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Evidence from Safety Culture that Risk Perception is Culturally Determined

Abstract

Analyses of a construction related Risk Perception Questionnaire (n=194) and ten distributions of a Safety Climate questionnaire, sampling a total population of 1325 personnel from three industrial sectors (Manufacturing, Chemicals and Foods) consistently revealed statistically significant differences between occupational groupings in their perceptions of risk Multiple regression analyses provided insights into the organisational, job and individual biasing factors that appear to determine each groups 'frame of reference' when evaluating workplace risks, suggesting possible explanations for differences between the groups which are of both theoretical and practical importance.

Introduction

In January 1993, the Management of Health and Safety at Work Regulations (MHSWR)[1] came into effect, which require employers to assess the health and safety risks posed to employees and others, whilst in the workplace. In other words, every employer has to conduct risk assessments of all their activities. Moreover, these assessments must also be revised if the original assessment is no longer valid because of new or changed risks. However, people's ability to determine the risks of perceived hazards is influenced by a combination of situational, attitudinal and behavioural biasing factors. Situational biasing factors, for example, include the manner in which hazards are presented in communications [2, 3]. 'Attitudinal biasing factors include people's beliefs about the factors that cause accidents [4]; the amount of control individuals feel they have over hazards [5]; the ease with which past instances of risky or dangerous situations/events can easily be recalled or imagined [6, 7]; and Group characteristics [8]. Behavioural biasing factors will mainly include the on-the-job' experience of the individual [9].

Group Characteristics

With regard to group characteristics, although very little evidence is available that has examined differences in risk perception between occupational groupings in the workplace, marked differences in perceived risk have been found between different occupations [10, 11, 12, 13, 14]. Other research has revealed differences in risk perceptions between occupational groupings working on the same tasks, who are employed at different levels of the organizations hierarchy. For example, a questionnaire study conducted in the nuclear industry [15] examined three facets of perceived risk: Risk taking (Behaviour); The perceived risks involved in working in a nuclear plant (Situation); and, Acknowledgement of risks at work in combination with personal confidence to control the risks (Attitude). The results from a sample of 5,295 respondents indicated that managers and supervisors tended to be significantly more cautious in their approach to risks than process or craft workers; that line management and craft workers perceived the risks involved in the plant to be greater than process, laboratory and office workers; and that craft and process workers were more confident in their own ability to control the inherent risks than managers and support staff. Other studies have shown that supervisors are poor sources of information about the dangers inherent to a workers task, as they may be too far removed from operations to make meaningful assessments [16]., and under-estimate risks, when compared to workers own risk assessments [17, 18]. Importantly, if employee's perceive workplace risks to be underestimated by management, it is likely that their commitment and loyalty to that organisation will be undermined as the employer will be perceived to be unwilling to provide a safe working environment [19].

Organisational Culture

As a whole, the above body of evidence supports the notion that perceived risk is culturally defined [20] by factors such as occupation or hierarchical position. That is, the prevailing social norms within an occupation or hierarchical level, dictate each groups 'frames of reference' in relation to risk, which in turn dictates their risk-taking behaviour, and attitudes towards risk in general. Importantly, these norms are thought to be reflected in, and determined by the organisation's safety culture. Organisational culture has been defined as '... *the product of multiple goal-directed interactions between individuals, jobs and organisations* [21], whereby the prevailing culture of interest (e.g. safety, quality, etc.) is reflected in the dynamic inter-relationships between employees perceptions about organisational goals; their day-to-day goal-directed behaviour; and the presence and quality of organisational systems to support employees goal-directed behaviour. Reflecting Bandura's model of Reciprocal Determinism' derived from Social Learning Theory [22], Cooper's [21] model of safety culture (See figure 1) explicitly recognises that the relative strength of each element may differ in any given situation (e.g. the design of a production system may exert stronger effects on people's safety behaviour, than their attitudes towards safety). Similarly, the reciprocal

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influence of each element may not occur simultaneously (i.e. it may take time for a change in a groups safety behaviour to exert an influence and activate the reciprocal relationship with either the organisation's safety systems or the group's attitudes towards safety).

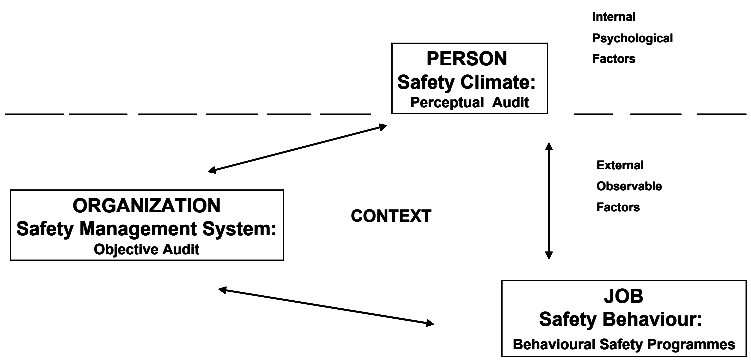

Figure 1: Cooper's(1993c) Reciprocal Safety Culture Model

As shown in figure 2, the practical utility of this analytic framework is enhanced by the fact that the model can be further applied to each individual element of the model. For example, in relation to safety climate, people may hold attitudes and perceptions about organisational safety goals that encompass person (e.g. attributions of blame), job (e.g. required workpace) and organisational (e.g. emergency preparedness) variables. Similarly, goal-directed safety behaviour could be affected by person (e.g. goal-commitment), job (e.g. goal-conflict) and organisational (e.g. communications) variables. Moreover, these reciprocal relationships could also apply to those organisational systems that support goal-directed job behaviour. For example, person factors (e.g. personnel selection) could interact with both job (e.g. .team-working) and organisational (e.g. allocation of resources) variables. Empirical efforts that have attempted to examine these relationships support the notion that safety culture can be meaningfully analysed by the use of this reciprocal model [22, 23 24].

Hypotheses

Much of the evidence discussed suggests that risk perception in the workplace is culturally determined by group characteristics[20]. As such, perceptions of risk should differ between hierarchical levels in an organisation, regardless of the industrial sector, because of differences in each group's 'frame of reference'. However, it is unknown at the present time what constitutes each groups frame of reference. Thus, making use of the safety culture model presented in figure 1, it is proposed to explore various situational, attitudinal and behavioural biasing factors to examine the extent to which each factor might be exerting an influence on the different groups frame of reference, when estimating risk.

Method.

Survey data from a risk perception measure conducted in the construction industry and seven separate administrations of various safety climate measures in the manufacturing, chemical and food industries were explored to examine the extent to which hierarchical position influenced perceptions of workplace risks. Each of these measures and the results of each are detailed below.

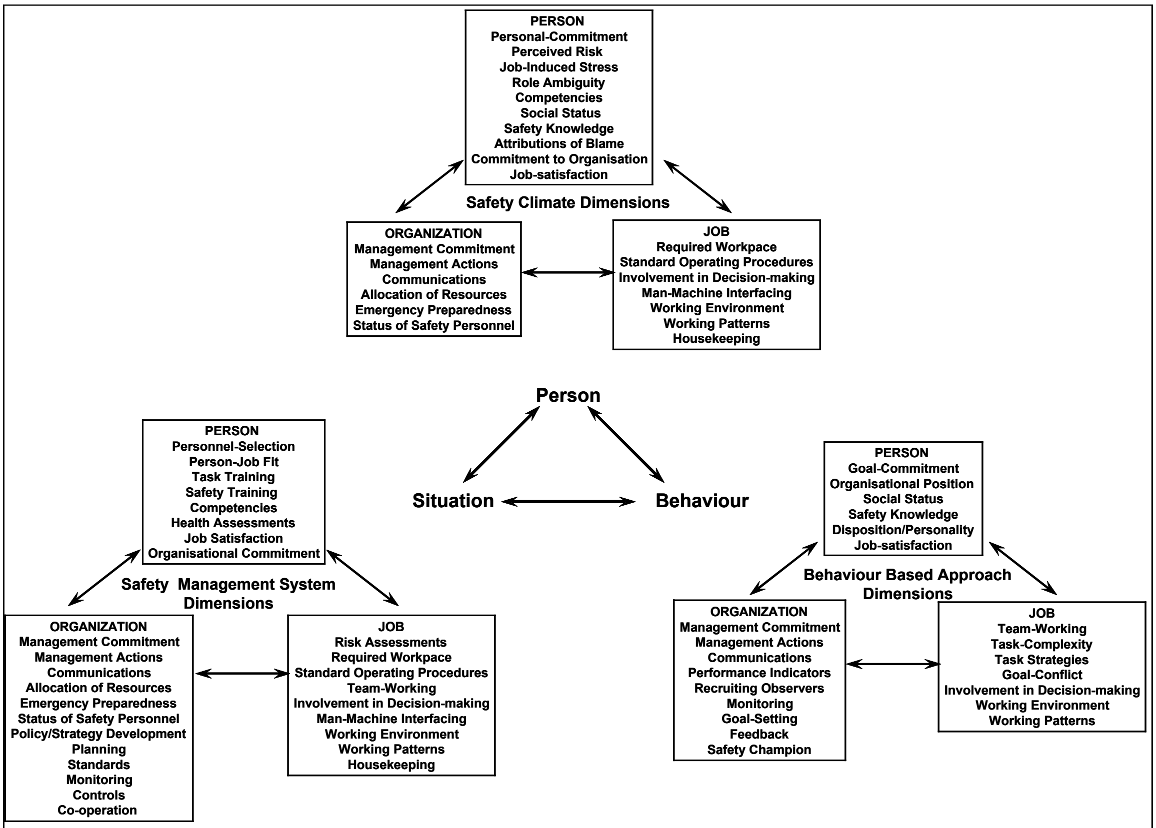

Figure 2: Cooper's (1993c) Reciprocal Model of Safety Culture applied to each element

Study One : Construction Industry

The construction industry has the worst safety record of any sector of the British economy. Year on year since 1905, there have been approximately 150 fatalities, 2500-3000 serious injuries requiring hospitalisation, 30-40,000 lost-time injuries and 750,000 minor injuries reported. Given the extent of under-reporting of accidents in this industry, these figures are considered to be conservative estimates. Due to this appalling accident rate, the British Health & Safety Executive funded a study to examine the utility of goal-setting and feedback techniques to improve construction site safety [25]. During this study, a questionnaire was constructed with a view to developing a generic site safety performance measure based upon industry personnel's perceptions of risk. This required the identification of a pool of unsafe acts and conditions derived from a detailed literature review of scientific journals, HSE publications, construction safety manuals, accident records and scripts from contractor's 'on site' training talks for operatives. Initially, 122 unsafe items were identified. On the basis of fatal and major injuries reported to the Health and Safety Executive[26] and a small sample pilot survey, Seventy-one of these items were selected and sub-divided into 38 observable behaviours and 33 conditions, and allocated to the following seven categories:

- Access to Heights
- Housekeeping;
- Excavations
- Personal protective equipment
- Scaffolding
- Mechanical Plant
- Roofing

The items were incorporated into a questionnaire and distributed to 200 site operatives, 200 site managers and 30 company safety officers. The respondents were required to rate each of the seventy-one activities, expressed in terms of unsafe acts or conditions, in terms of their frequency of occurrence, likelihood of an accident, and severity of injury. Frequency estimates were rated in percentage terms on an eleven point scale (range = 0-10). Each scale point was anchored on a continuum between Never and Always. The likelihood questions were also rated in percentage terms on an eleven point scale, but with each scale point anchored by different expressions of amount [27]. Severity was rated on a seven point scale, determined by industry standard definitions of various types of injury. These were:- 1] no injury; 2] injury not requiring medical attention; 3] injury requiring minor medical attention but able to work same day; 4] lost-time injury, more than one day, but less than three days off; 5] lost-time injury, three days or more; 6] major injury (i.e. Hospitalisation); 7] death. Respondents were also asked questions about their experience in the construction industry. To minimise the possibility of biased frequency ratings caused by those with many years experience in the industry, respondents were requested to rate the items based solely on their experiences in the previous five years. The means of the three ratings were multiplied to produce an indication of the perceived risk of each item (see figure 3).

Figure 3: Perceived risk Formula

When operatives are working on scaffolds......

How often do they work on platforms that are not fully boarded?	X	*What is the likelihood that an injury will occur?*	X	*What would the severity of injury most likely be?*		
Frequency		*Likelihood*		*Severity*	=	*Total*
4.32	X	*4.01*	X	*3.20*	=	*55.43*

<u>Construction Industry Results</u>

One hundred and ninety-four questionnaires were fully completed and returned, giving a 47% response rate. Site management (n=110) comprised the largest group, followed by operatives (n=69) and company safety officers (n= 15). Operatives had the least average trade (5.5 yrs) and construction industry (7.18 yrs) experience, followed by managers with 6.31 yrs trade and 14.26 yrs construction industry experience. Company safety officers had an average of 8.64 yrs trade and 18.14 construction industry experience. Twenty-one operatives, fourty-three managers, and one safety officer had been accident victims.

Initial analyses were conducted on each of the seven categories via a series of two-way ANOVA's (analysis of variance) to examine the possibility of any combined effects of occupational group with construction industry experience, trade experience, and accident involvement. However, no interactions were found, indicating that the data should be analysed by individual groupings. A series of Oneway Anova's were conducted on each category to test for differences in perceptions between occupational groupings, trade or construction experience, and accident involvement. Surprisingly, no significant effects emerged for trade or industry experience or accident involvement [9, 28]. However, main effects were found in relation to occupational grouping for the Access to heights, Scaffolding, Housekeeping, Mechanical plant, and Excavation categories (see table 1). Post-hoc comparisons (Scheffe test @ .05 level of significance) revealed that the operatives and managers ratings differed significantly for the Access to Heights, Housekeeping and Mechanical plant categories.

Table1: Oneway Anova Results for Category by Occupational Grouping.

					Mean Scores	
	df	n	F	p<	Operatives	Managers
Access to Heights	2	191	4.73	.01	72.14	48.24*
Scaffolding	2	191	3.21	.05	83.10	55.20
Housekeeping	2	191	6.98	.01	88.48	55.18*
Mechanical Plant	2	191	5.11	.01	79.73	45.46*
Excavations	2	191	4.30	.05	75.57	45.82
Roofing	2	191	1.42	ns	78.33	63.64
PPE	2	191	1.73	ns	69.14	45.86

*= Significant mean differences @ .05 level.

To examine the extent to which the groups differed in their estimates of frequency, likelihood and severity, a further series of Oneway Anova's were conducted. Main effects were found for all three components within the Scaffolding, Housekeeping and Excavation categories. Main effects for frequency of occurrence emerged in the Access to Heights and Mechanical Plant categories, and severity of injury in the Access to Heights category. In each case, post-hoc comparisons (Scheffe test with .05 level of significance) revealed that the operatives ratings were significantly higher than the managers (see table 2).

Table 2: Differences in Rating Components of Risk Formula by occupational grouping

	df	n	F	p<	Mean scores Operatives	Managers
Access to Heights						
Frequency	2	191	5.55	.01	3.09	2.16*
Likelihood	2	191	3.24	.05	3.22	2.66
Severity	2	191	5.09	.01	2.38	1.85*
Scaffolding						
Frequency	2	191	4.32	.05	3.21	2.07*
Likelihood	2	191	4.01	.05	3.75	2.73*
Severity	2	191	3.20	.05	2.63	1.95*
Housekeeping						
Frequency	2	191	8.46	.01	3.51	2.51*
Likelihood	2	191	8.42	.01	3.73	2.70*
Severity	2	191	10.20	.01	2.43	1.74*
Mechanical Plant						
Frequency	2	191	3.39	.05	3.08	2.15*
Likelihood	2	191	1.65	ns	3.29	2.67
Severity	2	191	2.37	ns	2.52	2.03
Excavations						
Frequency	2	191	3.79	.05	3.29	2.32*
Likelihood	2	191	8.04	.01	3.65	2.31*
Severity	2	191	3.92	.05	2.61	1.85*
Roofing						
Frequency	2	191	2.33	ns	3.02	2.37
Likelihood	2	191	2.44	ns	3.71	2.81
Severity	2	191	2.04	ns	2.70	2.17
PPE						
Frequency	2	191	1.96	ns	3.02	2.12
Likelihood	2	191	.69	ns	3.07	2.56
Severity	2	191	.90	ns	2.36	1.96

* = Significant differences in mean scores @ .05 level.

These results support the notion that group characteristics exert important influences on risk perception [8] and that managers consistently under-estimate the risks involved, compared to operative ratings [16,17,18]. However, they only partially support the findings of Slovic et al.[29] that groups differ in their perceptions of the likelihood of an accident occurring. The results presented in table 2 would, therefore, suggest that occupational groups are more likely to differ in their perceptions of the frequency of occurrence of certain events and the resulting severity of injury, rather than the likelihood of such an event leading to injury. Nonetheless, the question as to which group's subjective risk perceptions are the most accurate, still remains.

Safety Climate Resaerch

Because safety culture is a dynamic entity that is continuously changing there is a need for reliable and valid instruments that measure attitudes, behaviours and organizational safety systems so that the effectiveness of improvement programs can be properly assessed and evaluated. Psychometric measures focused on perceptions about, and attitudes towards safety are commonly used to assess the prevailing 'safety climate'. Research evidence shows that climate differs from culture in many important ways. In a review of this evidence, Rousseau [30] highlighted the distinctions between the two, and showed that climate is more specific as it refers to peoples *descriptions* about their everyday experiences, whereas culture largely reflects the prevailing social group norms. Thus, although the two are clearly related, culture alludes to the prevailing behavioural norms for a particular workgroup, whereas climate is more concerned with the way a person describes their perceptions of these behavioural norms. In essence, a good 'safety climate' is characterised by a collective commitment of care and concern, whereby those in an organisation share similar perceptions and positive attitudes to safety. These can be enhanced by the adoption of good technical, ergonomic and organizational practices that have been shown to improve safety. In combination these factors serve to construct a perceived image of risk, danger and safety in an organisation that is self-sustaining.

One method of studying 'climate' is to devise a measure of the specific attributes that make up a particular type of organizational climate, and to aggregate respondent's climate scores, based on the agreement of how they describe their environment [31, 32, 33]. The usefulness of this approach is that it allows the description of organisational attributes in terms that have meaning for the individual. It has been found that these 'collective' climates affect various work outcomes, because they serve as a 'frame of reference' that shapes people's attitudes and behaviours [34]. Various psychometric measures have been devised to specifically measure safety climate [35, 36, 37, 38].

Manufacturing Industry

Upon completion of the HSE funded research in early 1992, a behavioural safety initiative was implemented in the UK manufacturing sector [39]. An adapted Safety Climate measure, originally developed for the construction industry [38] was distributed to 540 employees prior to implementation. This comprised 50 items within 7 dimensions, which measured perceptions of risk, management attitudes, management actions, the required workpace, safety training, status of safety personnel, and the effects of working safely on employee's social status. A response rate of 71 percent, produced 374 fully completed questionnaires. Analyses proved the measure to be highly reliable (Cronbach's Alpha = 0.93) [40]. Occupational groupings were divided into managers (n=52), supervisors (n=11) and process workers (n=173) and subjected to a series of Oneway Anova's. Unfortunately 37% (n=140) did not indicate their occupational grouping and were excluded from the analyses. Nonetheless, perceptions of risk were found to differ between occupational groups ($F(2,234)=27.27$, $p<.0001$) supporting the notion that risk perception is culturally determined (see table 3).

A follow-up study to psychometrically validate the Safety Climate measure and empirically examine the effects of the behavioural safety initiative on safety climate [22] was conducted 12 months later, with 187 questionnaires being fully completed and returned. The results confirmed the measures reliability (Alpha = 0.93) and two factor structure [40]. Occupational groupings were again divided into managers (n=28) , supervisors (n=6) and process workers (n=150) and subjected to a series of Oneway Anova's. Although the behavioural safety initiative had clearly impacted upon employee perceptions of safety climate, main effects again emerged on the risk dimension ($F(2,181) = 18.51$, $p<.0001$), further suggesting that each groups 'frames of reference' differs substantially.

Table 3: Differences in risk perception by hierarchical level

Study	Distribution	df	n	F	P<	X Process	X Supervisors	X Managers
Manufacturing	1	2	234	27.27	.0000	2.75	2.42	3.74*
Manufacturing	2	2	181	18.51	.0000	2.96	2.92	4.13*
Chemical Plant A	1	1	29	5.89	.01	2.94		3.96
Chemical Plant A	2	1	32	0.69	ns	3.69		4.25
Chemical Plant B	1	1	51	9.62	.01	3.10		4.13
Chemical Plant B	2	1	47	21.54	.0000	3.37		4.78
Chemical Plant C	1	1	27	4.93	.05	2.93		4.25
Chemical Plant D	1	1	128	43.18	.0000	3.23		4.68
Chemical Plant E	1	2	407	23.62	.0000	3.58	3.63	4.61*
Food Processing	1	1	193	22.09	.0000	3.43		4.68

N.B. Lower mean scores indicate negative perceptions. * = Significant differences between groups @ .05 level using Scheffe test.

<u>*Chemical Industry*</u>

Plant A

In late 1994 an adapted version of the safety climate measure [41] used in the manufacturing study [41] was used to measure the safety climate of a small chemical process plant that included additional dimensions which addressed employee's personal commitment to safety, job-induced stress, beliefs about accident causation, safety communications and emergency preparedness. In addition, two contextual dimensions concerning Standard Operating Procedures (SOP's) and Feedback about non-compliance to SOP's were used. In total the measure comprised of 80 items, and a number of demographic questions. This was distributed to 52 employees. The response rate in plant A was 61.5% (n=32). The reliability of the measure (Cronbach's Alpha) was 0.90. The sample population was divided into occupational groupings comprising managers/supervisors and process workers, and analysed with a series of Oneway Anova's. .Main effects emerged on the Perceived Risk dimension ($F(1,29)=5.89, p<01$), demonstrating that managers (n=12) and process workers (n=20) differed significantly in their perceptions of risk. Thus, these results support the idea that managers and process workers operate in different 'worlds of risk' [11], which may be due to managers being too far removed from everyday operations to make meaningful risk assessments [16], which again supports the notion that hierarchical position influences risk perceptions because of cultural determinants at varying organizational levels.

In mid 1996, the safety climate of the plant was re-measured [42] to assess the effects of a behavioural safety initiative that had been implemented during the intervening period (n=32). Using a series of Oneway Anova's no significant differences were found in people's perceptions of risk ($F(1,32)=0.69$, n.s) between managers (n=10) and process workers (n=23) (see table 3), which may be due to the impact of the behavioural safety initiative.

Plant B

A slightly different version of the safety climate measure used in plant A comprising of the core eleven dimensions plus four contextual dimensions concerned with Manning levels, Job-redesign, Role-Ambiguity and Housekeeping were used in plant B [43]. The resulting 90 item measure was distributed to 96 employees. The response rate was 56% (n=54), while the measures reliability (Cronbach's Alpha) was 0.93. A series of Oneway Anova's revealed main effects on the dimension concerned with risk perception [$F(1,51) = 9.62$, p<,0.01)] with process workers (n=27) indicating more negative perceptions than managers (n= 23), further supporting the notion of group characteristics exerting cultural influences.

In mid 1996, the safety climate of the plant was re-measured [24] to assess the effects of a behavioural safety initiative (n=52). This revealed that the differences between the groups had become much larger over the intervening period [$F(1,47) = 21.54$, $p<.0000$)], with the managerial group indicating more positive perceptions of risk. This suggests that behavioural safety initiatives exert a greater effect upon manager's perceptions and attitudes than process workers. Nonetheless, these results tend to confirm that each group's frame of reference is culturally determined by group characteristics.

Plant C

A slightly different version of the safety climate measure used in plants A & B was distributed in 1994 in plant C [44]. The differences were due to two contextual dimensions concerned with Commitment to the Organisation and Working under Adverse Economic Conditions. Distributed to 60 employees the response rate was 47% (n=29). The reliability (Cronbach's Alpha) of this version was 0.96. Utilising a series of Oneway Anova's, a significant difference [$F(1,27) = 4.93$, $p<0.05$)] was again found between managers (n=10) and process workers (n=19)., further suggesting group characteristics exert an influence on perceptions of risk.

Plant D

The safety climate measure for this plant [45] utilised the core eleven safety climate dimensions used in plant A & B, plus dimensions concerned with Housekeeping; The effectiveness of Standard Operating Procedures; Responses to breaches of Standard Operating Procedures; Job Security; Manning levels; Role Ambiguity; Multi-skilling and Organisational Commitment comprising a total of 105 question items. The measure was distributed to 270 employees, with 130 fully completed measures being returned, giving a response rate of 48.15%. The reliability of the measure (Cronbach's Alpha) was 0.93. Utilising a series of Oneway Anova's, a significant difference [$F(1,128) = 43.18$, $p<0.0000$)] was again found between managers (n=25) and process workers (n=105), further indicating that group characteristics exert an important influence on people's perceptions of risk.

Plant E

The safety climate measure for this plant [46] again utilised the core eleven safety climate dimensions used in the other four chemical plants, plus seven contextual dimensions concerned with Housekeeping; Multi-skilling; Manual handling; Responses to breaches of Standard Operating Procedures; Role Ambiguity; The effects of Quality on Safety issues; and Organisational Commitment. The measure was distributed to 690 employees, with 414 fully completed measures being returned, giving a response rate of 60%. The reliability of the measure (Cronbach's Alpha) was 0.94. Utilising a series of Oneway Anova's, a significant difference [$F(2,417) = 23.62$, $p<0.0000$)] was again found between managers (n=60), supervisors (n=79) and process workers (n=271). These results indicate that group characteristics appear to exert an important influence on people's perceptions of risk, supporting the notion that risk is culturally determined [20].

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Food Industry

In mid 1996 an opportunity arose to measure the safety climate of a food processing factory [47]. The measure for this site comprised of the core eleven dimensions, and four contextual dimensions: Housekeeping, the effectiveness of Standard Operating procedures, Responses to breaches of Standard Operating Procedures, and Manual handling issues. This was distributed to 450 employees, with 198 completed measures being returned, giving a response rate of 44%. The reliability of the measure (Cronbach's Alpha) was 0.95. Utilising a series of Oneway Anova's, a significant difference [$F(1,193) = 22.09$, $p<0.0000$)] was found between managers (n=21) and process workers (n=177). Once again these results indicate that group characteristics exert an important influence on people's risk perceptions, further suggesting that risk is culturally determined [20].

Examination of each groups 'frame of reference'

Within each study, Stepwise Multiple Regression analyses were run separately for each group, to try and discover what constitutes each groups frame of reference. This analyses provides an indication of the amount of variance explained in the dependent variable (i.e. perceived risk), by other independent variables (e.g. management commitment). For reasons of brevity, only the number of times a particular dimension explained some of the variance associated with each group's perceptions of risk is reported. Making use of the safety culture model presented in figure 1, each of the independent variables (i.e. safety climate dimensions) was assigned to Organisational (i.e. situational), Job (i.e. behavioural) or Individual (i.e. attitudinal) factors. These show (see table 4) that, regardless of hierarchical group, the only job related dimension that appears to be taken into account when evaluating risk is the required workpace (i.e. speed of work). In terms of individual factors, personal commitment to safety impacted upon both groups risk perceptions, as did beliefs about the causes of accidents. Interestingly, the effects of job-induced stress appear to be taken into account by process groups, but not by the managerial groups. With regards to organisational factors, both group's perceptions of risk were influenced by manning levels, the sites emergency preparedness, and the status of safety personnel. However, whereas responses to breaches of Standard Operating Procedures and manual handling issues influenced some managers perceptions, management commitment and actions, safety communications, the effectiveness of safety training and the impact of quality issues on safety, influenced more of the process groups perceptions of risk. Thus, these results indicate that both groups 'frame of reference' is dictated more by evaluations of organisational factors, than either job or individual factors. However, it appears that process group's perceptions of risk are based upon a much wider appraisal of these factors than the managerial groups, particularly management's commitment to safety.

Table 4: 'Frame of reference' for each group's perceptions of risk

Safety Climate Dimensions	Managerial Group	Process Group
Job Factors		
The Required Workpace	7	8
Individual Factors		
Personal Commitment to Safety	3	3
Beliefs About the Causes of Accidents	2	3
The Effects of Job Induced Stress	0	4
Organisational Factors		
Manning levels	1	1
Emergency Preparedness	3	2
Status of Safety Personnel	3	2
Responses to breaches of Standard Operating Procedures	1	0
Job Design in relation to Manual Handling	1	0
Management's Commitment to safety	0	3
Management's Actions in Relation to Safety	0	1
The Effectiveness of Safety Communications	0	1
The Effectiveness of Safety Training	0	1
The Impact of Quality Issues on Safety	0	1

Discussion

The results of the various strands of research reported in this paper have consistently revealed differences in risk perception between occupational groupings when analysed by hierarchical position. Specifically, regardless of the industrial sector examined (i.e. construction, manufacturing, chemicals and foods), in comparison with employees, management appear to consistently under-estimate workplace risks [17,18]: These findings also tend to confirm that each group operates in different 'worlds of risk' [11], providing strong support to the notion that risk is culturally determined [20].

In relation to the construction industry study reported here, a partial explanation for the intra-group differences may reside in the magnitude of each group's estimates of the individual risk assessment components: Frequency, Likelihood and Severity. Previous research would suggest that the differences in the estimates of these components could be attributed to task or industry experience, or accident involvement [9,28]. However, in this study no significant differences were found for these variables. This may be due to the fact that most respondents were in broad agreement with regard to the rank ordering of the risks presented by each category. Nonetheless, these results suggest that future research should focus on why each group differs in their estimates of each component, using much larger samples.

The results of the multiple regression analyses conducted on the safety climate dimensions reported here strongly support the notion that safety culture factors affect perceptions of risk by differentially determining each occupational grouping's 'frame of reference'. This was demonstrated by the influence that organisational (i.e. situational), job (i.e. behavioural) and individual (i.e. attitudinal) factors exerted on each occupational grouping's perceptions of risk. Given that it would be expected for both managerial and process groups to use job factors as the main criteria for assessing workplace risks, it is surprising to find that only one job factor (i.e. the required workpace) explained a significant proportion of the variance in risk perception scores in every organisation that was surveyed.. This finding is striking, and suggests that the required workpace should be explicitly evaluated when risk assessments are undertaken. In relation to individual (i.e. attitudinal) factors, the dimensions concerned with people's personal commitment to safety and their beliefs about the causes of accidents explained some of the variance in risk perception scores for both occupational groups, whereas the effects of job-induced stress accounted for some of the variance in risk perceptions scores for the process groups only. This suggests that although job-induced stress does not influence the managerial groups 'frame of reference' when assessing risk, it does appear to exert an influence on the process group's 'frame of reference'. With regards to organisational (i.e. situational) factors, the results presented here indicate that manning levels, the organisation's emergency preparedness and the status of safety personnel (e.g. safety advisors, safety representatives and safety committees) will exert an influence on both managers and process workers frames of reference. The differences between the groups become much more apparent when other organisational factors are examined. Whereas the managerial groups frame of reference includes responses to breaches of standard operating procedures and job design issues related to manual handling, the process groups appear to evaluate other organisational factors, such as management's commitment to safety, management's actions in regards to safety, the effectiveness of safety communications, safety training and the impact of quality issues on safety, to form their 'frame of reference'. Thus, although both groups 'frame of reference' appear to be dominated by organisational, rather than job or individual factors, the process groups 'frame of reference' appears to be much broader than that of the managerial groups.

In summary, the research described above indicates that differences in perceptions of risk between managerial and other occupational groupings are very common within many industrial sectors. This supports the notion that each group's perceptions of risk are culturally determined, suggesting that the biasing factors described above should be explicitly be taken into account when risk assessments are undertaken. Although some may question how this might be achieved, it is possible that the scores from safety climate surveys could be fed into risk assessments, as some form of weighting. This would offer the considerable advantage of taking into account the social psychological aspects of organizational functioning that are involved in workplace risks.

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