A five factor measure of safety culture

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1.0 Introduction

Safety culture is loosely described as the culture in which safety is understood (Cullen, 1990). It lies within the wider organisational culture and alludes to individual, job, and organisational features that affect and influence health & safety (Cooper, 2000). It came to prominence following the 1986 Chernobyl disaster but, whilst it emphasizes the importance of organizational attitudes, values and beliefs to safety outcomes, safety culture lacks a clear theoretical framework around which measures may be constructed.

The purpose of this paper is to describe a five factor measure that sets safety culture empirically within a psychometric paradigm that supports rigorous measurement.

2.0 Development of the survey measure.

2.1 Step 1: Secondary analysis of INSAG survey data

In order to build on earlier work the starting point was a secondary analysis of survey data collected from a number of nuclear facilities as a small part of research into safety culture commissioned by the International Nuclear Safety Advisory Group (INSAG, 1991). This secondary analysis suggested a four factor model – see figure 1.

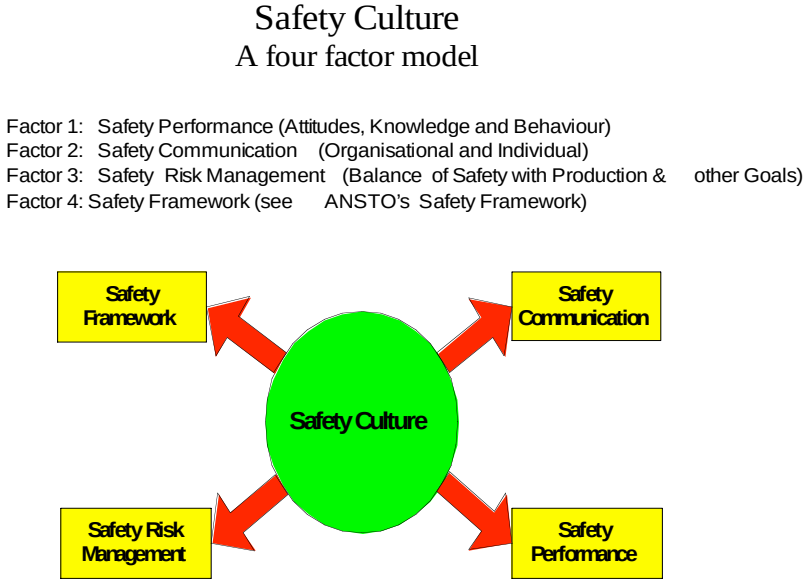

Fig. 1. Re-analysis of INSAG Safety Culture survey data (Smith and Garrett, 2004)

2.2 Step 2: Building on the knowledge base of safety managers

The second step was to further develop this model through discussion with BMA's Safety Managers. The two goals of this step were (a) to develop a series of questions that were meaningful to mine employees and (b) to consider the possibility of introducing additional factors to the measurement model. The results was a series of 60 questions that conceptually covered five safety factors: Leadership, Communication, Management, Change Readiness and Performance with Safety Leadership split across three sub-scales (i.e. supervisory support, goal clarity and work-life balance) and Safety Management also split across three sub-scales (i.e procedures, disciplinary process and training) – see figure 2.

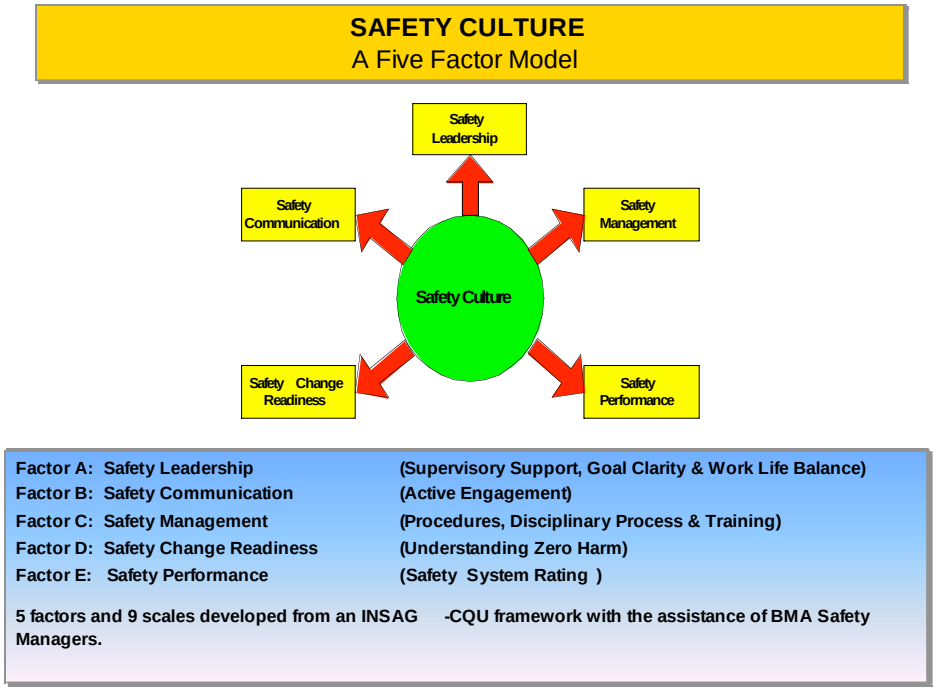

Fig 2. Conceptual Model for Safety Culture Survey developed with BMA's Safety Managers.

2.3 Step 3: Test of five factor safety model on a sample of 1071 mining employees

The third step was to test the factor structure empirically by presenting the questions as a self-report survey. This was done by adding the sixty questions in random order on to the end of two organisational culture surveys: the Organizational Culture Inventory (OCI) and the Organizational Effectiveness Inventory (OEI). This provided two data sets with a total of 1071 respondents

across several Queensland mine and other sites of a major Australian coal producer - see figure 3.

Total BMA Safety Culture Respondents N= 1071

Data	Frequency	Percentage
Organisational Role		
Executive member/Mine/Port Manager	9	.9
Manager	41	4.1
Superintendent	34	3.4
Supervisor	121	12.2
Engineer	71	7.1
Operating/Maintenance	470	47.3
Other	197	19.8
Prefer not to respond	51	5.1
Age		
under 20	16	1.6
20-29	162	16.1
30-39	270	26.8
40-49	299	29.7
50-59	198	19.7
60 or over	19	1.9
prefer not to respond	43	4.3
Gender		
Female	74	7.5
Male	889	89.6
prefer not to respond	29	2.9
Years With Organisation		
less than 6 months	78	7.7
6 months to 1 year	103	10.2
1 to 2 years	94	9.3
2 to 4 years	121	11.9
4 to 6 years	61	6.0
6 to 10 years	91	9.0
10 to 15 years	83	8.2
more than 15 years	330	32.5
Prefer not to respond	53	5.2

Fig 3. Structure of Safety Culture Survey Sample

The results from this survey were subject to a series of analyses to (a) establish the factor structure using data from the 546 respondents who completed the safety culture questions along with the OCI and confirming this structure using data from the 525 respondents who completed the safety culture questions along with the OEI; and (b) to test the validity of both safety culture and the OCI as predictors of the safety performance

3.0 **Results**

3.1 Alpha reliabilities of the 9 scales used to measure safety culture

The alpha reliabilities of the 9 safety culture scales and some example question items are shown in Table1.

Factor 1: Safety Leadership (3 scales)
Supervisory Support (6 items with an alpha reliability of 0.89)
Q37 My supervisor helps me find ways to achieve my safety objectives
Goal Clarity (4 items with an alpha reliability of 0.77)
Q19 I know and understand the company's safety goals
Work-Life Balance (3 items with an alpha reliability of 0.73)
Q48 Work allows me to balance my work and personal life

Factor 2: Safety Management (3 scales)
Procedures (6 items with an alpha reliability of 0.78)
Q43 Our safety procedures are too strict
Disciplinary Process (4 items with an alpha reliability of 0.70)
Q27 The company's safety disciplinary process on-site is fair & reasonable
Training (5 items with an alpha reliability of 0.82)
Q 40 The company's safety training explains both the how and the why of safety rules

Factor 3: Safety Communication (1 scale)
Active Engagement (8 items with an alpha reliability of 0.86)
Q6 It is simple to report breaches in safety practices

Factor 4: Safety Change Readiness (1 scale)
Understanding Zero Harm (5 items with an alpha reliability of 0.73)
Q35 Zero harm gives me a chance to learn and use new skills

Factor 5: Safety Performance (1 scale)
Safety System Rating (7 items with an alpha reliability of 0.88)
Q10 I would recommend my company as a safe place to work

Table 1. The Five Safety Culture Factors

3.2 Factor structure

The results show a clear five factor structure from the OCI sample that is confirmed using the OEI sample. The factor analysis results from both samples are illustrated for safety leadership in figure 4.

Safety Leadership

Outcomes of Confirmatory Factor Analysis (First Sample)

#	Standard Regression Weights	Error Variance	Squared multiple correlation R^2	Critical ratios	Composite reliability	Variance extracted
Supervisory Support					(B) 0.92	0.61
Q37	0.726	.439	0.527	11.627	(A) 0.91	0.63
Q45	0.765	.479	0.586	11.945		
Q56	0.834	.253	0.695	12.454		
Q60	0.841	.266	0.707	12.507		
Q46	0.777	.309	0.603	12.034		
Q54	0.772	.388	0.596	12.012		
Q47	0.525	.395	0.276	11.627		
Goal Clarity					0.86	0.62
Q19	0.805	.371	0.648	13.491		
Q20	0.778	.202	0.606	16.659		
Q22	0.719	.346	0.517	15.651		
Q23	0.620	.396	0.385	13.491		
Work Life Balance					0.76	0.54
Q25	0.722	.513	0.521	8.653		
Q26	0.994	.015	0.989	8.953		
Q48	0.378	.840	0.143	8.653		

Deleted Item: Q47 I am clear about my safety responsibilities

Safety Leadership

Outcomes of Confirmatory Factor Analysis (Second Sample)

#	Standard Regression Weights	Error Variance	Squared multiple correlation R^2	Critical ratios	Composite reliability	Variance extracted
Supervisory Support						
Q37	0.771	0.369	0.594	12.627	0.90	0.61
Q45	0.811	0.430	0.658	13.945		
Q56	0.794	0.344	0.630	13.454		
Q60	0.852	0.250	0.725	14.507		
Q46	0.676	0.428	0.457	15.034		
Q54	0.751	0.467	0.565	11.012		
Goal Clarity					(B) 0.85	(B) 0.53
Q19	0.772	0.187	0.596	13.491	(A) 0.83	(A) 0.56
Q20	0.705	0.371	0.497	16.659		
Q47	0.496	0.350	0.246	11.757		
Q22	0.668	0.373	0.446	15.651		
Q23	0.509	0.499	0.270	13.491		
Work Life Balance					0.75	0.52
Q25	0.668	0.581	0.446	8.653		
Q26	0.984	0.041	0.968	8.953		
Q48	0.448	0.864	0.201	8.653		

Deleted Item: Q47 I am clear about my safety responsibilities

Fig. 4 Confirmatory factor analysis for Safety Leadership

3.3 Validity tests of the safety culture measure

The validity multiple regression test results are illustrated in figures 5 to 7.

They show that the safety factors are strong predictors of safety performance measured as a safety system rating (see figure 5).

Safety Culture Predictiing Safety Performance (Safety System Rating)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Safety Leadership	.683[a]	.466	.466	.13309
Safety Communication	.756[b]	.571	.570	.11936
Safety Management	.768[c]	.589	.588	.11687
Safety Change Readiness	.770[d]	.594	.592	.11629

a. Predictors: (Constant), SafetyLeadership

b. Predictors: (Constant), SafetyLeadership, Safety Communication

c. Predictors: (Constant), SafetyLeadership, Safety Communication, SafetyManagement

d. Predictors: (Constant), Safety Communication, SafetyManagement, Safety Change Readiness

Safety Leadership predicts **47%** of the variance in Safety System Rating.

Overall the four Safety Culture variables predict **59%** of the variance in Safety System Rating (Safety Performance)

Fig. 5 Safety culture factors predicting safety performance

They also show that organizational culture measured, using the OCI, in terms of leadership styles also predicts safety performance measured as a safety system rating (see figure 6).

OCI Predicting Safety Performance (Safety System Rating)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Constructive	.467[a]	.218	.217	.59112
Passive Devensive	.485[b]	.235	.232	.58527

a. Predictors: (Constant), ConstructiveStyles

b. Predictors: (Constant), ConstructiveStyles, PassiveDevensiveStyles

Constructive leadership culture predicts **22%** of the variance in Safety System Rating.

The OCI CONSTRUCTIVE styles reflect a healthy balance of people and task relationshi ps leading to the attainment of organisational goals through the de velopment of people. The OCI PASSIVE/DEFENSIVE styles (excluding avoidance) emphasise predictability and security at the cost of learning and adaptability.

Together with Constructive styles, Passive/Defensive styles pred ict **23%** of the variance in Safety System Rating (Safety Performance)

Fig. 6 OCI as a predictor of safety performance

In particular, the regression results highlight the importance of communication – both safety and organizational (the latter measured using the OEI) – as a key predictor of safety performance measured as a safety system rating (see figure 7 and figure 8).

Communication Predicting Safety Performance

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.738[a]	.544	.543	.48528
2	.741[b]	.550	.548	.48285

a. Predictors: (Constant), Safety Communication

b. Predictors: (Constant), Safety Communication, Communication (up & down)

Communication predicts **55%** of the variance in Safety System Rating.

Fig. 7 Communication as a predictor of safety performance

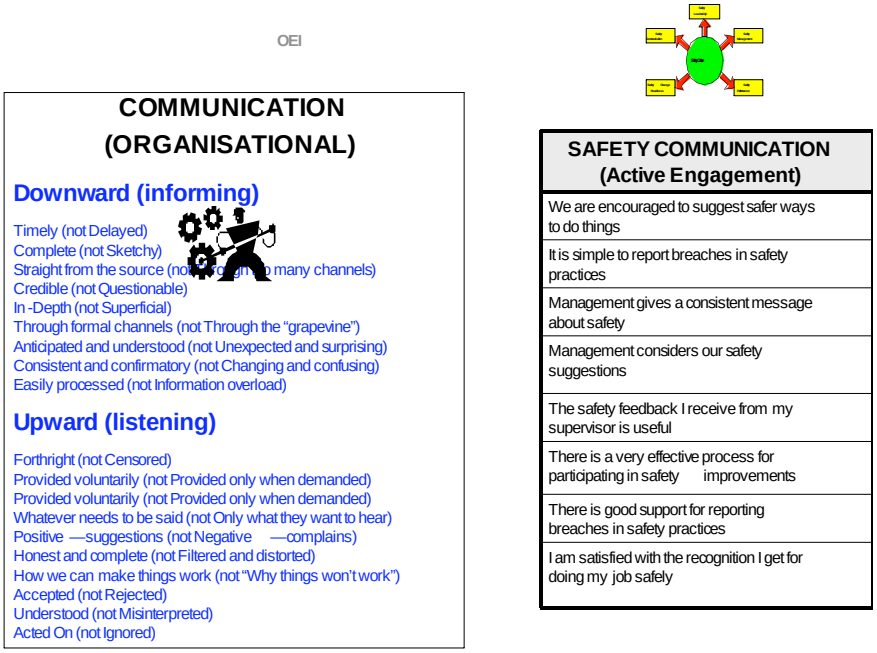

Fig. 8 Communication questions used in the surveys.

3.4 The Safety Culture Measure as a diagnostic tool

The use of a standard measure of safety culture enables cross-site and cross group comparisons. Figure 9, for example, illustrates the relationship between organizational role and safety communication with greater active engagement correlated with more senior roles.

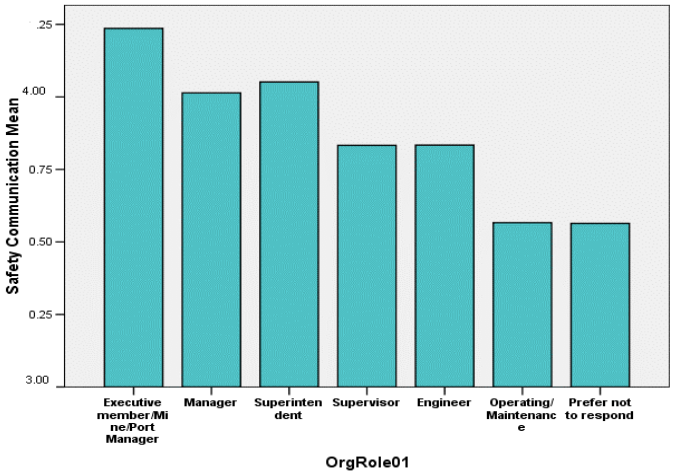

Fig 9 Safety communication and organizational role

4.0 **Discussion and conclusion**

Safety culture, when rigorously measured, shows that safety does not operate in a vacuum but rather that it lies within the wider organizational culture with, for example, the culture of leadership and communication impacting on employee's perception safety performance.

Validating safety culture measurement against employee's perceptions of safety performance is an important first step. In practical terms it is important that those who work within an organization can and do recommend it as a safe place to work. However, perception of performance is necessarily only one measure of performance. It is important that objective performance measures are also used to validate safety culture as a lead indicator. This validation is the next step of our research program that is exploring the relationships between safety culture and a number of safety and other organizational performance measures.

In conclusion, three practical advantages of understanding safety culture empirically within a rigorous psychometric paradigm are illustrated by this research. Firstly, that rigorous measurement provides a clear operational definition of safety culture – essential if results are to be meaningfully interpreted to inform safety management practice. Secondly, that rigorous measurement provides an opportunity to test the utility of self report survey measures as additional lead indicators and, thirdly, that it provides a potential for improving organisational performance through the use of a standardised benchmark measure.

5.0 **References**

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