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Task complexity matters: The influence of trait mindfulness on task and safety performance of nuclear power plant operators

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ABSTRACT

People with high level of trait mindfulness are more likely to maintain an open and present-focused awareness and attention. Whereas a positive link between trait mindfulness and well-being has been established, its influence on real-world performance has not been fully addressed. In Study 1, we validated the Freiburg Mindfulness Inventory (FMI) in a Chinese sample ($N = 294$) and found that a two-dimensional solution (a presence factor and an acceptance factor) best fit the data. In Study 2, using this validated scale, we directly investigated the influence of trait mindfulness on task and safety performance. In a sample of 136 Chinese nuclear power plant operators, it was found that trait mindfulness interacted with task complexity to influence performance. For high-complexity-task holders (the control room operators), the presence factor was positively related to their task and safety performance; for the low-complexity-task holders (the field operators), the presence factor had no influence on safety performance but a negative influence on task performance. The acceptance factor did not have any meaningful influences. These results suggest that the benefit of being mindful outweighs its cost for complex but not simple tasks. Implications are discussed.

1. Introduction

Mindfulness has been defined as a present-focused awareness and attention (the presence factor) with an open attitude toward ongoing events and experiences (the acceptance factor) (Bishop et al., 2004). The former can help individuals be more aware about otherwise unnoticed external stimuli and internal processes, while the latter refers to a more tranquil mind and better emotional state (Bishop et al., 2004; Brown, Ryan, & Creswell, 2007; Kohls, Sauer, & Walach, 2009).

Though most attention has been paid to the influence of mindfulness on well-being (for a review, see Brown et al., 2007), recent evidence has suggested that it has a positive influence on broader psychological functions such as sustained attention (Schmertz, Anderson, & Robins, 2009), cognitive flexibility (Moore & Malinowski, 2009), control of risk behavior (Lakey, Campbell, Brown, & Goodie, 2007) and interpersonal relationships (Dekeyser, Raes, Leijssen, Leysen, & Dewulf, 2008). Since these functions are particularly important for fulfilling tasks in an effective and safe manner, mindfulness may have a positive influence on individual performance in high risk industries such as nuclear power plants. However, research on its influence on real-world performance is still lacking (for theoretical exceptions see Dane, 2011; Weick, Sutcliffe, & Obstfeld, 1999). This study examines the mindfulness-performance relationship by taking the multi-dimensional nature of performance (task and safety performance) and the potential moderator (task complexity) into consideration and empirically tests it in a nuclear power plant context.

1.1. Mindfulness and task performance

Some initial attempts have been made to link mindfulness with task performance (the speed and quality of performing prescribed tasks). For example, in a group of disabled students, mindfulness training was found to increase their academic scores by reducing social anxiety (Beauchemin, Hutchins, & Patterson, 2008). Similarly, among MBA students, it was found that trait mindfulness has a positive influence on course performance for women (Shao & Skarlicki, 2009). In these cases, the benefits of mindfulness in performance can be ascribed to the acceptance factor reducing stress.

Some recent research has suggested that the presence factor of mindfulness can promote sustained attention, cognitive flexibility, situational awareness and better metacognitive skills (Bishop et al., 2004; Moore & Malinowski, 2009; Schmertz et al., 2009). These skills are especially important for performing complex process

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control tasks such as driving, air traffic control, and nuclear power plant operation (Vicente, Mumaw, & Roth, 2004). In a driving simulation task, for example, training participants to focus on their present experience was found to enhance individuals' situation awareness as measured by more accurate knowledge of vehicle and environment conditions (Kass, Van Wormer, Mikulas, Legan, & Bumgarner, 2011).

1.2. Mindfulness and safety performance

Unlike task performance which is more related to efficiency, safety performance refers to the behaviors that are the direct antecedences of accidents and injuries (Griffin & Neal, 2000). Safety compliance and safety participation are two components of safety performance. Safety compliance refers to personnel's in-role behaviors to maintain workplace safety, such as complying with rules. Safety participation, on the other hand, refers to the extra-role proactive behaviors that workers adopt to help colleagues or the entire organization prevent workplace accidents or injuries.

Being mindful can enhance safety compliance behavior for two reasons. First, mindful individuals are more likely to avoid cognitive failures, involuntary lapses or errors which are common causes of accidents because they are more aware of the external environment and internal processes (Herndon, 2008; Reason, Manstead, Stradling, Baxter, & Campbell, 1990). Second, as they are more concerned about the social externality of their behaviors and more capable of controlling their risky behavioral inclinations (Lakey et al., 2007), mindful people are less likely to violate certain rules or procedures intentionally, such as taking shortcuts to make the operation easier to perform(Zohar & Erev, 2007). As a result, it is likely that mindful operators will have a higher level of safety compliance.

The relationship between mindfulness and safety participation may also be positive. First, mindful people may be more aware of their coworkers' failures and the potential risks in the system because being mindful can preclude automatic and categorical thinking, biased judgments and habitual reactions (Bishop et al., 2004; Brown et al., 2007). This provides an important precondition for safety participation. Further, mindfulness is linked to empathy, better social skills and improved interpersonal relationships (Brown et al., 2007). Caring more about their coworkers and being more willing to communicate their ideas, mindful people will be more likely to exhibit safety participation behavior and thus demonstrate more capabilities and willingness with regard to safety participation.

1.3. Task complexity as a moderator

From the above analysis, it seems clear that being mindful can greatly improve task and safety performance. However, Dane (2011) has suggested that while paying impartial and continuous attention is beneficial for making an unbiased decision, an often-neglected fact is its time-consuming nature. Therefore, the benefit of being mindful depends on task complexity. For complex-task-holders, small errors or missing information could seriously undermine the whole performance, so the benefit of being mindful greatly outweighs the corresponding time cost. Conversely, for simple-task-holders, the benefit of being mindful will not exceed its time cost. So being mindful is more beneficial for improving complex task performance. However, this complexity-as-moderator hypothesis has not been empirically tested and has been made upon task performance only. Since efficiency is less important for the evaluation of safety performance, the negative influence of being mindful on safety performance in simple tasks may not be as strong as on task performance.

1.4. The current research

Based on these findings and analyses, we postulate that for complex task holders, being mindful could increase both task and safety performance whereas for simple task holders, it may reduce task performance but not safety performance.

To test these hypotheses, we firstly validated the Freiburg Mindfulness Inventory (FMI) in a Chinese sample (Study 1). We then conducted a field study in a nuclear power plant context (Study 2) where the task complexity between control room operators (CROs) and field operators (FOs) provides a good setting to test the moderation hypothesis. While both operators are required to do similar basic tasks such as monitoring and fault finding, the complexity is different. FOs are only responsible for monitoring and operating a few pieces of front-line equipment with limited decision freedom, whereas CROs have to monitor more than 1000 displays and have direct responsibility for maintaining the safety of the whole system (Vicente et al., 2004). This difference presents an opportunity to conduct a natural experiment to test the task-complexity-as-moderator hypothesis.

2. Study 1: Validating the FMI in a Chinese sample

The FMI was used in our research because it has good validity and reliability in both clinical and general populations (Walach, Buchheld, Buttenmüller, Kleinknecht, & Schmidt, 2006). However, it has not been used in any Chinese populations before and there was a dispute recently about its dimensionality (Kohls et al., 2009; Ströhle, 2006; Walach et al., 2006), so the main purpose of Study 1 was to explore its structural validity in a Chinese sample. In terms of criterion-related validity, two well established scales in Chinese, Cognitive Failures Questionnaire (CFQ) and Self-rating Depression Scale (SDS), were included to test whether scores of FMI can predict two proved functions of being mindful: increased awareness (less cognitive errors) and emotional tranquility (less depressive symptoms) (Brown et al., 2007; Herndon, 2008).

2.1. Methods

2.1.1. Participants and procedure

In total, 205 college students and 99 workers participated in the research. The students were recruited by offering 10 Yuan reimbursement and completed questionnaires in groups in a quiet room. The workers were recruited from a previously established online research portal by offering a free self-analysis report. Upon agreement, the online survey link was sent to participants' email address. After excluding 10 incomplete responses, a final set containing 202 students and 92 workers was used. Ages ranged from 17 to 43 ($M = 24.2$, SD = 5.2) with 60.9% ($N = 179$) males.

2.1.2. Measurement

2.1.2.1. FMI. All 14 items of FMI (Walach et al., 2006) was translated into Chinese following a standard translation and back-translation procedure. Participants were asked to rate how often (1 never – 4 very often) they had experiences such as "I pay attention to what is behind my actions" in the recent month. The overall α was .74.

2.1.2.2. CFQ. The Chinese version of the CFQ contains 25 items to measure daily cognitive errors (Chan, 1999). Participants were asked to rate how often (1 never – 4always) they encountered deficits of cognitive functioning such as "Do you find you forget appointments?". The α was .81.

2.1.2.3. SDS. The Chinese version of the SDS was used to measure depressive symptoms (Wang, Wang, & Ma, 1999, p. 196). Participants were asked to rate how often (1 never – 4 very often) they had feelings such as "I have trouble sleeping at night". The α was .83.

2.2. Results

Table 3 shows the confirmatory factor analysis (CFA) results of the one and two dimensional models. However, these solutions did not fit well with the current data. As a result, a further exploratory factor analysis (EFA) was conducted.

Firstly, parallel analysis (PA) was conducted to determine the number of factors to be retained. Following O'Connor's (2000) recommended procedure, 1000 random sets of data were created to produce 'baseline' eigenvalues. Since the actual eigenvalues of the first two components extracted from the principal component analysis of the real data (2.954 and 1.752) were larger than the 95% percentile generated by PA (1.461 and 1.348), they were retained and varimax rotated (see Table 1). By discarding items which had low loadings (<.40) and large secondary loadings, a reduced 10-item scale containing two factors was obtained. The first factor was named as 'Acceptance' as all its 6 items were in Ströhle (2006)'s acceptance factor and the second as 'Presence' as all its 4 items were in Ströhle (2006)'s presence facet. This reduced 2-factor solution yielded acceptable fit indices (see Table 3), but a reduced internal consistency (.69 for the whole 10-item scale, .69 for Acceptance and .60 for Presence).

To investigate its criterion-related validity, the partial correlations between the original FMI, all FMI subscales, as well as the CFQ and the SDS by controlling for working condition (students or workers), gender and age were calculated (Table 2). All correlations were significant and in the expected directions.

2.3. Discussion of Study 1

The results of Study 1 suggested the Chinese version of the Freiburg Mindfulness Scale has acceptable structural and criterion related validity. Its reliability was also comparable to Kohls et al. (2009). Due to the exploratory nature of this study, values below .70 were also acceptable.

3. Study 2: Predicting Nuclear Power Plant Operators' Performance

Study 2 was to directly test the mindfulness-performance relationship in a NPP context with the validated Chinese FMI. As some personality traits such as neuroticism, conscientiousness and agreeableness were found to be correlated with both trait mindfulness and performance (Costa and McCrae,1992; Giluk, 2009), we included these as control variables in our research.

Table 1
Factor loadings of FMI in Study 1 ($N = 294$).

Items	Acceptance (18.8%)	Presence (14.8%)
FMI-9	.65	
FMI-10	.63	
FMI-12	.61	
FMI-4	.59	
FMI-14	.57	
FMI-8	.48	
FMI-6	.38	
FMI-1	.37	
FMI-2		.69
FMI-7		.64
FMI-5		.62
FMI-3		.52
FMI-11	.33	.40
FMI-13	.32	−.33

Table 2
Zero-order correlations between all variables ($N = 294$).

	FMI10	Presence	Acceptance	CFS	SDS
FMI-14	.94**	.63**	.82**	−.22**	−.32**
FMI-10		.72**	.83**	−.22**	−.29**
Presence			.21**	−.12*	−.19**
Acceptance				−.20**	−.26**
CFS					.33**
SDS					–

Note: (1) FMI: Freiburg-Mindfulness-Inventory; CFS: Cognitive-Failures-Questionnaire; SDS: Self-rating-Depression-Scale.
* Significant at .05 level.
** Significant at .01 level.

3.1. Methods

3.1.1. Participants and Procedure

In total, 63 CROs and 73 FOs at two newly operating reactors run by one nuclear energy corporation participated in this research. All were male college graduates between 24 and 33 years old ($M = 27.7$, $SD = 1.70$) with industry experience of 1 to 6 years ($M = 4.12$, $SD = .88$). All participants completed questionnaires during their regular training sessions. Afterwards, their supervisors were separately contacted in person and asked to rate the performance of their subordinates.

3.1.2. Measurement

3.1.2.1. FMI. The same FMI as in Study 1 was used. The reduced-two-factor solution fit the data well (see Table 3). As a result, we used the summed item scores of acceptance and presence factors in the following analysis. The reliability coefficients were .75 for Acceptance and .61 for Presence.

3.1.2.2. Personality. Three 12-item scales from the Chinese version of the NEO Five Factor Inventory were used in our study to measure Neuroticism, Agreeableness and Conscientiousness (Costa & McCrae, 1992). The participants rated each statement on a 5-point Likert scale ranging from 0 "strongly disagree" to 4 "strongly agree". In the current sample, the alpha coefficients for Neuroticism, Agreeableness, and Conscientiousness were .86, .60, and .80, respectively.

3.1.2.3. Task and safety performance. Task performance was measured by the 7-item general task performance scale developed by Williams and Anderson (1991). Safety compliance and participation were measured by two three-item scales (Jiang, Yu, Li, & Li, 2010). Supervisors were asked to rate the frequency of their subordinates' behavior in the past three months in a 5-point Likert scale from 1 "almost never" to 5 "almost always". Sample items were "[he] adequately completes assigned duties" (task performance), "uses all necessary safety protection in work" (safety compliance) and "voluntarily carries out tasks or activities that help to improve workplace safety" (safety participation). As shown in Table 3, the three-factor-model of performance best fit the data. The alpha coefficients for task performance, safety compliance and participation were .79, .72 and .87, respectively.

Table 3
Model Fit Indices of FMI and Performance Measurements.

Model types	*df*	χ^2	CFI	TLI	RMSEA
FMI (Study 1, N = 294)					
One-factor-model (Walach et al., 2006, CFA)	77	246.0	.64	.58	.09
Two-factor-model (Ströhle, 2006, CFA)	76	213.8	.71	.65	.08
Reduced-two-factor-model (EFA)	34	54.4	.94	.92	.05
FMI (Study 2, N = 136)					
One-factor-model (Walach et al., 2006, CFA)	77	148.6	.82	.79	.08
Two-factor-model (Ströhle, 2006, CFA)	76	148.5	.83	.79	.08
Reduced-two-factor-model (determined by Study 1, CFA)	34	54.2	.94	.92	.05
Performance (Study 2, N = 136)					
One-factor model (CFA)	65	212.2	.80	.76	.12
Two-factor model (CFA, safety and task performance)	64	155.1	.87	.85	.10
Three-factor model (CFA)	62	101.6	.95	.93	.07

3.2. Results

3.2.1. Initial analysis

Workers at reactors 1 ($N = 89$) were slightly older ($M_{difference} = 1.21$ years, Cohen's $D = .33$) and showed more safety participation behaviors ($M_{difference} = .92$, Cohen's $D = .43$) than workers at reactor 2 ($N = 47$). To control for any difference between them, a dichotomous variable named 'ReactorNo.' was created for further analysis. To make a note, in the current sample, both kinds of operators were recruited from university graduates and cultivated to be future CROs to meet the great need of the expanding industry. So their difference in education or intelligence was minimum. Also, there was no significant difference between CROs and FOs in terms of age, mindfulness and personality variables. But the CROs had worked .61 years longer (Cohen's $D = .74$) than the FOs (actually, receiving training earlier was the main reason why they become CROs), and showed more safety participation behaviors ($M_{difference} = .75$, Cohen's $D = .35$). Therefore, a dichotomous variable named task complexity, in which 0 represents the CROs and 1 represents the FOs, was created for further analysis. No interactions between ReactorNo. and task complexity was found.

In term of zero-order correlations, safety participation correlated with age ($r = .21$, $p < .05$) and the presence factor ($r = .24$, $p < .01$). While all personality variables did not correlate with any performance criterion, they significantly correlated with both facets of mindfulness. Descriptive statistics and zero order correlations between all variables are shown in Table 4.

3.2.2. Hierarchical multiple regression analysis

Three multiple hierarchical regression analyses were conducted following Aiken and West's (1991) recommended procedure. The summed item scores of three performance criterions were treated as dependent variables. In the first step, Reactor No., age, work experience, and personality were entered as control variables. Next, two factors of mindfulness and task complexity were entered. In the final step, the interaction terms between the two mindfulness factors (centered) and task complexity were entered Details of these regression analyses are shown in Table 5.

In the regression model predicting task performance, adding the interaction term in the third step significantly increased the model fit ($\Delta R^2 = .12$, F (2, 124) = 8.57, $p < .001$). In the final step, neuroticism ($\beta = -.25$, $p < .05$), the presence factor ($\beta = .51$, $p < .01$) and the interaction term between the presence factor and task complexity ($\beta = -.59$, $p < .01$) became significant predictors. We used Aiken and West's (1991) suggested procedure to further depict and test the simple slope tendency for both groups (see Fig. 1). The presence factor had a positive effect on task performance ($\beta = .51$, $p < .01$) for the CROs, but a marginally negative effect for FOs ($\beta = -.27$, $p = .053$).

In the regression model predicting safety compliance, adding the interaction term significantly increased the model fit ($\Delta R^2 = .06$, F (2,124) = 4.33, $p < .01$). In the final step, age ($\beta = .18$, $p < .05$), the presence factor ($\beta = .32$, $p = .051$), and the interaction term between the presence factor and task complexity ($\beta = -.34$, $p < .05$) were significant. In terms of the simple slopes, the presence factor had a marginally positive effect on safety compliance ($\beta = .32$, $p = .051$) for CROs, but a non-significant effect for FOs ($\beta = -.08$, ns).

In the regression model predicting safety participation, adding the interaction term significantly increased the model fit ($\Delta R^2 = .06$, F (2,124) = 5.48, $p < .01$). In the final step, reactor No. ($\beta = -.22$, $p < .05$), age ($\beta = .17$, $p < .05$), the presence factor ($\beta = .50$, $p < .01$), task complexity ($\beta = -.21$, $p < .05$) and their interaction term ($\beta = -.44$, $p < .01$) were significant predictors. In terms of the simple slopes, the presence factor had a positive effect on safety participation ($\beta = .50$, $p < .01$), but a non-significant effect for FOs ($\beta = -.07$, ns.).

3.3. Discussion of Study 2

Although the internal consistency was still not very good, Study 2 replicated the FMI factor structure determined in Study 1.

Table 4
Descriptive Statistics and Zero-order Correlations of All Variables in Study 2 ($N = 136$).

	M	SD	1	2	3	4	5	6	7	8	9
1. Age	27.74	1.70	–								
2. Work Experience	4.10	.88	−.04	–							
3. Neuroticism	27.26	6.97	.11	−.02	–						
4 Agreeableness	44.35	4.69	.01	.01	−.57**	–					
5. Conscientiousness	47.13	4.94	−.14	.03	−.63**	.55*	–				
6. Acceptance	19.67	3.11	−.15	.12	−.30*	.22**	.19**	–			
7. Presence	14.02	1.80	.03	.11	−.23**	.23**	.24**	.59**	–		
8. Task Performance	31.12	2.78	.02	.04	−.13	−.03	.01	.07	.08	–	
9. Safety Compliance	13.76	1.24	.11	−.03	−.03	−.10	−.06	.02	.04	.64**	–
10. Safety participation	11.49	2.19	.21*	.01	−.06	.08	.02	.13	.24*	.64**	.52**

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

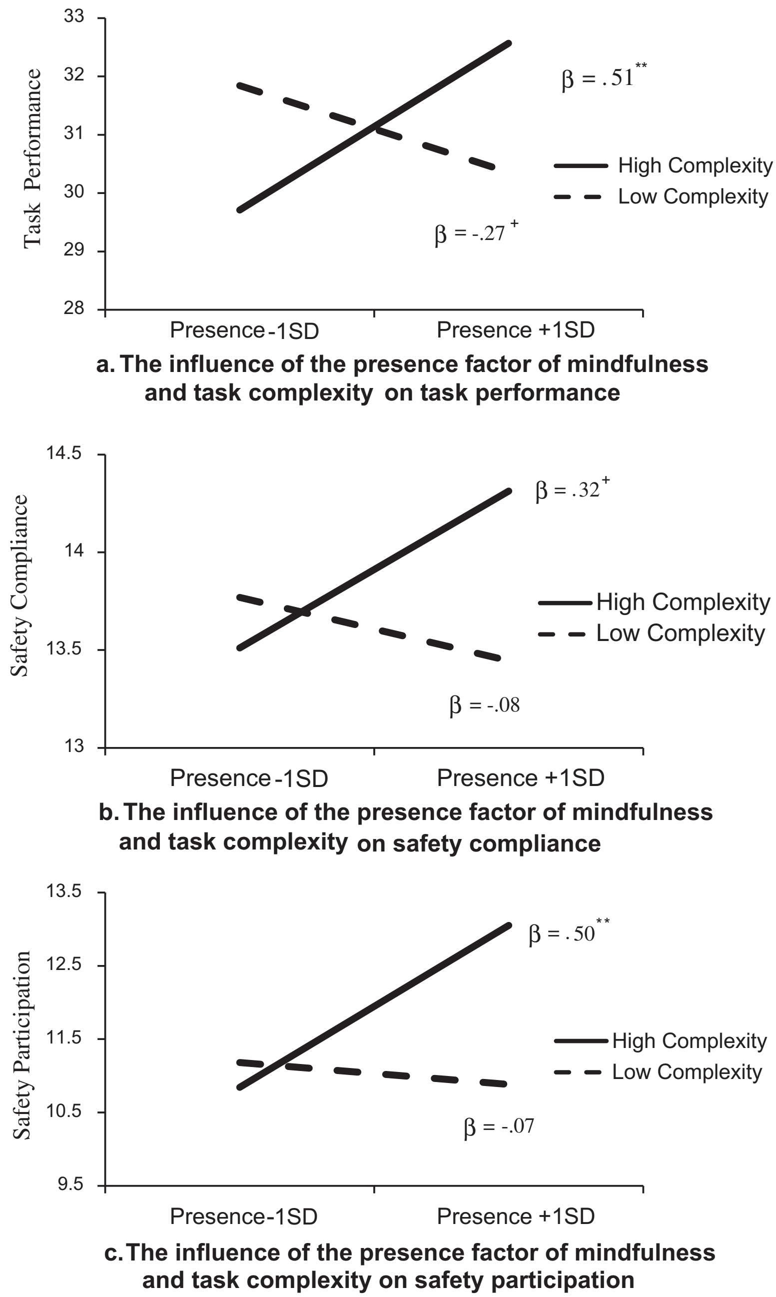

Fig. 1. The Influence of the Presence Factor of Mindfulness and Task Complexity on Task and Safety Performance. *Note:* **significant at .01 level; +significant at. 10 level.

Further, the regression analysis showed a consistent influence of the presence factor on performance and the moderation of task complexity.

4. Discussion

Our study sought to examine whether trait mindfulness and task complexity interacted to influence performance. The results suggested that the interaction did exist. For high-complexity-task holders (the CROs), the presence factor of trait mindfulness had a significant positive influence on their task and safety performance; for low complexity task holders (the FOs), it had a negative influence on task performance but a non-significant influence on safety performance.

The study has several important implications. Firstly, consistent with previous findings that mindfulness can promote task performance in academic and laboratory settings (e.g. Beauchemin et al., 2008; Shao & Skarlicki, 2009), trait mindfulness was also found to influence real world performance. The evidence re-emphasizes the value of keeping a present-focused awareness in a high risk industry and provides a more general trait-related approach which is different from the organization culture concept developed by Weick et al. (1999). However, this study also addressed the issue of the potential cost of mindfulness for low-complexity-tasks especially when assessing whether they are done efficiently (task performance) rather than accurately (safety performance). Exploring possible mechanisms that can reduce the cost of being mindful – an issue that is often neglected – might be promising for future research.

Secondly, while the presence factor was found to play an important role in operators' performance, the acceptance factor was not found to have any meaningful influence. One reason, as suggested by Brown and Ryan (2004), is that it is subordinate to the presence

Table 5
Hierarchical Multiple Regression Predicting Task and Safety Performance (n = 136).

Independent variables	Task performance			Safety compliance			Safety participation		
	B	SEB	β	B	SEB	β	B	SEB	β
Reactor No.	−.22	.54	−.04	.28	.25	.11	−1.00	.41	−.22*
Age	.08	.15	.05	.13	.07	.18*	.22	.11	.17*
Work experience	.10	.29	.03	−.06	.13	−.05	−.29	.21	−.12
Neuroticism	−.10	.05	−.25*	−.03	.02	−.15	−.02	.03	−.05
Agreeableness	−.09	.06	−.14	−.04	.03	−.17	−.02	.05	−.05
Conscientiousness	−.04	.07	−.07	−.02	.03	−.07	.00	.05	.01
Presence	.79	.25	.51**	.22	.11	.32*	.61	.18	.50**
Acceptance	−.10	.16	−.11	.04	.07	.09	−.03	.12	−.04
Task complexity (TC)	−.04	.50	−.01	−.30	.23	−.12	−.92	.37	−.21*
Presence × TC	−1.21	.32	−.59**	−.31	.15	−.34*	−.70	.24	−.44**
Acceptance × TC	.16	.19	.14	−.04	.09	−.07	.06	.14	.07
ΔR^2 of step2	.01			.02			.07*		
ΔR^2 of step3	.12**			.06*			.07**		
Total R^2	.16			.12			.25		

Note: 1. +significant at .10 level, *significant at .05 level; **significant at .01 level.
2. TC (0 for control-room-operators and 1 for field-operators).
3. Due to space limitation, only the final step was shown, detailed information could be asked from the author.

factor and therefore cannot be reliably measured and distinguished. However, in both our and some previous studies (e.g. Kohls et al., 2009), the two factor solution best fit the data and the reliability of the acceptance factor was even higher. Another possible explanation is that there may be some important moderators which were not directly investigated by us. Since the acceptance factor is more related to emotion regulation, its effect on performance might be stronger under more stressful situations. Consequently, it may be fruitful to investigate the level of stress or workload as a moderator in future research.

Except for neuroticism, other personality traits did not contribute to operators' performance. One possible explanation might be that their predictive validity is attenuated by a restricted range as these operators had already been selected based on personality tests (especially for consciousness). Another possible reason might be that in eastern culture the personality structure is somewhat different which could undermine the reliability (especially for agreeableness).

Several limitations must be addressed. First, the cross-sectional nature of the current study did not warrant a causal relationship between trait mindfulness and performance. Future studies should use longitudinal and experimental designs to investigate whether a third variable (such as the safety training) could increase both mindful practice and performance. Second, although the questionnaire we used in our research had comparable psychometric properties with previous work (e.g. Kohls et al., 2009), its structure may not be fully invariant across all populations (the correlation between presence and acceptance was stronger in the NPP context). Future research may investigate whether working under an environment requiring mindful operation (Weick et al., 1999) may influence the measurement structure.

5. Conclusion

This study has provided initial evidence from the nuclear power industry regarding the influence of trait mindfulness on both task and safety performance and its boundary conditions. For researchers, the cost of being mindful warrants further attention. For practitioners, trait mindfulness could be used as one of the criteria in personnel selection but the degree of task complexity must be carefully considered.

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References

Aiken, L., & West, S. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: Sage Publications.
Beauchemin, J., Hutchins, T., & Patterson, F. (2008). Mindfulness meditation may lessen anxiety, promote social skills, and improve academic performance among adolescents with learning disabilities. *Complementary Health Practice Review, 13*, 34–45.
Bishop, S., Lau, M., Shapiro, S., Carlson, L., Anderson, N., Carmody, J., et al. (2004). Mindfulness: A proposed operational definition. *Clinical Psychology: Science and Practice, 11*(3), 230–241.
Brown, K., & Ryan, R. (2004). Perils and promise in defining and measuring mindfulness: Observations from experience. *Clinical Psychology: Science and Practice, 11*(3), 242–248.
Brown, K., Ryan, R., & Creswell, J. (2007). Mindfulness: Theoretical foundations and evidence for its salutary effects. *Psychological Inquiry, 18*(4), 211–237.
Chan, R. C. K. (1999). What does cognitive failures questionnaire measure: General failures or specific domain deficits? *Archive of Clinical Neuropsychology, 14*, 735–736.
Costa, P., & McCrae, R. (1992). *Neo PI-R professional manual*. Odessa, FL: Psychological Assessment Resources.
Dane, E. (2011). Paying attention to mindfulness and its effects on task performance in the workplace. *Journal of Management, 37*(4), 997–1018.
Dekeyser, M., Raes, F., Leijssen, M., Leysen, S., & Dewulf, D. (2008). Mindfulness skills and interpersonal behaviour. *Personality and Individual Differences, 44*(5), 1235–1245.
Giluk, T. L. (2009). Mindfulness, big five personality, and affect: A meta-analysis. *Personality and Individual Differences, 47*(8), 805–811.
Griffin, M., & Neal, A. (2000). Perceptions of safety at work: A framework for linking safety climate to safety performance, knowledge, and motivation. *Journal of Occupational Health Psychology, 5*(3), 347.
Herndon, F. (2008). Testing mindfulness with perceptual and cognitive factors: External vs. internal encoding, and the cognitive failures questionnaire. *Personality and Individual Differences, 44*(1), 32–41.
Jiang, L., Yu, G., Li, Y., & Li, F. (2010). Perceived colleagues' safety knowledge/behavior and safety performance: Safety climate as a moderator in a multilevel study. *Accident Analysis & Prevention, 42*(5), 1468–1476.
Kass, S., Van Wormer, L., Mikulas, W., Legan, S., & Bumgarner, D. (2011). Effects of mindfulness training on simulated driving: Preliminary results. *Mindfulness, 20*(4), 236–241.
Kohls, N., Sauer, S., & Walach, H. (2009). Facets of mindfulness-results of an online study investigating the Freiburg Mindfulness Inventory. *Personality and Individual Differences, 46*(2), 224–230.
Lakey, C., Campbell, W., Brown, K., & Goodie, A. (2007). Dispositional mindfulness as a predictor of the severity of gambling outcomes. *Personality and Individual Differences, 43*(7), 1698–1710.
Moore, A., & Malinowski, P. (2009). Meditation, mindfulness and cognitive flexibility. *Consciousness and Cognition, 18*(1), 176–186.
O'Connor, B. (2000). SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, 32*(3), 396–402.
Reason, J., Manstead, A., Stradling, S., Baxter, J., & Campbell, K. (1990). Errors and violations on the roads: A real distinction? *Ergonomics, 33*(10–11), 1315–1332.

Schmertz, S., Anderson, P., & Robins, D. (2009). The relation between self-report mindfulness and performance on tasks of sustained attention. *Journal of Psychopathology and Behavioral Assessment, 31*(1), 60–66.

Shao, R., & Skarlicki, D. P. (2009). The role of mindfulness in predicting individual performance. *Canadian Journal of Behavioural Science, 41*(4), 195–201.

Ströhle, G. (2006). *Empirische Erfassung der Achtsamkeit: ein Vergleich der deutschsprachigen Achtsamkeitsskalen*. Jena: Friedrich-Schiller-Universität Jena.

Vicente, K., Mumaw, R., & Roth, E. (2004). Operator monitoring in a complex dynamic work environment: A qualitative cognitive model based on field observations. *Theoretical Issues in Ergonomics Science, 5*(5), 359–384.

Walach, H., Buchheld, N., Buttenmüller, V., Kleinknecht, N., & Schmidt, S. (2006). Measuring mindfulness – the Freiburg Mindfulness Inventory (FMI). *Personality and Individual Differences, 40*(8), 1543–1555.

Wang, X., Wang, X., & Ma, H. (1999). *Rating scales for mental health*. Beijing: Chinese Mental Health Journal Publication.

Weick, K., Sutcliffe, K., & Obstfeld, D. (1999). Organizing for high reliability: processes of collective mindfulness. In R. S. Sutton & B. M. Staw (Eds.). *Research in Organizational Behavior* (Vol. 1, pp. 81–123). Stanford: Jai Press.

Williams, L., & Anderson, S. (1991). Job satisfaction and organizational commitment as predictors of organizational citizenship and in-role behaviors. *Journal of Management, 17*(3), 601–617.

Zohar, D., & Erev, I. (2007). On the difficulty of promoting workers' safety behaviour: Overcoming the underweighting of routine risks. *International Journal of Risk Assessment and Management, 7*(2), 122–136.