



# Risk-Taking Propensity During a Prolonged Voyage at Sea: A Simulator Experiment Study

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**Abstract.** Long-term isolation and rotating watch-keeping schedule in extended voyage might impact seafarers' risk-taking propensity. The present study aimed to explore how seafarer's risk-taking propensity varies with the prolonged voyage. 12 subjects were recruited to commit a prolonged "voyage" in a self-developed maritime chamber simulator. They lived and worked together following a rotating watch-standing schedule. Social isolation was realized by cutting off the communication between inside and outside world. Balloon Analogue Risk Task (BART) and Sensation Seeking Scale V (SSSV) were adopted as behavioral and self-assessed measures of risk-taking. Participants completed these two assessments before the "voyage" (baseline), at five different time points during the "voyage" and after the "voyage" (post-voyage). Number of explosions and adjusted number of pumps, which represent the riskiness on BART, decreased with the ongoing of the voyage, though the magnitude of the declination is small in size. Accordingly, the scores on SSS and its four subscales, especially the thrill and adventure seeking (TAS) subscale, also declined with the voyage. The results implicated that the sleep deprivation caused by the rotating shift and the stimulation deprivation caused by isolation together would reduce people's riskiness in decision making and the willingness to engage in high-risk and sensational activities as the prolonged voyage going on.

**Keywords:** Risk-taking propensity · Prolonged voyage · Sleep loss · Social isolation

## 1 Introduction

### 1.1 Risk-Taking at Sea

When at sea, the environment can be very complex and change rapidly. The ship should be ready to cope with very unpredictable situations or even some critical disasters, such as fire, environmental pollution, ship hull damage, ship grounding, and some unlawful acts that would threaten the safety of the members on the ship. Therefore, the capacity of seafarers, especially the officer of the watch (OOW) and the master, to make reasonable

decisions and take reasonable actions at risk is crucial for the safety of the ship and all members on it. The trait of risk-taking propensity plays an important role in risk decision making.

Risk-taking was constituted by two components: decision making in a high-level cognitive task (e.g., Balloon Analogue Risk Task, Iowa Gambling Task) and self-assessment of risk-taking propensity (e.g. sensation seeking). Balloon Analogue Risk Task (BART), developed by Lejuez et al. (2002), measures impulsive decision-making as risk-taking. It involves decisions based on evaluation of potential outcomes (i.e., risks and rewards) and choices to risk rewards already gained for the potential of higher rewards. Sensation seeking personality is characterized by the need for varied, novel, complex, and intense sensations and experiences, and the willingness to take physical, social, legal and financial risks for the sake of such experiences (Zuckerman 1994). The experience is needed for subjects to reach their optimal level of stimulation required to maintain the optimal level of arousal. Sensation seeking is related to risk taking in all kinds of risk areas, including driving, crime, financial, social violations, sports and so on (Jonah 1997; Dahlen et al. 2005; Horvath and Zuckerman 1993).

Working at sea, such as on large container ships, is regarded as stressful due to monotony, social isolation, fatigue, stress and rotating shift during the long voyage. Seafarers' mental health, cognitive function, as well as risk-taking propensity might be impaired.

## 1.2 Effect of Rotating Watch-Keeping Schedule on Risk-Taking

Ships are operated under a rapidly rotating watch-keeping schedule. This irregular working time arrangements will bring problems of fatigue, circadian rhythms, and sleep disruption to seafarers, which may affect their physiological and psychological functions (Eriksen et al. 2006; Colquhoun et al. 1988).

Sleep loss has been proved to induce sleepiness, fatigue and mood changes, and cause impairments in cognitive performance according to a review by Reynolds and Banks (2010). However, there is still no clear consensus about whether sleep deprivation impairs risk-taking. A review by Womack et al. (2013) concluded that sleep loss was overall positively associated with risk-taking behavior. Telzer et al. (2013) even revealed by functional magnetic imaging (fMRI) that poor sleep disrupts brain function related to cognitive control and reward processing. However, studies with different research findings cannot be neglected. Killgore (2007) showed that sleep deprivation decreased risk-taking in both decision making with the balloon analogue risk task and risk propensity with the EVAR scales. In the study of Chaumet et al. (2009), risk-taking propensity decreases during the night of sleep deprivation, and remains stable the following day. Moreover, Demos et al. (2016) showed partial deprivation did not alter the risky decision making assessed with the balloon analogue risk task.

## 1.3 Effect of Long-Term Social Isolation and Monotony on Risk-Taking

The monotony in the prolonged voyage, restricted possibilities for social contacts, sexual problems, insufficient leisure-time activities have adverse effects on seafarers and have been recognized as risk factors for seafarers' mental health and welfare (Lileikis 2014;

Iversen 2012; Sampson and Thomas 2003). However, knowledge about how social isolation, confinement and monotony affect cognitive functions is still limited. Few studies, especially experimental studies, have investigated the long-term effect of isolation (i.e., social isolation, information isolation) on decision making and risk-taking propensity.

A longitudinal study (Gow et al. 2013) with older adults found that perceived isolation was associated with deficits in cognitive functions, as well as slower processing speed. In the study of Duclos et al. (2013), feeling of isolation and exclusion engendered by a Cyberball game increased financial risk-taking. The authors state that interpersonal rejection exacerbates financial risk-taking by heightening the instrumentality of money (as a substitute for popularity) to obtain benefits in life. An experiment study by Chaumet et al. (2009) showed that impulsiveness increases in a confined environment under a normal sleep-wake schedule, as combined to the baseline.

The present study aimed to explore how seafarer's risk-taking propensity change with the extended voyage under sleep deprivation and isolation conditions (i.e., social isolation, confinement).

## 2 Method

### 2.1 Subjects

12 male subjects aged 24–37 years took part in this experiment. This study passed the ethics review [Certificate No: 2019013], and each subject signed on the written informed consent.

### 2.2 Measures

The Balloon Analogue Risk Task (BART) was applied in this experiment as the objective and behavioral measure of risk-taking. At the start of the BART, the computer screen displayed four items: a small balloon accompanied by a balloon pump, a reset button labeled Collect, a Total Earned display, and a second display labeled Last Balloon that listed the money earned on the last balloon. The subjects can choose between “collect” and “pump” as long as the balloon does not explode. Each click on the pump inflated the balloon a little, and money was accumulated. When a balloon was pumped past its individual explosion point and exploded, all money for this trial was lost. The number of pumps at which the balloon explodes obeys a uniform distribution from 1 to 128. There are a total of 30 balloons (i.e., trials) in an assessment (Lejuez et al. 2002).

Two highly correlated indices, the adjusted number of pumps across balloons (defined as the average number of pumps on balloons that did not explode) and the number of explosions, were adopted to represent participants' riskiness on BART. According to White et al. (White et al. 2008), risky behavior on the BART (adjusted average pumps) has been proved to have acceptable test–retest reliability across days ( $r = +.77$ ,  $p < .001$ ). Test–retest reliabilities for the present study are higher than  $+ .77$ , as shown in Table 1.

The 40-item self-reported Sensation Seeking Scale V (SSSV) was selected as a subjective measure of risk propensity. The SSS form V has the following subscales: (1) Thrill and Adventure Seeking (TAS), which expresses a desire to engage in sports or other

physical activities involving speed or danger; (2) Experience Seeking (ES), represents the seeking of experience through the mind and senses, travel, and a nonconformist life-style; (3) Disinhibition (DIS) represents the desire for social and sexual disinhibition as expressed in social drinking, partying, and variety in sexual partners; and (4) Boredom Susceptibility (BS), represents an aversion to repetition, routine, and restlessness when things are not changing (Zuckerman 1994).

Zuckerman et al. (1978) have provided data supporting the internal consistency of the measure, with alpha coefficients ranging from .83 to .86. The alpha coefficient for the current sample was mostly higher than .76, except for the alpha (.64) for the first-time assessment. Test–retest reliabilities shows in Table 1. The correlation coefficients of the total score, TAS and ES were all greater than .69. The test-retest reliability was especially high between the five-time points within the voyage. The reliability coefficient for Disinhibition on the SSS remained above .88 (all significant) across the five assessments within the voyage, but reduced to .42 (not significant) between the last assessment within the voyage and the assessment just after the voyage. The test-retest reliability for Boredom Susceptibility (BS) is poor, with the lowest correlation coefficient as  $-.03$ .

**Table 1.** Test-retest reliability: correlations between successive time points

| Test | Measures                            | BL-T1 | T1-T2 | T2-T3 | T3-T4 | T4-T5 | T5-Post |
|------|-------------------------------------|-------|-------|-------|-------|-------|---------|
| BART | Explosions                          | .76** | .85** | .83** | .92** | .83** | .77**   |
|      | Pumps                               | .92** | .98** | .95** | .94** | .96** | .87**   |
| SSS  | SSS total score                     | .87** | .87** | .91** | .90** | .91** | .80**   |
|      | Thrill and Adventure Seeking        | .73** | .96** | .97** | .94** | .95** | .97**   |
|      | Disinhibition                       | .67*  | .88** | .92** | .91** | .91** | .42     |
|      | Experience Seeking                  | .92** | .69*  | .73** | .73** | .86** | .71*    |
|      | Boredom Susceptibility <sup>b</sup> | .43   | .66*  | .61*  | .52   | .12   | $-.03$  |

<sup>b</sup>Spearman rho correlation coefficient

\*\*significance level < .01

\*significance level < .05

### 2.3 Procedures

The 12 subjects committed a prolonged “voyage” in a self-developed maritime chamber simulator. They lived and worked in the chamber following a rotating watch-keeping schedule. The communication and network connection with the outside was cut off, and subjects were provided no chances to meet anyone else except the other subjects in the chamber. These manipulations are to simulate the social isolation and monotony on real oceangoing ships. Subjects completed BART and SSS right before the “voyage” (baseline), at 5 evenly distributed time points during the “voyage”, and just after the “voyage” (post-voyage).

2.4 Statistics

Repeated measures ANOVA or Friedman ANOVA with SPSS 26.0 was adopted to test the time effect based on the normality of the data at all the timepoints. Since there are 7 levels of treatment, post-hoc with Bonfferoni correction will inflate the type 2 error. Therefore, post-hoc with Tuckey’s HSD was used. Studentized Range Statistic (q) for Tuckey test is directly tied to the t statistic. Since there is no Tuckey test in SPSS for within subject measures. we converted the paired t test on the means to a q statistic, by multiplying t by the square root of 2.

3 Results

3.1 Effect of Time on Riskiness on Balloon Analogue Risk Task

As illustrated in Fig. 1 and Fig. 2, the overall trend for both the number of explosions and the adjusted number of pumps for BART is downward.

With a relatively large number of explosions from baseline to the 2<sup>nd</sup> time point, the declination in explosions mainly occurred from the 2<sup>nd</sup> time block to the 4<sup>th</sup> time block within the voyage. According to the repeated measures ANOVA, the differences between the time blocks did not reach significance. Post-hoc analysis with Tuckey’s HSD correction revealed that the reduction in number of explosions from the 2<sup>nd</sup> time block to the 4<sup>th</sup> time block reached marginal significance, ( $14.58 \pm 5.68$  vs.  $12.13 \pm 5.50$ , respectively,  $q(7, 11) = 4.872$ ,  $p = .062$ ). No other significance was found between the other time blocks.

The number of pumps exhibited a similar but more modest downward trend as compared with the number of explosions. Repeated measures ANOVA and post hoc analysis with Tuckey’s HSD correction revealed no significant differences between the time points.

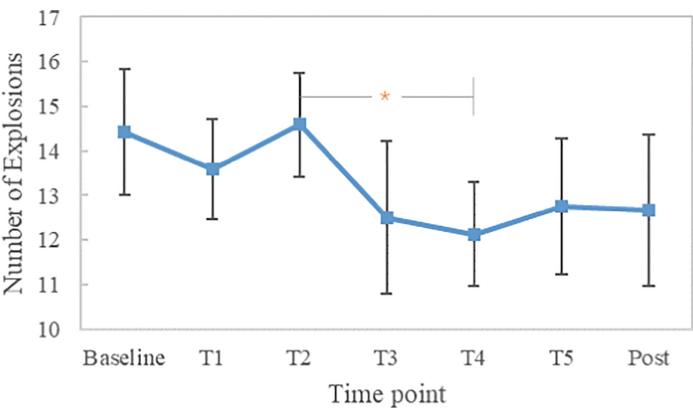


Fig. 1. Number of explosions in BART at different time points (\*significance level < .05)

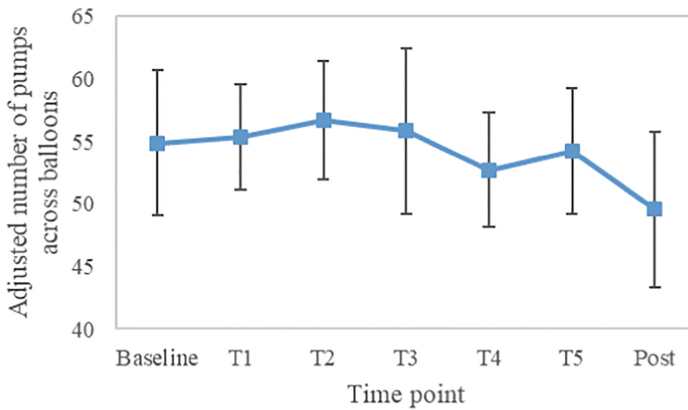


**Fig. 2.** Adjusted number of pumps across balloons in BART at different time points

### 3.2 Effect of Time on Sensation Seeking

The means and standard errors for total score on SSS at each time point are shown in Fig. 3, from which an overall declining trend can be found. A repeated measures ANOVA with a Greenhouse-Geisser correction determined that the differences in the total score on SSS between the 7 time points reached marginal statistical significance ( $F(1.335, 14.684) = 3.650, p = .066$ ). However, post-hoc analysis corrected by Tuckey's HSD did not reveal any significance on the paired differences.

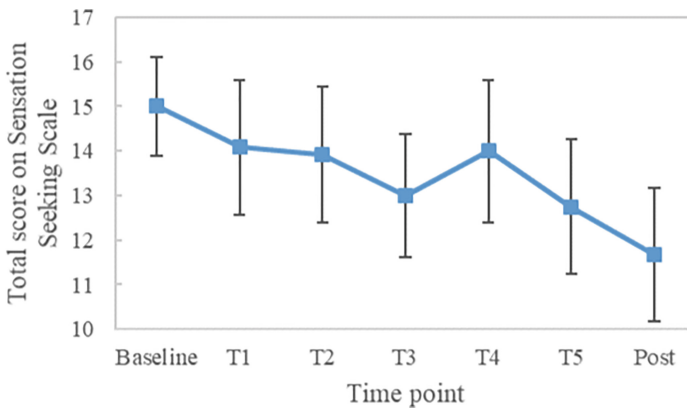


**Fig. 3.** Total score on Sensation Seeking Scale at different time points

According to Fig. 4, the score on TAS declined apparently from Baseline to the 1st time point within the voyage, remained relatively stable to the 3rd time block, then declined steadily afterwards until the post-voyage time point. A repeated measures ANOVA with a Greenhouse-Geisser correction determined a significant effect of time on the TAS ( $F(1.268, 12.947) = 4.776, P < .039$ ). Post hoc tests using the Tuckey's

HSD correction revealed that the TAS reduced significantly from 6.00 (S.D. = 2.92) in the 3rd time block to 5.42 (S.D. = 3.03) in the 5th time block within the voyage ( $q(7, 11) = 5.549, p = .029$ ), and further reduced significantly to 4.92 (S.D. = 2.94) after the voyage ( $q(7, 11) = 5.327, p = .038$ ).

The difference between the 1st voyage time point and the baseline did not reach significance. After checking the data separately for all subjects, the declination in TAS was found to be mainly formed by the sharp drop of two subjects. Change in the TAS score for the other subjects was relatively slight and the direction of change (upward, downward or unchanged) varied among subjects.

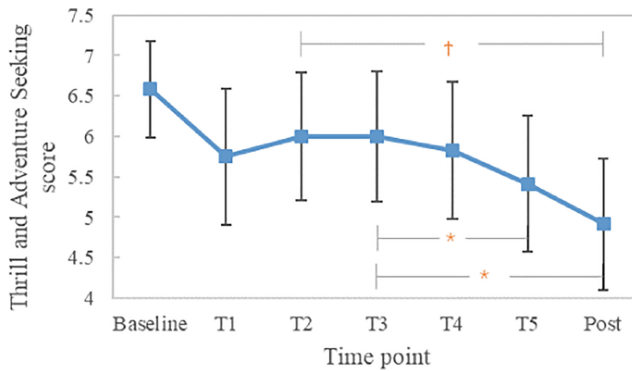


**Fig. 4.** Score on Thrill and Adventure Seeking in Sensation Seeking Scale at different time points (\*significance level < .05; † significance level < .1)

After a quick increase from the baseline to the 1<sup>st</sup> time point, the score on disinhibition exhibited an overall declining trend (see Fig. 5). However, examination of time effect with a repeated measures ANOVA corrected by Greenhouse-Geisser determined that the differences on Disinhibition (DIS) between time points did not reach statistical significance.

A repeated measures ANOVA with a Greenhouse-Geisser correction determined no significant overall effect of time on mean ES. Post hoc tests using Tuckey's HSD correction revealed that ES of the first time block reduced to  $2.58 \pm 1.51$ , which was statistically significantly different from baseline ( $3.36 \pm 1.69, q(7, 11) = 5.911, p = .020$ ). However, the ES score in the remaining assessments remains at the low level of the first time block as shown in Fig. 6, and no significance was reached between any pair of the remaining assessments.

The means and standard errors for total score on SSS at each time point are shown in Fig. 7. Repeated measures Friedman ANOVA determined that no significant overall effect of time on mean BS ( $\chi^2(6) = 12.159, p = .059$ ).

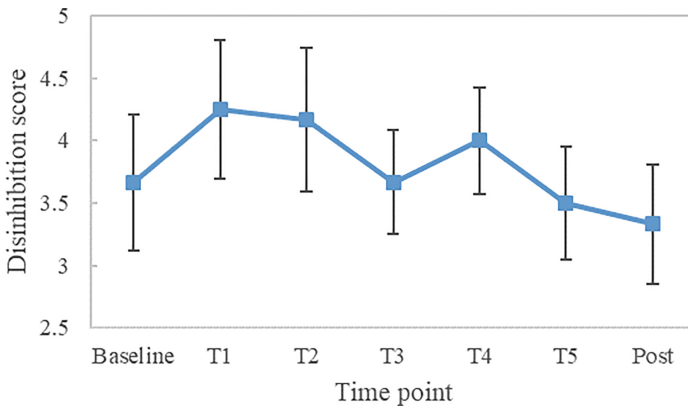


**Fig. 5.** Score on Disinhibition in Sensation Seeking Scale at different time points

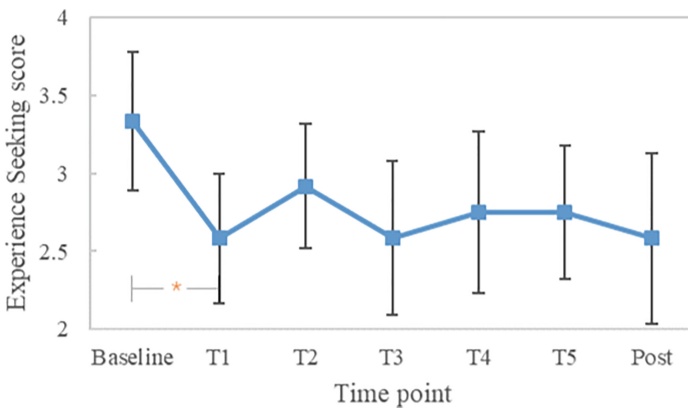


**Fig. 6.** Score on Experience Seeking in Sensation Seeking Scale at different time points (\*significance level < .05)

## 4 Discussion

An overall descending trend was observed on both the behavioral and self-assessed risk-taking propensity in the subjects with the proceeding of the simulated “voyage”, characterized by rotating watch-keeping schedule and isolation. This declination might be results of the combined effect of both sleep loss and isolation. However, it is difficult to tell whether they are joint effects or counteracting ones, since little or inconsistent knowledge is known about the effect of each factor. The authors try to elaborate on these effects based on related research findings to investigate the implications of this declination for further research.

The risk-taking propensity, as depicted by sensation seeking, represents the optimal level of stimulation the subjects need to maintain their optimal level of arousal. The information isolation in the prolonged voyage is essentially the deprivation of stimulation. As compensation for the lack of stimulation, people would seek for new sensations,

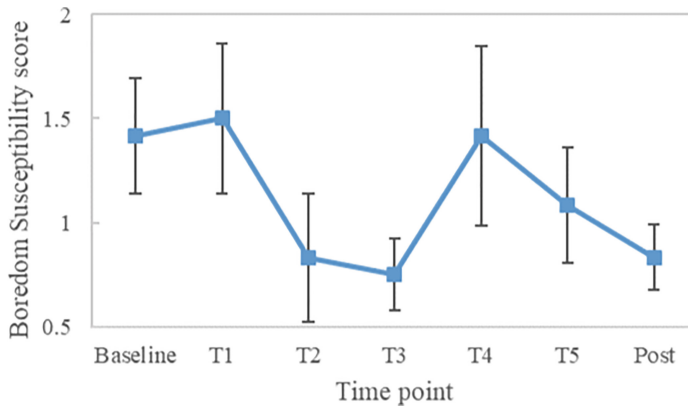


**Fig. 7.** Score on Boredom Susceptibility in Sensation Seeking Scale at different time points

as shown in the studies of Zuckerman et al. (1996) and Ha and Jang (2015). However, the isolated condition in the present experiment make opportunities of new sensations very limited, and the repeated assessments of the test and scale could not serve as new stimulus at all. Hence, a compromise, which means reducing the need for stimulation, might be adopted by the subjects. Reduction in the scores of Sensation Seeking Scale might be the reflection of this compromise. This could be regarded as an adaptation to the conditions.

Contradicted with the overall positive effect of sleep loss on risk-taking according to the review by Reynolds and Banks (2010), sleep loss caused by the rotating shift in the present study was correlated with less risk propensity. One possible causation of this contradiction might the differences in the form and duration of sleep loss between the present study and many other studies. The majority of studies focused on the total sleep deprivation, which means elimination of sleep for a period of time and no chances to catch up on sleep. The rotating watch-keeping schedule in the present study, on the other hand, provided people with reasonable duration of the sleep time window, but the time window changed every day. Besides, the sleep loss in previous experimental studies only lasted for several days, which could not reveal the long-term effect as shown in the present study. The other two possible reasons for this contradiction might be that the negative effect of isolation suppressed that of sleep loss, and that the declination in the number of pumps is due to loss of interest or a sense of futility rather than risky behavior in itself.

The other thing to be addressed is the low significance of the time effect on the risk-taking propensity. One straight forward reason for this might be that the magnitude of the time effect itself is small in size. The other reason is that, even though the overall trend might be downward for the majority of subjects, the descending process is fluctuated, other than straight and steady. This would result in great individual differences in the change directions between two specific time points, which impact the significance.

## 5 Conclusion

An experimental study was conducted to investigate how seafarers' risk-taking propensity change with the proceeding of extended voyage characterized by rotating watch-keeping schedule and isolation (i.e. social isolation, information isolation and information isolation). Both behavioral and self-assessed risk-taking propensity exhibited an overall descending trend with the voyage, though magnitude of the declination seemed to be small in size. It implicated that the sleep deprivation caused by the rotating shift and the stimulation deprivation caused by isolation together would reduce people's riskiness in decision making and the willingness to engage in high-risk and sensational activities.

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