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The Trade-off between Real-world and Simulation Scenario-based Training in the Dutch Navy

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Abstract

Dealing with stressful situations is an essential skill in military actions, since high levels of stress-arousal result in emotional, cognitive and/or physiological stress arousal and often impair performances. In the Navy, scenario-based training (SBT) is used to reduce the negative effects of stress. However, it remains challenging to adapt these trainingscenarios to real-life events. This study investigates the trade-off between real-world SBT and simulation SBT in Navy officer trainees by means of stress-related arousal, namely cognitive appraisal, heart rate and state anxiety, and influences of environmental factors on motion sickness, sleep quality, daily load, difficulty of the task and length of stressortime in both tasks. We expected both scenarios to induce stress-related arousal, but more stress-related arousal in the real-world SBT than in the simulation SBT. Results revealed that both SBTs evoked anxiety. Participants perceived both SBTs to cost the same amount of effort; however the weather and other shipping appear to be more impeding during the simulation SBT. Furthermore, findings indicate more motion-sickness and more/longer stressors in the real-world SBT. Although the scenarios differ significantly, results show equivalent heart rates and cognitive appraisals. These findings indicate that SBTs indeed can be seen as motivated-performance situations evoking stress-related arousal and there is a trade-off between the two SBTs arising from task complexity and environmental factors.

Keywords: psychophysiological stress, arousal, simulation scenario-based training, real-world scenario-based training, Royal Netherlands Navy, cognitive appraisal, state anxiety.

The Trade-off between Real-World and Simulation Scenario-Based Training in the Dutch Navy

Soldier Kovic becomes disoriented during battle. As he is blinded by dust and sunlight, a looming figure approaches. He pannicks and accidently shoots one of his fellow soldiers. Kovic is tortured by guilt for the rest of his live (Kovic, 2005). This plot describes Kovic's story. Unfortunately, many more soldiers have similar experiences. Military professionals still often enter high-risk situations in which information uncertainty, the risk of harm and time pressure could evoke severe stress (Binsch, Banko, Veenstra, & Valk, 2015; Driskell & Johnston, 1998). This could result in emotional, cognitive and/or physiological stress reactions (Delahaij, van Dam, Gaillard, & Soeters, 2011). Although the job of military professionals is to perform well in complex risk situations, high levels of arousal often impair their performances (Cohen, et al., 2015), which could result in fatal errors. For instance, on january the 12th 2008, two Dutch soldiers were killed due to human error in a stressful situation near Deh Rawod in Uruzgan (van Middelkoop, 2008). Certain incidents leave the survivors wounded and/or psychological traumatized (i.e. grief, guilt, anger, etc.) possibly leading to severe mental disorders such as Acute Stress Disorder or Post-Traumatic Stress Disorder (Friedman, 2011). Thus, dealing with stressful situations is an essential skill in military actions; not only to maintain optimal performance, but also to keep troops permanently deployed. To this aim the Ministry of Defence arranged that military trainees receive a great amount of stress training during their education (Binsch, Banko, Veenstra, & Valk, 2015). However, it remains challenging to adapt these training scenarios to real-life events. If currrent educational practices can induce a realistic amount of stress, these scenarios can be used in the future to better train stress coping skills, select recruits and prepare military trainees for upcoming events. The aim of the present study is to determine the trade-off between simulation and real-world stress training in the Navy. Based on existing literature, the psychological and physiological consequences of stress on an individual will be identified. Furthermore, we will distinguish the main differences between the two forms of training. Subsequent, the trainings can be compared by the evoked psychological and physiological stress-related arousal.

The Cognitive Appraisal Model

Military operations may be seen as *motivated-performance situations,* in which an individual must respond actively to accomplish a goal that is important to the individual in some way (Blascovich & Tomaka, 1996, p. 18; Seery, 2011). Every individual has a personalized stress response and coping mechanism to a stressor (Delahaij, van Dam, Gaillard, & Soeters, 2011; Blascovich & Tomaka, 1996). Presumably performance will not always get deteriorated due to the negative consequences of arousal. When a military trainee perceives the situation as challenging, this may improve his or her performance (Locke, Shaw, Saari, & Latham, 1981; Tomaka, Blascovich, Kelsey, & Leitten, 1993). Lazarus and Folkman (1984) described this process of evaluating a stressor in the *cognitive appraisal model*, also defined as "*the process of categorizing an encounter and its various facets, with respect to its significance for well-being*" (p. 31). In other words, during a cognitive appraisal the individual balances the demands of the situation and their own resources. These evaluations results in either a *challenge* or a *threat* appraisal (Tomaka, Blascovich, Kibler, & Ernst, 1997; Seery, 2011; Lazarus R. , 1991). When a situation is appraised as a challenge an individual sees the opportunity to overcome the stressor and thereby improve his or her performance. They believe to have sufficient resources to cope with the stressor. On the contrary, when an individual appraises a situation as a threat, they perceive it as if they are in great danger. They feel as if there are not enough resources to overcome the stressor, therefore, the outcome will most likely be unwanted (Blascovich & Mendes, 2000; Lazarus & Folkman, 1984). This appraisal leads to decisions and actions by the individual to overcome the stressor (Delahaij, 2009; Lazarus R. , 1991; Binsch, Banko, Veenstra, & Valk, 2015). When the stressor continues, the process starts over again. Besides the cognitive appraisal process, a stressor also influences affect (Blascovich & Tomaka, 1996). If a stressor is appraised as threat is will more likely result in negative psychological arousal.

Physiological stress responses

Previous research indicates that psychological stressors evoke physiological stress responses that can be measured (Blascovich & Tomaka, 1996; Dickerson & Kemeny, 2004; Delahaij, van Dam, Gaillard, & Soeters, 2011). A stressor causes a disruption to the homeostasis (i.e. the tendency of a system, especially the physiological system, to maintain internal stability). To achieve stability the body reacts with several changes via the allostatic system (Nagy & Fülöp, 2015). Within the allostatic system, the hypothalamic–pituitary–adrenal axis (HPA axis) and the sympathetic-adrenal-medullary system (SAM axis) are the most important (figure 1). Previous research associated HPA axis activity to threat appraisals and SAM activity with challenge appraisals (Blascovich & Mendes, 2000, p. 59; Dickerson & Kemeny, 2004). The two systems have overlapping functions that strengthen the stress response but differ in reaction time to the stressor. The SAM reacts within seconds and lasts only minutes, whereas the HPA axis responds after 10-20 minutes and can last for several hours (Nagy & Fülöp, 2015; Seery, 2011).

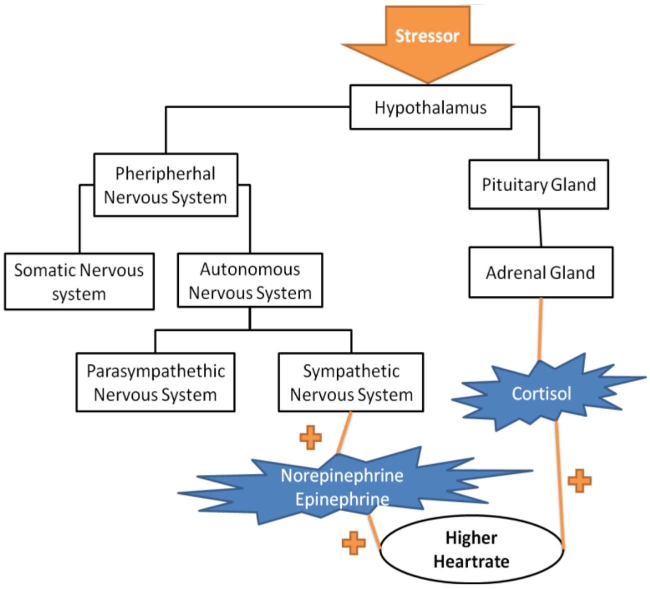

Figure 1. A schematic representation of SAM axis (left) and HPA axis (right) activation in stress.

The SAM axis is de endocrine component of the sympathetic nervous system (SNS). The SNS is one branch of the autonomous nervous system (ANS), whereas the parasympathetic nervous system (PNS) is the other branch (Blascovich & Tomaka, 1996). The SNS is often referred to as the ‘fight or flight’ system, while the PNS is referred to as the ‘feed and breed’ system. The ultimate level of activity in the organs is determined by the balance of the sympathetic, i.e. increasing activity, to parasympathetic, i.e. decreasing activity, outflow (Nagy & Fülöp, 2015). As a consequence, the effect of parasympathetic and sympathetic activity on the internal organs is asynchronous over the course of a stressor (Nagy & Fülöp, 2015). Besides nervous input, the SNS activity increases the level of circulating epinephrine and norepinephrine (see Nagy & Fülöp, 2015, or Dickerson & Kemeny, 2004, for a full review on endocrine activity during stress). This mechanism is known as the SAM-axis. During a challenge appraisal, heart rate and blood pressure increase rapidly in response to this sympathetic activation (Seery, 2011; Nagy & Fülöp, 2015). In this way, glucose and oxygen can be transported faster to the muscles and to the brain.

During a threat appraisal, the hypothalamus activates the HPA axis (Dickerson & Kemeny, 2004). Cortisol, the end product of the HPA axis, can cross the blood-brain barrier, therefore it also affects the central nervous system. While epinephrine increases heart rate, cortisol narrows the arteries forcing the heart to pump blood harder and faster (Dickerson & Kemeny, 2004). In sum, physiological activation in response to a stressor is primarily mediated by the SNS, but enhanced by the HPA axis. Furthermore, the hypothalamus is part of the limbic system, which facilitates cognitive processes such as attention and memory. When the HPA axis is active it causes disruption of cognitive processes possibly leading to deterioration of performance (Nagy & Fülöp, 2015; Dickerson & Kemeny, 2004). These negative consequences of stress are undesirable in military operations given the nature of the job and the significance of their performance.

Scenario-based Training in the Dutch Navy

Current educational practices aim at improvement of coping with stress and include technical advances or training environments which induce stress, such as *scenario-based training (SBT)* (Salas, Priest, Wilson, & Adler, 2006, p. 33; Cohen, et al., 2015). These mental representations help soldiers to prepare for upcoming missions (Salas, Priest, Wilson, & Adler, 2006). The goal of this training is to acquire complex skills by letting the trainees perform their job in realistic storylines, called *scenarios* (Driskell & Johnston, 2006). The scenario can be dynamically adapted by experienced professionals during the training. Based on their experience the professionals recognize when a trainee is bored, overwhelmed or lost. They control the storyline, manipulate the levels of support during the role-play and, thereby, increase the effectiveness of the training (Peeters, van den Bosch, Meyer, & Neerincx, 2014). This type of learning enables to teach front-end lessons on use of technical systems, while giving the trainee a realistic experience (Cesta, Cortellessa, & Benedictis, 2014).

This study investigates the scenario-based training sessions of Dutch Navy officer trainees. The trainees learn performing in stressfull situations using new material and with a lack of information. Normally, an officer of the watch is entrusted with safe navigation of the vessel and the safety of the crew during the watch. Doing so, the officer supervises a team on the bridge of the vessel (i.e. the operation room) including a navigator, a lookout and a helmsmen. According to the traditional three-watch system the company is devided into three groups and the day into six watches of four hours. Every individual fulfills two watches, i.e. one at day and one at night, seperated by eight hours for preparation, sleep and recreation. In this study the SBTs occured during these watches. Each SBT starts with a briefing from the Navy officer trainee to his team. Hereafter the task is executed. At the end of the scenario, there is a debriefing with the Navy officer trainee, the team and the instructor. The task is demanding, for example due to high workload or ambiquity, but the briefing and debriefing are more socially demaning. The other trainees depend strongly on this briefing and debriefing, poor performance of the officer trainee could result in negative judgement of the other trainees. Previous research demonstrated that social threat can evoke stress (Nagy & Fülöp, 2015; Berkman, Lieberman, & Gable, 2008; Dickerson & Kemeny, 2004).

In all SBTs this set-up is the same. There are however differences between SBTs arising from differences in tasks and differences in the type of SBT. For each scenario, the task and the level of difficulty are determined. Difficulty can be controlled by manipulating the levels of support or more stressors during the scenario (for instance; saving a drowning man, technical equipment failures etc.). Second, various types of SBT exist, but this study will only focus on SBT in a simulated environment (simulation SBT) and SBT in a real environment (real-world SBT).

Presence in Real-World and Simulation Scenario-Based Training

In *real-world SBT* the scenarios are re-enacted in real-life. The set-up of this type of SBT concerning learning objectives and guidance by the instructor is similar to simulation SBT. As a difference, the training takes place on a training vessel (i.e. in this study the '*Van Kinsbergen')*. The trainees reside for prolonged time on the vessel (i.e. in this study for 10 days), while they have to execute missions. The vessel also sailed at night. Consequently trainees have shorter, sometimes splitted, sleep and less recreational time than during the simulation SBT. Therefore, external factors, such as fatigue or motion sickness, have a more realistic and bigger influence on the trainees. This type of learning enables front-end lessons on the use of technical systems, while giving the trainee a realistic experience. The risks and dangers involved in the scenario are real, which can greatly influence one's perception of the situation (Cesta, Cortellessa, & Benedictis, 2014).

Real-world SBT proved to be an effective form of training, but also has disadvantages (Salas, Priest, Wilson, & Adler, 2006). Manipulations are restricted to technical aspects, as it is not possible to manipulate the weather in real life. Therefore, only parts of the task complexity can be controled. The situational environment on the trainingsvessel is quite essential for the training, but also makes it very expensive and time consuming. Given the instructors have to stay on the vessel for a prolonged time, they are not always available and their employment is expensive (Salas, Priest, Wilson, & Adler, 2006; Peeters, van den Bosch, Meyer, & Neerincx, 2014). Hence, there is a growing demand for a modification on real-world SBT with lesser man-power, but the same effectiveness.

Simulation SBT meets this demand, allowing a reduction in costs, since it requires less man-power, organization, time to rebuild the environment and planning (Peeters, van den Bosch, Meyer, & Neerincx, 2014). In simulation SBT a computer creates the task environment, in which environmental aspects (i.e. the weather) and technical aspects (i.e. system errors etc.) can be controled by the instructors (Peeters, van den Bosch, Meyer, & Neerincx, 2014). The simulation SBTs for the Dutch Navy officer trainees take place in a brigde handling simulator of the Royal Netherlands Navy in Den Helder. Generally, the traditional three watch system does not apply in simulation SBT, meaning the scenarios only occur during the daytime and the trainees sleep in their own beds instead of on a boat. Another advantage of this type of SBT is full control over environmental and technical aspects. Thereby, increasing influence on task complexity. Furthermore, the trainees experience stressful situations similar to those they might experience in real life without any actual threat (Cohen, et al., 2015; Cesta, Cortellessa, & Benedictis, 2014).

However, the exact effects of simulations are rather unclear. For instance, Wiederhold and Wiederhold (2005) suggest individuals already feel aroused when placed in simulated environments, without any stressors present. This is very inconvenient if true, since the adjustment to a simulated environment is not a goal of stress training in the Navy. However, other research did not replicate these findings (Busscher, de Vlieger, Ling, & Brinkman, 2011). Furthermore, Busscher et al. (2011) considered it difficult to design a completely neutral world in a simulated environment. Let alone the ambiguity that arises in a more complex simulated world, i.e. involving specific stressors. Being present in a simulated environment is a subjective experience that comes from a mental model of the self being located in that environment (Schubert, 2009). It has been suggested that an individuals' imaginative power influences their perceived presence in the simulation (Huang, Himle, & Alessi, 2000). More vivid visualization intensifies the experience in the simulation (Busscher, de Vlieger, Ling, & Brinkman, 2011). However, if the environment is vivid enough, individuals do not need their imagination to create a convincible simulated environment (Wallach, Safri, Marilyn, Samana, & Roy, 2010). The conflictions in current literature indicate that full understanding of simulated environments is not yet achieved and scientific research on the bridge handling simulator is rare, so questions on the convincibility of the bridge handling simulator remain.

In sum, motivated-performance situations can arouse an individuals' psychological and physiological state and the Royal Netherlands Navy teaches their trainees to cope with the negative aspects of arousal using SBT. However, it remains challenging to adapt a simulation to actual real-life events. Currently, fully understanding which qualities or aspects are lost and/or gained in SBT compared to real military operations has not yet been achieved. Presumably, it is hard to realize measurement of the generated arousal in actual military operations due to possible danger and/or hinder in their performances. But we can measure and compare the generated arousal in simulation and real-world SBT. Since the aim of these training sessions is to cope with stress, stress-related arousal in the trainees could be a good indicator for the trade-off between these situations.

Measuring Arousal in Scenario-Based Training

Previous research on cognitive appraisal in motivated-performance situations demonstrated better performance associated with challenge appraisals and worse performance in threat appraisals (Drach-Zahavy & Erez, 2002; Tomaka, Blascovich, Kibler, & Ernst, 1997). Since the present study focuses on negative psychological arousal in motivated-performance situations, assessing other negative emotions besides cognitive appraisal is interesting. A negative emotion that is linked to stress often is anxiety state (Bloomer & Kendall, 1994; Maes, et al., 1998). Cognitive appraisal and anxiety state can be observed with use of self-report questionnaires (Drach-Zahavy & Erez, 2002; van der Bij, et al., 2003). As an advantage these questionnaires indicate the polarity of the appraisal, i.e. more threat or more challenge, relatively easy. However, questionnaires can be quite subjective and context specific. The results can contain noise due to momentary perception biases and social desirable answers. Thereby, the questionnaires assess the arousal after the stressor rather than simultaneously with the stressor.

Arousal in motivated-performance situations can also be determined with physiological parameters related to the endocrine and nervous system. These measurements have the advantage to measure stress real-time and more objectively than self-report measurements, since they do not rely on individuals' reflection and conscious attention (Seery, 2011). Previous research provided a variety of physiological indicators differentiating threat and challenge appraisals, such as cardiac output, blood pressure, total peripheral resistance and ventricular contractility (Blascovich & Tomaka, 1996; Seery, 2011; Seery, 2013; Tomaka, Blascovich, Kelsey, & Leitten, 1993; Tomaka, Blascovich, Kibler, & Ernst, 1997; Wright & Kirby, 2003). The physiological differentiation of threat and challenge in both SBTs will be investigated in follow-up studies. The main focus of the present study is whether both SBTs actually generate physiological arousal and if this arousal differs between the two situations. For that reason we use heart rate as parameter, since it increases due to activity in the SAM (i.e. challenge) and/or HPA axis (i.e. threat) (Blascovich & Tomaka, 1996; Blascovich & Mendes, 2000). Thus, apart from the polarity of the appraisal, heart rate will increase during the SBTs if they are perceived as stressful motivated-performance situation.

If SBTs can induce a realistic amount of arousal, these scenarios can be used in the future to better train stress coping skills, select recruits and prepare military trainees for upcoming events. The aim of this study is to investigate the psychological and physiological arousal levels that are reached by Navy officer trainees during simulated SBT and real-world SBT and to what extent these can be compared with each other. Therefore, we state the following research question;

To what extend is stress generated within simulation scenario-based training and how does this relate to the stress generated in similar real-world scenarios in the Dutch Navy?

Design and expectations

To answer our research question we will test Navy officer trainees in simulation and real-world SBTs. Since the Navy aims at reducing the negative consequences of stress with the use of

SBTs, we expect stress-related arousal during and after the scenarios. We will compare the outcomes in order to conclude how much arousal each SBT evokes, how convincible both SBTs are and whether the simulations are comparable to the real-world SBTs. Applying the previously mentioned theories to our research question, we hypothesise that; (a) influences of the environmental factors will be greater in the real-world SBT compared to simulation SBT, i.e. more motion sickness, poor sleep quality, more sleepiness, perceived daily load, general appraisal of the scenario, and stressortime (b) during both SBTs there will be physiological arousal, i.e. higher heart rate, compared to baseline, (c) both SBTs will induce negative psychological arousal, i.e. higher scores of state anxiety after the scenario compare to baseline, and (d) the real-world SBT will induce more arousal than simulation SBT, reflected by higher heart rates, higher state anxiety scores, and higher threat scores. To test our expectations we measured heart rate continuously during baseline and the scenarios, state anxiety before and after the scenarios and cognitive appraisal after the scenarios of a group Navy officer trainees in simulation and real-world SBT.

Method

Participants

This study was conducted in close collaboration with the Royal Netherlands Navy (RNN). Participants were recruited via the RNN and participated voluntarily. The sample consisted of 7 Dutch Navy officer trainees of the RNN (*all male, age;* $\mu = 21.86$*, SD=1.68, years of enrollment;* $\mu=1.57$*, SD= .54*). Navy officer trainees were used since they often work in high-risk domains and frequently encounter uncertain, complex and risky situations that may not affect them during their task performance. The participants are in training to become an officer of the watch, therefore the present study analysed only data of the trainee in officer function (i.e. not look out, helmsmen or navigator). One participant completed a higher education at a University before engaging in this education. The participants had to perform both types of SBT.

Measures

Heart Rate.

We measured physiological arousal with the use of *Shimmers*. This wearable equipment is capable of collecting data of different bio-physiological measures. Each participant wore shimmers to collect ECG data with a sampling rate of 256 Hz. Five disposable Kendall ECG HS135 SG 43x35mm electrodes were placed on the torso of the participant (figure 2). With an elastic strap, the Shimmer was attached to the participants' torso. The Shimmer records the pathway of electrical impulses through the heart muscle. The signals collected by the electrodes were sent to the Shimmer via leads. At the end of the day, the data was imported to a laptop with Consensys, a Multi-Sensor Management System. Consensys creates an Excel file displaying the recorded values in each lead per time unit with an accuracy of 2 milliseconds.

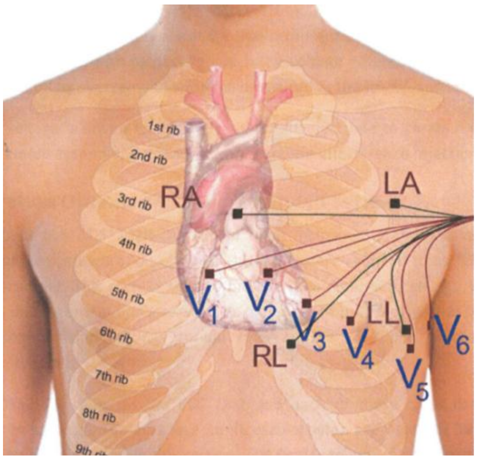

Figure 2. Placement of the ECG electrodes; RA, LA, RL, LL and V_5

Questionnaires.

State Anxiety.

We added a state anxiety questionnaire before and after the scenario to check whether negative psychological arousal was evoked (appendix A). The short form of the Spielberger State-Trait Anxiety Inventory (STAI) contains 6-items assessing the situation specific component of anxiety; state instead of trait (Marteau & Bekker, 1992). The items contained questions about anxiety-related feelings, such as '*I am worried*' or '*I am enthusiastic*'. Participants were asked to rate to what extent these statements were applicable to them on a 7-point Likert scale, 1 standing for '*not at all*' and 7 for *'very much'*. We used the Dutch version of STAI, translated and validated by Van der Bij, de Weerd, Cikot, Steegers and Braspenning (2003) *(α = .83)* and recoded items 2, 4 and 6 for the analyses. In the present study, the Cronbach's alpha coefficient was .781 with an inter-item correlation of .399 ranging from .115 to .725. For such short scales, these scores are large enough (Pallant, 2010, p. 97).

Threat and Challenge Appraisal.

We used a perceived threat and challenge questionnaire validated by Drach-Zahavy and Erez (2002)(appendix B). The appraisal was measured with questions describing participants' perceptions of the consequences of the situation for them (i.e. primary appraisal) and participants' perception of controllability and their overall success (i.e. secondary appraisal). Primary appraisal contained 8 items, of which 4 items focus on perceived challenge, such as '*this task seems like a challenge for me'* and 4 items on perceived threat, such as '*the task seems like a threat to me'*. The secondary appraisal was measured by four items, such as '*I am worried that I lack the abilities to perform the task successfully'.* The Cronbach's alpha coefficient of the challenge scale is .440. We could increase Cronbach's alpha to .654 by removing item 1 '*this task was a challenge for me'*. However, this scale is quite short (i.e. 6 items); therefore it is likely to find a lower Cronbach's alpha coefficient (Pallant, 2010). The inter-item correlation of the scale without item 1 had a mean of .291 ranging from -.088 to .683. Threat was measured by 6 items, such as '*the task seems like a threat to me'*. In the present study, the Cronbach's alpha coefficient was .690. Participants were asked to rate the items on a 7-point Likert scale ranging from 1= '*strongly disagree'* to 7 = '*strongly agree'.* For assessing challenge and threat appraisal, we averaged responses to the first and second appraisal items for challenge and threat.

Control Variables and Environmental Factors.

A survey with a demographics section was created to receive background information about our participants. It contained several questions concerning age, educational background, experience, motivation and perceived success rate (appendix C). Furthermore, a pre-survey, concerning sleep quality, sleepiness, daily load and motion sickness, was assessed before each scenario (appendix D). To receive information about sleeping behaviour, quality, and current sleepiness three questionnaires were used. The first is a Subjective Sleep Record (SSR) which contains eight questions about sleeping behavior during the previous night such as '*how long did it take before you fell asleep?'* (appendix

D1). Secondly, the Groninger Sleep Quality Scale (GSQS) contained 14 statements about the quality of sleep, such as '*I felt tired after getting up the next morning' (α= .90)* (Jafarion, Garouhi, Taghva, & Lofti, 2008)(appendix D2). Participants were asked to tick the boxes of the statements they could identify themselves with. The total number of ticked boxes was calculated and higher scores indicated poorer sleep quality. Third, the Stanford Sleepiness Scale (SSS) was used to assess sleepiness and alertness at the start of each experiment *(α= .90)* (Hoddes, Zarcone, Smythe, Philips, & Dement, 1973) (appendix D3). This rating scale consists of 7 states between '*wide awake'* and '*fighting sleep*'. Participants had to choose one state which corresponded with a score ranging from 1-7; higher scores indicate higher levels of sleepiness and lower levels of alertness. Furthermore, a daily load questionnaire indicated the perceived load of the day with questions as '*I am excited to begin today'* *(*appendix D4). The total score on the daily load monitor is calculated by adding the scores for each question. Because our experiments took place in a setting with a (simulated) sea and motion sickness can have major consequences on persons' well-being questions, the Misery Scale (MISC) was added to the survey (appendix D5). This validated scale concerns an 11-point ordinal scale rating motion sickness severity (0 = '*not at all'* and 10 = '*vomiting*') and exploits the fact that nausea is usually preceded by other symptoms such as a headache, stomach awareness and dizziness (Wertheim, Ooms, De Regt, & Wientjes, 1992).

Although the tasks during both scenarios are similar, there are many unpredictable stressors influencing one's perception of the scenario. For example, the instructor and the team members behave differently or there are more problems with the technical equipment etc. Therefore, a survey concerning an individuals' general appraisal of the scenario and a stressor file was developed. In the survey a few questions concerning the scenario in general were asked (appendix D6). To measure perceived effort during the task, we developed 5 items, such as '*how nervous were you during the past scenario?'* Instead of using a Likert scale participants had to answer these questions by drawing a vertical dash on a horizontal line of 10 centimeters. We did this to prohibit that the participant could tick the same rating after each scenario. This was followed by an open-ended question concerning the most stressful event of the past scenario. The total score on perceived effort was calculated by adding item 1,2,4,5 minus item 3 (= '*how successful were you during the task'*) Afterwards participant had to indicate which external factors (*the weather, the equipment, the instructor, the crewmembers, the other ships, and their own preparation)* impeded their performances on a 10-point Likert-scale. The impeding factors were analyzed per item.

Furthermore, the experimenters noted the stressors in a stressor file (appendix E). The possible stressors were divided into social stress (i.e. '*instructor asks difficult question'),* workload (i.e. '*lots of information at once')*, ambiguity (i.e. '*inefficient communication')* and powerlessness (i.e. *'unexpected difficulty with the technical systems')*. Doing so, the file indicates the length of stressor time during the scenario, allowing to calculate a stressor percentage (i.e. stressor time divided by scenario time). Additionally, external factors such as wind, weather and quantity of other shipping were noted. This information makes it possible to test whether the different scenarios are similar enough.

Procedure

The explanation of the study took place on January 6, 2016, in Den Helder. In a plenary session, the objectives of the research program were explained to the Navy officer trainees and other parties involved at the RNN. They received information about the aspects of human subject research, such as their right to end the experiment at any time without reason. Because the measurements were carried out during training sessions, it was discussed how the trainees had to handle the extra load. The directive was to ignore the researchers and their presence as much as possible. Data was collected through experiments during two training scenarios; a real-world scenario on the Navy training vessel '*Van Kinsbergen'* and the bridge handling simulator at the RNN in Den Helder. Both SBTs occurred during the daytime, in week 13 (= real-world) and 14 (= simulation), 2016.

Before the experiment information about when and how the measurements took place was given. Hereafter, the participants signed the informed consent, filled in the first questionnaire with demographic questionnaires. On the day of the experiment, the participant arrived 30 minutes before the scenario started. After undressing their torso, we placed the heart measure equipment. The participants completed the pre-survey. Before the scenario, a baseline measurement of six minutes took place during which the participant had their eyes closed and their ears covered to obstruct distracting stimuli. Before the scenario, the officer trainee briefed his team. During the scenario, the experimenter marked the possible stressors in the stressor file. After the scenario, the participant filled in a questionnaire concerning the general appraisal, anxiety state and perceived threat and challenge. Hereafter, the participant started debriefing his team and instructor followed by feedback from them. Eventually, we removed the measuring equipment.

Tasks and Materials

Two bridge handling simulators and the training vessel *Van Kinsbergen* from the RNN were used for the SBTs. The scenarios lasted between 30 and 60 minutes. In each scenario the Navy officer trainees received support from fellow students in the roles of lookout, helmsmen and navigator. This study focuses on the stress responses and performance of the Officer Navy officer trainee. In both scenarios the task was navigating the vessel in narrow water, in foggy weather with use of the radar. The Navy officer trainee had to communicate with his team and other vessels in the water. During the scenario, one or two instructors were present to manipulate the scenario, keep the trainees focused, answer their questions, ensure the safety of the vessel and eventually assess the performances of the Navy officer trainee. Performance of the Navy officer trainees in the scenarios was graded by the instructors and counted for their education. Hence, the trainings sessions can be seen as a motivated-performance situation.

For the simulation SBT, the bridge handling simulators represented two frigates; *Hr. Ms. Tromp* and *Hr. Ms. Van Amstel* (figure 2a). The simulators had realistic features. For example, the horizon was moving along with the swell of the vessel. The environmental factors (i.e. the weather, other shipping etc.), technical aspects (i.e. the electronic equipment on the bridge) and course of the assignment were regulated by the instructors. Both frigates completed the scenario in the same virtual environment. Doing so, they could to communicate with each other and other virtual shipping. For the real-world SBT the Navy officer trainees stayed 10 days on the Navy Trainings Vessel '*Van Kinsbergen'* (figure 2b). The participants completed several scenarios on board while the vessel navigated from Kiel, Germany, to Copenhagen, Denmark. This study focuses on the scenario which was most comparable to the scenarios in the simulation SBT (i.e. narrow water, foggy weather, use of electronic equipment, and focus on communication). To simulate foggy weather, the windows in the bridge of the ship were covered with white curtains (figure 2b).

Figure 1. (a) An overview of the bridge in the Navy ship handling simulator *'Hr. Mr. Van Amstel'* frigate and (b) the operating bridge in the *'van Kinsbergen'* during training with covered windows.

Analysis

Data Reduction.

The pre-processing of the raw heart rate data was performed off-line using the software package MATLAB 2015b with a signal processing toolbox (The MathWorks, 2015). We imported the stressor file and the raw ECG data from the Excel file created by Consensys to MATLAB. The R-peaks of the QRS complex (figure 4) were identified with the Pan Tompkins ECG detection algorithm (Pan & Tompkins, 1985). Hereafter the R-R intervals in seconds and heart rate in BPM were calculated. Unrealistic extreme values were eliminated by setting a cut-off point of 140 Hz. Based on previous research by Kamath and Fallen (1992) the data points were replaced if the R-R interval between the R-peaks were less than or equal to 80%. The heart rate signals of one participant in the simulation SBT was very noisy and therefore excluded from the analyses of the physiological data.

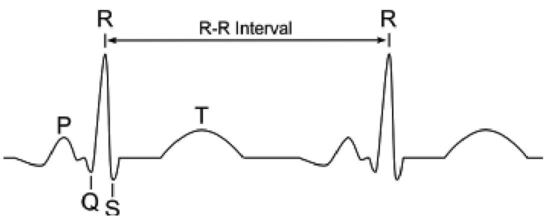

Figure 2 Schematic representation of a normal electrocardiogram with a QRS complex and R-R interval.

The scenario times retrieved from the stressor file served as an indicator of four experiment phases: (1) baseline, (2) briefing before the scenario, (3) stressor onset and (4) debriefing after the scenario. Per participant, the mean heart rate per experiment phase was calculated. Furthermore, to check whether each participant in each SBT had been subjected to the same duration of stress, the percentage of time in the experiment with stressor onset was also calculated, i.e. stressor time divided by scenario time. The values were imported to a CSV file.

Statistical Analysis.

The statistical analysis was conducted using SPSS software version 22.0 (IBM Corp., 2013). The study has a within-subject repeated measures design to test whether different types of scenario-based training result in different physiological and/or psychological parameters in maritime trainees. Outcome variables were heart rate, state anxiety, cognitive appraisal, sleep quality, sleepiness, motion sickness, daily load, general appraisal of the scenario and stressor percentage. First, the environmental factors (i.e. sleep quality, sleepiness and motion sickness), general appraisals of the scenario and differences in stressor percentage between the two SBTs were compared using paired-sample t-tests.

The main analyses were conducted with several repeated measures analysis of variance: The first was conducted for state anxiety scores with experiment phase (i.e. before scenario and after scenario) as the independent variable. Multiple paired sample t-test were performed to investigate the effect of SBT on the cognitive appraisal. The dependent variables were the total score of threat and a total score of challenge. The independent variable was the type of SBT; (1) real-world or (2) simulation. To analyse the physiological arousal (i.e.) in each experiment phase for both scenarios, a repeated measures analysis of variance with two independent variables is conducted. (Field, 2009, p. 482). In the real-world SBT, the officer trainees did not brief their team. Therefore, the heart rate during the briefing was excluded from the analysis when we compared the simulation and real-world SBTs[1]. The independent variables are the type of SBT; (1) real-world SBT and (2) simulation SBT, and experimental phase; (1) during baseline, (2) during a stressor and (3) during debriefing.

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[1] The heart rate data during briefing in the simulation SBT was analysed and compared with the other experiment phases, i.e. baseline and stressor. Results indicated no significant difference between baseline, briefing, stressor and debriefing.

Results

Analyses focus on the stress-related arousal and influences of environmental factors on 7 Navy officer trainees completing the same task in a real-world and simulation SBT. The mean values and standard deviations for the sample of 7 participants are depicted in table 1.

Table 1.

Descriptive Statistics of the Outcome Variables in simulation SBT and real-world SBT.

	Real-World		Simulation	
Variables	M	SD	M	SD
1. Heart Rate				
Baseline	85.589	19.845	76.182	12.119
Stress	86.815	15.762	79.539	13.420
Debriefing	82.609	12.384	79.276	11.730
2. Cognitive Appraisal				
Challenge	10.107	1.098	9.321	1.106
Threat	5.179	1.441	6.000	1.683
3.State Anxiety				
Before	17.29	3.638	18.00	4.320
After	22.71	1.976	22.29	2.138
4. Environmental Factors				
DLM	26.429	3.505	26.571	3.309
GAS (effort)	12.229	2.421	11.529	2.338
GSQS	3.857	1.464	2.429	2.225
SSS	3.143	0.690	3.143	1.069
MISC	1.286	1.380	0.571	0.787
Stress percentage	84.23	8.748	73.47	11.220

Note. N= 7, * $p < .05$, ** $p < .01$, *** $p < .001$

DLM = Daily Load Monitor, GAS = General Appraisal of the Scenario: Perceived Effort, GSQS = Groninger Sleep Quality Scale, SSS = Stanford Sleepiness Scale, MISC = Misery Scale

Environmental factors.

Four paired samples t-tests were performed to the environmental factors (i.e. sleep quality, sleepiness, motion sickness, and daily load) in both SBTs with alpha set at 5% level (Field, 2009, p. 316). We tested the hypothesis that the scores were similar for both scenarios. Most environmental factors were statistically similar in both scenarios (table 2). However, there was a statistically significant difference in motion sickness comparing the real-world SBT (*M* = 1.286, *SD* = 1.380) with the simulation SBT (*M* = 0.571, *SD* = 0.787), *t* (6) = 2.500, *p* = .047, *d* = 0.945, which indicates that participants experienced more motion sickness in the real-world SBT than in the simulation SBT.

Table 2.

Comparing the Control Variables in Real-World SBT versus Simulation SBT.

	Real-World SBT		Simulation SBT				
	M	SD	M	SD	t	*p*	Cohen's d
DLM	26.429	3.505	26.571	3.309	-0.108	0.917	-0.041
GSQS	3.857	1.464	2.429	2.225	1.901	0.106	0.719
SSS	3.143	0.690	3.143	1.069	0.000	1.000	0.000
MISC	1.286	1.380	0.571	0.787	2.500	0.047*	0.945

* p < .05, Higher scores on the daily load monitor (DLM) indicated lower perceived daily load. GSQS = Groninger Sleep Quality Scale, SSS = Stanford Sleepiness Scale, MISC = Misery Scale

We analysed differences in general appraisal of the scenario with a paired samples t-test per item. Total scores on the perceived effort on the tasks in simulation SBT (*M* = 11.529, *SD* = 2.338) and real-world SBT (*M* = 12.229, *SD* = 2.421) indicated no differences *t* (6) = .255, *p* = .807. For the impeding factors, the test for normality, examining the Shapiro-Wilks test, indicated that the item '*did the technical equipment impede the execution of your task in the past scenario?'* was not statistically normal (*SW* = .715, *p* = .005). There was a statistically significant increase in the item *'To what extent did the weather impede the execution of your task in the past scenario?'* comparing the real-world SBT (*M* = 1.857, *SD* = 1.380) with the simulation SBT (*M* = 4.571, *SD* = 1.718), *t* (6) = -2.955, *p* = .025, *d* = -0.024. There was also a significant difference in the item *'To what extent did other shipping impede the execution of your task in the past scenario?'*) comparing the real-world SBT (*M* = 2.571, *SD* = 1.397) with the simulation SBT (*M* = 4.286, *SD* = 1.113), *t* (6) = -2.661, *p* = .037, *d* = 0.057. Participants perceived both scenarios to cost the same amount of effort, however, the weather and other shipping appear to be more impeding during the simulation SBT compared to the real-world SBT.

The stressor file was used to indicate whether the presence of stressor in time was similar in both scenarios. Paired-samples t-test showed a statistically significant difference between the stress percentage in real-world SBT (*M* = 84.23, *SD* = 8.748) and simulation SBT (*M* = 73.47, *SD* = 11.220), *t* (5) = 2.948, *p* = .032, *d* = 1.204. The mean decreases in scores were 12.53 with a 95% confidence interval ranging from 1.606 to 23.46. This indicates that there were more or longer stressors during the real-world SBT compared to the simulation SBT.

Main analyses

State Anxiety.

A repeated measures analysis of variance was conducted for state anxiety scores with experiment phase (i.e. before scenario and after scenario) as the independent variable. There was a significant main effect of experiment phase, Wilks' Lamba = .367, *F* (2, 6) = 10.337, *p* = .018, multivariate partial eta squared = .633, indicating that both scenarios evoked negative psychological arousal in the form of anxiety.

Threat and Challenge Appraisal.

Multiple paired sample t-test were performed to investigate the effect of SBT on the cognitive appraisal. The dependent variables were the total score of threat and a total score of a challenge. The independent variable was the type of SBT; (1) real-world or (2) simulation. Preliminary assumption testing was conducted to check for normality, linearity, and outliers. Threat scores deviated from normality (W = .799, p = 0.040). Although the descriptive statistics indicate that challenge scores were higher in real-world SBT and threat scores were higher in simulation SBT, the difference was not significantly different (table 4). In the simulation SBT the challenge and threat scores did not differ significantly (*t* (6) = 2.070, *p* = .084). However, the challenge scores were significantly higher than threat scores in the real-world SBT (*t* (6) = 5.292, *p* = .002).

Table 4.

Comparing Cognitive Appraisal in Real-World SBT and Simulation SBT.

	Real-world SBT		Simulation SBT			
	M	SD	M	SD	t	*p*
Challenge	10.107	1.098	9.321	1.106	1.061	0.330
Threat	5.179	1.441	6.000	1.683	-1.037	0.340

Heart rate.

For physiological arousal (i.e. HR), we used a repeated measures analysis of variance with two independent variables to the differences in heart rate arousal on different experiment phases in both scenarios (Field, 2009, p. 482). The independent variables are type of SBT (1) real-world SBT and (2) simulation SBT, and experimental phase; (1) during baseline, (2) during a stressor and (3) during debriefing. Missing data was excluded pairwise. The assumption of normality was tested by examination of the unstandardized residuals. Results for the Kolmogorov-Smirnov test for normality indicated that only the values of the heart rate during baseline in the real-world SBT deviated from normality (KS = .346, p = .011). There were no significant effects for experiment time, (Wilks' Lamba = .691, F (1, 4) = .896, p = .477), type of SBT (Wilks' Lamba = .729, F (1, 4) = 1.860, p = .231) or an interaction between type and experiment phase (Wilks' Lamba = .620, F (2, 4) = 1.227, p = .384).

These findings indicate no significant results concerning heart rate in this study. However, previous studies stated that every individual has a personalized stress response (Delahaij, van Dam, Gaillard, & Soeters, 2011; Blascovich & Tomaka, 1996). To study the individual responses, a visual respresentation of the heart rate during the three experiment phases in each participant during both scenarios is given in figure 6a and 6b. The figures show distinct patterns for each participant in each scenario. Since the scenarios were the same for everyone, this could indicate that there possibly is a personalized physiological stress response.

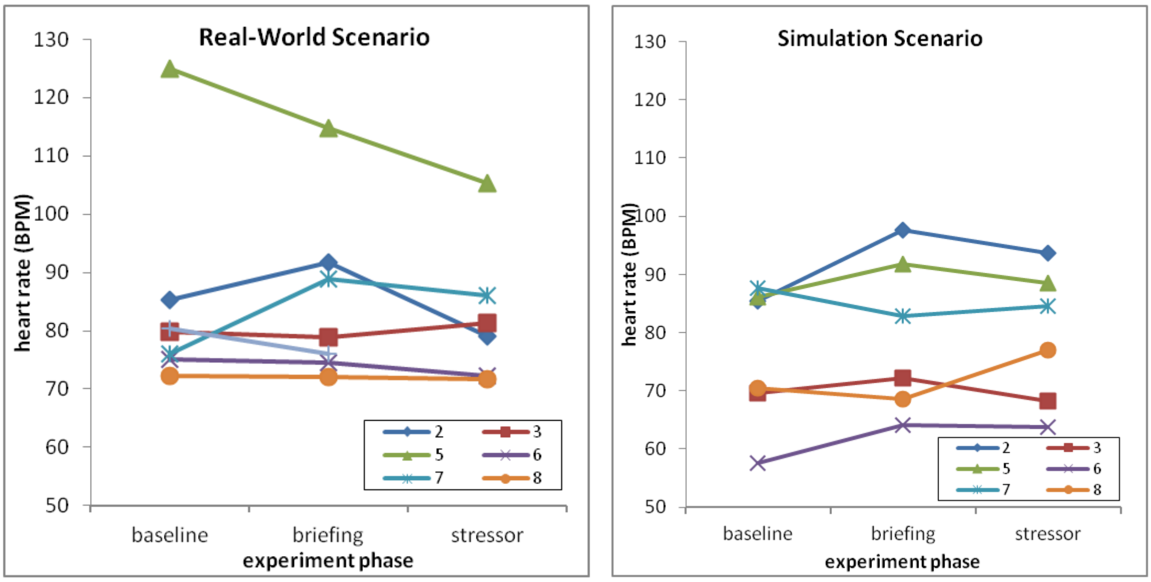

Figure 3. Heart rate (in BPM) per participant during baseline, stress and debriefing in (a) real-world and (b) simulation SBT.

Discussion

The present study examined the difference between simulation scenario-based training and real-world scenario-based training by comparing generated stress-related arousal and environmental influences in Navy officer trainees. Based upon existing theories, we proposed that arousal is generated in both SBTs. We predicted more influences of environmental factors in the real-world SBT. And it was expected that real-world SBT would generate more arousal than the simulation SBT reflected by higher heart rate, higher scores on the state anxiety inventory and higher threat scores during cognitive appraisal.

The findings indicated that participants experienced more motion sickness in the real-world SBT than in the simulation SBT. On the contrary, the participants perceived their performance to be more impeded by the weather and other shipping in the simulation SBT than in the real-world SBT. This indicates there may be differences in environmental factors between both SBTs. The findings confirmed that both SBTs triggered negative psychological arousal by means of higher state anxiety compared to the baseline, but no difference in state anxiety between the SBTs. Results of cognitive appraisal, showed significant higher challenge than threat scores in the real-world scenario and almost significantly higher challenge than threat scores in the simulation. Furthermore, the values of threat scores in simulation SBT were higher than the values on the threat scores in real-world SBT. Exactly the opposite was true for the challenge scores. Although this was unexpected it could indicate that the type of SBTs indeed triggers different cognitive appraisals.

Furthermore, the findings indicated no effect of experiment phase or type of SBT on the mean heart rate values. We expected to find significant higher heart rates during stressor and debriefing compared to baseline in both SBTs, associated with SAM and/or HPA axis activity. Although the increases and decreases in the present study are relatively small, the visual representation of the mean heart rate shows distinct patterns for each participant comparing the experiment phases, but also comparing the two types of SBT. This may indicate that individuals indeed have a personalized stress response, as stated in previous research (Cohn, Weltman, Ratwani, Chartrand, & McCraty, 2010), and that stress-arousal research could use a more specific, interactive and personalized approach. Furthermore, the number of participants in this study the sample was too small to make solid statements about our variables, but it is also notable that these effects already occurs within a sample size of N = 7.

Extending Findings and Alternative Explanations

The unexpected findings concerning cognitive appraisal may be explained by the non-similarity between the scenarios influencing demands and resources. We found higher challenge than threat appraisals in both scenarios. We assumed the environmental factors of the real-world SBT to be more demanding and, thereby, have a larger effect on cognitive appraisal, since threat and challenge appraisals are strongly influenced by the perception of a situation (Blascovich J. , Mendes, Hunter, Lickel, & Kowai-Bell, 2001; Cesta, Cortellessa, & Benedictis, 2014). As expected our findings indicated that motion sickness was stronger present in the real-world SBT, demonstrating an extra load during that scenario. Given the resources of the trainees remained largely the same in the short time between the two scenarios (i.e. one week), this was more likely to result in a threat appraisal. However, the findings indicated higher challenge appraisals. An explanation could be that for the trainees this was one of the first times that they could practice their skills in a real environment, and there occurred no severe causalities or accidents. The longer their performance on the vessel was high, the more confident they became with their own abilities and skills. This confidence enlarged their perceived resources, possibly resulting in a challenge appraisal.

Besides that, the threat appraisals being higher in the simulation SBT compared to the real-world SBT may be explained by the finding that the participants perceived their task execution to be more impeded by the weather and other shipping in the simulation SBT. These factors could increase task complexity. Task complexity is determined by dynamic complexity, component complexity and coordinating complexity. The first refers to the changes in information and the foresee ability of the changes. The second concerns the number of performance dimensions that must be performed simultaneously. The last concerns the sequence of activities to complete the task (Wood & Locke, 1990). It could be argued that dynamic complexity is largely influenced by shipping and the weather as their presence is unexpected and uncontrollable. On the contrary, the dominant environmental factor in the real-world SBT, motion sickness, was expected long before the scenario started, making lesser impact. This is in line with the article of Dickerson and Kemeny (2004), stating that uncontrollability of a stressor elicits the largest stress response measured in cortisol. Alongside the previous explanation, task complexity is closely linked with cognitive appraisal (Cohen, et al., 2015). As tasks become more complex the typical motivational effects of specific goals may become harmful as it is harder to set clear goals (Drach-Zahavy & Erez, 2002). Therefore, we could argue that the uncontrollability is more demanding than the authenticity in the scenarios, explaining the higher threat appraisals in simulation SBT.

Another explanation for the higher threat appraisals in simulation compared to real-world could be the amount of instructors present. In the simulation, there are always two instructors in each bridge handling simulator (two in Hr. Mr. Van Amstel and two in Hr. Ms. Tromp), plus two or three instructors in the ‘kitchen’, where the task is manipulated/controlled. This makes a total of six or seven instructors. On the Van Kinsbergen, there are also two instructors on the bridge. But, although there are at least six instructors on board, the other instructors are busy with other things (i.e. sleeping, eating, preparation etc.) and do not interact with the trainees. The presence of more instructors may induce more arousal since these are the people evaluating the trainees. Previous research demonstrated individuals have a goal to maintain their self-image, as group membership can be an essential key to survival (Nagy & Fülöp, 2015). A threat occurs when an aspect of the self-identity (i.e. their performance) is or could be negatively judged by others. It may reveal the lack of a certain ability or trait, which eventually could lead to a loss of social esteem, respect or social status (Dickerson & Kemeny, 2004). Since there are more instructors actively evaluating their performances in the simulation scenario, the trainees may perceive it as if negative evaluations are more likely.

Another explanation for the unexpected results in cognitive appraisal emerges from a language bias. The English perceived threat and challenge questionnaire by Drach-Zahavy and Erez (2002) was translated into Dutch by Van der Bij et al. (2003). Our results indicate that the reliability of the scale considerably increases when challenge-item '*this task was a challenge for me'* and threat-item *'I found this task long and boring'* were deleted. In English a challenge is defined as; '*a test of one's abilities or resources in a demanding but stimulating undertaking'* (The American Heritage Dictionary, 2011). In contrast, the Dutch definition of a challenge is '*a task that is difficult to achieve'*. Therefore, the English definition may be perceived as more motivating than the Dutch definition. Furthermore, asking whether a task is '*long and boring*' may measure merely the reluctance towards the task than the threatening feeling of the individual. These subtle differences between the Dutch and English definition of a challenge could result in significant changes between English and Dutch participants in a larger sample and may have caused a bias in the present study.

The lack of significant results on heart rate data is probably caused by the small participant group. In addition, using solely heart rate as measurement for physiological stress-related arousal may have been insufficient. Previous studies have also investigated heart rate in motivated-performance situations but as an indicator for task engagement instead of cognitive appraisal (Seery, 2011; 2013; Blascovich J. , Mendes, Hunter, Lickel, & Kowai-Bell, 2001). Heart rate increases in a motivated-performance situation regardless of the appraisal (Seery, 2011; 2013; Blascovich J. , Mendes, Hunter, Lickel, & Kowai-Bell, 2001). We proposed that the scenarios can be seen as a motivated-performance situation and expected a significant difference between baseline and stressor, which we did not find. However, the baseline measurements occurred shortly before the scenarios, i.e. in the previous hour or at the beginning of that day. Although there were no acute stressors during the baseline, it is likely the participants were generally more aroused since they were living up to a motivated-performance situation. Meaning their heart rate could be higher than normal during the baseline explaining the lack of significant differences.

Limitations and Further Research

An obvious limitation of this research is the group of participants. With only 7 useful participants the power of the statistical tests was just sufficient or too low to really prove or reject our hypotheses. But we did find negative psychological arousal in both scenarios, significant differences in environmental factors and between threat and challenge. Thus, there is a possibility that with a larger participant group repetition of this experiment also shows significant findings in heart rate and cognitive appraisals.

Another limitation may be that our experiment was not precise enough in time accuracy. As stated, HPA axis and SAM axis activity are involved in a physiological stress response. Although SAM axis responds fast, the HPA axis is relatively slow (i.e. 20 minutes after stressor onset) (Nagy & Fülöp, 2015). Other studies demonstrated that physiological stress responses arise within seconds after stressor onset (van der Vijgh, Beun, Rood, & Werkhoven, 2014). In this study the physiological responses were averaged per experiment phase, causing an extreme reduction in accuracy. Furthermore, as in most experiments, cognitive appraisal is assessed after the stressor; however it is theorized that the appraisal process occurs during the stressor (Blascovich & Tomaka, 1996). Given the scenarios lasted approximately 30-60 minutes, there is a large interval between the first stressor and the questionnaire afterwards. During this interval, there could be other factors influencing the participants' evaluation of the event. Likewise, the present study also lacks accuracy in different types of stressor and their effects. Previous research indicates that different stressors can evoke different stress responses (Dickerson & Kemeny, 2004). Although our stressor file made a distinction between different stressors, this was not used in the analyses. For future research, it would be useful to indicate how long a stressor has to be present to elicit a stress response and how long that stress response stays present for different kinds of stressors. To bypass these limitations in future research, we suggest research with a more delicate approach, i.e.more time and stressor accuracy.

Besides a larger participant group and more accuracy, it would be interesting to physiologically differentiate between threat and challenge, instead of merely psychologically. Recent articles (Seery, 2011; 2013; Nagy & Fülöp, 2015) use more profound physiological stress measures such as blood pressure, cardiac output, total peripheral resistance and heart rate variability as indicators for threat and/or challenge appraisals. It would be interesting to analyses these measures and examine their relationship with cognitive appraisals and/or negative psychological arousal. Furthermore, if SBTs evoke arousal, combined with extended knowledge of physiological stress reactions it could be possible to develop a more personalized stress training approach, such as a biofeedback game. In a biofeedback game, an individual learns to manipulate their stress reactions, which makes them more able to manages their reactions and improve their performances (Varvogli & Darviri, 2011; Zhu, Zheng, & Xie, 2011). Alternatively, the psychophysiological measure of arousal could serve as an indicator of task difficulty, making it possible to adapt the training real-time and personalized. This indicates there are lots of possibilities to incorporate stress in military training programs using arousal as beneficial instead of pathological. However, future research towards a full understanding of the endocrine and nervous system processes during a stress reaction has to be done as discussions still occur. For instance, Wright and Kirby (2003), argue that the theories of Blascovich et al. (2000; 1996; 2001) do not explain why heart rate does not differ between challenge and threat.

Another suggestion for further research may concern the conscious act of cognitive appraisal in relation to the physiological stress responses. Previous research assesses cognitive appraisal based on the cognitive appraisal theory of Lazarus and Folkman by calculating the ratio between the primary appraisal (‘*How stressful do you expect the upcoming task to be?*’) versus the secondary appraisal (‘*How able are you to cope with this task?*’) (Tomaka, Blascovich, Kelsey, & Leitten, 1993; Drach-Zahavy & Erez, 2002). During the *primary appraisal* the individual interprets the stressor and evaluates the potential threat. In the *secondary appraisal* the individual evaluates their own resources to cope with the stressor (Tomaka, Blascovich, Kelsey, & Leitten, 1993; Seery, 2011; Tomaka, Blascovich, Kibler, & Ernst, 1997). Both appraisals are assessed by means of a Likert scale (a 7-point Likert scale in the Tomaka et al. 1993 article, and a 6-point Likert scale in the Tomaka et al. 1997 article). However, when answering these questions a conscious action is required. Doing so, unconscious activities may be ignored, although these may also influence the appraisal. To illustrate, Evans (2008) describes the differences between fast, unconscious system I processing and the slow conscious system II processing by means of the dual process theory. Thoughts, behaviors, and feelings result from the interplay between endogenous and exogenous forms of attention. Both types of attention can be applied to either increase or decrease the level of activation. Therefore, behavior is determined by the interplay of System I and II, respectively automatic and controlled processing (Feldman Barrett, Tugade, & Engle, 2004). Likewise, Gazzaniga, Ivry and Mangun (2009) stated conscious and unconscious perception via the primary and secondary visual cortex. Even Blascovich and Tomaka (1996) describe the interplay of internal and external attention. Considering the above, measuring the cognitive appraisal with solely conscious primary and secondary appraisal may be insufficient. Especially since the physiological reactions occur within seconds after the stressor and arise unconsciously, whereas interval between the stressor and the cognitive appraisal is much larger. This may explain imbalances between the physiological and psychological stress responses. Therefore, the development of a method to measure online cognitive appraisal consciously and unconsciously could be an interesting topic for further research.

It is likely that his study suffers from a content validity problem. It is questionable if the measures represented all the involved assets of the problem. For instance, Blascovich (1996) theorized that intra-/interpersonal factors also cause differences in the demand and resources evaluation of the cognitive appraisal. A brief literature study shows that there are a lot of possible intra-/interpersonal factors that could play a role (i.e. personality, desirability for control, self-esteem, perceived control, encouragement of evaluation and much more) and full understanding of their influence on cognitive appraisal is not yet achieved (Blascovich & Mendes, 2000). To illustrate, more recent research demonstrated that neuroticism influences cognitive appraisal and task performance (Schneider, Rench, Lyons, & Riffle, 2011; Schneider, 2004). This demonstrates that it is short-sighted to treat solely physiological and psychological reactions as indicators of stress. It could be that in a situation one person suffers from a lot of psychological stress, but no physiological reaction and good performance, whereas the other suffers from no psychological stress but performs bad. To truly make a statement about the amount of stress-related arousal elicited in a motivated-performance situation, we have to consider stress-related history of our subjects. Thus, besides personalizing the physiological measurement for stress responses, the psychological background and health history of an individual should be taken into account when conducting stress research.

Since the current educational practices aim at reducing negative effects of stress by evoking stressors in controlled settings, it would be useful to indicate someone's coping mechanism and how this influences performance and perception of the situation. Coping with the stressor can either be *problem-focused* or *emotion-focused coping;* the first is focused on changing the situation itself and the latter on changing the emotional experience of the situation. The coping strategy that is chosen may depend on the appraisal, but also on the emotional state of the individual, since emotion influences judgement (Lazarus R. , 1991). Both coping strategies eventually result in certain actions and decisions by the individual to make a constructive change in the status quo towards a better situation (Delahaij, 2009). When the stressor continues, the appraisal process starts over again. In other words, when the coping strategy is ineffective, the stress response lasts longer. Currently, there is no method for accurately measure coping styles. Assessing and evaluating coping styles would be interesting to include in the SBTs since they aim at the best performance. This could be the most effective coping mechanism.

With the result, the extended findings and the limitations taken in to consideration, there is still a question that remains; how do these findings relate to real-life event? To give a satisfactory answer to this question a comparison with an actual life event is required, after which the exact same scenario with the same people and the same resources are re-enacted in a simulation SBT. The possibility of this happening is extremely small. However, the present study takes the first steps in this equation between simulation and real-world. It demonstrates a trade-off between the two scenarios. For instance, more realistic and demanding environmental factors do not necessarily have a negative impact on someone's perception and/or performance. And more control on task complexity is not the solution to sufficient stress training either. However, many aspects in this comparison remained underexposed in the present study. For instance, trainees' imaginative power and their 'presence' in the scenario could be further researched. Thus, the present study is a good indication of the complexity of possible involved scientific disciplines and underpinning theories tangled in this problem.

Conclusion

The aim of this study was to compare real-world and simulation scenario-based training. The psychological and physiological arousal levels that are reached by Navy officer trainees during simulated SBT and real-world SBT were investigated. The findings of this study indicate that SBTs indeed can be seen as a motivated-performance situation evoking negative psychological arousal. Furthermore, parts of the trade-off between simulation SBT and real-world are identified; more perceived task complexity in simulation versus more and/or longer lasting stressors and motion sickness in real-world. This demonstrates that the induced stress in simulation SBT may not be realistic enough. This study encourages further investigation concerning the use of stress arousal in training. However, results of this study should be implemented with care, due to the small group of participants. In sum, psychophysiological stress research needs a more delicate approach.

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Appendices

Appendix A: State-Trait Anxiety Inventory (STAI).

We used the Dutch version of STAI, translated and validated by Van der Bij, de Weerd, Cikot, Steegers and Braspenning (2003) *(α = .83)*.

De volgende vragen gaan over het gevoel dat je hebt na de wacht/scenario.

		Helemaal oneens				Helemaal eens		
1	**Ik maak me zorgen**	1	2	3	4	5	6	7
2	**Ik voel me zelfverzekerd**	1	2	3	4	5	6	7
3	**Ik ben angstig**	1	2	3	4	5	6	7
4	**Ik ben optimistisch**	1	2	3	4	5	6	7
5	**Ik ben ongerust**	1	2	3	4	5	6	7
6	**Ik ben enthousiast**.	1	2	3	4	5	6	7

Appendix B: Perceived Threat and Challenge.

By Drach-Zahavy and Erez (2002).

De volgende vragen gaan over het gevoel dat je had tijdens de afgelopen wacht/scenario. Per vraag is er één optie mogelijk.

	Helemaal oneens				Helemaal eens		
Chal1: Deze taak was een uitdaging voor mij	1	2	3	4	5	6	7
Chal2: Deze taak gaf mij de mogelijkheid om mijn cognitieve vaardigheden (bijv. problemen oplossen, besluiten nemen) te laten zien	1	2	3	4	5	6	7
Thre 2: Ik ben bezorgd dat deze taak mogelijk mijn zwakke plek heeft bloot gelegd	1	2	3	4	5	6	7
Thre 3: Deze taak vond ik lang en saai	1	2	3	4	5	6	7
Chal 3: Deze taak gaf mij de mogelijkheid om drempels te overkomen.	1	2	3	4	5	6	7
Chal 6: Ik denk dat ik de capaciteiten had voor een succesvolle prestatie.	1	2	3	4	5	6	7
Thre 1: Deze taak was een dreiging voor mij	1	2	3	4	5	6	7
Chal 4: Deze taak gaf mij de mogelijkheid om mijn zelfvertrouwen te versterken	1	2	3	4	5	6	7
Thre 5: Over het algemeen denk ik dat ik niet succesvol was in deze taak	1	2	3	4	5	6	7
Thre 4: Ik ben bezorgd dat deze taak mogelijk mijn zelfvertrouwen heeft aangetast	1	2	3	4	5	6	7
Thre 6 Ik ben bezorgd dat ik de capaciteiten niet had om deze taak succesvol uit te voeren.	1	2	3	4	5	6	7
Chal 5: Over het algemeen denk ik dat ik succesvol was in de uitvoering van deze taak.	1	2	3	4	5	6	7

Appendix C: Demographics Questionnaire.

Wat is je leeftijd? ………….………….

Wat is de hoogst genoten opleiding die je hebt afgerond?

a. Middelbare school
b. HBO/WO bachelor
c. WO master
d. Anders, nl:…..

Hoelang is jouw opleidingstraject bij het KIM? ………….………….

In het hoeveelste jaar van je opleiding zit je nu? ………….………….

Heb je vertraging opgelopen in deze opleiding?

- Nee
- Ja, namelijk ………….………….………….………….………….………….………….……………..

Heb je hiervoor een andere opleiding gevolgd?

- Nee
- Ja, namelijk ………….………….………….………….………….………….………….…………….
  afgeronde studiejaren: ………….………….………….………….…………..………….………….……

Had je vaarervaring voor je aan deze opleiding begon?

- Nee
- Ja, namelijk ………….………….………….………….………….………….………….…………….

Waarom heb je gekozen voor deze opleiding?

………….………….………….………….………….………….………….………….………….……..……

………….………….………….………….………….…………..………….………….………….……….……

Wat is naar jouw idee de gemiddelde slagingskans van de studenten in deze opleiding?

a. 0 - 20%
b. 20 – 40%
c. 40 – 60%
d. 60 – 80%
e. 80 – 100%

Hoe hoog schat jij jouw eigen slagingskans in? ………….………….

Appendix D: Environmental Factors.

1. *Subjective Sleep Record (SSR)*

De volgende vragen gaan over je slaapgedrag van afgelopen nacht.

Hoe laat ben je naar bed gegaan? …………………………..

Hoe lang heeft het geduurd voor je in slaap viel? …………………………..

Hoe laat ben je wakker geworden? …………………………..

Hoe laat ben je opgestaan? …………………………..

Hoe lang heb je geslapen? …………………………..

Hoe vaak ben je wakker geworden? En wat was hiervoor de reden?

………….……….………….………….………….…………..……….………….………..………….

2. *Groningen Sleep Quality Scale (GSQS)*

By Jafarion, Garouhi, Taghva and Lofti (2008). Higher scores indicate poor sleep quality.

Ieder vakje dat van toepassing is mag je aankruisen; **meer dan een antwoord mogelijk**

- ☐ Geen oog dicht gedaan
- ☐ In slaapperiode vaak opgestaan
- ☐ Erg liggen woelen
- ☐ Vaak wakker geworden
- ☐ Heel slecht geslapen
- ☐ Maar een paar uur geslapen
- ☐ Minder dan 5 uur geslapen
- ☐ Goed geslapen
- ☐ Gemakkelijk ingeslapen
- ☐ Slaap te kort gekomen
- ☐ Langer dan een half uur wakker gelegen voor inslapen
- ☐ Wakker geworden, moeilijk weer ingeslapen
- ☐ Na opstaan moe gevoel
- ☐ Na opstaan goed uitgerust

3. Stanford Sleepiness Scale (SSS)

By Hoddes, Zarcone, Smythe, Philips and Dement (1973). Higher scores indicate more sleepiness.

Hoe voel je jezelf op dit moment? Kruis het item aan dat op dit moment het meest van toepassing is. **Er is maar één optie mogelijk.**

- ☐ Klaarwakker; zeer alert; optimale concentratie mogelijk
- ☐ Alert; goed in staat te concentreren
- ☐ Ontspannen; wakker; redelijk alert
- ☐ Minder alert; een beetje duf
- ☐ Duf; wakker blijven begint moeilijk te worden; aan het inzakken
- ☐ Slaperig; vechtend tegen de slaap; het liefst gaan slapen; versuft
- ☐ In slaap aan het vallen; gevecht tegen de slaap aan het verliezen

4. Daily Load Monitor.

Welk cijfer (1 t/m 7) geeft je de onderstaande stellingen?

		Helemaal oneens						**Helemaal eens**
1	Ik was tevreden over wat ik deed en hoe ik presteerde in de afgelopen 24 uur.	1	2	3	4	5	6	7
2	Ik heb vannacht goed geslapen.	1	2	3	4	5	6	7
3	Ik voel me op dit moment fysiek (lichamelijk) topfit.	1	2	3	4	5	6	7
4	Ik voel me op dit moment cognitief (kunnen leren, herinneren, denken, probleem oplossen) uitstekend.	1	2	3	4	5	6	7
5	Ik heb er zin in om vandaag te beginnen.	1	2	3	4	5	6	7
6	Ik verwacht dat ik vandaag goed zal presteren.	1	2	3	4	5	6	7

5. Misery Scale (MISC)

By Wertheim, Ooms, De Regt and Wientjes (1992).

In hoeverre heeft je op dit moment last van de volgende symptomen? Een score van 0 geeft aan dat je jezelf perfect voelt en bij 10 bent je aan het overgeven. Je scoort tussen de 6 en 9 wanneer je misselijk bent. Voelt u zich niet misselijk, maar ook niet fit dan scoor je tussen de 2 en 5.

Symptomen		***MISC***
Geen enkel probleem		0
Niet helemaal lekker (zonder herkenbaar symptoom)		1
Duizeligheid, warm, hoofdpijn, bewust van de maag, zweet, ..., maar geen misselijkheid	vaag	2
	beetje	3
	nogal	4
	ernstig	5
misselijkheid	beetje	6
	nogal	7
	ernstig	8
	(bijna) kokhalzen	9
Overgeven		10

6. General Appraisal of the Scenario

Onder staande stellingen gaan over de hele periode dat je een bepaalde functie tijdens de wacht/scenario vervulde. Plaats een verticale streep op de horizontale lijn op de plek die het meest overeenkomt met je mening.

Perceived effort

GAS1: Hoe moeilijk was de afgelopen wacht/scenario?

Helemaal niet **Heel erg**

GAS2: Hoe zenuwachtig was je tijdens de afgelopen wacht/scenario?

Helemaal niet **Heel erg**

GAS3:Hoe succesvol was je in het uitvoeren van deze wacht/scenario?

Helemaal niet **Heel erg**

GAS4: Hoeveel moest je je mentaal inspannen om deze prestatie te bereiken?

Helemaal niet **Heel erg**

GAS5: Hoe onzeker, ontmoedigd, geïrriteerd en/of gestrest was je tijdens de wacht/scenario?

Helemaal niet **Heel erg**

GAS6: Wat vond je het meest stressvolle van de afgelopen wacht/scenario en waarom? Beschrijf specifiek de gebeurtenis en welk effect dit op jouw had.

………

………

Impeding factors

In hoeverre bemoeilijkte onderstaande externe factoren het uitoefenen van je taken tijdens deze wacht?

		Helemaal niet						Heel erg
1	**GAS7: Het weer**	1	2	3	4	5	6	7
2	**GAS8: De apparatuur**	1	2	3	4	5	6	7
3	**GAS9: De instructeur**	1	2	3	4	5	6	7
4	**GAS10: Mijn medestudiegenoten**	1	2	3	4	5	6	7
5	**GAS11: De scheepvaart**	1	2	3	4	5	6	7
6	**GAS12: Mijn eigen voorbereiding**	1	2	3	4	5	6	7

Appendix E: Stressor file.

TNO'er:
Brugsimulator nummer:
Sessie nummer:
Starttijd sessie:
Eindtijd sessie:
Datum:

Proefpersoonnummers
Officier van de wacht:
Kaart:
Uitkijk:
Roerganger:

Briefing
Starttijd:
Eindtijd:

Korte omschrijving sessie
(zicht, scheepvaart, windkracht, etc.)

Cijfer prestatie
Technisch:
Niet-technisch:

Naam instructeur:

Debriefing door OvdW
Starttijd:
Eindtijd:
Debriefing door instructeur
Starttijd:
Eindtijd:

Sociale stress		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65		**Sociale stress**
Instructeur stelt moeilijke vraag	s																																																																			s	Instructeur stelt moeilijke vraag
Instructeur staat dichtbij adelborst/kijkt op vingers	s																																																																			s	Instructeur staat dichtbij adelborst/kijkt op vingers
Instructeur corrigeert adelborst/wijst op fout	s																																																																			s	Instructeur corrigeert adelborst/wijst op fout
Conflict met collega adelborst	s																																																																			s	Conflict met collega adelborst
Call maken (VHF, trackbriefing, etc.)	s																																																																			s	Call maken (VHF, trackbriefing, etc.)
Workload		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65		**Workload**
Informatie binnen krijgen / hard nadenken	s																																																																			s	Informatie binnen krijgen / hard nadenken
Tijdsdruk	s																																																																			s	Tijdsdruk
Fix (vaste fix, shoot-up)	s																																																																			s	Fix (vaste fix, shoot-up)
Draaipunt (op moment dat draaipunt wordt gemaakt)	s																																																																			s	**Draaipunt** (op moment dat draaipunt wordt gemaakt)
Peilen	s																																																																			s	Peilen
Uitleg	s																																																																			s	Uitleg
Ambiguity		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65		**Ambiguity**
Verwarring	s																																																																			s	Verwarring
Powerlessness		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65		**Powerlessness**
Systemen/materialen werken tegen, geen informatie uit te krijgen	s																																																																			s	Systemen/materialen werken tegen, geen informatie uit te krijgen
Extra / overig		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65		**Extra / overig**
	s																																																																			s	
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Opmerkingen sessie

Opmerkingen sessie