

Sleep and naval performance

The impact of personality and leadership



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Thesis for the degree of Philosophiae Doctor (PhD)
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Scientific environment

The current dissertation was completed at the Department of Psychosocial Science, Faculty of Psychology, University of Bergen. The candidate was enrolled at the Graduate School of Human Interaction and Growth (GIGH) and was a member of the Operative Psychology Research Group and the Bergen Sleep and Chronobiological Network. Data for the project were collected with the cooperation of the Royal Norwegian Navy. The project also included collaboration with members of the Bergen Bullying Research Group.

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Abstract

Adult life consists of work, non-work, and sleep. All individuals experience a relationship between how well and how much they sleep and subsequent functioning the next day, and the amount and quality of sleep is determined by external and internal factors. Internal factors include personality, individual sleep patterns, and physiological systems, and external factors include the time available to sleep and the sleep environment. For some individuals, the lines between sleep, non-work, and work are more blurred than others, and external factors shape sleep patterns to a greater extent. This is especially the case for military and naval personnel during combat operations and exercises. The primary aim of this thesis is to provide a framework for understanding how sleep quality and sleep duration affect job performance. The research within is based on four key assumptions. Firstly, that lack of sleep and low quality sleep in general decreases cognitive, emotional, and social functioning, which subsequently negatively influences job performance. Secondly, individuals are affected differently by disturbed sleep quality. Thirdly, that group processes, such as leadership, can moderate the negative impact of disturbed sleep on performance. Lastly, the link between sleep and one's own and others' perceived job performance is not uniform for different work-sleep schedules. The thesis investigates these hypotheses in three samples of naval personnel of the Royal Norwegian Navy during active combat operations and during naval training exercises. The first paper tracks sleep quality, as measured by symptoms of insomnia, during a four-month counter-piracy mission in the Gulf of Aden, including measurements before the mission, at the halfway point, and towards the end. It separates the crew of 281 naval personnel into

high and low hardiness groups based on the mean hardiness level as measured by the DRS-15-R (Dispositional Resilience Scale 15 Revised). Repeated-measures ANOVA showed that the overall sleep quality and insomnia symptoms among the personnel were highest at the midway point and that the high hardiness group showed a trend of overall better sleep quality. The results also showed a significant interaction of hardiness and time, where the lower hardiness group experienced a stable trend of worse sleep quality, while the high hardiness group showed an increase in sleep problems in the middle of the mission, but fewer problems before and towards the end of the mission. The paper concludes that having a hardy disposition is associated with better sleep quality during a naval mission and that external factors such as operational tempo, stress, and fatigue might remove differences between resilient and less resilient sailors at the midway point of the mission. The second paper aims to elaborate on the hardy advantage identified in paper 1. Insomnia is a multi-faceted construct, and it confounds sleep quality and the next day's performance. In the second paper, we investigate if the results of paper 1 are due to hardy sailors having better sleep quality and subsequent increased performance (mediation) or if hardy sailors are less affected by disturbed sleep quality as measured by next day performance (moderation). The two hypotheses were tested in a sample of 65 naval cadets during a challenging training exercise using a diary study format. Hardiness was measured with the DRS-15-R before the mission, daily sleep quality and duration were measured with single sleep diary items, and daily naval work performance was measured by peer ratings of performance. The results were also controlled for individual differences in neuroticism and were obtained using multi-level analysis. The results did not support a hardy

advantage due to better sleep quality, but rather that hardy sailors do not show the same deterioration of performance when faced with worsening sleep quality. High-hardiness naval personnel have an overall performance advantage, which increases as the crew experiences a drop in sleep quality. Overall, paper 1 and paper 2 indicate that resilient and hardy naval personnel have a different response to disturbed sleep. This effect might be due to differences in susceptibility to mood and cognitive impairment, but also to increased willfulness and increased engagement of high-performance individuals as the whole crew experiences cumulative fatigue at sea.

The thesis's third paper explores the role of sleep duration in addition to sleep quality in a sample of 78 naval cadets during a similar type of demanding training exercise as the sample in paper 2. The overall research focus of paper 3 was to uncover the isolated effects of sleep duration and sleep quality on two self-rated performance measures – task performance and contextual work performance – as well as to uncover the possible role of high-quality leadership as a buffer against the effects of disturbed sleep quality on work performance. The possibility of paradoxical negative performance outcomes due to increased sleep is rarely discussed in organizational and military/operational sleep research. However, during extraordinarily demanding 24-hour continuous operations with severe limitations on sleep, increasing sleep might come at the cost of non-task-related work activities. We hypothesized that sleep quality is positively related to both measures of performance, while sleep duration is positively associated with task performance but negatively associated with contextual performance (e.g. helping others or volunteering for extra work). We also hypothesized that perceived high quality transformational leadership negatively

moderates both links between sleep quality and performance. The results showed that sleep quality was positively related to both performance measures. Sleep duration was, however, negatively related to contextual work performance but showed no directional relationship with self-rated task performance. In addition, perceived transformational leadership moderated the link between sleep quality and task performance, but not the link between sleep quality and contextual work performance. The results of the study suggest that during challenging work conditions with extraordinary 24-hour shift work, increasing sleep duration is associated with a drop in contextual performance, an effect that leaders and managers should take into account when planning. The results also show how leaders can partially mitigate the negative effects of worsening sleep quality.

In conclusion, the results from paper 1 and paper 2 both suggest that disturbed sleep might cause a drop in work performance and that this drop is partially dependent on the individual's resiliency to the worsening sleep quality associated with a naval mission. This could inform personnel selection and might provide a framework for increasing sailors' work capacity when facing high-paced 24-hour operational activity. The results from paper 1 and paper 3 collectively show that sleep quality and duration have different effects in the context of 24-hour operations, and increasing the demands on the crew without any considerations for time available to sleep can decrease work performance because the crew has to prioritize between sleep and work. Additionally, all three papers point to two possible solutions to the inevitability of disturbed sleep during a naval mission – selecting the most resilient crew based on dispositional hardiness and using transformational leadership as a tool to buffer its negative effects.

List of Publications

Nordmo, M., Hystad, S. W., Sanden, S., & Johnsen, B. H. (2017). The effect of hardiness on symptoms of insomnia during a naval mission. *International Maritime Health*, 68, 147-152. <https://doi.org/10.5603/imh.2017.0026>

Nordmo, M., Olsen, O. K, Hetland, J., Espevik, R., Bakker, A. B., & Pallesen, S. It's been a hard day's night: A diary study on hardiness and reduced sleep quality among naval sailors. Submitted to *Military Psychology*. 03.04.2019

Nordmo, M., Olsen, O. K, Hetland, J., Espevik, R., Bakker, A. B., & Pallesen, S. Sleep, leadership and work performance in a 24-hour work environment: how sleep duration and quality impacts performance, and the moderating role of transformational leadership. Submitted to *Journal of Human Resource Management*. 11.01.2019

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List of abbreviations

ANOVA: Analysis of variance

BIS: Bergen Insomnia Scale

DRS-15-R: Dispositional Resilience Scale 15 revised

EEG: Electroencephalograph

LSD: Least significant difference

MLQ: Multi Factor Leadership Questionnaire

NATO: North Atlantic Treaty Organization

NEO-FFI-R: Neuroticism Extroversion Openness Five-Factor Inventory revised

NSD: Norwegian Center for Research Data

PSD: Partial sleep deprivation

RNNA: Royal Norwegian Naval Academy

SPSS: Statistical Package for Social Science

SD: Standard deviation

TL: Transformational leadership

TSD Total sleep deprivation

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1. BACKGROUND

The empirical background for this thesis consists of the multitudes of studies indicating that poor sleep quality and lack of sleep cause a number of work-related human dysfunctions. For example, studies have shown that too little sleep and sleep problems are associated with poor cognitive functions and impaired motor awareness (Horne, 1993; Kerkhof & Van Dongen, 2010; Lim & Dinges, 2010; Pilcher & Huffcutt, 1996). Sleep deprivation causes a deterioration in performance in most cognitive categories such as simple attention, complex attention, working memory, processing speed, and reasoning, both in terms of speed and accuracy (Lim & Dinges, 2010). The literature also shows that mental arithmetic, logical reasoning, memory, awareness, and meta-cognition suffer as a result of sleep deprivation (Harrison & Horne, 2000). However, generalizing experimental laboratory results into real world naval and military work performance should be done cautiously because a number of studies indicate that humans have a high capacity for overcoming lack of sleep. For instance, there were no significant differences in mortality outcomes between cardiac surgeons operating in a rested and sleep-deprived state (Ellman et al., 2004). In addition, case studies of individuals undergoing severe sleep deprivation have found that some aspects of human performance remain largely intact¹ (Chokroverty, 2009). Most early experimental studies demonstrated negative effects using simple, monotonous problems with little novelty (Pilcher & Huffcutt, 1996). The use of simple problems in unstimulating environments might maximize the adverse effects of sleep

¹ Such as rehearsed sensory motor performance

deprivation. Some studies have found that using more exciting and complex cognitive tasks, like IQ tests², logical reasoning, and rehearsed problems seem to be less affected by sleep deprivation, even after 36 hours with no sleep (Harrison & Horne, 1998). This remarkable sleep deprivation resilience with more novel and complex problems seems to show that the negative effects of sleep deprivation are significantly reduced with the use of new, interesting, and challenging problems (Wilkinson, Broughton, & Ogilvie, 1992) and that deficits are most pronounced on monotonous, less attractive, and repetitive tasks. The lack of ecologically valid laboratory studies at the time led some researchers to argue that sleep deprivation does not affect complex cognition and decision-making (Wilkinson, 1964), both of which are relevant for military performance. However, the prevailing evidence indicates that, as an isolated effect, poor sleep quality and short sleep duration cause a decline in human functioning in terms of cognitive functioning, mood, and sociability (Harrison & Horne, 2000; Pilcher & Huffcutt, 1996), and this has been shown to affect real-world performance. Harrison and Horne (1999) used one night of sleep deprivation and showed a reduction in performance in a marketing game where the participants failed to revise their strategies as the game grew more complex. The participants instead preferred to emphasize meaningless parts of their decision-making strategy that had no effect on the outcome of the game. A military field study found a similar pattern in an 80-hour long, team-based simulated military operation (Banderet, Stokes, Francesconi, Kowal & Naitoh, 1981). After 36 hours, the soldiers and officers failed to detect and remember critical details. Research also shows that performance in conventional planning, which

² Wechsler Adult Intelligence Scale (WAIS)

requires participants to ignore previously rewarded and successful strategies, is significantly affected after one night without sleep (Wimmer Hoffman, Bonato & Moffit, 1992; Horne 1999), and the lack of sleep caused the participants to fail to update their original strategies in light of new information. May and Kline (1987) monitored performance on a wide range of cognitive problems by military personnel after two nights without sleep. When sleep deprived, the soldiers mastered convergent problems, where the solution could be found through logical deduction, but were significantly worse at solving problems where the solution required innovation and spontaneous ideas. Flexibility in cognitive processes is assumed to be of major importance when individuals are faced with complex and unpredictable events (Bennet & Bennet, 2008). There is also evidence to support the notion that sleep deprivation causes differences in risk assessment. One study found that sleep-deprived participants evaluated negative consequences differently when they were presented with a potentially high reward (Bechara, Damasio, Tranel, & Damasio, 1997). The aforementioned research efforts and others that have focused on mood control (Horne, 2018), insight into one's own performance (Dinges & Kribbs, 1991), temporal memory (Harrison & Horne, 2000), and communication (Whitmore & Fisher, 1996) all show a marked negative effect of sleep deprivation on key complex cognitive skills.

A key feature of this line of research is strong manipulation of sleep. Total sleep deprivation³ (TSD) across one or more nights (Harrison & Horne, 1999; Kerkhof &

³ Long TSD can be defined as >45 hours without sleep, while short TSD refers to <45 hours without sleep (Pilcher & Huffcut, 1996).

Van Dongen, 2010) is, however, arguably not very common in most organizations⁴. Although many occupations require periodical night or shift work or continuous work, very few occupations plan for periods of TSD (Luckhaupt, Tak & Calvert, 2010). In this regard, generalizing from these studies to real-world scenarios gives the impression that lack of sleep is inevitably detrimental to human functioning and causes severe drops in work performance. Several observations illustrate how this simplistic view is likely wrong. Firstly, less severe restriction of sleep⁵ does not negatively influence decision-making, attention or inhibition in healthy young adults (Schaedler, Santos, Vincenzi, Pereira & Louzada, 2018). Secondly, the sheer number of persons working with restricted and lack of sleep during shift or night work (Parent-Thirion, Fernandez Macias, Hurley & Vermeulen, 2007; Åkerstedt, 2003) indicates that the increases in errors and drops in work performance do not outweigh the organizational benefits of having 24-hour operations⁶. Thirdly, the relationship between sleep and performance might vary widely across different work situations. For persons working ordinary 9 to 5 jobs with a stable circadian rhythm, poor sleep quality and short sleep duration will likely cause a drop in next-day performance. However, in many occupations the separations between work, non-work, and time available to sleep are more distorted (Crain, Brossoit, & Fisher, 2018). This includes doctors and nurses working long hours across different shifts and only sleeping when no other duties are required (Gander, Purnell, Garden, & Woodward, 2007), military

⁴ The prevalence of short sleep duration (<6 hours) has, however, increased over the last two decades (Luckhaupt, Tak & Calvert, 2010).

⁵ three hours of restricted sleep, in either morning or night

⁶ Sleepiness and fatigue are related to workplace accidents and to several catastrophes throughout history (Dinges, 1995).

and naval personnel during training and missions (Hardaway & Gregory, 2005; Miller, Shattuck & Matsangas, 2011), and any other extraordinary work situations that require individuals to work extended hours into the night to achieve some goal. Individuals within these occupations face a choice of sleeping or working, and this interplay affects objective and subjective work performance. Sometimes more sleep leads to higher cognitive, social, and general human functioning, and subsequently to better work performance. Other times, when demands are high and there is little time available to sleep, prioritizing more sleep might lead to a decline in performance. This eventuality is especially relevant in military and naval work situations that commonly see periods of continuous operations and lack of sleep (Hardaway & Gregory, 2005; Miller & Shattuck, 2005; Miller et al., 2011). The interplay between sleep duration and work performance is thus based on three factors – the potential performance benefit of working rather than sleeping, the size of the effect of lack of sleep per time unit on work performance, and the extent of sleep deprivation. In a military and naval setting – the context for the current thesis – there is reason to believe that the relationship between sleep and performance is more complex. Sailors and soldiers are frequently faced with demanding continuous operations during which increasing sleep duration might reduce work performance because there is no downtime. Secondly, while some sleep loss is common (Gal & Mangelsdorff, 1991), multiple days and nights of total sleep deprivation, as seen in laboratory studies, are unlikely because such situations are actively avoided through operational procedures (Troxel et al., 2015). Thirdly, the size of the effect of short sleep duration on military and naval work performance is based on the nature of the work being done. If the sailor or soldier is engaged in

complex decision-making, reasoning, or other cognitively demanding tasks, then their performance would likely suffer (Harrison & Horne, 2000). However, the nature of military and naval work is comprised of many heterogeneous work activities. Some require complex thinking while others are highly trained and rehearsed and are not likely to be susceptible to short sleep duration. Lastly, simplistically generalizing experimental sleep research to military and naval work performance does not account for the procedures and techniques employed by service men and women to combat sleepiness during deployment and training. One of the key findings from the sleep deprivation literature is that the effects of sleep deprivation on performance do not last after restorative sleep (Chokroverty, 2009). High-quality military and naval leadership and group processes are likely able to moderate reductions in human functioning after sustained lack of sleep and to allocate more sleep time to alleviate the effect.

Another limitation within the sleep-performance literature is the reliance on cross-sectional survey results to demonstrate the positive correlation outside of experimental studies. Cross-sectional sleep surveys have a clear drawback in that they omit the critical fact that the effects of changes in sleep on functioning are immediate and have consequences the following day, and cross-sectional measures might fail to detect key daily changes due to natural variations in sleep duration and quality (Scott & Judge, 2006). Large surveys might also be prone to introducing unintended cohort effects. Experimental sleep research largely solves this problem but introduces a new one, namely limited ecological validity. Thus, lab experiments might not share the same generalizability as studies where people sleep in a natural state. Shortitudinal

data collection, with daily measures tracking changes within persons, presents a solution to this methodological problem (Scollon, Prieto & Diener, 2009).

Another problem with many sleep surveys is the confounding of sleep quality and sleep duration. Organizational sleep studies demonstrate that there is a potentially important empirical distinction between sleep quantity and sleep quality (Barnes, Schaubroeck, Huth & Ghumman, 2011; Kuhnel, Bledow & Feuerhahn, 2016). A reduction in sleep quality might be a better predictor of performance in occupational settings where there are few direct limitations on sleep quantity and subsequent sleep deprivation. In military, naval, and high-reliability organizations, this distinction might also play an important role. Here restrictions on available time to sleep might reduce sleep quantity, but not necessarily sleep quality (Jepsen, Zhao & van Leeuwen, 2015), and increasing sleep debt might paradoxically increase perceived sleep quality after sustained operations (Miller, 2008). In comparison, there is no direct way to compensate for poor sleep quality because repeated awakenings and trouble falling and staying asleep lead to less restorative sleep, even when there are few or no restrictions on sleep time (Harvey, 2008). In most settings, the effects of sleep quality and sleep duration are parallel and additive, but in work contexts with severe limitations on sleep duration they might have opposite effects.

1.1 Sleep and performance in the armed forces

“*Sleep when you are dead*”, goes a popular navy slogan (Weinstein, 2017)⁷. This view of sleep in the armed forces reflects how individual soldiers and sailors experience and learn to cope with periods of partial sleep deprivation (PSD). This view of sleep deprivation as something that can be overcome also supports the notion of a more complex dynamic within the armed forces context. The available evidence indicates that military training and service do indeed tax sleep, and studies of sleep in modern military campaigns have found that disturbed sleep and sleep deprivation are relatively commonplace (Miller et al., 2011). The results of a survey of 273 American soldiers deployed during Operation Iraqi Freedom showed that sleep deprivation was a common occurrence (Dohoney, 2004), and between 73% and 83% of the soldiers showed moderate symptoms of sleep deprivation, and 14% to 23% showed significant symptoms of sleep deprivation. That study concluded that the soldiers who had a plan for sleep and rest maintained better operational capability. Another survey asked 49 American officers returning from deployment to describe their own and their subordinate soldiers’ sleep patterns (Miller et al., 2011). The survey also asked about efforts and procedures to mitigate sleep deprivation. The results showed that 80% of the participants had not received any information on how or why to improve sleep. Over half the officers reported that fatigue, due to lack of sleep, was a problem in their troops. During missions with high operational tempo, where the troops spent over half

⁷ Often referred to as the unwritten 11th standing general order

their time in combat operations, the officers reported that their soldiers slept about 4 hours a day.

The benefits associated with 24-hour operations extend to private companies as well as the military, industrial, and health sectors (Barnes, Jiang, & Lepak, 2016). Many companies use periodical extended shift and night work to meet surges in demand (Caruso, 2006), and many industrial manufacturing organizations operate 24-hours a day because the cost of shutting down machines and the production process is high. The numbers of individuals working night and shift work vary by nations. In a representative sample of 58,000 employed Swedes, 23% were working according to a shift-work schedule⁸ (Åkerstedt, Fredlund, Gillberg, & Jansson, 2002). However, there are likely to be important differences in the sleep-performance link between the disturbed sleep of individuals working planned and scheduled shift work and the disturbed sleep of sailors and soldiers. The primary difference is the consistency and predictability with which short sleep duration or poor sleep quality is experienced. A shift-work schedule gives the benefit of planning extra sleep before or after long working hours and night shifts to compensate for increasing sleep debt. In contrast, a sailor or soldier during a live mission or training periodically experiences much less predictability in regards to sleep and work schedule. During particularly demanding operational periods, the option of ending a shift or having free leisure time that can be used to ameliorate increasing sleep debt is partly or totally removed. In these periods,

⁸ 4% worked night shifts

prioritizing sleep might lead to a decrease in individual as well as collective work performance.

1.2 Sleep during naval missions and training

The stressor dimensions of modern military operations are also relevant in naval missions, but the naval context is characterized by some distinct stressors (Comperatore, Rivera, & Kingsley, 2005; Hardaway & Gregory, 2005). Maritime work features sailors and officers living and working in a complex system of stressors that affect their ability to maintain operational readiness. Lack of sleep, difficult work conditions, extreme temperatures, uncertainty, and isolation from civilian life make modern maritime operations demanding for the individual (Comperatore et al., 2005). The crew has to endure chronic stressors in order to maintain physical and psychological functioning, and the heavy workload can reduce psychological health (Vaitkus, Bartone, & Adler, 1998; Eid & Johnsen, 2005). Modern counter-piracy fleet operations have the added stressors of an unknown enemy, even if the risks of injury or casualties are reduced with this type of mission (Leland, 2010).

Disturbed sleep cycles or sleep deprivation are potential distinct stressors during such missions because the working conditions might entail long periods without sleep (Johnson, 1982). In addition, the sleep environment aboard ship consists of several physical stimuli that might negatively affect sleep quality and sleep pattern. These include ship movements and exposure to blue artificial light⁹. The brain uses light as a

⁹ Disturbed sleep, fatigue, and long working hours are also common among civilian seafarers (Jepsen, Zhao & van Leeuwen, 2015)

circadian cue, where the light activates the suprachiasmatic nucleus that inhibits the release of melatonin from the pineal gland. This process is especially sensitive to light from the blue spectrum (450–495nm) (Viola, James, Schlangen & Dijk, 2008), which is the type of light that is produced from the computer screens and displays on modern naval vessels. Melatonin secretion contributes to the maintenance of a circadian rhythm (Langer, Hartmann, Turkof, & Waldhauser, 1997), and long-term exposure to blue light can disturb the circadian cycle and cause symptoms of insomnia and poor sleep quality.

1.3 Sleep cycles and work

Sleep patterns are determined by internal psychobiological forces and by external forces. The internal forces include circadian rhythms, sleep-drive homeostasis, and physiological activation according to dual-process theory (Borbély, 1982). The external forces refer to the restrictions on time available to sleep and the sleep environment itself. Humans most easily fall asleep when three conditions are met. First, after they have been through a period of wakefulness, increasing the homeostatic drive to sleep (Oswald, 1962). Second, the internal biological clock (circadian rhythm) registers nighttime and triggers the release of sleep-inducing neurotransmitters such as melatonin (Dubocovich, 2007). Last, there must be an opportunity within the environment to support sleep. This includes a physical place to sleep, but also the absence of perceived danger and stressors or other activating stimuli. The interaction of these three elements provides a key to understanding the sleep disturbances and low levels of sleep sometimes experienced during naval

missions and training. Going for long periods without the opportunity to sleep increases the homeostatic sleep drive, and this leads to sleepiness at times when the circadian rhythm does not signal nighttime. Lack of timing of sleep with the circadian system results in shallower sleep with reduced restorative properties (Bjorvatn & Pallesen, 2009). Because of this, during continuous naval and military operations or during shift and night work in general, there are reductions in restorative sleep even if the person has 8 hours allocated to sleep.

Several theories have been proposed to explain why reductions in sleep quality and duration cause a drop in human performance. The first mechanism to be proposed postulated that long periods of wakefulness increase lapses in attention and unresponsiveness due to episodes of micro sleep (Williams, Lubin & Goodnow, 1959). Periods of unresponsiveness lead to increased errors, especially in tasks that require sustained vigilance (Harrison & Horne, 2000). Other proposed mechanisms include the role of motivation, disruptions of the circadian rhythm, and situational factors (Doran, Van Dongen, & Dinges, 2001; Kjellberg, 1977). 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 (Doran, Van Dongen, & Dinges, 2001). However, sufficient motivation can periodically counteract the effects of sleep deprivation (Kjellberg, 1997). Lastly, our understanding of sleep stages aids our understanding of how PSD interacts with sleepiness and subsequent performance. After sustained wakefulness, stage 1, stage 2,

and REM sleep are reduced, while slow-wave sleep¹⁰ is not affected (Brunner, Derk-Jan, Tobler & Borbély, 1989). In the recovery period, REM sleep increases as a rebound effect. The practical implication of this effect is that soldiers and sailors experiencing sleep deprivation might reach deep REM sleep faster, even during brief naps, and might need several nights to return to their normal sleep architecture (Borbély, 1982).

1.4 Individual differences

Although several lines of sleep-deprivation research show marked impairment on both simple and complex cognition, some studies suggest that individual factors might act as moderators of disturbed sleep (Van Dongen & Belenky, 2009). Curiously, some individuals appear to be unaffected by sleep deprivation or are well able to compensate through effort after losing sleep. In addition, these differences seem to be stable across multiple sleep-deprivation sessions. Van Dongen and Kerkoff (2010) argue that this stability is a naturally occurring trait and is possibly due to variability in specific polymorphisms in human clock genes (Von Schantz, 2008). In addition, some individuals are better at changing their sleep schedule to fit environmental demands. Sleep flexibility refers to the ability to fall asleep at different times of the day (Costa, Lievore, Casaletti, Gaffuri, & Folkard, 1989), and individuals who are high in sleep flexibility are not particularly bound to their sleep habits and have an advantage in situations where sleep is restricted, such as shift work (Axelsson, Åkerstedt, Kecklund, & Lowden, 2004). In a similar vein, sleep languidity refers to the individual's ability

¹⁰ Stages 3 & 4

to overcome drowsiness and feelings of lethargy following reductions in sleep, and this is also associated with a tolerance for shift work (Storemark et al., 2013; Di Millia, Smith & Folkard, 2005). Combined, these individual differences might be correlated with naval and military work performance during training and missions when the sailors and soldiers work for longer hours without sleep. Given the prevalence of sleep disruptions during military and naval missions and training, being more resilient to sleep disturbances is likely to be a significant advantage in such contexts. Individual differences also affect how much effort is used to compensate for sleep loss (Engle-Friedman, 2014). In this context, effort refers to the extent an individual exerts him or herself to compensate for lack of sleep. Sleep loss usually negatively impacts effort-related choices, but some individuals are less prone to this (Lim & Chee, 2007). In a naval and military work situation, differences in the ability to self-mobilize resources to combat sleepiness¹¹ are likely to produce differences in work performance during continuous missions and training.

1.5 Personality factors

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, there is a well-documented relationship between poor sleep, circadian

¹¹ Such as increasing physical activity, engaging in social interactions, or drinking coffee

typology, and neuroticism (Tonetti, Fabbri, & Natale, 2009). Studies also point to the positive benefit of having a conscientious personality type on sleep patterns (Tonetti et al., 2009). Such individuals tend to have better sleep hygiene, and conscientiousness is generally positively related to health-promoting behaviors (Tonetti et al., 2009). In one survey, conscientiousness explained 19% of the variance of sleep quality (Duggan et al., 2014). Neuroticism and conscientiousness are also related to diurnal types, and conscientious individuals tend to be morning types while neurotics tend to be evening types (DeYoung, Hasher, Djikic, Criger, & Peterson, 2007; Tonetti et al., 2009). Lastly, having a personality high in dispositional hardiness might be related to resilience against sleep disturbances (Storemark et al., 2013). This thesis will first present a general overview of the concept of resilience and hardiness before presenting the evidence for the role of hardiness in sleep and in tolerance of disturbed sleep.

1.6 Hardiness

Resilience is defined as the ability to cope with and even thrive under demanding circumstances due to risk, change, or adversity (Hass & Graydon, 2009). The concept has its roots in developmental psychology (Tusaie & Dyer, 2004), and the development of the resilience concept is marked by having to overcome both conceptual and temporal problems (Skodol, 2010). The temporal challenge is to determine if difficult life circumstances have developed into resilience to subsequent challenges or if the individual had high resilience all along. Retrospective studies are methodologically unable to determine whether resilient individuals become more resilient in the face of adversity or if they were resilient all along. In addition,

resilience is a multi-faceted concept with several synonyms such as positive adaptation (Conger & Conger, 2002) and reality orientation (Sagy & Antonovsky, 2000). In spite of this, the resilience concept is still quite popular, and many studies have investigated the personality trait and the mechanisms underlying the concept.

The concept of hardiness is the result of the work by Salvatore R. Maddi at the University of Chicago. During the 1970s there was a scientific debate regarding the role of stress, strain and subsequent psychological growth. Maddi's contribution was a 12-year study of the workers at Illinois Bell Telephone Company (Maddi, 2002). The company downsized significantly during these years, and the researchers followed 450 male and 12 female managers and measured them every year regarding medical and psychological health variables. Many of the workers suffered somatic and psychological health deterioration, but about one third of the sample showed an opposite trend and reported few adverse effects and seemed to thrive in the poor predicament they found themselves in (Maddi & Kobasa, 1984). The sub-sample was coined as "hardy" individuals, and the researchers concluded that there must be significant differences in individuals' ability cope with stress and demanding life circumstances.

For most individuals, stress, frequent and long-lasting sympathetic nervous system activation, and perceived inability to cope lead to adverse health and performance outcomes (Selye, 1956). Constant and intense stress might lead to the collapse of functioning as the individual unconsciously evaluates the situation to be such that the only feasible option is to conserve resources and avoid non-essential behavior (Selye, 1956). Maddi believed that the hardy individual is able to summon

efforts to counter the negative effects of stress and strain and subsequently to cope due to the belief in personal control and thus viewing the stressors as challenges and committing to rather than avoiding the situation (Maddi & Kobasa, 1984). If successful, the hardy individual increases their belief in their ability to cope and grows more resilient to future stressors. After nearly 50 years and over 600 research studies (Maddi, 2002), hardiness stands as a framework for individual differences in resilience. The current understanding is one of a general attitude towards life and is described as an individual's pattern of thinking and behavior when faced with adversity (Bartone, 2006). Hardiness is comprised of three fundamental attitudes – challenge, commitment, and control. The challenge dimension reflects the attitude that the unknown and new experiences are exciting, and such an attitude reflects how life's challenges are viewed as learning opportunities and not as something to fear. Individuals scoring high on the challenge dimension view life as inherently demanding and challenging, but that this is an opportunity to grow, learn, and develop wisdom (Maddi, 2002). The commitment dimension refers to how individuals have a sense of commitment to themselves and their surroundings. Persons high in commitment are highly involved in their activities and with other individuals, regardless of the stressful nature of the situation. A person low in commitment is characterized by avoidance and social isolation, especially when stressed. Control refers to the individual's belief in their ability to cope with adversity and that personal resources that can affect important outcomes are available. A person who scores high on the control dimension wishes to have high impact on the outcomes of life, regardless of how difficult this is to obtain. Passivity and helplessness are viewed as poor options, and there is an overall

goal of achieving personal autonomy. Together, the three dimensions make up a personality style that functions as a buffer against stressful events that involve physical or mental adversity (Maddi, 2006). These attitudes turn stress into an opportunity for growth and personal development and are assumed to be correlated (Kobasa, 1979). Originally, Maddi believed that the hardy personality required high levels of all three dimensions (Maddi, 2002). Recent research efforts have determined the factor structure of the hardy personality, and a confirmatory factor analysis showed that a three-factor hierarchical structure with an overall latent factor of general hardiness fit the data the best (Hystad, Eid, Johnsen, Laberg, & Bartone, 2010). The structure is assumed to be relatively stable and to develop early in life (Maddi, 2004), but there is limited evidence for how the hardy attitude develops. Given that hardiness grows out of and buffers stressors, it is an inherently interesting and relevant subject to study in military or other operational contexts, such as police, naval personnel, firefighters, and medical personnel, where extraordinary demands are relatively prevalent. In line with this, high levels of hardiness predict military (Hystad, Eid, Laberg, & Bartone, 2011; Johnsen et al., 2013), police (Picano, 2016), and firefighter performance (Maddi, Matthews, Kelly, Villarreal, & White, 2012). Why this happens is largely unknown, but social processes, emotional stability, and likability are likely to be involved (Bartone, Roland, Picano, & Williams, 2008).

The main criticism of the hardiness concept is the conceptual overlap between hardiness and neuroticism (Funk, 1992), the reliability and validity of the hardiness measures, and possible response styles and common method bias (Reio, 2010). Research controlling for negative effects has established the hardy personality as

distinct from neuroticism (Johnsen, Snook, Laberg, Eid, & Bartone, 2009), and recent measurements show high internal consistency (Hystad et al., 2010). The observed negative correlations between neuroticism and hardiness do not necessarily mean that the two concepts are the same, and such correlations are also found within the facets of the five-factor model (Digman, 1997).

1.7 Hardiness and resilience to sleep disturbances

A brief search of the literature revealed five studies that have investigated the role of hardiness as a protective factor in terms of tolerance to disrupted sleep and performance at work. Most of the research that has been performed has sought to predict coping or lack of coping within shift work. Shift work refers to the organization of staff where the workers replace one another in temporal succession (Totterdell, 2005). Coping with shift work represents a good model for testing the role of hardiness in relation to sleep disturbances because some circadian disruptions, low sleep quality, and short sleep durations are inevitable during night shifts. The available evidence suggests that hardiness is associated with tolerance to shift work among nurses (Saksvik-Lehouillier et al., 2012; Storemark et al., 2013), and it has also been found to be negatively associated with depression, anxiety, insomnia, and sleepiness in samples of two and three-shift workers¹² (Natvik et al., 2011). Two studies failed to find an association with hardiness and sleep outcomes. When adjusted for other variables such as morningness and demographics, hardiness did not predict shift work disorder (Flo et al., 2012). Lastly, hardiness was found to be a poor predictor of shift

¹² First shift is morning, second shift is afternoon and evening. Three shift workers have an additional overnight shift.

work tolerance and of dissatisfaction with night and shift work and was confounded with neuroticism (Bohle, 1997). The aforementioned research efforts suggest the possibility of hardiness being related to resilience against sleep disruptions, but this is not yet conclusive. In addition, the current research cannot determine if hardiness has a main effect on sleep and health outcomes directly, or if the effect is a buffer against the negative effects of poor sleep and health on well-being (Bohle, 1997).

1.8 Leading the sleep deprived

The prevalence of disturbed sleep and periodically short sleep durations during training and live missions (Hardaway & Gregory, 2005; Miller et al., 2011) indicates that leaders might be well served to be mindful of the impact this can have on military and naval performance. The management and leadership of personnel in situations that require periods of extended work hours and a subsequent drop in time available to sleep and in sleep quality can take two forms. Firstly, leaders can introduce measures to increase sleep time and sleep quality directly. Sleep leadership (Gunia, Sipos, LoPresti, & Adler, 2015) refers to a set of domain-specific leadership behaviors that collectively aid sleep among one's subordinates. The behaviors typically include asking subordinates about their sleep habits and encouraging them to get adequate sleep and to take naps if possible, as well as working to ensure a high quality sleep environment, going to sleep on time, and discouraging the use of caffeine and nicotine at night. Research on sleep leadership indicates that such leadership decreases physical, psychological, and organizational strain among deployed service members (Gunia et al., 2015) by decreasing sleep problems and increasing sleep duration and

quality. Interestingly, general leadership and sleep leadership are positively correlated, but sleep leadership was a better predictor of outcome in the aforementioned study. The sleep leadership approach of influencing sleep directly is a worthwhile addition to the leader's toolkit, but in some situations, such as a crisis, sustained continuous operations, or other extraordinary events, reductions in sleep are largely unavoidable, and increasing time available to sleep might in these special circumstances have negative performance outcomes. Because of this, many service members might reject a simple heuristic of more sleep equals better outcomes. The content of this thesis suggests that military, naval, and other leaders are best served with a more nuanced understanding of the relationship between sleep and performance, the basis of which are the observations that a lack of sleep and poor sleep quality cause a deterioration in human functioning but that in certain demanding high-tempo situations increasing time for sleep might come at a performance cost. In situations where there is no option for leaders to delegate more time for sleep or to increase sleep quality, high-quality leadership can still play a role in moderating disturbed sleep's effects on performance, for example, by taking frequent breaks in monotonous environments or by taking actions to increase stimulation in such cases.

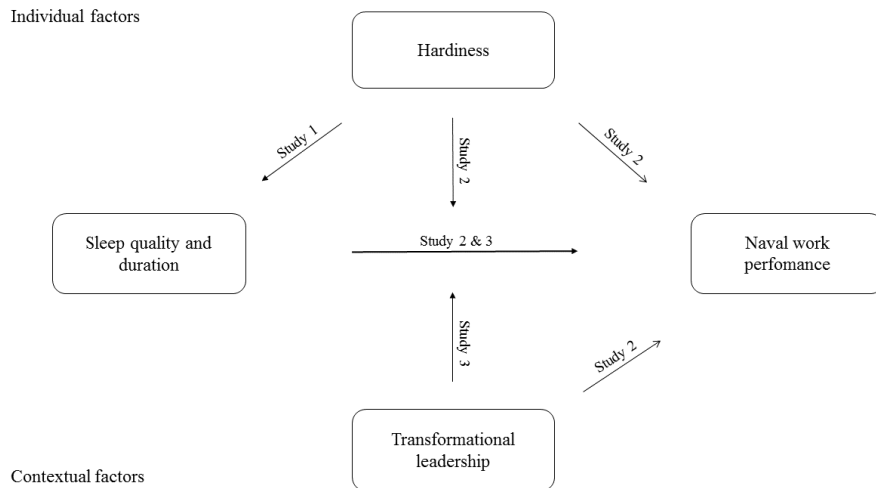
The conceptual definition of what leadership means has changed over the last decades, with implications for leaders of sleep-deprived individuals. In general, leadership refers to an individual's ability to influence, motivate, and make others capable of contributing to the effectiveness and success of the organization (Nohria & Khurana, 2010). Early research efforts into the leadership process focused on leadership traits and behavioral and contingency theories, and only later did the role of

the leader as a constructive transactional agent emerge as one who rewards and punishes based on a transactional model (Burns, 1978). Within a sleep-performance context, a transactional leader mitigates some of the reductions in performance due to sleep loss by utilizing praise, reprimands, and physical rewards such as time and is responsive to drops in performance. The transactional managerial style employs management by exception, maintaining performance among individuals and only correcting for drops in usual performance. The transactional leader of sleep-deprived personnel motivates by appealing to the individual's sense of self-interest (Burns, 1978), and this might entail more leisure time or other perks awarded to those who do not let their performance drop during continuous operations and sleep loss. However, sleep loss is likely to cause some forms of disengagement among the crew, and a more pro-active leadership style might be better suited to buffer the negative effects of sleep loss on performance. Transformational leadership (TL) is characterized by pro-active behaviors that seek to provide a sense of mission and to stimulate higher-order intrinsic needs (Cox, 2011). Transformational leaders are charismatic and encourage their followers to put the group's interest first (Odumeru & Ogbonna, 2013), and they have the ability to transform work efforts into a more a more collective vision through inspiration and team commitment (Kuhnert, 1994). This process might be well suited to reducing the impact of poor sleep on team and individual functioning. Disturbed sleep has obvious negative effects in humans, and engaging and inspirational leaders who focus on stimulating individuals might increase vigilance, efforts, and motivation among their sleep-deprived subordinates.

2. Main aims

This thesis aimed to investigate how sleep quality and duration affect work performance during naval missions and training. The relationship between job functioning and sleep was tested in samples with differing levels of external regulation of sleep, and the thesis aimed to disentangle the effects of sleep duration vs. the effects of sleep quality on different types of work performance. The second main aim was to uncover how a hardy and resilient personality is related to naval performance and sleep. Firstly, by identifying how a hardy personality influences the symptoms of insomnia and sleep quality, and subsequently testing the relationship between sleep, hardiness, and work performance in order to uncover the nature of the hardy performance advantage observed in military psychology. Lastly, the thesis aimed to identify the role of high-quality leadership in buffering the negative effects of disturbed sleep on performance. The thesis draws on military/operational, sleep, personality, and organizational backgrounds, and the relationships between the variables included in this thesis and their hypothesized relationships are summarized in figure 1.

Figure 1. The current thesis's conceptual framework showing how the relationships between variables are represented in the three studies. The thesis contains investigations of both individual and contextual factors.



Although considerable research efforts are aimed at sleep, the unique combination of different research fields and the subsequent novelty of the research questions are best described through an exploratory approach.

2.1 Objectives of paper 1

Exploring the development of symptoms of insomnia during a naval counter-piracy mission and identifying different patterns of sleep quality based on dispositional hardiness were the objectives of paper 1. The research question was how operational demands affect sleep quality and perceived work performance the next day as a function of where in the mission the crew were at three measurement time points, and

how this interacts with having a resilient disposition. This objective and the research background led to the formulation of the following hypotheses:

H1: There is a significant main effect of hardiness level on the sum of insomnia symptoms experienced during the mission.

H2: There is a significant main effect of time on symptoms of insomnia

H3: There is a significant interaction effect of time and hardiness level.

2.2 Objectives of paper 2

The findings of paper 1 led to the research question of paper 2. The main objective of paper 2 was to determine if the hardy advantage in military performance in general is related to the pattern of increased sleep quality observed in paper 1. Insomnia is a multi-faceted construct, and it includes poor perceived sleep quality and negative next-day performance effects. Sleep duration might also be affected, but this is not a criterion for diagnosis (Ohayon, 1997). The aim of paper 2 was to determine which of these facets the hardy disposition interacts with and to determine if the hardy performance advantage seen in military research is related to coping with sleep loss. The hypothesis derived from the results of paper 1 presents two non-mutually exclusive possibilities that form the basis of the hypotheses of paper 2.

H1: Daily sleep quality mediates the relationship between dispositional hardiness and daily peer-rated job performance.

H2: The relationship between poor sleep quality and job performance is stronger for naval personnel who score low (vs. high) on hardiness, producing a negative interaction effect of sleep quality on the link between hardiness and performance.

2.3 Objectives of paper 3

Leadership and management of naval personnel during 24-hour continuous work operations comprised the theme for paper 3. The aim was to determine the effects of sleep quality and duration on task performance and contextual work performance. Additionally, the paper identifies the role of perceived high-quality TL as a buffer of poor sleep quality on work performance, as well as a unique positive contribution to work performance. The paper includes the following hypotheses:

H1: Daily sleep quality is positively associated with (a) daily task performance and (b) contextual work performance.

H2: Daily sleep duration is positively associated with daily task performance.

H3: Daily sleep duration is negatively associated with daily contextual work performance.

H4: Daily TL is positively associated with (a) daily task performance and (b) daily contextual work performance.

H5: TL decreases the impact of poor sleep quality on (a) daily task performance and (b) daily contextual work performance.

3. Methods

3.1 Procedures

This thesis is based on three separate longitudinal studies with separate samples. The data used in paper 1 were collected as part of the routine follow-up of naval personnel before, during, and after a mission. The data were collected in three waves by the Royal Norwegian Navy during an 8-month period in 2013. Here, the crew of KNM Fritjof Nansen completed a measure of hardiness and a measure of insomnia symptoms 4 weeks before the mission (during a preparation and training phase) that was a part of the NATO operation “Ocean Shield”. The crew was informed of the purpose of the study. Sleep and insomnia symptoms were again measured after 8 weeks into the mission and then again during the last part of the mission, 12 weeks after mission start. The crew was separated into two groups based on their hardiness score in relation to the mean score of 49. The group of high hardiness had 88 sailors, and group of low hardiness had 76 sailors.

The data used in paper 2 and paper 3 were gathered at the Royal Norwegian Naval Academy (RNNA) at two separate times and were collected in two different samples completing a longitudinal diary survey. The data for paper 2 were gathered in 2017, and the data for paper 3 in 2018. The background for data collection was the same, the first 30 days of a naval training mission. The respondents were naval cadets admitted to the RNNA. A part of their training to become naval officers includes crewing a large 100-year-old sailing ship with limited modern technology during a crossing of the Atlantic Ocean. During the voyage, the naval cadets function in roles as

leaders or crewmembers at all levels of the organization. The cadets live in close quarters, sleeping side by side in hammocks. The voyage is considered to be challenging because the cadets are usually relatively inexperienced sailors. The voyage features high operational tempo, an unpredictable work environment, potential negative consequences for mistakes, lack of sleep, seasickness, high workload, and socialization into a new and unknown work environment. The data collection was approved by the Norwegian Center for Research Data. During the first 30 days of the mission, the cadets filled out measures of sleep, leadership, and performance daily at approximately 17:00. In addition, hardiness, neuroticism, and general sleep quality and duration were measured before the mission.

3.2 Samples

The sample for paper 1 included 90 officers, 70 sailors, and 58 enlisted¹³ personnel, and 63 persons did not report a military rank. The total sample included 281 individuals in total and consisted of mostly male sailors. The sample was reduced from 281 to 164 because of missing data at one or more of the measurement intervals. The sample for paper 2 comprised 50 male cadets (89.2%) and 6 female cadets (10.8%). The mean age of the cadets was 23.1 years ($SD = 2.6$). The sample in paper 3 included 70 (89.7%) male cadets and 8 female (10.3%) cadets. The mean age of the cadets was 22.9 years ($SD = 2.2$).

¹³ Enlisted personnel are serving a one-year mandatory military service, while sailors have completed this service and continued their career in the Navy. Sailors are older than the enlisted personnel

3.3 Measures

Hardiness

Hardiness was assessed in both papers 1 and 2 with the validated Norwegian adaptation of the 15-item Dispositional Resilience Scale (DRS-15-R) (Hystad et al., 2010). The measure assesses the three dimensions of Commitment, Control, and Challenge, and 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). Cronbach’s alpha for the composite score was 0.63 in paper 2 and 0.73 in paper 1. The low inter-item reliability score in paper 2 is most likely at least partly due to the restricted range of hardiness in our high hardiness sample, but also due to the three-factor structure of the concept.

Trait-level Neuroticism

Neuroticism was measured with the subscale included in the Revised NEO Five-Factor Inventory (NEO-FFI-R) (McCrae & Costa, 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 in paper 2.

Sleep quality and duration

In paper 1 we measured insomnia symptoms with the Bergen Insomnia Scale (BIS) (Pallesen et al., 2008). The BIS is a self-report scale consisting of six questions regarding symptoms of insomnia, and the questions are based on the inclusion criteria for insomnia found in the fourth edition of the American Psychiatric Association diagnostic manual (American Psychiatric Association, 2013). The scale consists of six items scored on an eight-point scale indicating the number of days that insomnia symptoms are experienced during a week. The symptoms include difficulty falling asleep, awakening during the night, experiencing non-fulfilling sleep, and sleepiness during the day. The BIS has been validated through subjective sleep reports and EEG studies in both clinical and normal groups (Pallesen et al., 2008). Cronbach's alpha coefficient for the BIS measurements was 0.89.

In paper 2 and paper 3, daily sleep quality was measured with a single item: *How well have you slept in the last 24 hours?* The cadets responded on a six-point scale (1 = very poorly, 2 = quite poorly, 3 = poorly, 4 = quite well, 5 = good, 6 = very good). We measured the day-level sleep duration with a single item: *How many hours and minutes have you slept in the last 24 hours?* In paper 2, regular sleep quality and duration were measured with the questions *How well do you usually sleep* and *How many hours and minutes do you usually sleep?*

Day-level self-rated task and contextual work performance

In paper 3, self-rated task performance was measured with four items from the task performance subscale developed by Goodman and Svyantek (1999). 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*”, and “*I have met the formal requirements for my work during today’s shift*”.

Self-rated contextual work performance was measured with four items from the same subscale, originally developed as a measure of organizational behavior by Smith, Organ, and Near (1983). Example items include “*I have helped others with their work when they have been absent*”, and “*I have taken the time to show a personal interest in others*”. Responses were provided on a five-point Likert scale (1 = totally disagree to 5 = totally agree). The average within-level Cronbach’s alpha for the 30 days was 0.82 for task performance and 0.80 for contextual performance.

In paper 2, peer-rated job performance was measured with four items from the same task performance subscale, but aimed at another person (e.g. observer rating). Example items are “*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 Likert scale (1 = totally disagree to 5 = totally agree). The average within-level Cronbach’s alpha for the 30 days was 0.82.

Transformational leadership

We assessed day-level perceived TL in paper 3 with seven items from the MLQ-5-X (Bass & Avolio, 1995). Three 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)*”, and “*instills pride*

and respect in others and 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.

3.4 Statistical analysis

All of the studies in the current thesis had measurements nested within individuals at different time points. Several statistical techniques can be used in the analysis of nested/repeated data, each with its own strengths and weaknesses. Repeated-measures analysis of variance (ANOVA) was chosen in paper 1, while multi-level mixed effect random intercept modeling was chosen in papers 2 and 3. The data analysis for study 1 was done with SPSS and Statistica. Most of the analyses in study 2 and 3 were performed with Stata v.15, but within and between person correlations were obtained with Mplus. Missing data were handled with case-wise deletion. To correct for this when testing the explained variance from the null model to the main effects model and the interaction effect models in papers 2 and 3, the null models were calculated using only case data with registered data in the predictor variables because including missing data from predictors would overinflate the variance in the null model.

Paper 1

Paper 1 used a longitudinal between-within group ANOVA with repeated measurements to determine the main effect of time and the interaction effect of hardiness on insomnia symptoms. The sailors were divided into two groups based on the mean hardiness score in the sample. The repeated-measures ANOVA included a

main effect test of both hardiness and time, as well as the interaction between them. In addition, least squared difference post hoc tests were used to investigate significant within-group changes and to determine the between-group differences at the three measurement points. The measurements of insomnia symptoms revealed a floor effect and data skewed towards zero. The BIS scores were therefore transformed using a square root conversion.

Paper 2

In paper 2 and paper 3, the daily measures (sleep quality, sleep duration, and job performance) constituted the within-individual level of analysis. Hardiness and neuroticism were assessed at the inter-individual level of analysis. The data in paper 2 comprised daily observations (Level 1; $N = 1710$) nested within individual cadets (Level 2; $N = 67$). In both papers 2 and 3, day-level measurements were centered around the person's mean and trait-level job performance on the grand mean for both predictor and moderator variables. This centering procedure (Hoffman & Stawski, 2009) removed inter-individual variance from the Level 1 variables. This eliminated 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, we tested a multi-level mediation model using generalized structural equation modeling (Krull & MacKinnon, 2001). We defined successful mediation and a significant indirect effect if the multiplication (non-linear combination) of the two indirect paths from hardiness to sleep quality and from sleep quality to job performance resulted in a significant effect (Preacher, Zyphur, & Zhang, 2010). To test hypothesis 2, we applied three multi-level models on the measure of job

performance to investigate the effect of sleep, hardiness, and their interaction on peer-rated job performance, one unpredicted null model, the predicted main-effect model, and an interaction model. We graphically plotted significant moderation interactions as continuous slopes from very bad to very good sleep quality and the interaction of sleep quality with hardiness using the predicted margins of our interaction model. The predicted values of performance were at two standard deviations (SDs) above and below the centered mean sleep quality and one SD above and below the grand mean of hardiness. We calculated the likelihood ratio tests (chi-squared) to compare the model fit of the three (null, main effect, and interaction) models.

Paper 3

Another set of mixed multi-level models was used in paper 3 to determine the effect of sleep quality, sleep duration, and TL on the two outcome variables of task performance and contextual job performance. The same centering procedure as described in paper 2 was employed to remove individual differences. We tested three multi-level models on daily measures on both task and contextual work performance to investigate the effects of sleep quality, duration, and leadership, including an unpredicted null model, the predicted main-effect model, and an interaction model. As in paper 2, we calculated the likelihood ratio tests (chi-squared) to compare the model fit of the three (null, main effect, and interaction) models. We plotted the main effects of sleep duration and sleep quality on both measures of performance using predicted means and marginal effects in Stata, as well as the interaction of daily sleep quality and perceived TL.

3.5 Ethical considerations

Papers 2 and 3 were approved by the NSD (Norwegian Center for Data Security). To ensure that respondents remained non-identifiable in the research, data from papers 2 and 3 were kept separate from a coding key, which could be used to match an individual's ID with their age and other data that could make them identifiable. The data from the studies within this thesis were obtained with informed consent and the ability to opt out. In paper 1, participation also served the purpose of follow-up of the mental health of deployed service members. The participants in paper 1 were informed that only results on the group level were to be used for feedback to the commanding officers. After deployment, the research data within this thesis were processed to insure the removal of all potentially identifying variables such as name, age, service number, year of birth, etc. Individual data from paper 1 were handled as health data and subject to the same legislation as all health records within the Norwegian health services¹⁴. This includes the legislated right to view your own medical file. The Norwegian Navy has a standing order to improve personnel handling after deployment, and measurements of sailors' health and psychological well-being are routinely made before, during, and after deployment by naval support teams¹⁵. Research efforts, such as the ones conducted within this thesis, are central in this endeavor.

¹⁴ As regulated by pasientjournal-loven (LOV-2014-06-20-42).

¹⁵ Naval support teams (sjøforsvarets støttelag) are multidisciplinary psychosocial support teams that include doctors, psychologists, nurses, and clergy.

4. Results

All of the associations, main effects, and interaction effects described below were statistically significant at $p < .05$ unless otherwise specified.

4.1 Paper 1

Sleep quality was overall quite good, and most of the crew experienced relatively few symptoms of insomnia before or during the mission. The sample was found to be overall quite high in hardiness, with a mean hardiness score of 48.19 (SD = 4.41). The results of the repeated-measures ANOVA of insomnia symptoms (the BIS) supported the study's hypotheses and showed that insomnia symptoms increased from pre-mission levels to the midway point and from the middle of the mission to the end. The results also showed a main effect of dispositional hardiness on insomnia symptoms in general. We also found an interaction between hardiness level and time. The difference in insomnia symptoms between the high and low hardiness groups of sailors was greatest at pre-mission, while the difference was non-significant at the midway point of the mission. We found that the high hardiness group varied throughout the three time points and that the lower hardiness group, while having more insomnia symptoms overall, showed little variation. The results show that the different stages of a naval mission were associated with varying levels of insomnia symptoms. We believe that these results indicate that the middle of the mission strains the crew the most, thus removing differences in insomnia symptoms due to individual factors.

4.2 Paper 2

In paper 2 we found that the crew experienced significant reductions in sleep quality and duration during the 30-day training mission. On average, the crew slept 50 minutes less than they normally do, and some days they slept as little as 5 hours. Sleep quality was also reduced from a mean of 3.88 (SD = .78) during ordinary pre-mission work duty to an average of 3.29 (SD = .94) during the mission. The average hardiness level was quite high, with a mean hardiness score of 45.73 (SD = 3.84), and the results of the multi-level analysis showed that hardiness was positively associated with peer-rated job performance. The results of the mediation analysis did not show support for the role of increasing sleep quality as an explanatory mechanism for this effect, thus disconfirming hypothesis 1. However, the results did support that hardiness negatively moderates the link between sleep quality and performance, thus supporting hypothesis 2. In other words, the difference in performance rating between high and low hardiness cadets increases as the crew experiences worsening sleep quality, and when the crew experiences good sleep quality the differences between the hardy and less hardy cadets become non-significant. The results were controlled for individual differences in neuroticism. We found that neuroticism was negatively associated with sleep quality during normal work duties, but not during the mission. Additionally, we found no correlations between off-duty sleep quality and sleep quality during the mission. Overall, the results suggest that a decline in sleep quality is likely for all crewmembers during demanding continuous naval operations, but that a hardy disposition provides resilience to disturbed sleep as measured by peer-rated performance.

4.3 Paper 3

A similar reduction in mean sleep quality and duration was seen in paper 3, with a mean sleep duration of 6.36 hours per day and a mean sleep quality of 4.09 during the 30-day training mission. The results of the multi-level analysis supported that sleep quality was positively associated with both task and contextual work performance. The results did not support a positive main effect of sleep duration on task performance, but supported a negative main effect on contextual work performance. The results also supported the hypothesis that perceiving high TL is associated with an increase in both task and contextual performance. The results partly supported the buffering moderation effect of TL on the link between sleep quality and performance because the effect was found on task performance but not contextual performance. Overall, the results support the notion of differential effects of sleep duration and sleep quality on self-reported work performance during a demanding 24-hour work situation. Contextual work duties, such as volunteering, helping others, and contributing to the psychosocial work environment decrease as the cadets trade sleep for contextual work. The results also support the notion of high-quality leadership as a potential tool in work situations where few adjustments can be made to increase sleep quality directly. The magnitude of the effects of leadership and sleep quality on performance is such that a person with poor sleep quality (-1 SD) but a good leader has roughly the same work-performance as an individual with high sleep quality but a poor leader.

5. Discussion

The overall purpose of this thesis was to develop a better understanding of the role of sleep and performance in naval work settings during training and deployment, where time available to sleep is restricted and reductions in sleep quality are likely. In three studies, the present thesis has documented how sleep quality and duration vary over time during training and while deployed and how sleep and subsequent performance outcomes are associated with individual differences in hardiness and perceived high-quality transformational leadership. The thesis also contributes to the sleep literature by presenting three real-life empirical investigations of the complex role of sleep in operational work organizations where some sleep loss and disturbed sleep is inevitable. The thesis's key results are the following.

1. In a demanding naval work environment, sleep duration and quality are reduced, likely due to the operational demands and night/shift work experienced by the crew.
2. In two separate studies we found that sleep duration was negatively associated with work performance, as rated by the sailors themselves and by each other.
3. In two separate studies we found that sleep quality was positively associated with work performance, as rated by the sailors themselves and by their peers.
4. Having a resilient and hardy personality was associated with fewer symptoms of insomnia and higher sleep quality while deployed on a naval mission.
5. During demanding naval work situations with notable restrictions on sleep quality and duration, the hardy advantage was not related to sleep quality itself,

but rather to reducing the negative impact of poor sleep quality on work performance.

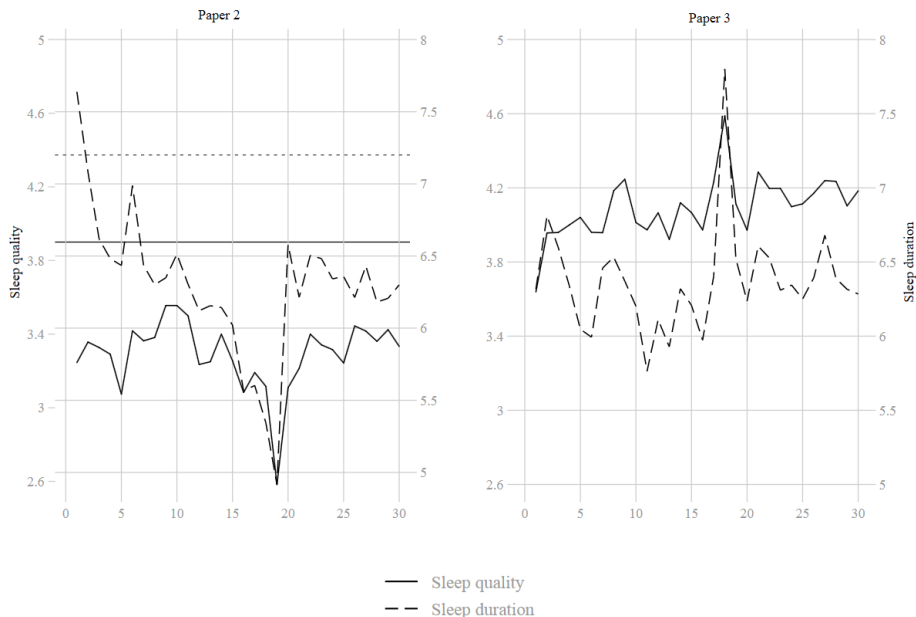
6. Sailors perceiving high-quality TL had higher work performance and were less affected by poor sleep quality.

5.1 The impact of sleep on naval work performance

The research backdrop of the current thesis is largely comprised of laboratory, animal, or organizational research highlighting how lack of sleep causes a number of detriments to human functioning (Harrison & Horne, 2000; Pilcher & Huffcutt, 1996), but such research often does not distinguish between sleep quality and sleep duration. The practical implication derived from these research efforts is that increasing sleep time and quality will positively affect psychological functioning (Harrison & Horne, 2000) and subsequent performance (Shahly et al., 2011). For individuals with clear separations between work life and home life, increasing sleep duration and quality largely consists of prioritizing sleep over other at-home activities (Barnes & Drake, 2015) and taking the necessary steps to increase sleep hygiene (Stepanski & Wyatt, 2003). These steps are likely to impact performance at work for most individuals with a clear separation of work, non-work, and sleep. However, this is not the case for individuals employed in organizations where adjustments to sleep are a key feature, such as military/naval personnel on duty or civilian shift workers. In these work contexts, there are periodical limitations on time available to sleep, and sleep quality and duration might not be as correlated. In addition, the lines between work activities, free leisure time, and time available to sleep are severely blurred in such situations.

When this happens, increasing sleep duration might lead to a drop in job performance, especially in terms of contextual work activities. The findings in papers 2 and 3 support this notion. The cadets studied in these papers work shifts, have other requirements when they are not on shift, and experience a notable drop in time available to sleep. Their mean sleep time and drop in sleep quality do not constitute total sleep deprivation, but at some points during the mission they accumulate a sleep debt comparable to PSD (Reilly & Piercy, 1994). In experiments with PSD, a 40–50% reduction in total sleep time is often used over the course of 1 or 2 weeks (Herscovitch & Broughton, 1981; Van Dongen, Maislin, Mullington, & Dinges, 2003). The samples in papers 2 and 3 experienced a mean of 12.5% and 14.9% PSD, spread out over 30 days, with a few days seeing as much as 38.9% PSD, as seen in figure 2.

Figure 2: Sleep quality and duration in paper 2 and paper 3. The horizontal reference lines for paper 2 denote sleep quality and duration during a normal workday.



The cumulative effect of this PSD is moderately increasing sleep debt. The key finding within this thesis is that this moderate sleep debt is not enough to cause a drop in performance on its own, because individual sailors can increase their work performance by working instead of sleeping. Paper 3 suggests that contextual work performance suffers more from low sleep quality than work performance defined as part of the individual sailor's job description. Clearly defined tasks, which are easy to monitor in terms of progress, might thus be less susceptible to reductions by workers increasing their sleep time. One way of framing these findings is in terms of the direction of causality. Experimental and survey research has shown that short sleep duration causes negative effects on functioning and on work performance-related cognitive, motor, and mood measures (Harrison & Horne, 2000; Pilcher & Huffcutt, 1996; Shahly et al., 2011). The reversed correlational relationship observed in this study is interpreted such that decreased time sleeping increases performance, thus suggesting the opposite causal relationship. It is likely that both processes (drops in performance due to poor sleep and achieving higher performance by working instead of sleeping) occurred within our samples but that the cumulative effects of sleep debt were not higher than the effect of voluntarily reducing sleep time to work.

The same pattern of reduced sleep quality was seen during the training mission in paper 3. Sleep quality saw a mean drop of 16.3% in paper 2 and 16.8% in paper 3. This might be due to several factors, including movement of the ship, unusual sleep environments, circadian disruptions, and a host of other physical and psychological factors (Comperatore et al., 2005), the most prominent of which is arguably general stress and worry about upcoming demanding activities. Daily sleep quality and

duration were moderately correlated with each other in both studies, but had opposite effects on self and peer rating of work performance. The explanation for this is likely that negative sleep quality has a more unidirectional effect on the next-day's performance. There are no positive benefits of less restorative sleep, more sleep disruptions, difficulty falling asleep, or early waking. The strength of the association between sleep quality and work performance is also bolstered by its likely bidirectional nature. Low sleep quality causes reductions in human functioning and job performance (Shahly et al., 2011), and underperforming at work might itself cause a drop in sleep quality because individual sailors are likely to have stronger negative emotions (e.g. worry) as a result (Ross, Murray, & Steiner, 2005). Overall, the research in this thesis suggests that the distinction between sleep quality and duration is necessary in order to observe nuances in the sleep-work relationship, especially in an operational 24-hour work context, and this has important practical implications.

5.2 Sleep, self-rated and peer-rated naval performance

This thesis allows for the direct comparison of the effect of sleep quality and sleep duration on two different measurement procedures with the same measurement constructs in highly comparable samples. Paper 2 used peer ratings, while paper 3 measured performance as rated by the cadets themselves. The main effect of sleep duration on task performance was negative in both samples, and the effect was more notable when performance was judged by others. This might be due to the teamwork-oriented work environment among the crew. If an individual sailor chooses to sleep more, their peers might have to do more work and thus evaluate their peer's

performance lower. The individual sailors might rate their self-performance lower as well, but probably not to the same degree as their peers. Another notable finding is that there was an effect of sleep quality on self-rated performance but no effect on peers' ratings if different levels of dispositional hardiness are not taken into account. The reason for this is likely due to a comparison effect, where individuals cognitively evaluate their own performance in terms of mean changes from day to day, while peers rate others more as a function of their relative performance compared to themselves. In other words, peers who undergo the same overall relative sleep deprivation 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 sailor is not affected by disturbed sleep, but the relative rank order performance between each sailor does not change because the whole sample experiences reduced sleep duration and quality and general fatigue during the mission. This is supported by the interaction of sleep quality and dispositional hardiness observed in paper 2. Naval task performance can be measured with more objective indicators such as missions and tasks completed, or by having senior non-participatory and well-rested personnel rating the cadets. Measuring individual sailor's naval task performance in more objective terms is likely to show negative mean level changes as opposed to rank order changes when they experience poor sleep quality.

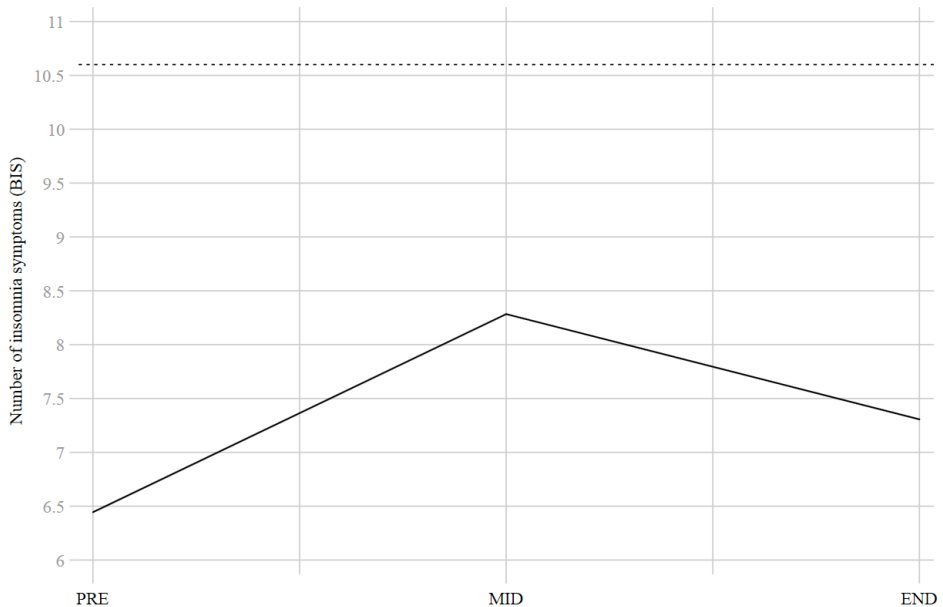
5.3 The impact of hardiness on sleep in different naval work environments

Papers 1 and 2 suggest that having a resilient disposition of hardiness is linked with sleep and the effect of poor sleep on work performance. Paper 1 supports the

notion of hardy sailors having fewer sleep problems as defined by the number of insomnia symptoms experienced according to the BIS. However, this measure does not discriminate by the types of symptoms that are experienced. The BIS has items reflecting quality as well as subjective evaluations of sleepiness/fatigue that affect work performance. Lucavei, Pougnet, Dewitte, Lodde, and Pougnet (2017) noted this in a commentary article in which they state that a link between good sleep and hardiness, as observed in paper 1, does not necessarily result in higher performance among sailors who are high in hardiness. Measures of insomnia include items that measure sleep quality, duration, and effects on next-day performance due to reduced sleep. As such, the negative relationship identified between hardiness and symptoms of insomnia might be due to one or more of these factors. Based on this criticism, we tested two non-mutually exclusive possibilities in a sample of naval cadets during a demanding 30-day training mission. The first was that sleep quality mediates the link between hardiness and performance. The second was that hardy sailors do not show the same performance drop due to reductions in sleep quality as less hardy sailors. The results did not support the notion of increased sleep quality as an explanatory mechanism for why hardy sailors outperform their less hardy counterparts. It did, however, show that hardy individuals are less adversely affected by worsening sleep quality. The findings of paper 1 and 2 correspond with each other, but there were differences between the samples and situations that might influence the relationships between the three variables. Specifically, the level of hardiness and the selection of the two samples (as discussed below regarding collider bias), as well as the role of strong situational demands that might eliminate variation due to individual differences, are

relevant here. Sleep was under different amounts of external pressure in papers 1 and 2. In paper 1, the crew onboard the deployed naval vessel experienced some drops in sleep quality during the mission, and probably some nights with very little time available to sleep, but overall did not necessarily show increased sleep debt during the mission. Typically, modern naval deployment considers sleep to be important (Gunia et al., 2015; Miller et al., 2011), and personal communication with the officers in paper 1 showed that they try to limit crew sleep debt throughout the mission. Although paper 1 does not include any direct measure of sleep duration, comparing the amount of insomnia symptoms experienced here to an average sample gives an indication of how their sleep was taxed. The mean BIS was 11.88 (SD = 7.43) in a comparable student sample and 10.67 (SD = 9.73) in a community sample (Pallesen et al., 2008), as seen in figure 3. The sample in paper 1 had a mean BIS score of 6.44 (SD = 5.70) before the mission, 8.28 (SD = 7.09) at the midway point, and 7.30 (SD = 6.51) towards the end of the mission. These low scores reflect how the sailors in paper 1 experienced increased insomnia symptoms – compared with pre-mission levels– but experienced an overall high sleep quality. This indicates that sleep quality was not highly taxed during the deployment, as seen in figure 3.

Figure 3: The development of sleep quality during the mission in paper 1. The dashed line represents the mean of a community sample



In contrast, paper 2 shows growing sleep debt across the 30-day training mission. When comparing these two results and the role of individual differences, the differences might be partly attributable to strong situations. Strong situations generally refer to the availability and strength of external cues and environmental forces that influence the desirability of potential behaviors (Cooper & Withey, 2009). In broader terms, they refer to situations where individual differences in personality are less relevant in predicting behavioral outcomes. Under normal circumstances, sleep quality and duration are partly based on individual differences in sleep-relevant traits such as neuroticism and conscientiousness (Duggan et al., 2014) and hardiness (Saksvik-Lehouillier et al., 2012). However, if the demands of a naval crew are such that every

crewmember sleeps erratically in a poor sleep environment (quality) and has very little time allocated to sleep (duration), the usual associations between individual differences in sleep-relevant traits and sleep quality are eliminated. Such a pattern can be observed in paper 2, where there is a small but significant correlation between neuroticism and general off-duty sleep quality, but no relationships between the personality measures and the sleep quality experienced during the mission. This finding can be interpreted as situational factors overtaking individual differences as predictors of sleep quality. This mechanism also serves as a possible explanation for the lack of differences between the hardy and less hardy groups in the middle of the deployment, as reported in paper 1. Here, the total number of insomnia symptoms was the highest across all three measurements, and this was the only time there was no statistically discernable difference in sleep quality between the two groups. The interval with the largest difference between the two groups was during preparation for the mission. Of the three intervals, this point in time is arguably the most affected by individual differences because hardy and less hardy individuals' sleep patterns are more controlled by the persons themselves as compared to when they are deployed.

5.4 Level of hardiness

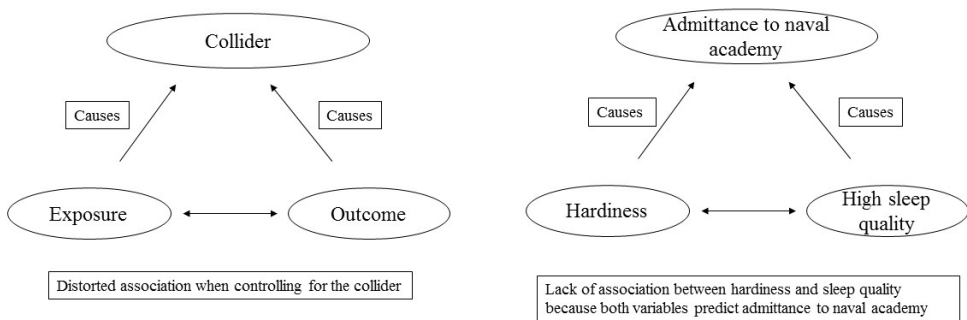
The generalizability of the results of paper 1 and paper 2 is closely related to the samples that were measured. In this sense, the results should be interpreted with caution when applied to a broader context. The reason for this is that there were considerable differences in dispositional hardiness in the samples in paper 1 and 2 compared to the general population. Surveys of mean hardiness in a comparable Norwegian population

gave a mean hardiness score of 31.60 (SD = 5.34) (Hystad et al., 2010). In paper 1, the sample of sailors and officers had a mean hardiness score of 48.79 (SD = 4.41), and the sample of Royal Navy cadets in paper 2 had a mean hardiness score of 45.73 (SD = 3.84). These high scores are likely the product of the selection process to become a naval sailor and a naval cadet. The selection process to become a naval cadet is more thorough than to become a naval sailor, and it is not unreasonable to expect the most commonly selected applicants to be the most hardy because military and police selections are associated with high levels of hardiness (Bartone, Roland, et al., 2008; Johnsen et al., 2013; Picano, 2016). The sample of naval personnel deployed in active duty service (paper 1) showed a higher hardiness level compared to the naval cadets (paper 2). This difference is likely at least partly due to the naval cadets being informed that their answers were for research purposes only, while the naval personnel in paper 1 were specifically told that the measures obtained during their deployment were partly to evaluate them and their mental health and well-being. This increases social desirability (Fisher, 1993) and is a likely cause for the difference.

The highly selected sample in paper 2 offers an explanation for why we found no main effect of hardiness on sleep quality. “Collider bias”, also called “admission bias” or admission rate bias”, refers to the controlling of a third variable by study design or statistical analysis between two variables (Munafò, Tilling, Taylor, Evans, & Davey Smith, 2017). If the third variable is caused by both variables independently, this can distort the relationship between the two variables (Figure 4). A prominent example of this is the presence of a relationship between locomotor disease and respiratory disease when sampling hospital patients. Both diseases cause individuals to be hospitalized,

and by looking at only hospitalized patients, a relationship between the two diseases was observed, when there was no relationship in the general population (Preston & Stokes, 2014). Collider bias can also explain why some analyses find no relationship between height and average points scored in the NBA (Stone, 2015) because both being tall and scoring points increases the likelihood of being a professional basketball player and thus removes the relationship between height and points scored when sampling the NBA. The participants in paper 2 were a highly selected sample, and collider bias might be responsible for the lack of a relationship between hardiness and sleep quality in paper 2. Military selection favors hardy individuals, and high sleep quality is also likely to be an advantage in the military selection process. These two processes collide and might eliminate the otherwise observed relationship between hardiness and sleep quality seen previously (Saksvik-Lehouillier et al., 2012; Storemark et al., 2013) and in paper 1 (see figure 4).

Figure 4. Admittance to the Naval Academy as a collider for the relationship between dispositional hardiness and sleep quality during a naval training mission.



5.5 Sleep and military performance – the use of hardiness in personnel selection

The results within this thesis are relevant to situations with inherent disturbances of sleep, such as the military and naval context (Maddi, 2002). The findings of paper 1 and paper 2 suggest why hardiness is related to success in military selection (Bartone, Roland, et al., 2008; Hystad et al., 2011), and for military performance in general (Bartone, Helge Johnsen, Eid, & Arne Nissestad, 2008; Johnsen et al., 2013), for which the underlying mechanisms are not fully understood. Military service usually includes some inevitable reductions in sleep quality and restrictions in time available to sleep, and a buffering effect of hardiness might partly explain why hardy service members fare better during conditions of semi-sleep deprivation and low sleep quality. In addition, research shows that active-duty soldiers experience widespread sleep disruption (Taylor et al., 2014). Given this pattern, our findings provide a plausible explanation for why hardy military personnel display increased military performance. Modern military campaigns and military selection tax sleep (Gunia et al., 2015; LoPresti et al., 2016), and individual differences in personality traits that decrease the impact of sleep impairment on performance provide those individuals with an operational advantage. However, the distinction between the direct effects of hardiness on sleep or as a moderator of sleep on performance is important in any demanding 24-hour work environment where disturbed sleep quality and/or severe reductions in the time available to sleep might be largely unavoidable during times of high activity. Our findings add to the growing literature implicating a hardy personality being able to tolerate sleep impairment, shift work, and symptoms of insomnia. Taken together, this underscores the relevance of a thorough selection of

psychological hardiness among personnel involved in operational settings, and possibly in particular the importance of weeding out those with low levels of hardiness.

The psychometric approach to personnel selection is contingent on measurements that are standardized, reliable, and valid. The results of paper 1 and 2 add to the growing body of literature suggesting that hardiness can be a valuable tool in personnel selection because it predicts a number of relevant outcomes (Bartone, Roland, et al., 2008). One of the strengths of using measures of hardiness over general personality questionnaires is the sensitivity to resilience factors (Hystad et al., 2010), and measuring neurotic traits in a high-hardiness population might not achieve the same predictive power as assessing hardiness. The results of paper 2 support this notion because neuroticism was not associated with naval work performance. One explanation for this might be the restricted range of scores on neuroticism but a larger diversity of hardiness scores. The use of personality questionnaires regarding hardiness is a valid method for selecting personnel in operative/military situations, but these should be used with some caution. While some studies have found that successful selection is associated with one or more of the hardy sub-facets (Hystad et al., 2011), others have not (de Beer & van Heerden, 2017; Van Heerden & De Beer, 2014; Gayton & Kehoe, 2015). The diverging results might be due to one or more of the following factors:

1. What measure of hardiness was used
2. The sample size

3. Informing the candidates of the purpose of the measure¹⁶

4. Pre-selection of the sample

Different hardiness measures have different psychometric properties (Funk, 1992). Some of the above-cited studies (de Beer & van Heerden, 2017; Van Heerden & De Beer, 2014) measured hardiness using items that have been criticized and since removed from different instruments (Bartone, 1991). The studies that manage to predict admission to Special Forces and officer training generally utilize a more reliable version of the hardiness measure (DSR-15-R & DSR-30) (Hystad et al., 2010) than the studies that fail to predict admission. One study employed a high-quality measure but did not find any differences in hardiness between candidates who were selected for Special Forces training and those who were not (Gayton & Kehoe, 2015). That study informed the candidates that the measure of hardiness would not influence the selection process, increasing its methodological quality. However, the study did not have a large sample size (N = 95). Studies that inform the candidates that the use of the hardiness measure is to select the best candidates, as opposed to being used for research only, are less likely to successfully predict admitted candidates and are more likely to reflect social desirability rather than true hardiness scores. However, Hystad et al. (2011) controlled for social desirability and had a very large sample size and found that the hardiness measure predicted selection outcomes in the Norwegian armed forces. Lastly, the usage of any kind of psychometric measure to predict military selection is partly contingent on the candidates being pre-screened/pre-

¹⁶ Purpose of research or purpose of selection of candidates

selected or being a representative and diverse sample of the population. Hystad et al. (2011) found an effect in a sample with little pre-selection, while other studies that failed to find an effect of the hardiness measure often assessed hardiness in already selected samples, i.e. those who had completed a preparation phase or who had previous operational experience (de Beer & Van Heerden, 2014; Gayton & Kehoe, 2015). This could mean that the use of hardiness as a tool for personnel selection to the armed forces is more useful early in the selection process where there is a greater variety of hardy and less hardy candidates.

5.6 Methodological considerations

Paper 2 and paper 3 share the limitation of measuring sleep quality and duration with single items. Using single items makes reliability measurements impossible and might in general be prone to systematic and random error. However, in papers 2 and 3 it is argued that a single item of sleep quality is a valid measure partly because of general single-item research showing high test-retest correlations (Littman, White, Satia, Bowen, & Kristal, 2006) and because of strong correlations with multiple-item scales (Wanous, Reichers, & Hudy, 1997). More specifically, 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). In addition, sleep quality has been found to have the same subjective meaning in individuals with and without insomnia (Moskovitz, Harvey, Virk, Stinson, & Whitaker, 2008). This supports the notion that sleep quality is not a lexical construct with multiple different interpretations that might introduce systematic bias to the measure and outcome variables in papers 2 and 3.

Random bias is also reduced by having a large number of repeated measurements. Thus, the use of single items for sleep quality and duration is a practical solution to the problem of including multiple time-consuming measurement scales in long-lasting diary studies, where there is a risk of participants perceiving the number of questions to be too many to be worth their time. Paper 1 also has a severe limitation with the use of a mean split. This procedure might introduce unintended differences in the two groups – for example, differences in military rank – and is generally advised against (Iacobucci, Posavac, Kardes, Schneider, & Popovich, 2015). Splitting the sample in two also reduces the variance in the analysis. Because of this, we reanalyzed the data from paper 1 with a more robust multi-level regression analysis, the results of which are presented briefly below. The use of mixed effect analysis allows for the variations of individuals rather than groups, and given that the current thesis focuses on individual differences, not group differences, this represents an improvement. However, re-analyzing the data in paper 1 with a random intercept model with pre-mission levels as the reference point, and treating time as an indicator variable and with military rank as a control variable, revealed a similar pattern of results. The hypotheses tested in the analysis were similar to those tested in paper 1, but their specific wording changed because the analysis treated time as a categorical variable with pre-mission levels of insomnia as the reference point.

H1: Hardiness is negatively associated with symptoms of insomnia

H2: Symptoms of insomnia increase during the middle part and towards the end of the mission compared to the pre-mission baseline.

H3: Hardy individuals show less deterioration of sleep quality over time, and thus hardiness negatively moderates the development of insomnia symptoms during the mission.

Table 1. Null, main, and interaction models of time and hardiness on the BIS with time as a categorical variable. Pre-deployment scores were the reference.

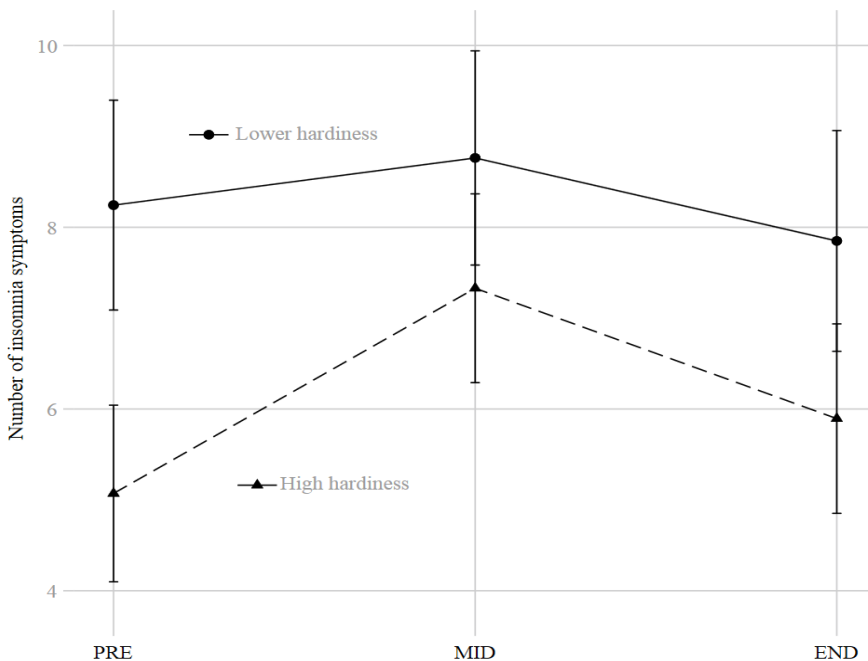
	Null model		Main model		Interaction model	
	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>	<i>B</i>	<i>SE</i>
Intercept	7.38**	.33	21.19**	3.76	26.86**	4.56
Military rank			-.53**	.40	-.53	.40
Hardiness			-.28**	.07	-.39**	.09
Pre			REF	REF	REF	REF
Mid			1.51**	.43	-9.04	4.75
End			.32	.44	-7.09	4.86
Hardiness × Pre					REF	REF
Hardiness × Mid					.21*	.09
Hardiness × End					.15	.09
Variance level 2 (Between)	23.10 (54%)	2.74	15.51	2.11	15.62	2.21
Variance level 1 (Within)	19.68 (46%)	1.36	18.54	1.35	18.27	1.34
Log likelihood		-2199.13		-1788.76		-1786.14

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

As shown in table 1, there was a main effect of hardiness on the BIS ($B = 0.37$, $p < .01$) and a main effect of time on the BIS. The number of symptoms was higher in the middle of the mission ($B = 1.15$, $p < .01$), but not towards the end, compared to pre-mission levels. We also found a positive interaction of time and hardiness at the

midway point ($B = 0.21, p < .05$), but not towards the end. The interaction pattern was plotted at marginal estimates of the BIS when hardiness was set at one SD above and below the mean hardiness score in figure 5. We used chi-square tests to investigate differences in marginal estimates and found a similar pattern to paper 1. The groups were different before ($\chi^2(1) = 19.12, p < .01$) and towards the end of the deployment ($\chi^2(1) = 6.45, p < .01$), but not in the middle of the mission ($\chi^2(1) = 3.62, p = .057$). The same interaction pattern was found in the reanalysis of the data as well. The increase in insomnia symptoms from pre-deployment to the middle of the mission was larger for hardy individuals. Lower hardiness reduced variation in sleep quality in the original ANOVA and in the reanalysis.

Figure 5. Marginal estimates of time and hardiness on insomnia symptoms (BIS). Hardiness is set at one SD above and below sample mean.



One difference from the ANOVA analysis did however emerge. When applying multi-level regression, the interaction between hardiness and time was only found when comparing symptoms at the midway point to the pre-mission levels. There was no interaction towards the end of the mission. This implies that categorically splitting the sample in two induced a difference in insomnia symptoms between the high and lower hardiness groups. One likely candidate for the difference is the military rank within each hardiness group. The analysis in paper 1 did not control for military rank, thus one hardiness group might have had more officers than sailors. When controlling for military rank, the interaction between hardiness groups regarding insomnia symptoms towards the end of the mission was non-significant.

5.7 Limitations and further studies

The samples for all three papers in this thesis comprised selected naval personnel, and this puts a limit on the generalizability of the findings, especially in papers 2 and 3 because naval cadets have been through an extensive selection process. In papers 1 and 3, the outcome and predictor measure were based on self-reports, meaning that the findings might be partly due to subjective reactions to differing levels of fatigue and sensitivity towards negatively toned questions. Having the same person reporting on predictor and outcome variable also increases the risk of common-method bias (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003). Another limitation concerns the use of subjective measures of sleep, and future studies should use objective measures of sleep¹⁷. A key limitation within papers 2 and 3 concerns the measurement

¹⁷ i.e. actigraphs

of sleep quality and duration with single-item measurements. Using a single item to measure psychological constructs has the drawback of introducing possible random or systematic errors. However, this general view has been challenged (Gardner, Cummings, Dunham, & Pierce, 1998). Research indicates robust test-retest correlations (Littman, White, Satia, Bowen, & Kristal, 2006), and in many cases the scores of the single items correlate strongly with the scores of multiple-item scales (Wanous & Reichers, 1996). 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 (Brekke et al., 2014; Burkhalter et al., 2013). Thus, single-item measurements might be a practical solution in regards to cost efficiency without compromising the predictions in diary studies (Nagy, 2002). However, to confirm the findings within this thesis future studies might employ multi-item sleep scales to avoid any possible bias associated with single-item measures. The findings of this thesis are primarily of interest in military and naval work situations, and future research might examine the real-world consequences of sleep on performance in other areas that vary in how they tax sleep.

5.8 Conclusions and practical implications

This thesis contributes to the current body of evidence on the role of sleep in human performance and functioning by documenting how a naval mission strains sleep quality and sleep duration. It also presents a more nuanced understanding of the role of sleep quality and duration on work performance. In brief, this thesis presents

evidence that sleep quality is positively related to work performance and that sleep duration is negatively related to work performance during demanding 24-hour naval work situations – especially in terms of contextual work that is not a part of the naval personnel’s formal job description. Additionally, poor sleep quality was documented to be negatively associated with work performance during demanding 24-hour operations. Through two studies, the role of individual differences in hardiness was shown to affect sleep quality during naval deployment and to be related to better naval work performance during a demanding training mission. Reducing sleep quality among the crew increases the hardiness advantage in performance, indicating that resilience to disturbed sleep quality is an important element in maintaining high naval work performance when faced with 24-hour continuous operations. Lastly, high-quality transformational leadership was found to be associated with higher performance in general and to buffer the negative effects of sleep quality on performance during a demanding training mission.

The results of this thesis have a number of practical implications, both within the naval and military context and beyond. The effects of low-quality sleep in any organization represent a practical problem (Barnes, 2012), especially in high-intensity shift work (Åkerstedt, 2003). Paper 3 shows that high-quality leadership is a concrete measure to improve performance and to reduce the negative effects of poor sleep quality. As a general rule, for managers and leaders in non-shift work without daily sleep restrictions, the available evidence supports measures to increase workers’ sleep duration (Barnes & Spreitzer, 2015). However, paper 2 and 3 outline how this approach might have unintended negative consequences in a high-paced shift work

environment. The results of paper 3 indicate that increasing sleep time might constitute a trade-off with activities that are not explicitly part of the job but that nonetheless contribute to the social and psychological core of the organization. Time constraints and whether tasks are clearly defined are the most likely explanation for this phenomenon. This means that to achieve higher performance by increasing sleep time, leaders and manager might need to reduce workloads or restructure the work to avoid drops in contextual work performance. In addition, tasks that are not well defined in regard to time or action, such as contributing, helping, or volunteering, are likely to drop with increased sleep time unless such tasks are specified more concretely. Papers 2 and 3 also strongly suggest that measures to improve sleep quality – such as fewer chronobiological disturbances, better sleep environment, reduced general stress, and clear separation of work and leisure time – will improve overall work performance. The results of papers 2 and 3 suggest that leaders and managers might take into account the different effects of sleep quality and duration and might try to improve sleep quality even when there are no options to increase time available to sleep. If managers and leaders have to increase sleep duration in order to increase sleep quality, the evidence presented here suggests that the small negative effect on contextual performance is outweighed by the noticeable increase in both measures of performance due to sleep quality. The results of paper 3 document that leaders can indirectly affect task performance when there are no options to increase sleep quality, and the use of TL to stave off symptoms of fatigue presents a way to buffer the negative effects of reduced sleep quality on work performance. The importance of high-quality leadership grows as individual workers experience disturbed sleep. Based

on these findings and similar research, we recommend the following managerial and leadership approach to regulating sleep as a strategic resource in a high-intensity 24-hour shift work environment. Firstly, increase the time available to sleep when possible, and manage and plan for possible reductions in non-task-related work performance, such as helping others, volunteering, and contributing to social networks. Secondly, employ sleep leadership behaviors (Gunia et al., 2015) to achieve as high quality sleep as possible. This includes considering sleep when planning and working to secure a good sleep environment and encouraging workers to go to sleep on time. Lastly, if the work situation does not allow for any direct measures to increase sleep quality or duration (crises, extraordinary organizational demands), take advantage of social effects, such as TL and social support (Åkerstedt et al., 2002), to buffer the effects of disturbed sleep on work performance.

6. References

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Doctoral Theses at The Faculty of Psychology,
University of Bergen

1980	Allen, Hugh M., Dr. philos.	Parent-offspring interactions in willow grouse (<i>Lagopus L. Lagopus</i>).
1981	Myhrer, Trond, Dr. philos.	Behavioral Studies after selective disruption of hippocampal inputs in albino rats.
1982	Svebak, Sven, Dr. philos.	The significance of motivation for task-induced tonic physiological changes.
1983	Myhre, Grete, Dr. philos.	The Biopsychology of behavior in captive Willow ptarmigan.
	Eide, Rolf, Dr. philos.	PSYCHOSOCIAL FACTORS AND INDICES OF HEALTH RISKS. The relationship of psychosocial conditions to subjective complaints, arterial blood pressure, serum cholesterol, serum triglycerides and urinary catecholamines in middle aged populations in Western Norway.
	Værnes, Ragnar J., Dr. philos.	Neuropsychological effects of diving.
1984	Kolstad, Arnulf, Dr. philos.	Til diskusjonen om sammenhengen mellom sosiale forhold og psykiske strukturer. En epidemiologisk undersøkelse blant barn og unge.
	Løberg, Tor, Dr. philos.	Neuropsychological assessment in alcohol dependence.
1985	Hellesnes, Tore, Dr. philos.	Læring og problemløsning. En studie av den perseptuelle analysens betydning for verbal læring.
	Håland, Wenche, Dr. philos.	Psykoterapi: relasjon, utviklingsprosess og effekt.
1986	Hagtvet, Knut A., Dr. philos.	The construct of test anxiety: Conceptual and methodological issues.
	Jellestad, Finn K., Dr. philos.	Effects of neuron specific amygdala lesions on fear-motivated behavior in rats.
1987	Aarø, Leif E., Dr. philos.	Health behaviour and sosioeconomic Status. A survey among the adult population in Norway.
	Underlid, Kjell, Dr. philos.	Arbeidsløyse i psykososialt perspektiv.
	Laberg, Jon C., Dr. philos.	Expectancy and classical conditioning in alcoholics' craving.
	Vollmer, Fred, Dr. philos.	Essays on explanation in psychology.
	Ellertsen, Bjørn, Dr. philos.	Migraine and tension headache: Psychophysiology, personality and therapy.
1988	Kaufmann, Astrid, Dr. philos.	Antisosial atferd hos ungdom. En studie av psykologiske determinanter.

	Mykletun, Reidar J., Dr. philos.	Teacher stress: personality, work-load and health.
	Havik, Odd E., Dr. philos.	After the myocardial infarction: A medical and psychological study with special emphasis on perceived illness.
1989	Bråten, Stein, Dr. philos.	Menneskedyaden. En teoretisk tese om sinnets dialogiske natur med informasjons- og utviklingspsykologiske implikasjoner sammenholdt med utvalgte spedbarnsstudier.
	Wold, Bente, Dr. psychol.	Lifestyles and physical activity. A theoretical and empirical analysis of socialization among children and adolescents.
1990	Flaten, Magne A., Dr. psychol.	The role of habituation and learning in reflex modification.
1991	Alsaker, Françoise D., Dr. philos.	Global negative self-evaluations in early adolescence.
	Kraft, Pål, Dr. philos.	AIDS prevention in Norway. Empirical studies on diffusion of knowledge, public opinion, and sexual behaviour.
	Endresen, Inger M., Dr. philos.	Psychoimmunological stress markers in working life.
	Faleide, Asbjørn O., Dr. philos.	Asthma and allergy in childhood. Psychosocial and psychotherapeutic problems.
1992	Dalen, Knut, Dr. philos.	Hemispheric asymmetry and the Dual-Task Paradigm: An experimental approach.
	Bø, Inge B., Dr. philos.	Ungdoms sosiale økologi. En undersøkelse av 14-16 åringers sosiale nettverk.
	Nivison, Mary E., Dr. philos.	The relationship between noise as an experimental and environmental stressor, physiological changes and psychological factors.
	Torgersen, Anne M., Dr. philos.	Genetic and environmental influence on temperamental behaviour. A longitudinal study of twins from infancy to adolescence.
1993	Larsen, Svein, Dr. philos.	Cultural background and problem drinking.
	Nordhus, Inger Hilde, Dr. philos.	Family caregiving. A community psychological study with special emphasis on clinical interventions.
	Thuen, Frode, Dr. psychol.	Accident-related behaviour among children and young adolescents: Prediction and prevention.
	Solheim, Ragnar, Dr. philos.	Spesifikke lærevansker. Diskrepanskriteriet anvendt i seleksjonsmetodikk.
	Johnsen, Bjørn Helge, Dr. psychol.	Brain asymmetry and facial emotional expressions: Conditioning experiments.
1994	Tønnessen, Finn E., Dr. philos.	The etiology of Dyslexia.
	Kvale, Gerd, Dr. psychol.	Psychological factors in anticipatory nausea and vomiting in cancer chemotherapy.

	Asbjørnsen, Arve E., Dr. psychol.	Structural and dynamic factors in dichotic listening: An interactional model.
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	Johannessen, Birte F., Dr. philos.	Det flytende kjønn. Om lederskap, politikk og identitet.
1995	Sam, David L., Dr. psychol.	Acculturation of young immigrants in Norway: A psychological and socio-cultural adaptation.
	Bjaalid, Inger-Kristin, Dr. philos.	Component processes in word recognition.
	Martinsen, Øyvind, Dr. philos.	Cognitive style and insight.
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	Brun, Wibecke, Dr. philos.	Subjective conceptions of uncertainty and risk.
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	Bjørkly, Stål, Dr. psychol.	Diagnosis and prediction of intra-institutional aggressive behaviour in psychotic patients
1996	Anderssen, Norman, Dr. psychol.	Physical activity of young people in a health perspective: Stability, change and social influences.
	Sandal, Gro Mjeldheim, Dr. psychol.	Coping in extreme environments: The role of personality.
	Strumse, Einar, Dr. philos.	The psychology of aesthetics: explaining visual preferences for agrarian landscapes in Western Norway.
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	Einarsen, Ståle, Dr. psychol.	Bullying and harassment at work: epidemiological and psychosocial aspects.
1997	Knivsberg, Ann-Mari, Dr. philos.	Behavioural abnormalities and childhood psychopathology: Urinary peptide patterns as a potential tool in diagnosis and remediation.
	Eide, Arne H., Dr. philos.	Adolescent drug use in Zimbabwe. Cultural orientation in a global-local perspective and use of psychoactive substances among secondary school students.
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	Manger, Terje, Dr. philos.	Gender differences in mathematical achievement among Norwegian elementary school students.
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	Vosburg, Suzanne K., Dr. philos.	The effects of mood on creative problem solving.
	Eriksen, Hege R., Dr. philos.	Stress and coping: Does it really matter for subjective health complaints?
	Jakobsen, Reidar, Dr. psychol.	Empiriske studier av kunnskap og holdninger om hiv/aids og den normative seksuelle utvikling i ungdomsårene.
1999	Mikkelsen, Aslaug, Dr. philos.	Effects of learning opportunities and learning climate on occupational health.
V	Samdal, Oddrun, Dr. philos.	The school environment as a risk or resource for students' health-related behaviours and subjective well-being.
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H	Saban, Sara, Dr. psychol.	Brain Asymmetry and Attention: Classical Conditioning Experiments.
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2000 V	Hovland, Ole Johan, Dr. philos.	Transforming a self-preserving "alarm" reaction into a self-defeating emotional response: Toward an integrative approach to anxiety as a human phenomenon.
	Lillejord, Sølvi, Dr. philos.	Handlingsrasjonalitet og spesialundervisning. En analyse av aktørperspektiver.
	Sandell, Ove, Dr. philos.	Den varme kunnskapen.
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	Eid, Jarle, Dr. psychol.	Early predictors of PTSD symptom reporting; The significance of contextual and individual factors.
2001 V	Skinstad, Anne Helene, Dr. philos.	Substance dependence and borderline personality disorders.
	Binder, Per-Einar, Dr. psychol.	Individet og den meningsbærende andre. En teoretisk undersøkelse av de mellommenneskelige forutsetningene for psykisk liv og utvikling med utgangspunkt i Donald Winnicotts teori.
	Roald, Ingvild K., Dr. philos.	Building of concepts. A study of Physics concepts of Norwegian deaf students.
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	Engelsen, Birthe Kari, Dr. psychol.	Measurement of the eating problem construct.
	Lau, Bjørn, Dr. philos.	Weight and eating concerns in adolescence.
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	Rosén, Gunnar O. R., Dr. philos.	The phantom limb experience. Models for understanding and treatment of pain with hypnosis.
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	Kallestad, Jan Helge, Dr. philos.	Teachers, schools and implementation of the Olweus Bullying Prevention Program.
H	Ofte, Sonja Helgesen, Dr. psychol.	Right-left discrimination in adults and children.
	Netland, Marit, Dr. psychol.	Exposure to political violence. The need to estimate our estimations.
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	Bjuland, Raymond, Dr. philos.	Problem solving in geometry. Reasoning processes of student teachers working in small groups: A dialogical approach.
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	Holsen, Ingrid, Dr. philos.	Depressed mood from adolescence to 'emerging adulthood'. Course and longitudinal influences of body image and parent-adolescent relationship.
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	Gabrielsen, Egil, Dr. philos.	LESE FOR LIVET. Lesekompetansen i den norske voksenbefolkningen sett i lys av visjonen om en enhetsskole.
H	Hansen, Anita Lill, Dr. psychol.	The influence of heart rate variability in the regulation of attentional and memory processes.
	Dyregrov, Kari, Dr. philos.	The loss of child by suicide, SIDS, and accidents: Consequences, needs and provisions of help.
2004 V	Torsheim, Torbjørn, Dr. psychol.	Student role strain and subjective health complaints: Individual, contextual, and longitudinal perspectives.

	Haugland, Bente Storm Mowatt Dr. psychol.	Parental alcohol abuse. Family functioning and child adjustment.
	Milde, Anne Marita, Dr. psychol.	Ulcerative colitis and the role of stress. Animal studies of psychobiological factors in relationship to experimentally induced colitis.
	Stornes, Tor, Dr. philos.	Socio-moral behaviour in sport. An investigation of perceptions of sportspersonship in handball related to important factors of socio-moral influence.
	Mæhle, Magne, Dr. philos.	Re-inventing the child in family therapy: An investigation of the relevance and applicability of theory and research in child development for family therapy involving children.
	Kobbeltvedt, Therese, Dr. psychol.	Risk and feelings: A field approach.
2004 H	Thomsen, Tormod, Dr. psychol.	Localization of attention in the brain.
	Løberg, Else-Marie, Dr. psychol.	Functional laterality and attention modulation in schizophrenia: Effects of clinical variables.
	Kyrkjebø, Jane Mikkelsen, Dr. philos.	Learning to improve: Integrating continuous quality improvement learning into nursing education.
	Laumann, Karin, Dr. psychol.	Restorative and stress-reducing effects of natural environments: Experiential, behavioural and cardiovascular indices.
	Hølgersen, Helge, PhD	Mellom oss - Essay i relasjonell psykoanalyse.
2005 V	Hetland, Hilde, Dr. psychol.	Leading to the extraordinary? Antecedents and outcomes of transformational leadership.
	Iversen, Anette Christine, Dr. philos.	Social differences in health behaviour: the motivational role of perceived control and coping.
2005 H	Mathisen, Gro Ellen, PhD	Climates for creativity and innovation: Definitions, measurement, predictors and consequences.
	Sævi, Tone, Dr. philos.	Seeing disability pedagogically – The lived experience of disability in the pedagogical encounter.
	Wium, Nora, PhD	Intrapersonal factors, family and school norms: combined and interactive influence on adolescent smoking behaviour.
	Kanagaratnam, Pushpa, PhD	Subjective and objective correlates of Posttraumatic Stress in immigrants/refugees exposed to political violence.
	Larsen, Torill M. B. , PhD	Evaluating principals` and teachers` implementation of Second Step. A case study of four Norwegian primary schools.
	Bancila, Delia, PhD	Psychosocial stress and distress among Romanian adolescents and adults.
2006 V	Hillestad, Torgeir Martin, Dr. philos.	Normalitet og avvik. Forutsetninger for et objektivt psykopatologisk avviksbegrep. En psykologisk, sosial, erkjennelsesteoretisk og teoriehistorisk framstilling.

	Nordanger, Dag Øystein, Dr. psychol.	Psychosocial discourses and responses to political violence in post-war Tigray, Ethiopia.
	Rimol, Lars Morten, PhD	Behavioral and fMRI studies of auditory laterality and speech sound processing.
	Krumsvik, Rune Johan, Dr. philos.	ICT in the school. ICT-initiated school development in lower secondary school.
	Norman, Elisabeth, Dr. psychol.	Gut feelings and unconscious thought: An exploration of fringe consciousness in implicit cognition.
	Israel, K Pravin, Dr. psychol.	Parent involvement in the mental health care of children and adolescents. Empirical studies from clinical care setting.
	Glasø, Lars, PhD	Affects and emotional regulation in leader-subordinate relationships.
	Knutsen, Ketil, Dr. philos.	HISTORIER UNGDOM LEVER – En studie av hvordan ungdommer bruker historie for å gjøre livet meningsfullt.
	Matthiesen, Stig Berge, PhD	Bullying at work. Antecedents and outcomes.
2006	Gramstad, Arne, PhD	Neuropsychological assessment of cognitive and emotional functioning in patients with epilepsy.
H	Bendixen, Mons, PhD	Antisocial behaviour in early adolescence: Methodological and substantive issues.
	Mrumbi, Khalifa Maulid, PhD	Parental illness and loss to HIV/AIDS as experienced by AIDS orphans aged between 12-17 years from Temeke District, Dar es Salaam, Tanzania: A study of the children's psychosocial health and coping responses.
	Hetland, Jørn, Dr. psychol.	The nature of subjective health complaints in adolescence: Dimensionality, stability, and psychosocial predictors
	Kakoko, Deodatus Conatus Vitalis, PhD	Voluntary HIV counselling and testing service uptake among primary school teachers in Mwanza, Tanzania: assessment of socio-demographic, psychosocial and socio-cognitive aspects
	Mykletun, Arnstein, Dr. psychol.	Mortality and work-related disability as long-term consequences of anxiety and depression: Historical cohort designs based on the HUNT-2 study
	Sivertsen, Børge, PhD	Insomnia in older adults. Consequences, assessment and treatment.
2007	Singhammer, John, Dr. philos.	Social conditions from before birth to early adulthood – the influence on health and health behaviour
V	Janvin, Carmen Ani Cristea, PhD	Cognitive impairment in patients with Parkinson's disease: profiles and implications for prognosis
	Braarud, Hanne Cecilie, Dr. psychol.	Infant regulation of distress: A longitudinal study of transactions between mothers and infants
	Tveito, Torill Helene, PhD	Sick Leave and Subjective Health Complaints

	Magnussen, Liv Heide, PhD	Returning disability pensioners with back pain to work
	Thuen, Elin Marie, Dr.philos.	Learning environment, students' coping styles and emotional and behavioural problems. A study of Norwegian secondary school students.
	Solberg, Ole Asbjørn, PhD	Peacekeeping warriors – A longitudinal study of Norwegian peacekeepers in Kosovo
2007	Søreide, Gunn Elisabeth, Dr.philos.	Narrative construction of teacher identity
H	Svensen, Erling, PhD	WORK & HEALTH. Cognitive Activation Theory of Stress applied in an organisational setting.
	Øverland, Simon Nygaard, PhD	Mental health and impairment in disability benefits. Studies applying linkages between health surveys and administrative registries.
	Eichele, Tom, PhD	Electrophysiological and Hemodynamic Correlates of Expectancy in Target Processing
	Børhaug, Kjetil, Dr.philos.	Oppseding til demokrati. Ein studie av politisk oppseding i norsk skule.
	Eikeland, Thorleif, Dr.philos.	Om å vokse opp på barnehjem og på sykehus. En undersøkelse av barnehjemsbarns opplevelser på barnehjem sammenholdt med sanatoriebarns beskrivelse av langvarige sykehusopphold – og et forsøk på forklaring.
	Wadel, Carl Cato, Dr.philos.	Medarbeidersamhandling og medarbeiderledelse i en lagbasert organisasjon
	Vinje, Hege Forbech, PhD	Thriving despite adversity: Job engagement and self-care among community nurses
	Noort, Maurits van den, PhD	Working memory capacity and foreign language acquisition
2008	Breivik, Kyrre, Dr.psychol.	The Adjustment of Children and Adolescents in Different Post-Divorce Family Structures. A Norwegian Study of Risks and Mechanisms.
V	Johnsen, Grethe E., PhD	Memory impairment in patients with posttraumatic stress disorder
	Sætrevik, Bjørn, PhD	Cognitive Control in Auditory Processing
	Carvalho, Susana Fonseca, PhD	Prevention of bullying in schools: an ecological model
2008	Brønnick, Kolbjørn Selvåg	Attentional dysfunction in dementia associated with Parkinson's disease.
H	Posserud, Maj-Britt Rocio	Epidemiology of autism spectrum disorders
	Haug, Ellen	Multilevel correlates of physical activity in the school setting
	Skjerve, Arvid	Assessing mild dementia – a study of brief cognitive tests.

	Kjønniksen, Lise	The association between adolescent experiences in physical activity and leisure time physical activity in adulthood: a ten year longitudinal study
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	Omvik, Siri	Insomnia – a night and day problem
2009	Molde, Helge	Pathological gambling: prevalence, mechanisms and treatment outcome.
V	Foss, Else	Den omsorgsfulle væremåte. En studie av voksnes væremåte i forhold til barn i barnehagen.
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	Wangberg, Silje C.	Internet based interventions to support health behaviours: The role of self-efficacy.
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	Guribye, Eugene	Refugees and mental health interventions
	Sørensen, Lin	Emotional problems in inattentive children – effects on cognitive control functions.
	Tjomsland, Hege E.	Health promotion with teachers. Evaluation of the Norwegian Network of Health Promoting Schools: Quantitative and qualitative analyses of predisposing, reinforcing and enabling conditions related to teacher participation and program sustainability.
	Helleve, Ingrid	Productive interactions in ICT supported communities of learners
2009	Skorpen, Aina	Dagliglivet i en psykiatrisk institusjon: En analyse av miljøterapeutiske praksiser
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	Wageningen, Heidi Karin van	The role of glutamate on brain function

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