

Title: It's been a hard day's night: A diary study on hardiness and reduced sleep quality among naval cadets.

Running head: SLEEP AND HARDINESS IN NAVAL CADETS

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Abstract

A hardy disposition is regarded as an advantage in demanding and stressful environments and is associated with improved military performance. Recent evidence suggests that hardiness may also be related to resilience with respect to sleep disturbances. The aim of the present study is to investigate the moderating role of hardiness in the sleep quality – job performance relationship in a sample of naval cadets during a demanding training exercise. We hypothesize that (1) Hardiness positively influences daily job performance, (2) daily sleep quality positively influences daily job performance, and (3) Hardiness buffers the impact of poor daily sleep quality on daily job performance. A sample of 56 naval cadets first filled in a general questionnaire, and then filled in a daily diary assessing sleep quality during a 30-day

training mission across the Atlantic Ocean. Daily job performance was assessed by using peer-ratings. Results of multi-level analyses showed a positive main effect of hardiness on job performance. Hardiness also moderated the sleep quality – job performance relationship. Cadets high (vs. low) on dispositional hardiness were less affected by poor sleep quality, also after controlling for neuroticism. The results suggest that hardiness moderates the effect of poor sleep quality on job performance.

Keywords: Sleep, hardiness, job performance, personality, navy

Individual military and naval performance is influenced by a number of psychological factors, including intelligence, stress tolerance, social and personality factors (Orasanu & Backer, 1996). Accumulating evidence indicates that a personality disposition high in hardiness is associated with higher levels of job performance within the military context. Hardiness can be defined as a personality trait that is associated with a person's ability to manage and respond to stressful life events with coping strategies that turn potentially unfortunate circumstances to opportunities for growth and learning (Kobasa, 1979) which increases resilience. Hardiness is associated with performance and retention of cadets at both the United States Military Academy (Maddi, Matthews, Kelly, Villarreal & White, 2012) and West Point (Maddi et al., 2017). Hardiness predicts adaptability in military leaders (Bartone, Kelly & Matthews, 2013), and leader performance (Bartone, Eid, Johnsen, Laberg & Snook, 2009; Bartone & Snook, 2000; Bartone, Snook, Forsythe, Lewis & Bullis, 2007). Individuals high in hardiness are

more likely to be successful in military selection programs (Bartone, Roland, Picano & Williams, 2008; Hystad, Eid, Laberg & Bartone, 2011; Johnsen et al., 2013) and hardy military trainees are more persistent and have higher physical capacity than their less hardy counterparts (Lo Bue et al., 2018). There is also evidence that hardy individuals are better able to cope with the strain of military deployment (Escolas, Pitts, Safer & Bartone, 2017). Hardy individuals are committed rather than withdrawn from stressors, perceive a sense of control over important event, and view stressors as challenges and not as threats (Maddi, 2002). However, exactly how hardy individuals achieve higher levels of military job performance is not known. Several mechanisms have been proposed, including coping mechanisms, self-efficacy, frustration tolerance, threat perception, physiological responses and stress appraisal (Contrada, 1989; Delaahaji, Gaillard & van Dam, 2010; Maddi, 1999; Rhodewalt & Agustdottir, 1984). Higher tolerance to stress, perceiving tasks as less threatening and lower physiological arousal in high hardiness subjects in response to a threatening event indicates that hardiness moderates the effects of stress on performance and health (Wiebe & McCallum, 1986). However, the understanding of hardiness and military performance can be further developed with more empirical tests of specific stressors. The aim of this study is to test the hypothesis of hardiness as a moderator of stress, conceptualizing stress as poor sleep quality during military training.

The goal of identifying resiliency mechanisms to poor sleep quality is highlighted by research showing a high frequency of sleep disturbances during military service (Miller, Shattuck & Matsangas, 2011; Taylor et al., 2014). Surveys of deployed soldiers reveal that disturbed sleep is a common occurrence (Dohoney, 2004; Gunia, Sipos, LoPresti & Adler, 2015). During training exercises, simulation of combat often results in reduced sleep duration and poor sleep quality (Opstad, 1994; Legg & Haslam, 1984). Military units train scenarios of periodical sleep loss, to attempt to alleviate some of the negative effects of sleep deprivation

and fatigue. A key feature of successful performance within these scenarios is to maintain functioning when faced with disturbed sleep, as individual differences in mood and cognition emerge when individuals experience sleep loss and fatigue (Lieberman et al., 2005). The naval context is characterized by some distinct stressors which may reduce sleep quality (Comperatore, Rivera, & Kingsley, 2005; Hardaway & Gregory, 2005). The sleep environment aboard a ship consists of several physical stimuli that might negatively affect sleep quality and sleep patterns. These include ship movements, exposure to blue artificial light, and other factors that make optimal sleep difficult to achieve. The prevalence of disturbed sleep and its consequences for health and human functioning has led to a call for resilience research in both military and civilian settings (Germain & Dretsch, 2016).

Individual dispositions and sleep

Poor sleep does not affect individuals uniformly (Pilcher & Huffcutt, 1996). Some individuals appear to be relatively resistant to the adverse effects of sleep deprivation (Van Dongen & Belenky, 2009). In addition, varying degrees of compensatory efforts may reduce the impact of poor sleep (Hockey, Wastell & Sauer, 1998). Such efforts may take the form of increased physical activity, engaging in social interactions, or drinking coffee. In addition, differences in personality may interact with variations in sleep. Several studies have identified neuroticism as a predictor of disturbed sleep and impaired sleep quality (Cellini, Duggan, & Sarlo, 2017; Duggan, Friedman, McDevitt, & Mednick, 2014). Compared to emotionally stable persons, neurotic individuals show increased inability to regulate emotions, have worse sleep hygiene, and are more sensitive to small changes in sleep quality (Mastin, Peszka, Poling, Phillips, & Duke, 2005). In all, the well-documented relationship between poor sleep, and neuroticism (Tonetti, Fabbri, & Natale, 2009) means that controlling for neuroticism is essential when trying to establish a unique effect of hardiness on sleep and performance without the confounding effect of negative affect. There is also a general critique of hardiness

as reverse neuroticism (Funk & Houston, 1987) without a unique explanatory contribution. In this critical view hardiness is first and foremost a personality defined by low negative affect. Both of these valid concerns suggest that the validity of studies on hardiness and sleep is improved if a measure of neuroticism is included as a controlling covariate.

Aims and hypotheses

The overall aim of this study is to investigate if naval personnel high in hardiness have a more adaptive performance response when faced with reduced sleep quality during a naval training mission. Based on the above-mentioned research, we also predicted that hardy individuals would have an overall performance advantage. This hypothesis is based on theory and empirical findings indicating that hardiness is a resilience resource (Oulette, 1993). A naval sailor achieves high job performance by overcoming of a wide variety of stressors, such as stress, fatigue, disturbed sleep as well as physical, psychological and social stressors. Resilience to these stressors, the ability to utilize pro-active coping behaviors (Delhaji, Gailard & van Dam, 2010) and viewing critical situations as less stressful (Maddi, 1999) suggest that individuals high in hardiness will outperform their less hardy counterparts during the mission.

Hypothesis 1: *Hardiness is positively associated with daily peer-rated job performance.*

Secondly, we predicted that a night of poor sleep quality would negatively affect next day's job performance. A multitude of studies strongly suggests a positive relationship between sleep quality and job performance (Engle-Friedman, 2014). Low sleep quality taxes mood and dulls cognitions (Harrison & Horne, 1999; Pilcher & Huffcutt, 1996). This process is likely to produce reductions in job performance. Poor mood may have negative consequences for group work, while reductions in cognitive performance may negatively

impact any task with a minimum requirement of analytical thinking (Killgore, 2010).

Research on job performance indicate that poor sleep quality leads to decrements in sustained performance, as a function of fatigue. The negative effects increase when workers experience complete sleep loss, fragmented sleep or disruptions of their normal sleep schedule (Krueger, 1889). Studies of military performance mirror these findings (Banderet, Stokes, Francesconi, Kowal & Naitoh, 1981; May & Kline, 1987; Krueger, 1991).

Hypothesis 2: *Daily sleep quality is positively associated with daily peer-rated job performance.*

Lastly, we predicted that hardy individuals show less deterioration in job performance when faced with reductions in sleep quality. This prediction is based on research showing that hardy individuals are better able to cope with the challenges of shift work (Wedderburn, 1995), and are less likely to develop sleepiness and insomnia as a consequence of shift work (Saksvik-Lehouillier et al., 2012; Storemark et al., 2013). Coping with shift work represents a good model for testing the role of hardiness in relation to naval sleep disturbances. Naval work requires periodical continuous operations and shift work (Haynes, 2007) which is likely to cause circadian disruptions and lower quality sleep. There is also evidence that hardy naval sailors are less likely to experience poor sleep quality, defined as symptoms of insomnia (Nordmo, Hystad, Sanden, Johnsen, 2017). Hardiness may moderate the sleep quality – job performance in several ways. Firstly, hardy individuals experience a higher sense of control which is related to alertness on nightshifts and the ability to overcome drowsiness (Smith, Spelten & Norman, 1995). Having high levels of commitment and challenge may also drive hardy individuals to meet the strain on sleep quality by increased self-regulation, personal engagement and initiative. Hardy individuals face stressful experiences, such as poor sleep

quality, with the belief that they are challenges to overcome, and not stressors to be endured (Kobasa, 1979; Kobasa, Maddi & Kahn, 1982). We predict that this advantage makes hardy individuals more committed and less likely to withdraw from work duties and thus raise their overall job performance, when faced with poor sleep quality. Thus we predict that the job performance of hardy individuals is less affected by poor sleep quality.

Hypothesis 3: *Hardiness negatively moderates the relationship between daily sleep quality and daily job performance.*

Methods

Design, participants and procedure

To test our hypotheses, we measured hardiness and demographics in a sample of 56 cadets at the Royal Norwegian Navy. The measures were administered before a demanding ten-week training mission aboard a large 100-years old sailship. During the mission, the cadets took turns functioning as leaders at different organizational levels – combined with roles as ordinary crew. The training mission is considered a challenging experience for novice cadets, encompassing two crossings of the Atlantic during the storm season. The cadets live in confined quarters sleeping in hammocks side by side with their colleagues and experience a demanding work schedule – including academic work, classes and demands of operational readiness also outside regular shifts. The cadets work shifts of four hours two times a day (08:00-12:00, 12:00-16:00, 16:00-20:00 or 20:00-24:00). Although the nature of the expedition is training, mistakes and poor naval performance yields real-world consequences, such as potential injuries and damage to the ship. The cadets experience little downtime, and sleep has to be prioritized by the individual. During the first 30 days of the mission, we measured daily levels of sleep quality and job performance, in a diary study format. The

cadets rated the performance of two fellow naval cadets, within the team. Whom the cadets rated, varied throughout the mission. In order to control for circadian effects, the cadets completed questionnaires every day at the same time (5 pm). The sample consists of cadets with varying levels of naval training. The cadets were previously identified as good candidates for training to become a commissioned officer in the Norwegian Navy. The total sample comprised 50 male cadets (89.2%) and 6 female cadets (10.8%). The mean age of the cadets was 23 years ($SD=2.6$). The cadets signed informed consent forms before the mission. The data collection has been approved by the Norwegian Center for Research Data.

Measures

Trait level measures

Trait level Hardiness

Hardiness was assessed with the validated Norwegian adaptation of the 15-item Dispositional Resilience Scale (DRS-15-R) (Hystad, Eid, Johnsen, Laberg, & Bartone, 2010). The measure assesses three dimensions: Commitment, Control, and Challenge. Each dimension is assessed by five items. The answers are registered on a four-point scale (1=totally disagree, 2=partly disagree, 3=partly agree, 4=totally agree). DRS-15-R has been used in both military as well as in civilian settings (Hystad et al., 2010). Example items include: “Most of my life is spent doing things that are meaningful” (commitment), “You can almost always reach your goals by working hard” (control), and “I enjoy the challenge of multitasking” (challenge). In a review of hardiness theory, Funk and Houston (1987) recommended DRS-15-R as the best instrument for assessment of hardiness. Cronbach’s alpha for the composite score was .63 in the present study. This low inter-item reliability score is most likely partly due to the restricted range of hardiness in our high hardiness sample, but also due to the three-factor structure of hardiness.

Trait level Neuroticism

Neuroticism was measured with the subscale included in the Revised NEO Five-Factor Inventory (NEO-FFI-R) (McCrae & Costa Jr, 2004). It includes twelve items, each rated from 0 (strongly disagree) to 4 (strongly agree). Example items include: “When I’m under a great deal of stress, sometimes I feel like I’m going to pieces,” and “I rarely feel lonely or blue” (reverse scored). Cronbach’s alpha for neuroticism was .79.

Day level measures

Day level sleep quality

Day level of sleep quality was assessed with a single item: How well have you slept the last 24 hours? The cadets responded on a five-point scale (1 = very bad, 2 = bad, 3 = somewhat good, 4 = good, 5 = very good). We also measured pre-mission sleep quality before the mission to serve as a reference point with the questions: “How well do you usually sleep?”

Day level peer-rated performance

Peer-rated job performance was measured with four items from the job performance subscale developed by Goodman and Svyantek (1999). Example items include, “The cadet has performed his/her work duties in a sufficient manner, during today’s shift”, and “The cadet has met the formal requirements in his/her work, during today’s shift”. Responses were provided on a five-point frequency scale (1 = totally disagree to 5 = totally agree). The cadets were rated by two of their peers and we calculated their mean score to represent daily peer rated performance. Peers refer to crewmembers who work alongside each-other. All cadets were performance-rated, and rated someone else, each day. Whom the cadets rated, varied from day to day. The average within-level Cronbach’s alpha for the 30 days was .82.

Strategy of analysis

STATA version 15 with mixed multi-level modeling to take the nested structure of the diary data into account was used to analyze the data. Correlations of the study’s variables within and between participants were obtained with Mplus. We included pre-mission sleep

quality in the correlation matrix to investigate the relationship between sleep quality as usual and correlations to hardiness or neuroticism. In the current study, the daily measures (sleep quality and job performance) constitute the within-individual level of analysis. Hardiness and neuroticism were assessed at the between level of analysis. The data is comprised of daily observations nested within individual cadets. Day level measurements were centered around the person's mean and trait level job performance on the grand mean on predictor and moderator variables. This centering procedure (Hoffman & Stawski, 2009) removes between-individual variance from the level 1 variables. This eliminates the possible confounding effect of individual differences on daily outcomes, thus making the resulting estimate a measure of day-to-day change.

To test hypothesis 1 and 2, we tested a multi-level main effects model on the measure of job performance to investigate the effect of sleep quality and hardiness. To test hypothesis 3, we applied a multi-level interaction model containing the interaction between hardiness and day level sleep quality. We also used an unpredicted null model to obtain local variance estimates and to determine explained variance. We graphically plotted significant moderation interactions as continuous slopes from very bad to very good sleep quality and its interaction with hardiness (Figure 2), using the predicted margins of our interaction model. The predicted values of performance are at two SD above and below the centered mean sleep quality and one SD above and below the grand mean of hardiness. Chi² tests were used to determine differences between marginal estimates. Missing data were handled with casewise deletion. To correct for this reduction in variance when calculating the explained variance, we calculated null models using only cases containing data in all predictor variables. Including missing data from predictors would overinflate the variance in the null model, because they are removed from the main and interaction effect models. This reduced the daily observations to 1171 and the number of cadets to 52, from a possible 1680 observations and all 56 cadets.

We calculated likelihood ratio tests (χ^2) to compare the null and the main effect model, and the main to interaction effect model in order to significance testing parsimonious model fit. We also calculated and plotted the crews mean sleep quality over the 30 days with reference lines to cadets' usual sleep quality (figure 1), to graphically describe how a naval mission strain sleep.

Results

Descriptive statistics

Means, standard deviations as well as within-person and between-person correlations are presented in table 1. We found no association between usual sleep quality and sleep during the mission, highlighting how operative naval work situations alter how the cadets sleep, and that the cadets who usually sleep well, do not necessarily show the same pattern during a demanding naval work situation. In line with previous research (Cellini et al., 2017) we found a negative correlation between neuroticism and pre-mission sleep quality. We also found a small negative correlation between hardiness and neuroticism. The interclass correlation for peer ratings of job performance was 0.36 (95% CI= 0.27, 0.45), and 0.46 (95% CI= 0.36, 0.55) for daily sleep quality.

-----INSERT TABLE 1 HERE-----

As shown in figure 1, sleep quality vary notably during the 30 days and are at all times lower than pre-mission measures (sleep as usual). The difference between the reference line and mean crew sleep quality during the mission show how sleep is taxed throughout the mission and varies from one day to the next. Mean usual sleep quality was 3.88 (SD = .78) while mean sleep quality during the mission was 3.29 (SD = .94). The substantial drop in

mean sleep values at day 19 is caused by a naval combat training exercise for a counter-piracy scenario.

-----INSERT FIGURE 1 HERE-----

Multilevel hypotheses testing

The results of the multi-level null, main and interaction effect models on peer rated job performance are presented in table 3. The first hypothesis stated that hardy individuals achieve higher job performance during the 30-day mission. The results show a positive main effect of hardiness on peer rated job performance ($B = 0.37, p < .05$), supporting hypothesis one. The results did not support hypothesis two, as there was no main effect of sleep quality on peer rated job performance. The main effect model explained 9.8% of the total between cadet variance in job performance. The results of the likelihood ratio test showed that the main effects model was a significant improvement over the unpredicted null model ($\chi^2(1) = 19.04, p < .01$). The results showed no effect of neuroticism on performance.

-----INSERT TABLE 2 HERE-----

The results supported hypothesis two, as hardiness moderated the link between daily sleep quality and daily peer rated performance ($B = -0.15, p < .05$). The likelihood ratio test comparing the main effects model with the interaction effect model showed a small but significant improvement ($\chi^2(1) = 4.41, p < .05$). The interaction between cadets high and lower in hardiness across differing levels of sleep quality is shown in figure 2. The interaction pattern showed that worsening sleep quality increased the difference in performance between high and lower hardiness cadets. The difference between the two becomes non-significant at 1

SD above mean sleep quality. Lower hardiness cadets showed a positive linear relationship between sleep quality and performance. High hardiness cadets did not show this trend. Thus, they were found to be more robust to the effect of worsening sleep on performance.

-----INSERT FIGURE 2 HERE-----

Discussion

The aim of this study was threefold. First, we wanted to examine the impact of hardiness and poor sleep quality in job performance during a naval mission. Secondly, we focused on the moderating effect of a hardy personality on the sleep quality – performance link. Finally, we examined these associations on a day-to-day basis. The results supported the hypothesis that hardy individuals have an overall performance advantage over their less hardy peers in line with previous research on military performance (Bartone et al., 2008; Johnsen et al., 2013; Maddi, 2007). Unexpectedly, we did not find a direct effect of daily sleep quality on performance for which we offer two possible explanations. First and foremost, we believe that the null effect is a product of using peer ratings of performance. Peers who undergo the same overall drop in sleep quality are likely to rate their peer's performance as a function of what can be expected with a certain level of fatigue. It is highly unlikely that objective mean performance within each cadet is not affected by disturbed sleep, but the relative rank order performance between each cadet may not change if the whole sample experiences reduced sleep quality and general fatigue during the mission. Secondly, the relationship is blurred by the interaction effect of dispositional hardiness. The results show a positive linear relationship between sleep quality and peer ratings of performance, but only for cadets lower in hardiness. In contrast, high hardiness cadets show a non-significant negative linear trend.

Hypothesis 3 stated that being high or low in hardiness moderate the sleep quality-

performance link. We found that cadets who are high in dispositional hardiness were more resilient to reductions in sleep quality, and their performance suffers less compared to lower hardiness cadets. The effect was small but it supports the notion that hardy naval cadets have a general performance advantage that grows when the crew experiences poor sleep quality. The multi-level statistical model predicts that the difference between high and lower hardiness cadets (1 SD above and below mean) disappears at *good* sleep quality, as shown in figure 2. This implies that one of the reasons for the overall performance advantage of hardy individuals is resilience to disturbed sleep, and support the notion of hardiness as a moderator of stress (Wiebe & McCallum, 1986). There are several processes which may explain this finding. Individuals differ systematically in their vulnerability to sleep disturbances (Rupp, Wesensten, & Balkin, 2012), and part of the explanation may be trait like differences in resiliency to the effect of disturbed sleep on cognitive functions, such as working memory (Whitney et al., 2017). Hardy individuals may also have better sleep flexibility (Costa, Lievore, Casaletti, Gaffuri, & Folkard, 1989), or sleep languidity- the ability to overcome drowsiness and feelings of lethargy following reductions in sleep (Di Millia, Smith & Folkard, 2005).

However, this is unlikely to fully explain the effect as the results showed no correlations between hardiness and sleep quality itself. Instead, the moderating effect may be partly due to the role of voluntary self-activated behavioral compensatory mechanisms (Engle-Friedman, 2014). If individuals are engaged in their work, committed to a plan, feel in control of the outcomes and find meaning in the challenge of working with severe reductions in sleep they may be more likely to take steps to keep up job performance, in the face of sleepiness and reduction in mood and cognition. This is likely reinforced by experiencing high performance overall. High pre-sleep disturbed job performance may decrease the likelihood of social withdrawal and disengagement to the work, because this early experience

have shown that efforts produce positive outcomes. Reversely, having low job performance may increase the likelihood of further reductions and withdrawal because previous experiences have shown that efforts only somewhat increase the job performance. This is especially relevant in a team dynamic, where time available to sleep is distributed among individuals and work can also be distributed.

The results also show how different aspects of personality is related to sleep during the mission and the cadets usual sleep pattern. In line with previous research (Cellini et al., 2017) we found that, neuroticism was related to general off duty sleep quality. Hardiness showed no relationship to off duty sleep quality. We believe these differences explain how neuroticism and hardiness do not reflect the same psychological processes. When cadets sleep as usual without restrictions, their sleep quality is more prone to be impaired due to negative affect, and sleep-incompatible cognitions (Soehner, Kennedy, & Monk, 2007), processes that are aptly described by differences in neuroticism. However, as our sample experience the strain of reduced sleep quality during the mission, differences in performance emerge as some cadets are more resilient to poor sleep quality. In this view, neuroticism and negative affect is the cause of disturbed sleep, when there are no strong external forces. In contrast, strong external forces that reduce sleep increase its role as a primary stressor and subsequently the differences between resilient and less resilient cadets. This distinction may be paramount to achieve a more nuanced view of sleep as usual and sleep during military missions, and who is affected. The findings are noteworthy given how little variation of hardiness there was in the sample and because measures of performance are not self-rated.

Practical military and naval implications

These present results are relevant in situations with inherent disturbances of sleep, such as the military and naval context (Maddi, 2007). The finding suggests why hardiness is related to success in military selection (Sigurd W. Hystad, Eid, Laberg, & Bartone, 2011), and

for military performance in general (Eid et al., 2008; Johnsen et al., 2013). Military service usually includes some inevitable reductions in sleep quality and restrictions on time available to sleep. A buffering effect of hardiness may partly explain why hardy service members fare better during condition of semi sleep deprivation and low sleep quality. The findings also add to the growing literature implicating a hardy personality being able to tolerate sleep impairment, shift work and symptoms of insomnia (Nordmo et al., 2017; Flo, Saksevik). Taken together, this underscores the relevance of thorough selection of psychological hardiness among personnel involved in operational settings, and possibly in particular the importance of selecting out those too low on hardiness.

Limitations and further studies

The current sample comprised highly selected cadets working in a 24-hour work environment, limiting the generalizability of the results to ordinary non-shift work settings. It is indeed possible that personality has a direct impact on sleep quality in the latter types of situations, as individuals have more control over timing and sleep environment in general. Another limitation of the present study is the use of single-item self-report measurements of sleep. Using single items of sleep quality renders reliability measures impossible and may, in general, be prone to systematic and random error. However, there is evidence that a single item of sleep quality is a valid measure. Sleep research often uses single item sleep diaries that correlate with multi item as well as objective measures of sleep (Brekke et al., 2014; Burkhalter et al., 2013). Multiple daily measures reduces random error and improves the measure as a practical solution to the problem of using large multi-item sleep measures every day. The study also has strengths that reinforce its findings. Firstly, the use of a diary design which makes interpretations of day-to-day changes possible. Secondly the control of trait level differences in neuroticism, in line with theoretical criticism of hardiness as a measure of reverse negative affect, and to control for the established effect of neuroticism on sleep

quality. Another advantage is the use of non-self-report measures which removes the possibility of response styles and common method variance (Podsakoff, 2003; Funk & Houston, 1987).

Although, using subjective sleep diaries is common practice in sleep research (Brekke et al., 2014), having activity monitors or other objective sleep measures would reduce possible differences in subjective judgments of sleep quality. In addition, although peer-ratings of performance are less systematically biased than self-report, there may be elements of random bias in the performance ratings of peers working alongside one-another, such as confounding socio-emotional processes. The findings within the current study would be well served to be replicated with senior officers' ratings or objective performance measures. The current study also has a low sample size at the trait level. Further studies could aim to explore why hardy individuals seem less affected by poor sleep quality with a larger N. There are several possible mechanisms behind the present findings: Hardy individuals may be less affected because they do not have the same cognitive or mood disturbances associated with sleepiness as less hardy individuals (Stepanski, Lamphere, Badia, Zorick, & Roth, 1984). Further studies could also elucidate whether the hardy advantage is related to sleep flexibility or the ability to overcome drowsiness and lethargy, following a reduction in sleep.

Conclusion

Most servicemen and women have experienced how the mind and body responds adversely to reduced levels of sleep quality and observed individual differences in performance impact. The results of this diary study suggest that a demanding naval training mission taxes sleep in all service-members without any discernable pattern based on either a neurotic or hardy resilient personality. However, hardy individuals have an overall

performance advantage, in these challenging working conditions, that increases as the crew experiences reductions in sleep quality.

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Tables

Table 1. Means, standard deviation, and within person- and between person level correlations for study variables ($N = 1710$ occasions, $N = 54$ cadets).

Variables	\bar{x}	SD	1	2	3	4	5
Day-level							
1. Daily sleep quality	3.29	.94	1.00	.01	.007	.06	-.01
2. Daily peer-rated performance	4.03	.50	.009	1.00	.02	-.03	.01
Person-level							
3. Trait level neuroticism	2.10	.51	--	--	1.00	-.13*	-.05*
4. Pre-mission sleep quality	3.88	.78	--	--	--	1.00	-.007
5. Trait level Hardiness	4.62	.25	--	--	--	--	1.00

Note: Correlations below the diagonal are correlations on the within (day) level and correlations above the diagonal are correlations on the between (person) level.

* $p < .05$, ** $p < .001$

Table 2. Null, main effect and interaction effect models on the effect of sleep quality and hardiness on peer ratings of naval job performance (SE in parentheses). N=51, 1153.

	Null model	Main effect model	Interaction effect model
Intercept	3.97** (.04)	3.97** (.04)	3.97* (.03)
Neuroticism		0.10 (.08)	0.10 (.08)
Hardiness		0.37* (.16)	0.37* (.16)
Daily sleep quality		0.01 (.01)	0.01 (.01)
Daily sleep quality*Hardiness			-0.16* (.06)
Variance level 2 (person)	.082 (.01)	.074 (.01)	.074 (.01)
Variance level 1 (day)	.143 (.006)	.143 (.005)	.143 (.005)
BIC	1201.64	1210.85	1211.51
AIC	1186.45	1175.41	1171.08
Likelihood ratio test	-	19.04**	4.41*
- Log likelihood	590.22	580.70	577.50

** $p < .01$, * $p < .05$

Figures

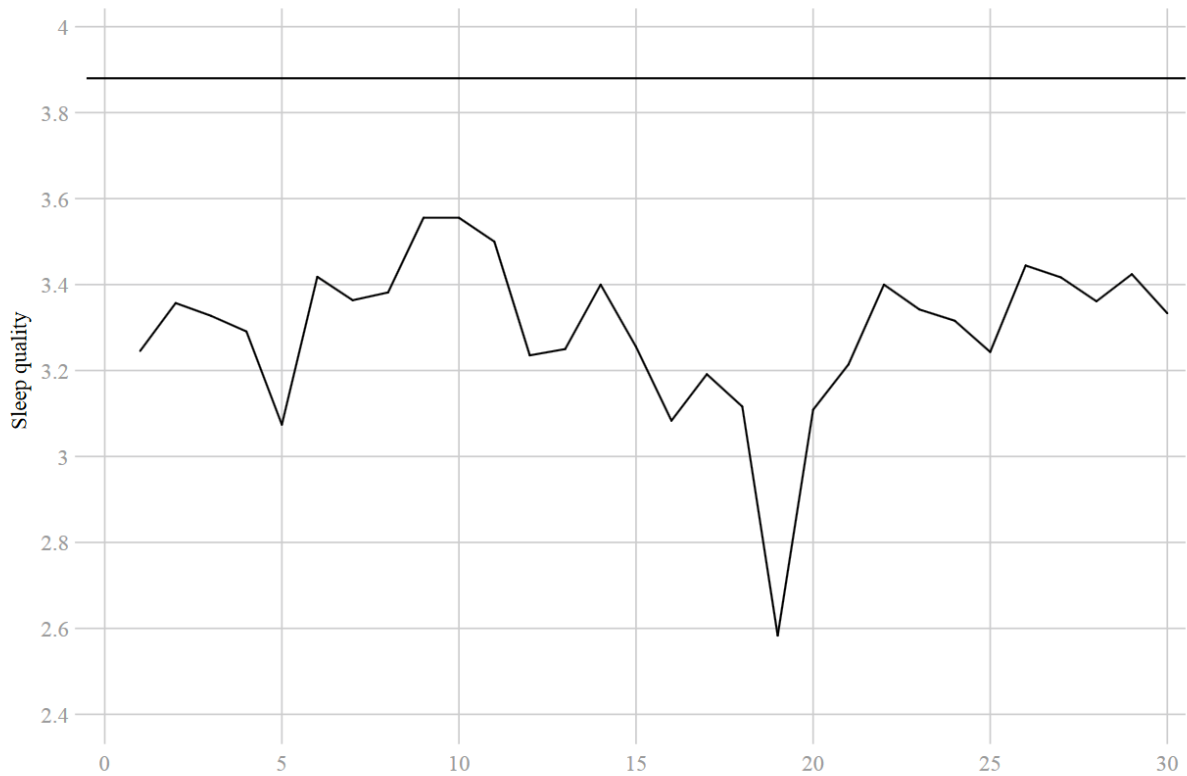


Figure 1: The development of crew sleep quality during the 30-day training mission. The horizontal reference line represent general off duty sleep quality.

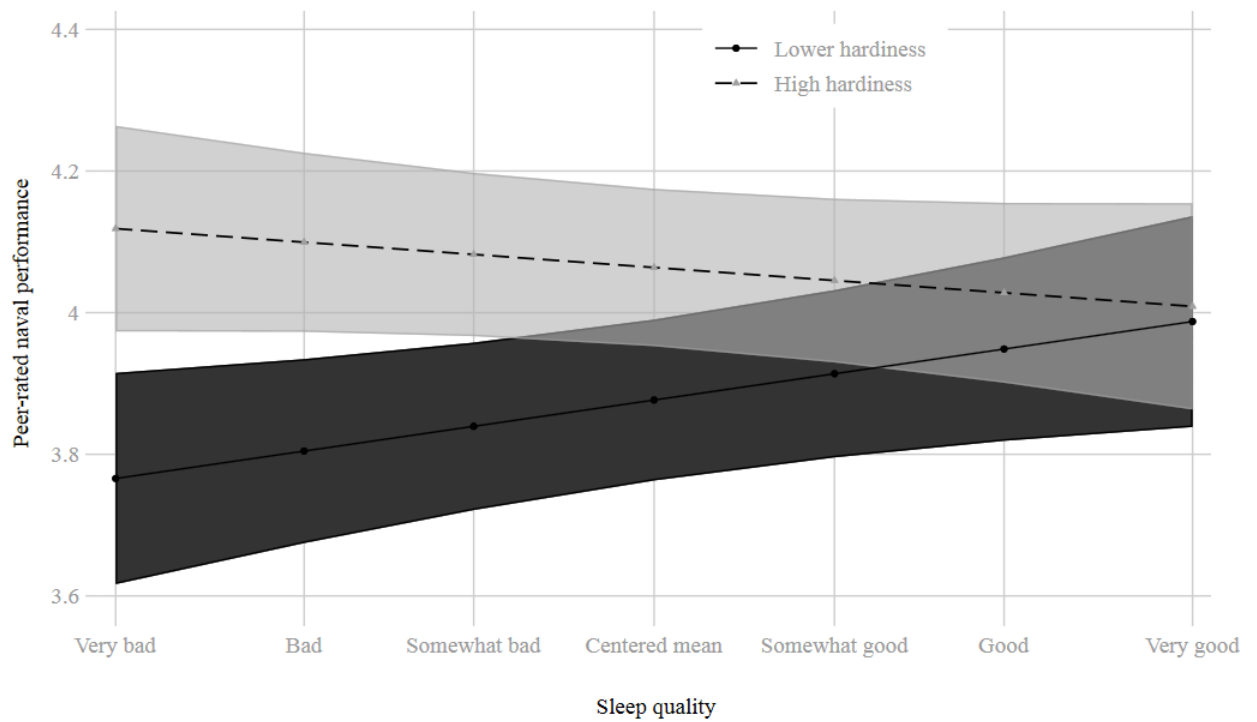


Figure 2: Predicted values of the sleep quality and hardiness interaction on peer-ratings of naval job performance. Marginal effects at 1, 2 and 3 SD above and below mean sleep quality and 1 SD above and below mean hardiness