

## RESEARCH ARTICLE

# The impact of stressors on cognition during a survival exercise in polar waters—results of an experiment in northern Norway

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## Abstract

As sea ice diminishes with global warming, new opportunities for commercial shipping, tourism and fishing arise in the polar regions in the winter. With this comes the risk of accidents. Long distances and extreme environmental conditions compound the challenges of search and rescue operations in Arctic waters. In the event of an incident in polar waters requiring evacuation from ship to lifeboat, sea ice or beach, the International Maritime Organization's Polar Code requires that passengers and crew can take care of themselves for a minimum of five days. To investigate how hypothermia, poor sleep, emotions and nutrition affect cognitive functions that may impact self-rescue and survival in a cold climate, a 36-hour experiment was carried out in October 2022 in the fjord Beisfjord, northern Norway. The study included cognitive pre- and post-tests, medical examinations, glucose measurements, observations and focus group interviews. The tests revealed a weakening of cognitive skills. Interviews and video recordings showed that the participants were restless and felt bored. The participants described being wet and cold and not having slept adequately. Glucose levels were normal. Some participants suffered mild hypothermia in spite of the wool clothing and survival suits provided. The study shows that human factors are important to consider in planning for emergency situations in polar waters.

## Keywords

Search and rescue; Arctic; maritime emergencies; sleep; hypothermia; survival kits

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## Abbreviations

GSK: group survival kit  
MJ: megajoule (1 MJ = 239 kcal)  
PSK: personal survival kit  
SARex: series of search and rescue exercises in Norway carried out by several Norwegian agencies

To access the supplementary material, please visit the article landing page

## Introduction

Under the extreme environmental conditions of the Arctic, which are often characterized by challenging weather and long distances, search and rescue operations can be particularly challenging. Demonstrating preparedness to deal with the rescue of large cruise ships involving many injured is considered almost impossible. For operations in polar waters, the International Maritime Organization's International Code for Ships Operating in Polar Waters—known as the Polar Code—requires self-rescue for survival for a minimum of five days from evacuation until rescue takes place (IMO 2016). Today, the expertise related to search and rescue in the Arctic is considered insufficient in Norway, and one of the main conclusions of Norway's maritime search and rescue exercises (2016–2022) was that, in the event of a cruise ship accident, it was unlikely that the majority of

evacuated passengers and crew would survive for five days, as required by the Polar Code (Maritimt Forum Nord 2023).

As more people visit the Arctic, interest in the human factors associated with search and rescue in the region has also grown. A Norwegian parliamentary white paper states that “The regulations for rescue equipment are mainly characterized by technical and functional requirements for equipment, with little focus on the human elements” (Ministry of Trade, Industry and Fisheries 2018–19: 31; our translation). The report also indicates that the experiences gained during rescue exercises make it clear that the technical requirements for rescue equipment are not enough in themselves. Reports have pointed out that survival in the Norwegian North following a maritime accident depends on a combination of such human factors as hypothermia and clothing, competence in the use of safety and rescue equipment, experience

with evacuation after a serious incident, experience of practical exercises, competent leadership, the amount and frequency of intake of emergency rations, exhaustion and cognition (Solberg et al. 2016; Solberg et al. 2017; Gudmestad & Solberg 2018; Ministry of Trade, Industry and Fisheries 2018–19; Husjord & Meidell 2019, 2023; Løyning 2019; Maritimt Forum Nord 2023).

## Cognition theory

Cognition involves the brain's ability to receive, process, store and express information (Olmstead & Kuhlmer 2015). Central cognitive functions are perception, attention, memory, logical thinking, problem-solving and communication. Cognitive problems include, among other things, difficulties in perception, learning, remembering, planning and organizing activities, as well as problems in perceiving time and understanding words. Impaired cognitive functioning brought on by negative or stressful influences can affect our attention and our ability to understand and think rationally, act purposefully and interact effectively with the environment (Bast-Pettersen & Wastensson 2020). A central element in cognition is memory, which is the mental process used to acquire (encode) and retain (store) information for later retrieval (Ashcraft & Klein 2010). The experiment that we report on here investigated how stress factors affected the participants' memory functions.

With the term "stress" we refer to physical and/or psychological discomfort or strain a person can experience in a situation. The effect stress can have on a person depends on the type of stressor, its strength and duration, and the individual's previous experiences (Chu et al. 2024). So-called positive stress can be experienced as stimulating and motivating, for example, in a work situation or during a physically hard exercise session. Events such as accidents create stress that can, on the other hand, negatively influence physical and mental health. In this study, three stressors were examined related to cognitive functioning: hypothermia, insufficient sleep and negative emotions. The effects of emergency food and water rations were also considered.

## Hypothermia

The mean air temperature during the exercise was 9.55°C. The maximum air temperature was 11.13°C, and the minimum air temperature was 5.67°C. The weather varied between rain, wind, sun and dry weather (Supplementary Tables S1, S2). The body's ability to regulate temperature is a homeostatic process that strives for a steady core temperature of approximately 37°C

(Blakemore & Jenett 2001; Knardahl et al. 2010). When a person is cooled below 35°C degrees, it is called hypothermia. According to Teien (2015), a body temperature of 35–33°C is graded as mild hypothermia, 33–30°C is moderate and below 30°C is deep. When the body is exposed to cold air or cold water, physiological processes such as shivering and the production or increased secretion of adrenaline, noradrenaline and the thyroid hormones reduce heat loss (Blakemore & Jenett 2001; Jones et al. 2017).

Experiments have shown different results about the cold's impact on cognitive functioning. For example, Taylor et al. (2015) showed that cold exposure between 10 and -20°C reduces cognitive functioning: reaction time increased and attention to the task solution was reduced. In their meta-analysis of 22 studies, Pilcher et al. (2002) found that exposure to cold air or cold water below 10°C had a negative impact on cognitive function. Other studies (Knardahl et al. 2010; Muller et al. 2012) have shown that short-term cold can improve alertness, which is believed to be due to increased adrenaline production, while Muller et al. (2012) show that longer cold exposures can impair vigilance and the ability to make decisions, and it negatively affects reaction time and memory.

## Nutrition

For men and women with average physical activity levels, the Nordic Council of Ministers recommends an intake of ca. 11 and 9 MJ of food energy, respectively (Blomhoff et al. 2023). The council recommends a water intake of 2 L for women and 2.5 L for men (Blomhoff et al. 2023). The need for intake of nutrition will vary according to age, weight, height and activity level and, among women, with the stages of pregnancy.

In an evacuation in a cold climate, a person will often be exposed to low temperatures so that shivering occurs. Stress can lead to physical reactions such as vomiting or diarrhea. In such situations, there will be an increased need for nutrition and drink to maintain the body's basic functions and to avoid dehydration.

## Sleep

Studies show that lack of sleep reduces mental performance and mood and increases the risk of psychological problems (Sivertsen et al. 2014; Sivertsen et al. 2015; Hysing et al. 2016). Stepan et al. (2019) showed that memory functions are significantly reduced after 24 hours without sleep, which may contribute to errors when carrying out routine tasks, a weakened ability to

take in new information and inappropriate storage in long-term memory. Lack of sleep may also affect the ability to make quick and appropriate decisions, which is considered important during evacuation and rescue (Stepan et al. 2019).

## Methods

The study used method triangulation, which involves multiple data collection methods. A combination of quantitative and qualitative methods was employed. Qualitative methods yielded insights into the participants' behaviour during the exercise as well as their personal experiences of cold, food and water rations, poor or insufficient sleep and emotions. The information gained through the qualitative methods was not quantified. An overview of how and when data were collected is presented in Supplementary Table S3.

Weather data, such as wind direction, air temperature and relative humidity, were recorded by a weather station in the field area (Supplementary Tables S1, S2).

## Participants

Twenty voluntary participants took part in the experiment. There were six women and 14 men, with an age range from 20 to 75 years and nationalities that included Norwegian, Italian, Swedish, Russian, German, Indian, French, US American, Brazilian, Nepalese and Dutch. The participants gave written, informed consent to participate.

During the fieldwork, five participants stayed in a closed lifeboat with windows, while 15 were located on the beach. These 15 participants were transported by

lifeboat and raft to the beach for a stay of 36 hours. The participants on the beach were divided into four groups (Fig. 1). The participants were exposed to, and experienced, several stress factors, such as cold and poorer-than-usual sleep quality; they received nutrition in the form of emergency rations. The participants on the beach and in the lifeboat were filmed during the entire field stay. Two researchers were present in the lifeboat during the field period; researchers were also present on the beach. After the fieldwork, the participants underwent final health checks, cognitive post-tests and focus group interviews.

## Survival suits and kits

The participants were informed in advance that they would go through a simulated rescue situation involving a lifeboat and a 36-hour stay on a beach, but they did not receive any recommendation about clothing. They showed up in their own clothes and were given survival suits before being taken out in a lifeboat from Narvik harbour and into Beisfjord (Fig. 1). On arrival at the beach in Beisfjord, the participants were given PSKs and GSKs for survival in polar waters, in accordance with the Polar Code (Lovdata 2017, points 9.1 and 9.2).

The contents of each PSK were a survival suit; a set of woollen clothing that included a sweater, long underwear, hat, gloves and socks; a cream to protect the skin against cold; sunglasses; a whistle; a drinking cup; a multi-tool comprising five individual tools; a waterproof carrier bag; food bars; and small drinking bags containing water. In addition, participants were given a toothbrush and toothpaste.



**Fig. 1** The location of the field exercise in (a) Norway, near (b) Narvik, (c) on the beach in Beisfjorden. In (b) the port of Narvik is marked with an X and the beach exercise area is marked with a circle. In (c), the locations of four groups are indicated with numbers 1–4. The lifeboat was near the shore. (The map of Scandinavia is a modified version of a map by copyright-holders Malte Humpert and The Arctic Institute. The map of Narvik–Beisfjord is from Norgeskart.)

The GSKs contained four tents; eight sleeping bags and eight sleeping mats, in accordance with the minimum requirement of one sleeping bag and one mat per two people; five first-aid kits; wipes; toilet paper; cooking appliances and fuel calculated for the period; one flashlight per tent; waterproof matches; and floatable and waterproof packing bags. In addition, a water pump, water containers and water purification tablets were supplied in the lifeboat.

The participants in the lifeboat had the same emergency equipment as the participants on the beach, except tents. A portable toilet was installed at the front of the lifeboat, and one was placed on the beach (Fig. 1).

### **Quantitative data collection on cognition: pre- and post-tests**

The study's quantitative data collection was carried out through pre-tests at the start of the field experiment and post-tests at the end of experiment, after 36 hours in the field.

The pre- and post-tests included the MMSE-NR3 Mental Status Evaluation test (Strobel & Engedal 2021) and the KT-NR3 Norwegian Revised Clock Test (Strobel et al. 2018). KT-NR3 was used in its entirety, where the hours of the clock and then the hands at the indicated time are recorded. For the MMSE-NR3, three subtests were selected: delayed recall, mental arithmetic and figure copying. In the recall subtest, the subject was asked to immediately repeat five words that had just been aloud, to demonstrate that the subject had heard and understood the word. (Subjects were given a choice between Norwegian and English word lists for this test.) Then, after a given period of time had elapsed and the subject had been distracted with the mental arithmetic test, the subject was asked to recall the five words (the order did not matter). The mental arithmetic task consisted of subtracting 7 from a given number (for example, 80) and then continuing to subtract 7 from the number until the test leader said stop, which was after five subtractions. In the figure copying subtest, the subject was asked to draw, in his or her own hand, a drawing provided by the tester.

To minimize the learning effect, the post-tests were not identical to the pre-tests. The words to be memorized were different (but the number of words was the same), the number in the mental arithmetic test was different, the figures in the copying test were different, and the time indications in the clock test were different.

The pre- and post-tests were scored as follows. For the MMSE-NR3 delayed recall subtest, one point was given for reproducing the set of words that had earlier been read aloud to the subject. Both definite and

indefinite forms of the word (in Norwegian) were accepted, but related words, plural forms, synonyms or paraphrases of the word did not give points. The delayed recall subtest gave a maximum of five points. In the mental arithmetic subtest, one point was given for each correct subtraction from the previous number, so the maximum number of points in this subtest was also five. In the figure copying subtest, the maximum score was one point, which was given for copying the given figure with a good degree of accuracy, regardless of whether the subject's drawing rotated or resized the original figure. For KT-NR3, a maximum of two points were awarded: one for the correct numbers written in the correct order on a circle representing a clock face; and one for drawing the clock hands in positions that correctly indicated a given time.

### **Quantitative data collection: body temperature and glucose levels**

To document any change in the participants' body temperature during the field exercise, this was measured three times. The participants' body temperature was first measured, at the university campus in Narvik, at about 21:00 on 6 October by the project's field doctor, before the start of the field exercise. Body temperature was measured again—in the lifeboat and in the field tent on the beach—at 08:00 on 8 October, approximately in the middle of the field exercise. At the end of the field exercise, a final body temperature measurement was carried out at 22:00 on 8 October (Supplementary Table S3) in the lifeboat and in the field tent.

All participants were allocated emergency rations and water in accordance with the Norwegian health authorities' recommendations for daily intake. To investigate whether changes in the participants' glucose levels corresponded with changes in cognitive performance (as measured by the pre- and post-tests), the participants had sensors (Freestyle Libre brand) attached to their arms that continuously measured and recorded glucose throughout the 36 hours of the field exercise.

### **Qualitative data collection: observation**

To minimize influencing the participants, the researchers observed the participants without participating themselves (see, e.g., Thagaard 2018). The researchers were identified to the participants.

Observations were recorded with five GoPro cameras that made video and sound recordings over 36 hours of the four tent camps on the beach and of the group that stayed in the lifeboat. In addition, GoPros recorded pre- and post-testing.

The aim of these non-participant, open observations was to see how the stress factors affected the behaviour of the participants and to record the survival behaviours of the participants and how they cooperated with one another. The observations helped to deepen the results of the cognitive tests. The videos were analysed using deductive thematic analysis (Brown & Clark 2022). Analytical themes included use of clothing, use of PSKs and GSKs, meals, the participants' activities (for example, walking on the beach to keep warm), sleep patterns, cooperation, 'atmosphere' (mood) within a group, use of strategy, use of time, endurance, concentration and verbal expressions.

### **Qualitative data collection: focus group interviews**

Shortly after the conclusion of the field exercise, three researchers led three focus group interviews, each involving between five and eight participants. These interviews lasted about one hour. The participants were given food and drink (not emergency rations) before the focus group interviews were carried out.

Focus groups yield information through group dynamic interaction processes (Kreuger 1994; Morgan 1997). Madriz (2000) argues for focus group interviews where one is concerned with experiences and attitudes. Large focus groups (10–12 people) provide more expressions, whereas smaller focus groups (three to four people) allow for topics to be explored in more depth (Justesen & Mik-Meyer 2010; Halkier 2018). Observing the group dynamic is important because it affects what is discussed in a focus group interview and the extent to which different points of view are expressed (Justesen & Mik-Meyer 2010). Important qualitative data in this study were the participants' descriptions of perceived experiences related to negative stressors such as cold and poor sleep, as well as their experiences of the rations that were provided to them and their own emotions.

A semi-structured interview guide was designed for the focus group interviews. Flexibility in the interview guide gave the researcher the opportunity to ask follow-up questions that were not in the interview guide (Kvale & Brinkmann 2015). The open questions in the interview guide revolved around the stressors in the research question. Examples of such questions were as follows. What did you wear and what do you think you lacked in clothing when you entered the field? How did you experience the cold on your feet, hands, head, whole body? What did you do to keep warm? How did you experience the content of the PSK and GSK? How did you experience the instructions for using the PSK and GSK? How often did you eat and drink water? Did you

consume all the allocated emergency rations—why or why not? Can you describe your own mood during your stay? How did you experience the atmosphere in your group at the start of the field exercise, in the middle of it and at the end? How much did you sleep and how was your sleep during your stay (compared to your usual sleep pattern)? Did you experience anything that affected the quality of your sleep?

The interviews were video-recorded (with sound) with GoPros. In the introduction to the focus group interviews, the participants verbally confirmed that interviews could be released and used in the study, under the condition of anonymity. Informed consent had been signed and received before the start of the field exercise.

The focus group interviews were transcribed, thematically analysed and interpreted by the authors, working together at the same time. Following the steps delineated by Brown & Clark (2022), we started by listening through each interview and writing a short summary of the participants' experiences of cold, sleep, negative emotions and food and water before we transcribed the interviews. We then read the transcriptions and coded them with single words and short phrases and sentences that reflected the main themes and sub-themes that we were interested in (Supplementary Table S4).

### **Ethics**

Ethical considerations were linked to subjecting the participants for an extended period of time to cold weather, rain, wind and little sleep, with emergency rations and limited equipment at their disposal. The movements of the participants in the lifeboat were constrained by the small space of the crowded vessel, and these participants also experienced a humid indoor climate, constant water motion and substandard sanitary conditions.

The project was approved by the Norwegian Centre for Research Data (application number 327506) and the National Committee for Medical and Health Research Ethics (application number 289596).

Requests for project participation and information letters were sent out to all participants. A consent form was also sent to the participants, requiring signing.

### **Results**

#### **Pre- and post-tests**

All the subtests showed a marked weakening of cognitive skills between the pre- and post-tests (Table 1). The participants also needed more time to complete the post-tests compared to the pre-tests. In the post-tests, the participants took longer thinking breaks, tried to

**Table 1** The average pre- and post-test scores for the 20 participants.

Subtests	Pre-test		Post-test		Mean difference
	Mean score	Max. score	Mean score	Max. score	
MMSE-NR3: recall	4.50	5.00	3.80	5.00	0.70
MMSE-NR3: mental arithmetic	4.85	5.00	4.25	5.00	0.60
MMSE-NR3: figure copying	1.00	1.00	0.95	1.00	0.05
KT-NR3: clock test	1.55	2.00	0.80	2.00	0.75

guess the words during the delayed recall subtest and had difficulty remembering the order of words. In the calculation tasks, the use of auxiliary strategies such as counting on the fingers and guessing numbers was also recorded. The participants were also more easily distracted by objects in the test tent and conversations outside the test area.

### **Body temperature and glucose measurements**

The medical check that was carried out at the end of the exercise showed that several of the participants had mild hypothermia; no signs of frostbite were recorded (Evju 2023). The air temperature ranged from 11.13°C (daytime) to 5.5°C (night).

The measurements of glucose, which were taken regularly throughout the experiment, showed only small individual variations within the normal range (Supplementary Fig. S1). Their glucose values ranged from 3.9 to 10; the average was 5.7. There was one exception: a participant who did not consume emergency rations during the experimental period of 36 hours. Because 19 out of 20 participants were within the normal range, we assume that this factor does not play a role in the results of the post-tests.

### **Focus group interviews and video recordings**

The focus group interviews and the videos showed that the participants were wet and cold, especially on the second day. On the beach, some chose to sleep outside the tents, using their survival suits as sleeping mats. Two of the groups on the beach lit fires to warm up. Some participants boiled water or walked around the beach or otherwise stayed physically active to keep warm.

In the lifeboat, where movement was limited, the cold was quickly felt on the body, and the night was experienced as extra cold. Nevertheless, some participants in the lifeboat sat on the roof, explaining that they wanted to be alone for a bit, to enjoy the silence and fresh air.

The lifeboat engine was started a few times during the experimental period to bring up the heat on board.

The participants carried out a buddy check, as they had been instructed, to ensure that the group members did not get frostbite and to encourage the use of the provided woollen clothing. Most of the participants wore their survival suits throughout the exercise. Some participants used their clothing in the wrong way or put it on after they were already wet or thoroughly cold, so they remained cold and wet. In spite of the buddy checks and information provided by the researchers regarding the importance of woollen clothing, six participants did not wear the provided woollen clothes underneath the suits. One of these participants used his own woollen clothes. Some participants on the beach reported getting damp inside their survival suits (regardless of whether woollen clothes were worn underneath) because their activity warmed up their bodies, creating dampness. Some participants chose to swim in the sea while wearing their survival suits; these participants reported that the suits had kept them comfortably warm and dry in the water.

Sleep quantity and sleep quality were perceived to be worse during the experimental period than under normal conditions. (We made no attempt to measure the quantity or quality of the participants' sleep before the exercise.) The participants reported that they slept for two to three hours during the night, with many awakenings, and this poor sleep could also be seen on the video recordings. Although the lifeboat was certified for 55 people, the participants who stayed in it experienced that there was little space to lie down and sleep. The separate room for a toilet and the storage of PSKs and GSKs reduced the space available for the participants to lie down. The air quality in the boat was perceived to worsen as time passed and when the boat was aired out it got cold.

In the focus group interviews, the participants expressed being in a good mood during the experiment, but restlessness, boredom and a desire to be alone gradually became dominant feelings. The videos provided additional evidence of this. At first, many people were busy finding the equipment they had available, setting up tents, making fires, etc., but as these tasks dwindled, it became boring to have nothing special to do. (The participants were not allowed to bring their mobile phones with them during the experiment.) Some participants tried to come up with joint activities—to make the time pass—and eventually began to wander around alone. In the lifeboat, individual participants sat on the roof to be alone for a while. A sense of restlessness was particularly evident when—well before the end of the exercise—the participants began to pack up and prepare for the conclusion of the exercise.

## Discussion

The purpose of the investigation was to show whether various factors such as cold, emergency rations, little sleep and negative emotions in a simulated evacuation and rescue situation of 36 hours in a cold environment can have an impact on certain cognitive functions. Comparing the pre- and post-test scores shows that there was such an effect. However, factors that were not taken into account in the study design could have given an even clearer result. If the exercise had taken place in January or February, air temperatures would have been lower. This would probably have resulted in greater differences between the pre- and post-test scores.

As the cognitive tests were carried out twice, a learning effect may have occurred, which may have reduced the differences in the results even though the pre- and post-tests were not identical in their content and the two sets of tests were carried out about 40 hours apart.

The experiment was not designed to investigate whether each factor in isolation had an effect on the tests. Nevertheless, the glucose measurements allowed us to rule out the food rations as contributors to the lower post-test scores.

The medical report shows that several of the participants had mild hypothermia (Evju 2023). Nearly all the participants expressed feeling cold. Taylor et al. (2015) and Pilcher et al. (2002) have shown that exposure to cold between 10 and  $-20^{\circ}\text{C}$  reduces cognitive functioning, and the air temperatures measured were within that range. Muller et al. (2012) confirm these findings related to reaction time and memory. The positive impact that increased adrenaline production can have on alertness was unlikely to have lasted for 36 hours.

During the exercise, some participants did not wear all of the provided clothing, and they used them incorrectly, for example, putting them on too late. The participants included people who had never slept in a tent and who came from regions warmer than northern Norway. They were variously dressed for autumn. Some came with running shoes and thin windbreakers, while others arrived in winter boots, hats and winter jackets. One can assume that tourists who are on cruises in the Arctic also have varying clothing and varying experiences of camping (Løyning 2019).

Sleep quality and sleep quantity are factors that can affect thinking and emotions. Individual sleep recordings would have provided precise data on the amount of sleep the participants had. Instead, we relied on self-reporting through the focus group interviews and our interpretations of the videos, which strongly indicated a lack of sleep. It should be noted that hypothermia can affect the quality of sleep (Stepan et al. 2019). The impairment of memory caused by inadequate sleep is important to be aware of in

a survival and rescue situation, where serious mistakes in routine tasks can cost lives and health (Stepan et al. 2019).

We cannot claim that the results of the exercise reported here show that mild hypothermia or poor or little sleep in isolation affects cognitive functioning. The stressors taken together in this experiment show a decline in cognitive functioning. Testing the individual stressors separately in a simulated rescue exercise under Arctic conditions can be difficult to carry out. Weather is unpredictable. Moreover, GSKs and PSKs can vary in content and quality, even if they meet the minimum requirements of points 9.1 and 9.2 of the Polar Code (Lovdata 2017).

Emotional encouragement and positive thinking are important to increase the ability and motivation for survival. In the exercise reported here, boredom became a dominant feeling. An ethically conducted maritime rescue experiment cannot simulate conditions that would elicit feelings like anxiety, fear and horror, which can occur in a real emergency situation. This limits our ability to experimentally test the effects of rescue situations on feelings like boredom and irritation.

Care must therefore be taken when comparing the results of different rescue experiments.

It is important that human factors such as feeling cold, sleep deprivation, poor sleep, negative emotions, impaired cognition, and little prior experience in cold settings or in using survival equipment are given consideration in the context of preparing for emergencies in polar waters. The Svalbard SARex results highlight that other important factors—not investigated in our study—are the crew's competence and leadership (Løyning 2019). Strong leadership helps minimize the negative effects of human factors by promoting cooperation and organizing regular times for meals, sleep and rest, activities and movement. In the event of incidents in polar waters, good leadership will be enhanced by professional competence and training with real evacuation exercises in cold climates.

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## References

- Ashcraft M.H. & Klein R. 2010. *Cognition*. Toronto: Pearson Education Canada.

- Bast-Pettersen R. & Wastensson G. 2020. *Kjemiska ämnens påverkan på kognitiva funktioner i arbetslivet. (The influence of chemical substances on cognitive function in working life.) Kunnskapssammaställning 2020(2)*. Stockholm: Swedish Work Environment Authority.
- Blakemore C. & Jenett S. 2001. *The Oxford companion to the body*. Oxford: Oxford University Press.
- Blomhoff R., Andersen R., Arnesen E.K., Christensen J.J., Eneroth H., Erkkola M., Gudaviciene I., Halldorsson T.I., Høyer-Lund A., Lemming E.W., Meltzer H.M., Pitsi T., Schwab U., Siksnas I., Thorsdottir I. & Trolle E. 2023. *Nordic nutrition recommendations 2023*. Copenhagen: Nordic Council of Ministers.
- Brown V. & Clarke V. 2022. *Thematic analysis. A practical guide*. London: Sage.
- Chu B., Marwaha K., Sanvictores T., Awosika A.O. & Ayers D. 2024. *Physiology, stress reaction*. StatPearls. Accessed on the internet at <https://www.ncbi.nlm.nih.gov/books/NBK541120/> on 7 November 2025.
- Evju S.H. 2023. *Medisinsk rapport fra feltøvelsen SAMF/Beisfjord oktober 2022. (Medical report of the field exercise SAMF/Beisfjord October 2022.)* Unpublished report. Tromsø: UiT The Arctic University of Norway.
- Gudmestad O.T. & Solberg K.E. 2018. *SARex3. Evacuation to shore, survival and rescue. Report no. 75*. Stavanger: University of Stavanger.
- Halkier B. 2018. *Fokusgrupper. (Focus groups.)* Oslo: Gyldendal.
- Husjord L. & Meidell A. 2019. The nutrition project—a pilot study SARex Svalbard spring 2019. In T.B. Løyning (ed.): *Cruise and data report from the cruise with CGV Svalbard. May 20–26, 2019*. Pp. 60–69. Narvik: Maritimt Forum Nord.
- Husjord L. & Meidell A. (eds.) 2023. *Summery report of the field exercise. 7th–9th October 2022. SARex Arktisk Maritim Folkehelse (SAMF). SARex Arctic Maritime Public Health*. Tromsø: UiT The Arctic University of Norway.
- Hysing M., Lundervold A.J., Posserud M.B. & Sivertsen B. 2016. Association between sleep problems and symptoms of attention deficit hyperactivity disorder in adolescence: results from a large population-based study. *Behavioral Sleep Medicine* 14, 550–564, doi: 10.1080/15402002.2015.1048448.
- IMO (International Maritime Organization) 2016. *International code for ships operating in Polar waters (Polar Code). MEPC 68/21/Add. 1. Annex 10*. Accessed on the internet at <https://www.imo.org/en/mediacentre/hottopics/pages/polar-default.aspx> on 4 August 2025.
- Jones D.M., Bailey S.P., Roelands B., Buono M.J. & Meeusen R. 2017. Cold acclimation and cognitive performance: a review. *Autonomic Neuroscience* 208, 36–42, doi: 10.1016/j.autneu.2017.11.004.
- Justesen L. & Mik-Meyer N. 2010. *Kvalitative metoder i organisations- og ledelsesstudier. (Qualitative methods in organizational and management studies.)* Copenhagen: Hans Reitzels Forlag.
- Knardahl S., Medbø J.I., Strøm V. & Jebens E. 2010. *Utredning om virkninger av arbeid i kalde omgivelser. (Study of the effects of working on cold environments.) Stami-Rapport 11(8)*. Oslo: National Institute of Occupational Health.
- Kreuger R.A. 1994. *Focus groups. A practical guide for applied research*. 2nd edn. Thousand Oaks, CA: Sage Publications.
- Kvale S. & Brinkmann S. 2015. *Det kvalitative forskningsintervju. (The qualitative research interview.)* 3rd edn. Oslo: Gyldendal Akademisk.
- Lovdata 2017. *Forskrift om sikkerhetstiltak for skip som opererer i polare farvann. (Regulations for safety measures for ships operating in polar waters.) For-2016-11-23-1363*. Accessed on the internet at <https://lovdata.no/dokument/SF/forskrift/2016-11-23-1363> on 5 August 2025.
- Løyning T.B. (ed.) 2019. *Cruise and data report from the cruise with CGV Svalbard. May 20–May 26 2019. SARex Svalbard 2019–2020*. Narvik: Maritimt Forum Nord.
- Madriz E. 2000. Focus groups in feminist research. In I. Nkandincin & Y.S. Lincoln (eds.): *Handbook of qualitative research*. 2nd edn. Pp. 835–850. London: Sage Publications.
- Maritimt Forum Nord 2023. *Sluttrapport. Arktisk maritim kompetanseneode. (Final report. Arctic maritime competence node.)* Narvik: Maritimt Forum Nord.
- Ministry of Trade, Industry and Fisheries 2018–19. *Meld. St. 30. Melding til Stortinget. Samhandling for bedre sjøtryggleik. (Parliamentary white paper 30. Report to the Storting [2018–2019]. Cooperation for better safety at sea.)* Oslo: Ministry of Trade, Industry and Fisheries.
- Morgan D.L. 1997. *Focus groups as qualitative research*. 2nd edn. Thousand Oaks, CA: Sage Publications.
- Muller M.D., Gunstad J., Alosco M.L., Miller L.A., Updegraff J., Spitznagel M.B. & Glickman E.L. 2012. Acute cold exposure and cognitive function: evidence for sustained impairment. *Ergonomics* 55, 792–798, doi: 10.1080/00140139.2012.665497.
- Olmstead M.C. & Kuhlmeier V.A. 2015. *Comparative cognition*. Cambridge: Cambridge University Press.
- Pilcher J.J., Nadler E. & Busch C. 2002. Effects of hot and cold temperature exposure on performance: a meta-analytic review. *Ergonomics* 45, 682–698, doi: 10.1080/00140130210158419.
- Sivertsen B., Harvey A.G., Lundervold A.J. & Hysing M. 2014. Sleep problems and depression in adolescence: results from a large population-based study of Norwegian adolescents aged 16–18 years. *European Child & Adolescent Psychiatry* 23, 681–689, doi: 10.1007/s00787-013-0502-y.
- Sivertsen B., Harvey A.G., Pallesen S. & Hysing M. 2015. Mental health problems in adolescents with delayed sleep phase: results from a large population-based study in Norway. *Journal of Sleep Research* 24, 11–18, doi: 10.1111/jsr.12254.
- Solberg K.E., Gudmestad O.T. & Kvamme B.O. (eds.) 2016. *SARex Spitzbergen. April 2016. Search and rescue exercise conducted off north Spitzbergen. Exercise report*. Stavanger: University of Stavanger.
- Solberg K.E., Gudmestad O.T. & Skjærseth E.Å. 2017. *SARex2. Surviving a maritime incident in cold climate conditions*. Stavanger: University of Stavanger.
- Stepan M.E., Fenn K.M. & Altmann E.M. 2019. Effects of sleep deprivation on procedural errors. *Journal of Experimental Psychology: General* 148, 1828–1833, doi: 10.1037/xge0000495.

- Strobel C., Aga O., Bekkhus-Wetterberg P., Brierley M., Bystad M., Engedal K. & Johansen H. 2018. *Norsk revidert klokketest (KT-NR3)*. (Revised Norwegian clock test [KT-NR3].) Oslo: Norwegian National Centre for Ageing and Health.
- Strobel C. & Engedal K. 2021. *Norsk revidert mini mental status evaluering (MMSE-NR3)*. (Revised Norwegian mini-mental status evaluation [MMSE-NR3].) Oslo: Norwegian National Centre for Ageing and Health.
- Taylor L., Watkins S.L., Marshall H., Dascombe B.J. & Foster J. 2015. The impact of different environmental conditions on cognitive function: a focused review. *Frontiers in Physiology* 6, article no. 372, doi: 10.3389/fphys.2015.00372.
- Teien H.K. 2015. *Forekomsten av nedsatt blodsirkulasjon i ekstremiteter hos norske soldater ved kuldeeksponering—en litteraturstudie*. (The incidence of impaired blood circulation in the extremities in Norwegian soldiers during cold exposure—a literature study.) FFI-rapport 2015/01906. Kjeller: Norwegian Defence Research Establishment.
- Thagaard T. 2018. *Systematikk og innlevelse. En innføring i kvalitative metoder*. (Systematics and empathy. An introduction to qualitative methods.) Bergen: Fagbokforlaget.