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The use of mindful safety practices at Norwegian petroleum installations

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Abstract

Offshore petroleum production involves several major hazards to health, safety and the environment. Employees may contribute to guard against these hazards in different ways. To obtain a better understanding of the type of contextual factors that affect employees' willingness to use *mindful safety practices* (*MSPs*) at Norwegian petroleum installations, an exploratory study was performed. The study comprised two parts: The first part constituted the original study ($n = 2928$), and the second part constituted the replication study ($n = 7207$). The two part studies were based on data obtained in questionnaire surveys performed by the Petroleum Safety Authority, Norway. The study suggested that safety management practices to promote employees' willingness to use *MSPs* would be most efficient if directed at the employee work groups and their local work environment, rather than at the individual employee or at employees on the installation in general. It further suggested that particular efforts might be needed to promote *MSP* use when employees were transferred to new work environments, and when changes were introduced into existing work environments. Based on the results, a set of concrete safety management practices aimed at promoting employees' willingness to use *MSPs* were suggested.

Keywords: Safe work practices; Safety management; Petroleum industry

1. Introduction

Offshore petroleum installations are complex socio-technical systems that involve several major hazards to health, safety, and the environment. To protect against these hazards a series of safety measures are applied, and employees working at the installations constitute important elements in many of these measures.

Studies directed at employees' contribution to safety in complex industrial socio-technical systems have gone through several evolutions during the latest decades. From around the 1950s, the safety contributions of employees were mainly considered from the perspective of risk (Rognin et al., 2000). Studies tended to be based on a *person approach* focusing on the errors of individuals (Reason, 2000). Important countermeasures to protect against safety hazards were to minimize and control human performance to the extent possible

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using automation and operating procedures, respectively. From the 1980s studies of employees' safety contributions were increasingly performed from a *system approach* (Reason, 1993). This shift was among other things based on the findings that factors at the organizational level had markedly impacted the development in a series of industrial accidents during the 1980s (ibid.). These accidents included: the explosion at the pesticide factory in Bhopal in 1984, the meltdown at the Chernobyl nuclear power plant in 1986, and the capsize of the ferry M/S Herald of Free Enterprise in 1987. The system approach implied that the effects of the *conditions of work* on employees' performance became the key focus of attention. As a consequence factors related to both the individual, the group, and the organizational levels tended to be included in studies directed at understanding the reason for accidents and for identification of countermeasures to protect against safety hazards (e.g., Gehman, 2003; Rogers, 1986; Snook, 2000).

In the mid 1980s, Perrow (1984) introduced the *normal accident perspective*. This sociologically-based perspective holds that accidents within high-risk industries are to be expected when interactively complex and tightly coupled production systems are applied. In these systems the number of possible interactions between the system components makes it impossible to predict and thus protect against all the possible safety hazards that may arise. For this reason safety hazards for which no contingency plans exist can be expected to occur from time to time, and these may result in accidents. The pessimistic view of the *Normal Accident perspective* was later challenged by a group of researchers representing the *High Reliability Organization perspective* (e.g., Bierly and Spender, 1995; LaPorte and Consolini, 1991; Rochlin et al., 1987; Sagan, 1993; Weick and Sutcliffe, 2001). The *High Reliability Organization perspective* took as its starting point that despite the many hazards that could happen in the high-risk systems addressed by the *Normal Accident perspective* these systems tended to operate very reliably in practice. The main issue in studies performed from the *High Reliability Organization perspective* was to obtain a better understanding of how these industries managed to obtain such excellent safety records. Even if it can be debated whether the studies performed from the *High Reliability Organization perspective* actually addressed the same type of industrial systems as the *Normal Accident perspective* (Marais et al., 2004), these studies have significantly impacted the perspective on human performance in safety studies. Employees' contribution to safety is no longer mainly considered from the perspective of risk but also from the perspective of their positive contribution to safety. This positive focus on employees' contribution to safety is adopted in the present study.

2. Mindful safety practices at Norwegian petroleum installations

Studies directed at Norwegian Petroleum installations suggest that employees may contribute to guard against safety hazards in at least three different ways: (1) by serving as *elements in safety barriers*, (2) by using *mindful safety practices*, and (3) by *improvising* (Skjerve et al., 2003, 2004).

Safety barriers are used to protect against *anticipated* dangers. At Norwegian petroleum installations these anticipated dangers are jointly referred to as *defined danger and accident situations* (Norwegian Petroleum Directorate, 2002). They comprise events such as hydrocarbon releases, fires and explosions, helicopter crashes, and ship collisions into the platforms. Serving as elements in safety barriers, the activity of employees tends to be pre-planned, and carried out with reference to dedicated operating procedures. This implies that task performance to a large extent will involve rule-based reasoning (Rasmussen, 1986). *Improvisation*, i.e. the ability to develop and implement a recovery plan within a limited time space (Andresen et al., 2008), has traditionally not been seen as a safety measure. Still, in practice employees' ability to improvise has in some situations markedly contributed to prevent the occurrence of major accidents (ibid.). Improvisation may be the only means left to prevent accidents in situations where *unanticipated* safety hazards or unanticipated combination of safety hazards occur, as no contingency plans will exist to ensure that these situations are recovered.

Mindful safety practices (MSPs) are discrete safety promoting work practices that may prevent the initiation of and/or interrupt unwanted but *not explicitly anticipated* types of event sequences (Skjerve, 2006). *MSPs* serve to protect against different types of safety hazards associated with the work processes of the employees (e.g., unsafe handling of tools) or factors in their work environment (e.g., unsafe storage of materials). The safety hazards addressed by *MSPs* cannot be explicitly anticipated (e.g., it is not possible to foresee all the ways in which tools can be handled unsafely at a petroleum installation), but the type of hazard they address can be anticipated (e.g., it can be anticipated that mishandling of tools from time to time may endanger safety). For this reason *MSPs* specify the type of hazards that employees should guard against, and provide high-level guidelines for how employees should respond in these situations (e.g., warn a colleague). The characteristics of *MSPs* imply that they encourage employees to review situations from different perspectives, to be open to the possible relevance of new information and/or to be open to the need for reinterpretation old information. These qualities are all attributes of the concept *mindfulness*, as suggested by Langer (1989), and for this reason the practices are considered to be mindful. A subset of the *MSPs* that are applied at Norwegian petroleum installations is outlined below:

- If you observe a person in danger, you should warn the person.
- An employee may be allocated the role as watchman ("Hawk's eye"), i.e. to warn his or her colleagues about *any dangers* that may come to inflict their task performance process.
- When faced with potential or actual safety-critical situations you should "Take Two" (minutes) to think through the situation before acting.
- If you realize that your performance may have negative safety consequences for you or your colleagues, you should stop.

When using *MSPs*, the activity of the employees tends to be *less procedurally guided* than when they serve as *elements* in safety barriers. They will rely more on their subjective, real-time evaluation of the situation-at-hand, and thus on knowledge-based reasoning (Rasmussen, 1986).

MSPs may be used informally or as part of the formal safety means at an installation (Aase et al., 2005). When used as part of the formal safety means, the requirement to perform a *MSP* will typically be specified in an instruction. An instruction may, e.g., state that an employee should serve as a "Hawk's eye" (see above) when a particular type of activity is performed. Still, even when a *MSP* is used as part of the formal safety means, no rules will specify how the *MSP* should be performed. The employee must rely on his or her own ability to be aware of critical factors in the environment and to act appropriately when dangers arise. The requirement to perform a *MSP* as part of an instruction will thus constitute a discrete task, which imposes different requirements to the employee than the performance of tasks guided by predefined rules.

To increase the likelihood that employees will use *MSPs* efficiently, i.e. that they will adequately intervene in situations where danger is present and not excessively in situations where no danger is present, three conditions must be fulfilled: (1) Employees must receive *education and training* to ensure that they possess the knowledge and skills required to identify safety hazards and to intervene to reduce/eliminated the hazards. This will include insight into the *safety standards* at the installation. A range of the activities performed at a petroleum installation can be associated with a certain level of risk (this is true even for merely staying at a petroleum installation). To adequately determine when MSPs should be used the employees must know what constitutes an unacceptable risk. (2) Employees must have the *possibility* for using *MSPs*. This implies that the physical layout of the installation (e.g., how easy it is for the employees to monitor each other's activity) and the work organization strategies (e.g., how much time the employees have available to monitor each other's activity) etc. must be designed to provide adequate possibility for *MSPs* use. (3) Employees must be *willing to use MSPs* in situations where they have identified safety hazards, possess the required knowledge and skills to intervene, and have the possibility for intervening. Whether or not employees are willing to use *MSPs* may depend on a variety of attitudinal and motivational factors, associated with the characteristics of the *individual employee*, the characteristics of the *work group and the local work environment*, and characteristics of the *overall organization*.

Employees' contribution to safety by the use of *MSPs* has generally received limited attention in safety studies. Studies performed from the *High Reliability Organization perspective,* however, constitute an exception (e.g., Rochlin et al., 1987; Sagan, 1993; Weick and Sutcliffe, 2001). This group of studies focus on what strategies high reliability organizations, e.g., nuclear power plants, apply to organise work activities to ensure that safety-critical decision will be timely and correct. The strategies uncovered are generally categorized as *decision/management redundancy* (Rochlin et al., 1987) or as *organizational redundancy* (Rosness et al., 2000), and they often imply the use of *MSPs*. Besides this group of studies, an example of a *MSP* that has frequently been addressed in the literature is the *four eyes principle* as applied within the domain of aviation.

This principle implies that pilot and co-pilot monitor the adequacy of each other's activity and are ready to intervene if they judge it to be necessary (e.g., Hawkins, 1987).

3. Purpose of the study

Within the framework of the project *HSE Petroleum: Change – Organization – Technology* (Hovden et al., 2004), an exploratory study was performed to obtain a better understanding of the type of contextual factors that may increase the use of *MSPs* at Norwegian petroleum installations. The study aimed at uncovering what factors that impact employees' *willingness* to use *MSPs*. Training programs can be introduced to ensure that employees have the *knowledge and skills* required to use *MSPs*. The physical work place and the work organization strategies can be designed to ensure that employees have the *possibility* for using *MSPs*. The types of initiatives that will serve to increase employees' *willingness* to use *MSPs* are, however, not as clear. The study aimed at uncovering whether factors associated with the individual level, the group level, or the organizational level would impact the employees' willingness to use *MSPs* to the same extent, or whether factors at one of these levels might have greater impact than the others. In practical terms, the purpose of the study was to provide guidance on what type of safety management initiatives that would most efficiently facilitate employees' willingness to use *MSPs*.

4. Method

The study was based on data obtained in two large-scale questionnaire surveys performed by the Petroleum Safety Authority Norway to assess the risk-level at the Norwegian Shelf (Husebø et al., 2002; Petroleum Safety Authority Norway, 2004). It comprised two parts: Part one, which was called the *original study*, and part two, which was called the *replication study*. The performance of the replication study was seen as necessary to increase confidence in the results obtained in the original study, due to the relatively low response frequency on the questionnaire survey (see below). The population was defined as all staff working on petroleum installations on the Norwegian Shelf. The original study was based on questionnaire responses obtained in the period 10–21 December 2001 (Husebø et al., 2002), and the replication study on questionnaire responses obtained 1 December 2003–18 January 2004 (Petroleum Safety Authority Norway, 2004). In all 3309 questionnaires were returned in the 2001-survey, and 8567 in the 2003/2004-survey. In both surveys, the response frequency was around 50–55% (Husebø et al., 2002; Petroleum Safety Authority Norway, 2004).

To obtain more control over the organizational contexts of the respondents both the original study and the replication study only included questionnaire responses in which the respondents had specified what work area they belonged to, i.e. *process*, *drilling*, *well service*, *catering*, *construction/modification*, *maintenance* or *crane/deck*. This implied that the number of participants was 2928 in the original study, and 7207 in the replication study.

The questionnaires applied in the 2001-survey and in the 2003/2004-survey were highly similar, even though some new items were added and some items slightly reformulated in the 2003/2004 survey. With the exception of a single item, all items used in the original study were repeated in the replication study. The structure of the two questionnaires was also identical. Both questionnaires had five parts. Part 1 addressed demographic data. Part 2 requested the respondent to evaluate 49 (original study) and 48 (replication study) items related to work place safety. The items were formulated very generally to ensure that they would be equally relevant to employees from all work areas. Four of the items contained in this part of the questionnaires referred to employees' use of *MSPs*: Three items referred to the respondent's use of *MSPs* (items A–C) and one item referred to the respondent's evaluation of his or her colleagues' use of a particular *MSP* (item D):

- Item A: I stop working if I find that continuing could imply a danger to myself or to others.
- Item B: I ask my colleagues to stop working, if I find that they perform their activities in a manner that threatens safety.

- Item C: If I observe dangerous situations, I report on these.
- Item D: My colleagues will stop me, if I work in a risky manner.

For all items in part 2 of the questionnaire, a standard five-point response scale with the following anchoring points was applied: Fully agree, partly agree, neither agree or disagree, partly disagree, and disagree. Part 3 of the questionnaire requested the respondent to evaluate the risk for a set of major accidents. Part 4 contained items that addressed the work environment and the recreational facilities offshore and, finally, part 5 contained items that addressed the respondent's state of health.

Based on the data obtained in the original study, a set of indexes was created to represent contextual factors that might impact employees' willingness to use *MSPs*. The score on each index was calculated by averaging the scores obtained on the individual items it comprised. The indexes represented contextual factors at three analytical levels: (1) The *individual level*, which referred to person-related factors. (2) The *group level*, which referred to factors related to the local work environment and the work group. (3) The *organizational level*, which referred to factors associated with the overall work environment at the installation. An index was seen as sufficiently reliable if it demonstrated a Cronbach's alpha value of 0.7 or more, as is the conventionally accepted minimum for rating scales (Murphy and Davidshofer, 2001).[1] In addition to the indexes a set of individual items was applied to represent contextual factors that could not be otherwise contained in the study. The adequacy of the assignment of variables to three analytical levels (individual, group, organisational) was tested using an exploratory factor analysis. The outcome of this analysis suggested that the assignment could be acceptable (Skjerve, 2005, 2006). Except for one index located at the individual level all indexes and single items that had been applied in the original study were also applied in the replication study. The reason for excluding this particular index was that it did not pass the reliability test in the replication study. For an overview of the variables applied in both part studies, see Table 1.

All analyses were performed using Statistica (Statsoft, 2001).

5. Results

5.1. Main characteristics of the respondents

The main characteristics of the respondents did not differ markedly in the original study and the replication study. In terms of age distribution, approximately 14% of the respondents were between 20 and 30 years old, 66% between 31 and 50 years old, and 20% older than 51 years. In terms of experience, around 10% had been working at petroleum installations between 0 and 1 year, 40% between 1 and 10 years, and 50% for more than 10 years. The respondents' distribution across work areas was also relatively similar in the two part studies (see Table 2).

It should be noted that the work area "crane/deck" only was applied as a separate work area category in the 2003/2004-survey. In the 2001-survey, crane/deck activities were classified in one of the other work area categories, depending on the dedicated purpose with the crane/deck activities (e.g., maintenance or well service, etc.).

5.2. Main characteristics of the datasets

Item analyses showed that the amount of variation in the subset of data based on part 2 of the questionnaires was limited in both part studies. In the original study the mean score was 3.71, and the mean standard deviation 1.13. In the replication study the corresponding figures were 3.93 and 1.00, respectively. The high level of homogeneity in the two datasets was not surprising given the very general formulations of the questionnaire items and the limited number of response alternatives. Still, it inevitably affected the outcomes of the data analyses. Thus, the strengths of the relationships uncovered between variables in the study were not necessarily representative (Hinkle et al., 1988). Stronger relationships might actually have existed.

[1] In one case, an index was accepted based on a Cronbach's alpha value of .69.

Table 1
Overview of the indexes and individual items applied in both the original study and the replication study

Name	Content of the items	A
Individual level		
Age	• Age?	
Overall health state	• In general, how would you characterize your state of health?	
Time in job position offshore	• Time in job position whole or part time off shore?	
Group level		
Task performance environment (index)	• I have received sufficient safety education and training. • The HSE procedures adequately cover my tasks. • Safety has first priority when I perform my job. • My colleagues are very engaged in HSE. • The safety delegates do a good job.	.71 *.69*
Managers' attitude to HSE (index)	• Suggestions and comments from safety delegates are being seriously dealt with by the management. • My leader appreciates that I call attention to issues of importance to HSE. • The company in which I work takes HSE seriously. • My leader is engaged in the HSE work at the installation.	.77 *.77*
Psychological work environment (index)	This index was calculated based on a subset of the items contained in part 4 of the questionnaire. The items applied requested the respondent to evaluate several aspects of the work environment offshore: (a) Possibility for planning own work; (b) Possibility for gaining in professional skills; (c) Relationship with colleagues; (d) Relationship with the immediate leader; (e) The manner in which the respondents work is appreciated; (f) The work environment in totality.	.82 *.82*
Colleagues' use of mindful safety practices (Item D)	• My colleagues will stop me if I work in a risky manner.	
Organizational level		
Overall work environment	*Index, composed of the following items:* • You can easily be perceived as quarrelsome if you call attention to dangerous conditions. • In practice, considerations for production are prioritized over considerations for HSE. • Insufficient maintenance has led to poorer safety. • Often parallel work operations lead to dangerous situations. • Insufficient co-operation between operator and contracting firms often leads to dangerous situations. • Reports about accidents or dangerous situations often become "trimmed"/"touched up."	.75 *.78*
Perceived risk level	This index was calculated based on part 3 of the questionnaire, which asked the respondent to rate the degree to which he or she felt personally endangered by different possible incident/accident events offshore. The events comprised: (a) Helicopter crash into the platform; (b) Gas leakages; (c) Fire; (d) Blow out; (e) Releases of poisonous gasses/materials/chemicals; (f) Collisions with skips or other objects in the sea; (g) Sabotage/Terror; (h) Breakdown in the installation's bearing constructions or loss of its ability to float; (i) Other work accidents.	.87 *.88*
Physical work environment	This index was calculated based on a subset of the items contained in part 4 of the questionnaire. These items requested the respondent to evaluate several aspects of the work environment offshore: (a) Noise; (b) Temperature; (c) Vibrations; (d) Hygiene/cleaning/tidiness; (e) Lightning conditions; (f) Air quality; (g) Protections against the weather; (h) Handling of chemicals; (i) Heavy lifts; (j) Repetitive work; (k) Work in inadequate positions; (l) Workload; (m) Work tempo; (n) Shift-work schedule; (o) Workplace design.	.89 *.88*
Spare-time and rest facilities	This index was calculated based on a subset of the items contained in part 4 of the questionnaire. These items requested the respondent to evaluate several aspects of the work environment offshore in terms of the quality of spare time and rest periods: (a) Noise; (b) Temperature; (c) Vibrations; (d) Hygiene/cleaning/tidiness; (e) Lighting conditions; (f) Air quality; (g) Food/Drink quality; (h) cabin standard; (i) Training facilities; (j) Additional recreational possibilities.	.87 *.87*

In relation to each index, two Cronbach's alpha values are reported. The first value refers to the outcome of the inter-item reliability test in the original study. The last value (in italics) refers to the outcome of the inter-item reliability test in the replication study.

Table 2
Distribution of respondents in terms of their work area association

Work area	Original study		Replication Study	
	%	*n*	%	*n*
Process	17.9	523	15.4	1108
Drilling	26	762	20.5	1480
Well service	7	205	8.2	589
Catering	10.9	319	10.2	733
Construction/Modification	7.3	215	7.5	542
Maintenance	30.9	904	31.5	2272
Crane/Deck			6.7	483

The distribution is reported in percent (%) and the actual number of respondents (*n*).

Table 3
Product-moment correlations between the three items on self-reported use of *MSPs* (casewise deletion of missing data)

Items	Item B		Item C	
	Original study		Replication study	
Item A	.30[a]	.28[a]	.26[a]	.26[a]
Item B			.46[a]	.45[a]

In the original study $n = 2884$. In the replication study $n = 7062$.
[a] $p < .001$.

5.3. Relationship between the use of different MSPs

Pearson product-moment correlations showed that the relationship between the *MSPs directed at other persons* (item B and item C) was *relatively* stronger than the relationship between these and the *MSP directed at the respondent him or her self* (item A). This was true in both the original and the replication study (see Table 3).

The results suggested that employees' willingness to use *MSPs* directed at other persons – at least to some extent – were affected by different contextual factors than their willingness to use *MSPs*, which only involved the respondent. The correlation coefficients obtained between the items representing *MSPs directed at other persons*, however, only accounted for around 20% of the variance in the datasets. This could suggest that the relationship might be weak, but the low levels of explained variation might also be seen as a consequence of the high level of homogeneity in the two datasets (see page 7).

Pearson product-moment correlations between the items on self-reported use of *MSPs* and the variables representing the contextual factors at the three analytical levels showed that the relationship between employees' willingness to use *MSPs* and *group-level* variables was stronger than the relationship with *individual level* and *organizational level* variables. This was true in both the original and the replication study (see Table 4).

The results further revealed that even though variables at the group level demonstrated stronger relationships with all three items on self-reported use of *MSPs*, the correlation coefficients obtained were higher for the *MSPs directed at other persons* (item B and item C) than for the *MSP directed at the respondent him or her self* (item A). Regardless of the fact that correlations say nothing about the direction of a relationship, it seemed reasonable in the present context to interpret the results to suggest that factors at the group level in general affect employees' willingness to use *MSPs* more markedly than factors at the individual and organizational levels, and that this particularly is the case with respect to *MSPs directed at other persons*.[2]

Separate multiple regression analyses performed on each of the three items on self-reported use of *MSPs* also suggested that employees' willingness to use *MSPs* was more markedly associated with the group level factors, than factors at the individual and organizational levels (see Tables 5–7).[3] In both part studies, the variables *task*

[2] It should be noted that Pearson product moment correlations performed separately on the datasets for each work area revealed a similar patterns of results as reported in Table 4.

[3] It should be noted that the tables only include variables that contributed to account for the variation in one or both of the studies.

Table 4
Product-moment correlations between the three items on self-reported use of *MSPs* and the contextual factors variables (casewise deletion of missing data)

Contextual factors	Item A		Item B		Item C	
	Original study	Replication study	Original study	Replication study	Original study	Replication study
Individual level						
Age	.05[a]	.05[c]	.10[c]	.08[c]	.13[c]	.11[c]
Overall health state	.02	.06[c]	.08[c]	.07[c]	.06[b]	.11[c]
Time in job position offshore	.03	.04[b]	.11[c]	.07[c]	.08[c]	.08[c]
Group level						
Task performance environment	.30[b]	.25[b]	.44[b]	.39[b]	.45[b]	.44[b]
Managers' attitude to HSE	.23[b]	.26[b]	.38[b]	.31[b]	.39[b]	.36[b]
Psychological work environment	.12[c]	.15[b]	.23[b]	.21[b]	.22[b]	.24[b]
Colleagues' use of mindful safety practices	.26[b]	.26[b]	.40[b]	.35[b]	.33[b]	.34[b]
Organizational level						
Overall work environment	.07[b]	.16[b]	.06[b]	.21[b]	.06[b]	.26[b]
Perceived risk level	.06[b]	.09[c]	.12[c]	.10[c]	.08[c]	.10[c]
Physical work environment	.08[b]	.12[b]	.17[c]	.16[b]	.18[c]	.20[b]
Spare time and rest facilities	.12[c]	.10[c]	.16[c]	.13[b]	.14[c]	.16[b]

In the original study $n = 2379$. In the replication study $n = 5506$.
[a] $p < .05$.
[b] $p < .01$.
[c] $p < .001$.

Table 5
Multiple regression analysis on item A

	Study	Beta	Standard error of beta	B	Standard error of B	$t(2422)$ $t(5508)$	p-level
Intercept	Original			3.08	0.16	19.37	0.000
	Replication			2.90	0.11	26.47	0.000
Colleagues' use of mindful safety practices	Original	0.16	0.02	0.13	0.02	6.87	0.000
	Replication	0.17	0.02	0.15	0.01	11.12	0.000
Spare-time and rest facilities	Original	0.06	0.03	0.07	0.03	2.21	0.027
	Replication						
Physical work environment	Original	−0.11	0.03	−0.15	0.04	−3.73	0.000
	Replication						
Managers' attitude to HSE	Original	0.07	0.03	0.07	0.03	2.30	0.022
	Replication	0.15	0.02	0.16	0.02	7.73	0.000
Task performance environment	Original	0.20	0.03	0.26	0.04	7.00	0.000
	Replication	0.09	0.02	0.12	0.03	4.68	0.000

Original study: Regression summary for dependent variable: Item 27. $N = 2433$. $R = .33$. $R^2 = .11$ Adjusted $R^2 = .11$ $F(10, 2422) = 30.07$ $p < .0001$. Standard Error of estimate: .72. Replication study: Regression summary for dependent variable: Item 25. $N = 5520$. $R = .32$. $R^2 = .10$. Adjusted $R^2 = .10$. $F(11.5508) = 56.047$ $p < .0001$ Standard Error of estimate: .70.

performance environment, *colleagues' use of MSPs*, and *managers' attitude to HSE* contributed most to account for the variation obtained. This was true both for the *MSPs directed at other persons* (item B and item C) and for the *MSP directed at the respondent him or her self* (item A).

In both the original study and the replication study the levels of explained variation accounted for in the multiple regression analyses were quite low. For items A, B and C, the variations accounted for in the original study were 11%, 24% and 23%, respectively. In the replication study, the corresponding figures were 10%, 19% and 22%, respectively. Again, this could suggest that the level of variation accounted for might be very limited or it might be seen as a consequence of the high level of homogeneity in the two datasets (see page 7).

Table 6
Multiple regression analysis on item B

	Study	Beta	Standard error of beta	B	Standard error of B	t(2420) t(5500)	p-level
Intercept	Original			1.60	0.15	10.73	0.0000
	Replication			1.97	0.10	19.03	0.000
Age	Original	0.06	0.02	0.04	0.01	3.04	0.0024
	Replication						
Time in job position offshore	Original						
	Replication	0.04	0.02	0.03	0.01	2.57	0.010
Colleagues' use of mindful safety practices	Original	0.22	0.02	0.19	0.02	10.26	0.0000
	Replication	0.21	0.01	0.18	0.01	14.69	0.000
Physical work environment	Original	−0.08	0.03	−0.10	0.04	−2.83	0.0047
	Replication						
Managers' attitude to HSE	Original	0.12	0.03	0.13	0.03	4.58	0.0000
	Replication	0.08	0.02	0.09	0.02	4.39	0.000
Task performance environment	Original	0.27	0.03	0.37	0.04	10.37	0.0000
	Replication	0.24	0.02	0.32	0.02	13.61	0.000

Original study: Regression summary for dependent variable: Item 35. $N = 2431$ $R = .50$ $R^2 = .25$. Adjusted $R^2 = .24$ $F(10, 2420) = 78.75$ $p < .0001$ Standard error of estimate: .68. Replication study: Regression summary for dependent variable: Item 33. $N = 5512$. $R = .44$. $R^2 = .19$. Adjusted $R^2 = .19$. $F(11.5500) = 117.79$ $p < .0001$ Standard error of estimate: .66.

Table 7
Multiple regression analysis on item C

	Study	Beta	Standard error of beta	B	Standard error of B	t(2424) t(5508)	p-level
Intercept	Original			2.49	0.12	20.63	0.0000
	Replication			2.37	0.08	29.23	0.000
Age	Original	0.07	0.02	0.05	0.01	3.97	0.0001
	Replication	0.05	0.02	0.03	0.01	3.06	0.002
Overall health state	Original						
	Replication	0.04	0.01	0.04	0.01	3.47	0.001
Colleagues' use of mindful safety practices	Original	0.12	0.02	0.08	0.01	5.44	0.0000
	Replication	0.15	0.01	0.10	0.01	10.45	0.000
Managers' attitude to HSE	Original	0.15	0.03	0.13	0.02	5.61	0.0000
	Replication	0.10	0.02	0.09	0.02	5.95	0.000
Task performance environment	Original	0.31	0.03	0.34	0.03	11.94	0.0000
	Replication	0.29	0.02	0.31	0.02	16.56	0.000

Original study: Regression summary for dependent variable: Item 38. $N = 2435$. $R = .48$ $R^2 = .23$. Adjusted $R^2 = .23$ $F(10, 2424) = 71.85$ $p < .0001$ Standard error of estimate: .55. Replication study: Regression summary for dependent variable: Item 36. $N = 5520$. $R = .47$. $R^2 = .22$. Adjusted $R^2 = .22$. $F(11.5508) = 143.27$ $p < .0001$ Standard error of estimate: .52.

To uncover *potential differences between employees' willingness to use MSPs between the work areas*, the three items on self-reported use of *MSPs* and the contextual factors variables were subjected to Pearson product moment correlations separately on the datasets from each work area. No marked differences could be found (Skjerve, 2005, 2006). In both part studies, the patterns of results obtained were all highly similar to the pattern reported in Table 4. Mann–Whitney U tests and Kruskal–Wallis One-Way ANOVA by Ranks tests were furthermore used to explore potential differences between the work areas (Skjerve, 2005, 2006). The results obtained in the original study indicated that employees might be more willing to use *MSPs* if they possessed a high level of familiarity with their local work area (e.g., generally working two or more years in the same work area), than if they possessed a lower level of familiarity with their local work area (e.g., generally working only 2–3 weeks only in a particular local work area). These results were, however, not replicated.

6. Discussion of the results

The results of the present study suggested that employees' willingness to use *MSPs* was more strongly associated with factors at the *group level*, i.e. factors associated with the employee work group and their local work environment, than with factors at the individual and organizational levels.

The relatively stronger influence of variables at the group level may suggest that employees' willingness to use *MSPs* is affected by *group norms.* Group norms can be defined as "... rules or standards established by group members to denote what is acceptable and unacceptable behaviour" (Glendon and McKenna, 1995, 171). It has long been recognized that group members may exert *strong* influences upon the way in which an individual group member acts (Asch, 1958; Sherif, 1936). Group norms were described in the classic studies of assembly-line workers in the Hawthorne Western Electric Factory (Roethlisberger and Dickson, 1939). These studies demonstrated that factory workers developed informal norms for how much group members should produce, as well as various sanctions (e.g., name calling) to be directed at group members that breached the norms. Group norms have often been addressed from the perspective of their potential *negative* effects. Some studies have reported that groups often make riskier decisions than separate individuals (e.g., Wallach et al., 1962). This phenomenon is generally referred to as *the risky shift* (Kogan and Wallach, 1964). Janis (1972) proposed that highly cohesive groups may engage in *group think,* i.e. a pattern of interaction that sometimes leads to unethical decisions or decision with catastrophic consequences. Group norms may, however, also have *positive* effects on employees' willingness to contribute to safety in an operational environment. This has been accounted for in various studies performed from the *High Reliability Organization perspective* (e.g., Bierly and Spender, 1995; Rochlin et al., 1987). An employee may learn what constitutes adequate safety-related behaviour through formal training and education, but informal feedback and observations of how colleagues deal with safety-related issues also have a strong effect on the work practices that the employee will adopt.

Donald and Canter (1993, as cited by Glendon and McKenna, 1995) identified three overall types of contextual factors which they suggested would impact employees' attitudes towards health and safety:

- Organizational rules, i.e., perceptions of others' attitudes, especially workmates, supervisors, higher management and safety representatives.
- Safety-object attitudes, i.e., the attitudes towards e.g., checking of equipment and making suggestions for how safety can be improved.
- Behaviour in respect of safety, herein with respect to (potentially) safety-critical situations.

The results of Donald and Canter correspond well with the finding in the present study.

A critical question is whether employees with a positive attitude to *MSP* use, which is anchored in work group norms, will *behave* according to their attitude in practice. *Cognitive Dissonance* theory (Festinger, 1957) holds that a person will experience unpleasant psychological tension, i.e. cognitive dissonance, when inconsistency exists between his or her attitude and behaviour. It claims that the person will strive to reduce or eliminate this tension by changing either the attitude or the behaviour. When a positive attitude to *MSP* use is anchored in work group norms, it is difficult for the individual employee to change the attitude. For this reason, the employees would be expected to behave according to the attitude, i.e. to use *MSPs*. More recent research has demonstrated that the attitude-behaviour relationship is more complex. During the latest decades, the theory of *Reasoned Action* (Fishbein and Ajzen, 1975), the closely related theory of *Planned Behaviour* (Ajzen, 1985, 1991), and the theory of *Attitude Accessibility* (Fazio, 1986) have served as key reference models on the attitude-behaviour relationship. The theories of *Reasoned Action* and *Planned Behaviour* focus on behaviour under volitional control. They are based on the assumption that humans tend to be rational and make systematic use of the information available. Both theories hold that a high correlation exists between a person's intention to behave in a particular way and his or her actual behaviour. However, they also identify a set of factors that moderates the attitude-behaviour relationship. These factors include the person's belief about what consequences that will follow from the behaviour and what important others will think if the person engage in the particular behaviour. In addition, the theory of *Planned Behaviour* introduces the factor 'perceived behavioural control' as a moderator. The theory of *Attitude Accessibility* is based on associative learning. It conceptualises an attitude as a learned association between a concept and an evaluation, and stresses that the attitude strength may vary. This theory holds that attitudes which are easy to recall from memory are more likely to guide behaviour than attitudes, which are not easily recalled. It further stresses that attitudes may automatically activate behaviour and thus guide performance without volitional control. The attitude-behaviour relationship has been the subject of a high number of studies, and it is by far beyond the scope of this paper to account for them all. The studies have produced a range of insights about the factors that moderate and mediate the attitude-behaviour relationship, but presently no final answer has been found on the attitude-behaviour relationship. Based on studies of the attitude-behaviour relationship it can, however, be concluded that *no direct link* can be expected to exist between employees' attitude to *MSP* use and their actual use of *MSPs.* A variety of situational factors, person characteristics, and characteristics of the attitude will moderate and mediate the attitude-behaviour relationship. However, since group norms have a marked impact on individual behaviour (Smith and Terry, 2003), the likelihood the employees will *behave* according to their attitude on *MSP* use can still be assumed to increase when their attitude is anchored in work group norms.

Another critical question is to what extent *other* work group norms, such as norms associated with productivity, may come to counteract *MSP* use. A work group that holds norms for *MSP* use can also be assumed to hold norms for other work place issues. For this reason situations may arise where the behaviour associated with a work-group norm based positive attitude to *MSP* use, and the behaviour associated with other work-group norm based attitudes, are *mutually exclusive*. If an employee, e.g., during the performance of a task reckons that *MSP* use is required, but at the same time reckons that using a *MSP* will imply that another workgroup norm is violated (e.g., a norm for completing operational tasks in time), he or she will face a goal conflict. The presence of goal-conflicts in situations where the use of *MSPs* are required can be assumed to markedly reduce the likelihood that *MSPs* will be used. Thus, positive attitudes and work group norms in support of *MSP* use are clearly essential factors for ensuring *MSPs* use. However, these factors alone do not guarantee that *MSPs* will be used in practice in situations where employees possess the skills and have the possibility for doing so (see Section 2). Obtaining a better understanding of the relationship between employees' attitudes and their behaviour will be an objective for future research.

Even though the main findings in the first part of the study were replicated in the second part of the study, the results should be considered with some care. The reason is that the first part of the study (the original study) is associated with a set of constraints that may impact the results, and that the second part of the study (the replication study) is associated with the same constraints: First, the response rate was around 50–55% (in both part studies) and there is a risk that the respondents may systematically differ from employees that did not respond to the questionnaire. Second, the contextual factors associated with the individual level were in most analyses covered by 1-item variables only, whereas factors at the group and organizational levels comprised more indexes. This may have reduced the possibility for uncovering relationships between the use of *MSPs* and factors at the individual level. Third, the identification and definition of the contextual factors was constrained by the items contained in the questionnaire. It seems likely that variables, which were not contained in the present study, such as e.g., personality traits associated with risk acceptance, might better account for employees' willingness to use *MSPs directed at the respondent him or her self*.

Still, the main part of the results obtained in the first part of the study was reproduced in the second part of the study, and the results seem plausible, as they demonstrate correspondence to the results obtained in earlier studies. This adds to the reliability and validity of the outcome of the study.

7. Practical implications

Based on the above interpretation of the results, the study suggests that safety management practices aimed at increasing employees' willingness to use *MSPs* will be most efficient if they are directed at the *employee work groups and their local work environments*, rather than at the employees individually or at the employees working on the installation in general. This is in particular true for *MSPs* directed at other persons. The study further suggests that employees' willingness to use *MSPs* might potentially change in two types of situations:

→ Situations where employees are transferred to a new local work environment.
→ Situations where changes are introduced in the present local work environment of the employees.

In these situations the alternations in the employees' local work environment might imply a partial or full breakdown in existing group norms, and systematic efforts to maintain or enhance the use of *MSPs* might be called for.

The study provides no knowledge about what *concrete* safety management practices that may contribute to increase employees' willingness to use *MSPs*, but it does suggest that the establishment of work group norms which support the use of *MSPs* will be a critical activity. To achieve this type of norms it seems essential first to ensure that *no negative sanctions* (such as name calling, being socially isolated, being intimidated, etc.) will be associated with *MSP* use, neither for the employee who uses the *MSPs* nor for any colleague which the practices may be directed towards. The use of *MSPs* is based on an employee's *subjective judgment* of the safety level in a given situation, and colleagues and managers may agree or disagree with the outcome of a judgement. Still, if an employee experiences negative sanctions from colleagues or managers in relation to *MSP* use, it is reasonable to assume that he or she will be more reluctant to use *MSPs* in the future.

With the above as a basis, a range of interrelated safety management practices could be suggested, to facilitate employees' *willingness* to use *MSPs* and to contribute to ensure that the use of *MSPs* will increase the safety level at an installation.

Depending on the characteristics of the work group members, it might be relevant to provide employees with the *knowledge and skills* required to effectively identify and intervene with *MSPs*. As discussed in Section 2, the task of deciding *when* to use a *MSP* is not necessarily straightforward, and clarification of what *safety standards* employees should adhere to is an important issue: Even if two groups of employees are equally willing to use *MSPs*, employees in a work group that adhere to lower safety standards can be expected to intervene more rarely (accepting more risk), than employees in a work group that adhere to higher safety standards (accepting less risk). To increase the likelihood that *MSP* use will contribute to increase the safety level at an installation, it should be ensured that the safety standards adhered to by work group members correspond to the needs in the local work environment.

Other educational and group-norm building activities could include, e.g., exemplifications of how the use of *MSPs* have contributed to safety in the past, clarification of the particular *MSPs* that work group members use, and offering employees opportunities for practicing *MSP* use. By providing hands-on experience with the challenges that may face an employee who judges whether or not to use a *MSP* and/or how to intervene, the employees may gain valuable insights into the factors that affect *MSP* use in practice. This last initiative might also contribute to raise employees' understanding of why *MSPs* sometimes are used less effectively that desired, and thus serve as a spur to create a work environment that facilitates effective use of *MSPs*. Finally, work group members could be encouraged to clarify and prioritize existing work group norms – and their associated attitudes and behaviours (as discussed in Section 6) – with the purpose of reducing the likelihood that goal-conflicts may come to negatively impact *MSPs* use.

In general, *MSPs* can be said to reflect the understanding of work group members about what risks their work entails, and the informal repertoire of *MSPs* applied by work group members may thus change across time depending on the attributes of the local work environment. Safety management practices that imply a continuous focus on *MSPs use*, such as including *MSPs* as a topic on the agenda in safety meetings, will contribute to ensure that new insights gained by individual work group members about risks in the local work environment are shared. This type of practices will increase the likelihood that the *MSPs* used at any given time will efficiently contribute to protect against risks in the local work environment. Introducing safety management practices aimed at increasing employees' willingness to use *MSPs,* and ensuring that the *MSPs* applied continually correspond to the needs in the local work environment, will add to the robustness of petroleum installations: It will increase the likelihood that employees are be able to efficiently identify and adequately intervene in situations were unanticipated safety hazards arise.

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