally stated: *Hypothesis 1: Daily sleep quality is positively associated with daily naval work performance.*

SLEEP, NAVAL PERFORMANCE AND THE ROLE OF LEADERSHIP

Leaders of naval personnel are in an extraordinary position to influence their followers sleep and naval work performance because they live and work in the same circadian work environment. This is in contrast to leaders who rarely see workers outside daytime office hours. There are several candidates for leadership models that can describe successful naval leadership with different implications for naval leaders aiming to buffer the negative work-performance effects of poor sleep quality among the crew. In general, leadership refers to an individual's ability to influence, motivate, and make others capable of contributing to the effectiveness and success of the organisation [21]. Early research efforts into the leadership process focused on leadership traits and behavioural and contingency theories [22]. Later, the role of the leader as a constructive transactional agent emerges as one who rewards and punishes based on a transactional model [23]. Within a sleep-performance context, a transactional leader mitigates some of the reductions in performance due to sleep loss by utilising praise, reprimands, and rewards, and is responsive to drops in performance. The transactional leader of sleep-deprived personnel motivates by appealing to the individual's sense of self-interest [22], and this might entail more leisure time or other perks awarded to sailors who do not let their performance drop. However, given the pervasiveness of poor sleep quality during naval missions, a more pro-active leadership style might be better suited to buffer the negative effects of sleep loss on performance, such as transformational leadership (TL). TL is characterised by pro-active behaviours that seek to provide a sense of mission and to stimulate higher-order intrinsic needs [23]. TL are charismatic and encourage their followers to put the group's interest first [24], and they have the ability to transform work efforts into a more a more collective vision through inspiration and team commitment [25]. This process might be well suited to reducing the impact of poor sleep on naval teams and individual sailors' functioning. Engaging and inspirational leaders who focus on stimulating individuals might increase vigilance, efforts, and motivation among their sleep-deprived subordinates. TLs are seen as role models to emulate during hardships and are found to stimulate positive energy and proactive involvement among followers [26]. In addition, TL has been shown to stimulate cohesion, collective focus and performance under stress [27]. TL is thus a likely candidate for reducing the daily impact of varying levels of sleep quality on naval work performance. This may happen in several different ways. TLs give more individual consideration. This may reverse the social withdrawal associated with poor sleep [28]. In addition, the inspirational element of TL may also contribute to the moderating effect. A leader

who inspires and creates commitment within the group [29] might be more likely to activate sleepy individuals who are more withdrawn in the social work dynamic [30]. Especially during naval missions with monotonous work and little variation in work duties, were the effects of reduced sleep quality might be most prominent. Based on this we predicted that high levels of TL would increase naval work performance in general and moderate the effects of reduced sleep quality on performance. Formally stated: *Hypothesis 2: Daily transformational leadership is positively associated with daily naval work performance* and *Hypothesis 3: Daily transformational leadership decreases the impact of poor sleep quality on daily naval work performance.*

MATERIALS AND METHODS

DESIGN, PARTICIPANTS AND PROCEDURE

In all, 78 Norwegian naval cadets were included in a 30-day diary study during an ongoing sailing mission at the Royal Norwegian Naval Academy. We measured demographic information and pre-mission work performance before the mission. The mission was part of the cadets training to become naval officers and lasted for 10 weeks. The naval cadets crewed a large sail-ship, with limited modern technology to aid the navigation, and their training mission included two crossings of the Atlantic Ocean and the North Sea during the storm season. The 30-day diary period started the first day at sea. The cadets completed questionnaires every day at the same time (approx. 1700). During the voyage, the naval cadets functioned in roles as leaders or crewmembers on all levels of the organisation, including roles as squad leaders (7 subordinates), quarter-leaders (23 subordinates), or duty captain (78 subordinates). The cadets lived in close quarters, sleeping in hammocks. The voyage is considered to be challenging, as the cadets are relatively unexperienced sailors. The challenging nature is also due to high operational tempo, unpredictable environment, serious potential negative consequences for mistakes, lack of sleep, seasickness, workload and the socialisation into a new and unknown work environment. The cadets are on duty 4 × 2 hours each 24 hours. During down time, they are subject to many other works (e.g. feedback sessions, preparations, theory classes and ship manoeuvres) leaving them with 6 to 8 hours for relaxation and sleep. The sample consisted of 70 (89.7%) male cadets and 8 (10.3%) female cadets. The mean age of the cadets was 22.9 ± 2.2 years. The cadets signed informed consent forms before the mission. The data collection has been approved by the Norwegian Centre for Research Data.

TRAIT LEVEL MEASURE

Pre-mission work performance. We measured self-rated pre-mission work performance with four items from the work performance subscale developed by Goodman and Svyantek [31]. The measure functions as a control variable limiting the possibility of response bias in the daily self-report performance measure. The cadets judge themselves on items measuring their usual performance on duty. Example items include; *"I fulfil all the requirements of my job"*. The cadets marked their response on a five-point scale (1 = totally disagree to 5 = totally agree). Cronbach's alpha for the measurement was 0.71.

DAY LEVEL MEASURES

We adapted existing questionnaires from their existing format, to short day level measurements to customise the questionnaires to a diary format.

Day level sleep quality. We measured day level of sleep quality with a single item: *How well have you slept the last 24 hours?* The cadets responded on a six-point scale (1 = very poor, 2 = quite poor, 3 = poor, 4 = quite well, 5 = good, 6 = very good).

Day level perceived transformational leadership. We assessed day level perceived TL with seven items from the MLQ-5-X [32]. Example items include; *"My leader communicates a clear and positive vision of the future (Vision), is clear about his/her values and practices what he/she preaches (leading by example), instils pride and respect in others, inspires me by being highly competent (Charisma)"*. Cadets rated their daily leader on a 5-point scale (1 = totally disagree to 5 = totally agree). The average within-level Cronbach's alpha for the 30 days was 0.87.

Day level self-rated work performance. Self-rated naval work performance was measured with four items from the same work performance subscale developed by Goodman and Svyantek [31]. Example items include; *"I have performed my work duties in a sufficient manner, during today's shift. I have completed the work described in my job description, during today's shift. I have met the formal requirements in my work, during today's shift"*. Responses were provided on a five-point frequency scale (1 = totally disagree to 5 = totally agree). The average within-level Cronbach's alpha or the 30 days was 0.82.

STRATEGY OF ANALYSIS

STATA version 15 with mixed multi-level modelling to take the nested structure of the diary data into account was used to analyse the data. Within- and between-cadet correlations were obtained with Mplus. In the current study, the daily measures (sleep quality, leadership and naval work performance) constitute the within-individual level of analysis. The control variable pre-mission work performance constitute the between level of analysis. The data is comprised of daily observations (Level 1; n = 1913) nested within individual cadets (Level 2; n = 72). We centred day level

measurements around the person's mean and pre-mission work performance on the grand mean to have meaningful interpretations of interactions between day and person level [33]. This centring procedure [34] removes between-individual variance from the level 1 variables. This eliminates the possible confounding effect of individual differences on daily outcomes. Missing data was handled with case wise deletion resulting in N = 1898 level 1 observations nested within N = 76 individuals in the multi-level models. We tested three multi-level models on daily measures on naval work performance to investigate the effect of sleep and leadership. One unpredicted null model, the predicted main effect model as well as an interaction model were tested. We graphically plotted the marginal effects of the interaction effect between TL and sleep quality. Two slopes were plotted as one standard deviation (SD) below and above the centred score for TL, as well two SD above and below person-centred mean sleep quality (labelled very poor-very good). We used chi-squared tests to post estimate significant differences between the marginal effects, as well as two likelihood ratio tests (χ^2) to test model fit.

RESULTS

DESCRIPTIVE STATISTICS

Means, standard deviations, within person- and between person-level correlations for all study variables are presented in Table 1. The mean and the SD shows that the analysis of sleep data is predominantly focused on discovering effects of medium, to quite well, and not poor sleep quality. The mean daily work performance and TL was also quite high, indicating that the crew is working effectively and with high quality leadership. We found a small positive correlation between sleep quality and naval work performance, at the day level. The results also show a small positive correlation between TL and work performance, at the day level. The control variable pre-mission work performance showed a small correlation to daily work performance. The interclass correlation was 0.39 for daily work performance, 0.44 for daily sleep quality and 0.18 for daily TL. The lower interclass correlation of leadership is likely due to the fact that the cadets took turns being leaders. The high interclass correlation for sleep quality show that much of the variance in sleep quality is based on individual´ sleep patterns, controlled for by centring daily sleep quality measures within individuals.

MULTILEVEL HYPOTHESIS TESTING

The results of the multi-level analysis of the impact of sleep quality, quantity and TL on naval work performance are shown in Table 2. Hypothesis 1 predicted a positive relationship between sleep quality and naval work performance.

In support of Hypothesis 1, we found a significant positive main effect of sleep quality on naval work performance (B = 0.10, p < 0.01). In support of Hypothesis 2, we found a positive association with daily TL and daily work performance. The control variable of general work performance was also positively related to daily work performance (B = 0.22, p < 0.01). The main effects model explained 6% of the between person variance and 7% within person variance. The likelihood ratio test indicates showed that the main effect model improved model fit from the null model (χ^2 (1) = 52.09, p < 0.05).

Hypothesis 3 stated that higher levels of perceived leadership would buffer the effect of sleep quality on performance. We found a significant negative interaction between TL and sleep quality on naval work performance (B = –0.077, p < 0.01), supporting Hypothesis 3. The effect is small, but the interaction model shows better model fit compared to the main effects model (χ^2 (1) = 7.08, p < 0.05). The plotted interaction pattern of TL as a moderator of sleep quality on naval work performance is shown in Figure 1. Both low (χ^2 (1) = 55.44, p < 0.01) and high (χ^2 (1) = 9.71, p < 0.01) TL slopes were found to be significant. The differences between slopes become non-significant at very good sleep quality. The predicted value for an individual experiencing very poor sleep quality but high TL is comparable to an individual with very good sleep quality, but low TL. The predicted difference in naval work performance between low and high TL becomes non-significant at two standard deviations above mean centred sleep quality.

DISCUSSION

The aim of this study was to investigate the day-to-day relationship between sleep quality, TL and naval work performance during a naval training mission. We found that the results supported the hypothesised relationships between daily events. The uniqueness and significance of these findings lies within the highly controlled context and daily diary data collection. The context is a controlled but natural workplace and leadership contexts where individual and team work performance have important consequences for the entire crew and are recorded daily, allowing for within-person deviations to be interpreted. The methodological approach used in the current study allows for the results to be interpreted as daily deviation from individual's baseline sleep and leadership and is important for two reasons. Firstly, that there are notable individual differences in sleep quality [35] that may confound between-individual studies of sleep and naval work behaviour. Secondly, that individual differences in leadership ratings are removed, via person centred TL scores. Although the cadets took turns being leaders, cross-sectional leadership surveys are likely to also measure general attitudes towards leaders. The find-

Table 1. Means, standard deviation, and within person and between person level correlations for study variables (n = 1913 occasions, n = 72 cadets)

Variables	$\bar{X}$	SD	1	2	3	4
Day-level						
1. Sleep quality	4.09	0.49	1.00	0.04	−0.01	0.03
2. Work performance	3.85	0.54	0.04**	1.00	0.009	0.03*
3. Transformational leadership	3.58	0.49	0.003	0.03**	1.00	0.005
Person-level						
4. Pre-mission work performance	4.22	0.40	–	–	–	1.00

Correlations below the diagonal are correlations on the within (day) level and correlations above the diagonal are correlations on the between (person) level; *p < 0.05; **p < 0.001; SD — standard deviation

Table 2. Null, main and interaction model of sleep quality and transformational leadership (TL) on work performance

	Null model		Main model		Interaction model	
	B	SE	B	SE	B	SE
Intercept	3.85**	0.04	3.85**	0.04	3.85**	0.04
Pre-mission work performance			0.22*	0.098	0.22*	0.09
Sleep quality			0.10**	0.01	0.10**	0.01
TL			0.16**	0.02	0.16**	0.02
Sleep quality × TL					−0.08**	0.03
Variance level 2 (person)	0.118 (37.6%)	0.02	0.111	0.01	0.112	0.01
Variance level 1 (day)	0.183 (62.3%)	0.006	0.172	0.005	0.170	0.005
AIC†	2391.95		2274.21		2269.14	
BIC††	2408.60		2307.51		2307.98	
Likelihood ratio test	–		123.74**		7.08**	
Log likelihood	1192.97		1131.10		1127.57	

*p < 0.05; **p < 0.01; †Akaike information criterion; ††Bayesian information criterion; SE — standard error
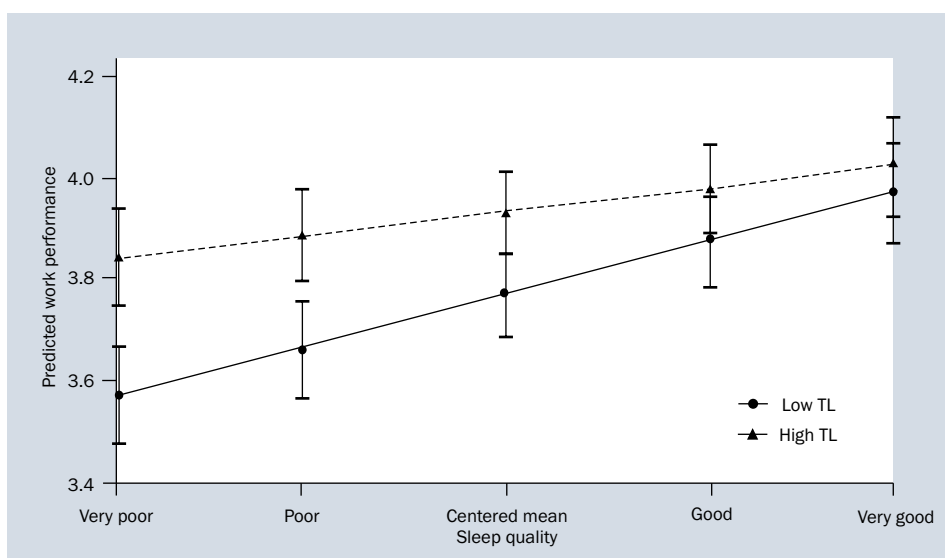

Figure 1. Predicted values of the sleep quality and transformational leadership (TL) interaction on naval work performance. Marginal effects at 1, 2 and 3 standard deviation (SD) above and below mean sleep quality and 1 SD above and below mean TL.

ings and practical implications of the results are discussed further below.

SLEEPY FOLLOWERS AND THEIR LEADERS

The results of the main effect model showed that sleep quality is positively associated with naval work performance, in similarity with previous findings [28, 36, 37]. The relationship between the two variables implies that a poor night's sleep is associated with reductions in work performance. The results cannot conclusively rule out that poor sleep quality only indirectly affects performance, by lowering mood and the tendency to low self-rating in all aspects. In addition, another interpretation of the finding is that when naval cadets negatively deviate from their usual naval work performance, they search for causes such as poor sleep quality. However, when the results are paired with the wide range of other experimental and correlational research showing a positive link between sleep quality and human functioning, we believe that the effect is at least partly due to sleep to performance effects. These may include the lowering of self-control [14], having sleep drive as a competing force, or negative changes to mood and cognition [4, 15]. The study also underscores the importance of leadership to achieve high work performance, a sentiment supported by theory and a high number of leadership studies [24, 26, 29]. The effects of sleep and TL on naval work performance show similar correlations.

The moderation of the sleep quality-work performance link by TL supports the current study's primary hypothesis. Sailors with a more inspirational, charismatic, pro-active leader, showed a significantly smaller drop in performance when they were faced with poor sleep quality. The moderating buffer interaction shows that the difference in work-performance between low and high TL are largest at lower levels of sleep quality. In simpler terms: Sleepy sailors need leadership more than rested sailors do. The magnitude of the effect is such that a cadet experiencing poor sleep but high TL, has about the same naval work performance as a cadet experiencing sufficient sleep quality, but lower levels of TL. The moderating role of TL can be interpreted in different ways, and we offer the following interpretation. The mean naval work performance experienced by the sample in this study is quite high, indicating that the participants are motivated, high-functioning, and capable. The sample is a selected group of individuals, working in non-typical novel and likely engaging work context (a naval training mission), which increase the work performance of each individual. A transformational naval leader transforms the work into a collective and more meaningful endeavour and sets a good example [23]. However, if the individuals are highly qualified, selected, motivated, well rested, with a high sense

of group membership and cohesion, the scores on a limited scale for work performance may peak. The plotted interaction pattern in Figure 1 shows that at two SDs above mean sleep quality, the predicted differences in work performance between cadets' experiencing high and low TL become smaller. Both cadets with high and low TL show very high levels of work performance when experiencing high-quality sleep. It is likely that a poor sleep quality reduces the initial psychological and social processes that originally supported high levels of naval work performance. When this happens, the performance rewards of high TL take effect. An inspirational, charismatic, leader whom creates a collective identity and promotes ownership of the work being done is more likely to engage otherwise sleepy and socially withdrawn cadets. The potency of high TL increases as individuals become sleepier and more fatigued. High TL leaders have a large impact on sleepy cadets, because they need leadership more. TL is often associated with high performance groups such as military teams [38]. The results of this study suggest that the effect of leadership in a high-performance work group is most prominent when otherwise very high functioning followers experience fatigue.

The results also partially answer the question: *When does naval leadership matter*? Leadership researcher have identified several contingencies under which leadership matter more or less, including opportunities for leadership, leader constraints, type of industry and many more [21]. This is the first study that uses human physiology as a contingency for leadership, and the results of the current study support the notion that in high performance contexts leaders matter most during hardship and fatigue. The same overall pattern is likely to emerge in a sample of non-high performing individuals, but the effect of TL would likely be present at all levels of sleep quality and fatigue. The practical implications of the current study's findings are presented below.

PRACTICAL IMPLICATIONS

The effects of low-quality sleep represent a practical problem in any naval organisation, especially during high intensity shift work [39]. For leaders of naval personnel, the available evidence and the results from this study supports measures to increase sailors sleep quality when possible [3]. This could entail measures to ensure less chronobiological disturbances, better sleep environment, reducing general stress and clear separation of work and leisure time. The results also document that leaders can indirectly affect naval work performance when there are no options to directly increase sleep quality. The use of leadership to stave off symptoms of fatigue presents a way to buffer the negative effects of poor sleep quality on naval work performance.

LIMITATIONS AND FURTHER STUDIES

As the present study comprised selected naval cadets, this put a limit on the generalisability of the findings. All measures were based on self-report, meaning that the findings may be partly be due to subjective reactions to differing levels of fatigue and sensitivity towards negatively toned questions, as well as increasing the risk of the common method bias [40]. Future studies could mitigate this problem with the use of objective measures of sleep (i.e. actigraphs) and using senior member judgement of naval work performance. However, given the high proportion of variance being on daily within cadet changes, it is unlikely that different response pattern between cadets invalidates the day level results. In addition, the results are likely not due to response patterns in daily naval work performance as the regression models includes pre-mission general work performance as a control variable. Another limitation concerns the use of a single item measure of sleep quality, which renders reliability analysis impossible. The use of non-Likert six-point scale also hurts the psychometric properties of the scale. However, single-item measures of sleep quality are used in many sleep diaries with predictive validity, and they maintain their predictive validity and their robust correlations to multiple-item scales of sleep quality and to objective measures of sleep [41]. Thus, single-item measurements might be a practical solution in regards to cost efficiency without compromising the predictions in diary studies [42]. Nevertheless, to confirm the current study's findings, future studies should employ multi-item sleep scales to avoid any possible bias associated with single-item measures. Future studies would also benefit from a more age diverse sample. Both the main effect of sleep quality on naval work performance and the moderating effect of leadership may vary across different age groups.

CONCLUSIONS

Overall, the results suggest that leadership can partly negate some of the reduction in naval work performance that often accompanies poor sleep, and that leadership becomes more important as the crew becomes sleepier.

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