Revealing Asymmetries in Safety Culture through Proactive Vision

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Communicating with personnel is difficult if the concept under consideration is complex, hard to perceive, and/or has characteristics that are fuzzy in nature and need a long-term perspective to show results as a real benefit and advantage. Safety culture concepts belong to this type of management object. They have characteristics that are difficult to manage and lead, and that are difficult to articulate in detail to the organization. In fact, safety culture is one of the key concepts in modern safety management science and research. Contemporary scientists like to bring in new constructs to understand the mechanisms behind safety culture better; however, measuring abstract concepts like these needs support from theory and methodology, so that communication with personnel can be objective and, from a management point view, effective. In this research, we have used online applications to evaluate current safety culture levels, and to gain insight into how members of industrial organizations are willing to reveal their proactive vision, as well as their priorities in safety culture concepts, within their organization. In this research work we present practical safety culture knowledge asymmetries, which are crucial to comprehend from the viewpoint of safety leadership and management. The dataset used for this article contains 14 industrial companies with hundreds of participants.

1. Safety culture asymmetry

An organization's culture can be seen as a concept that reflects shared behaviours, beliefs, attitudes and values (Williams et al., 1989; Cooper, 2000). Glendon and Stanton (2000) reveal that organizational culture is perceived and created by all of the organization's members; hence, it is not owned by any single group. However, the uniform culture of a company can be questioned as observed by Schein (1996). He found that an organization's culture in fact consists of several subcultures. Likewise, Williams et al. (1989) argue that culture can vary from division to division, department to department, workgroup to workgroup, and from individual to individual. Safety culture is a part of the overall culture of the organization (Cooper, 2000). Therefore, it is natural that safety culture too can vary within the organization. Parker et al. (2006) point out that the size and complexity of modern organizations is the source of variation in safety culture. Thus, it is apparent that general measures of safety culture, based on one overall index or score, provide at best a crude indication of this complex phenomenon (Parker et al., 2006). Hence, new methodologies are needed which should provide better understanding of asymmetries in safety culture.

It can be seen from the literature that the management is the key contributor to an organization's safety culture (Cox and Cox, 1991). However, the tools used by safety managers may not provide the information they need. The crucial information is lost in sums, means, and indexes. From a practical point of view, it is essential that a manager knows what he/she should do in order to improve safety. A manager has to gain a reliable insight of the current situation, but without proper tools the task is rather difficult. In this research, we introduce a novel way to analyse asymmetries in safety culture. This research focuses on safety culture, knowledge creation and learning concepts that are difficult to articulate and manage in organizations. The research shows the asymmetries between how people in industry view their current situation, as well as how they would like the future to look. Subsequently, we present the possibilities to

group the dataset to show the asymmetry between the proactive vision and the current and future desires to improve safety culture in industry. We also present evidence supporting the use of this methodology to reveal asymmetries and why it is so important to understand these in terms of management and leadership.

This research takes a different approach and methodology than earlier safety culture research in the CET community, where five levels of safety culture maturity were measured in the context of the Brazilian petrochemical industry (Goncalves et al., 2010).

2. Serpentine 2.0

In order to understand the concepts we need an ontology. An ontology is an explicit specification of the conceptualization of a domain (Gruber, 1993). Ontologies define the common words and concepts (meanings) that describe and represent an area of knowledge (Orbst, 2003). Therefore, an ontology can explicitly define the meaning of safety culture concepts.

An ontology-based safety culture research instrument has been developed at Tampere University of Technology, Pori, Finland, by Professor Hannu Vanharanta's research team (Salo, 2008; Porkka, 2012). The name of the research instrument is Serpentine, and the current version is 2.0. The 17 concepts included in Serpentine 2.0 (Salo, 2008; Porkka, 2012) are: 1) Safety training, 2) Support and encouragement, 3) Safety awareness and responsibility, 4) Safety attitudes, 5) Leadership, 6) Safety policy, 7) Management, 8) Working environment, 9) Organization's openness to new ideas, 10) Atmosphere, 11) Efficacy of the safety actions, 12) Resourcing for safety, 13) Co-operation, 14) Safety directions and regulations, 15) Flow of information, 16) Creating new knowledge and 17) Learning by doing.

To discover how these concepts are actually perceived in real industries and how to handle the imprecise human perception of safety culture concepts, fuzzy logic is required. Fuzzy logic is the precise logic of imprecise things (Zadeh, 1965; Zadeh, 1973). Fuzzy logic allows us to link the imprecise and unfamiliar-to-all concepts in the safety culture ontology to perceivable and familiar-to-all indicators of safety culture ontology concepts. Through extensive research we have been able to determine such links between two very different domains.

With the help of fuzzy measures in Serpentine 2.0 we can show how internal tacit knowledge of a specific situationality (of safety culture) can be quantified and visualized. The methodology as a whole offers new ways of understanding safety culture knowledge asymmetry. This kind of conceptual semantic will be important in the future as more and more research on safety culture enters industry. The real world results presented in this article give a solid indication of which areas of safety culture require immediate attention in companies. We believe that these initial results show how multi-dimensional and difficult a concept asymmetry really is in actual working environments – where safety is top priority.

3. The Evolute system

Evolute is an online system that supports specific-purpose fuzzy logic applications to be used over the Internet (Kantola et al., 2006; Kantola, 2009; Vanharanta et al., 2012). The Evolute system allows Serpentine 2.0 to be presented online to target groups. Evolute provides ontology-based "answers" to perceived linguistic propositions. The integral perception of a single person over all the presented propositions will produce an answer, called an instance (Kantola, 2009). The collection of instances reflects specific assets under scrutiny. The collection of instances forms the Instance Matrix (Kantola, 2009). The instance matrix, as a function of time, charts the organization's assets over time. The Instance Matrix is of great use for companies since it represents the collective mind of the stakeholders/target groups.

The Evolute system utilizes fuzzy logic to capture the subjective, abstract and vague nature of the safety culture without the individual having to convert any of this to a numerical scale. The goal is to capture a true bottom-up view of the current reality and envisioned future of the features and practices of the safety culture, knowledge creation and learning of a particular organization.

In addition to current states, employees are asked about desired future states. This gives them the opportunity to influence the priorities of development actions. Thus, the method reveals the proactive visions of the employees and therefore it can also be seen as a tool of empowerment.

The approach that has been developed enables a comparison between desired future and current states. In addition, asymmetries between respondents can be revealed, which is crucial information from a safety culture point of view.

4. Dataset

The Serpentine application was used in 14 industrial companies for safety culture assessment. These companies represent the metal, chemical and energy industries. However, ten of the companies are located in the same industrial park where safety practices should be common to all. They have also hired a joint safety manager for the park whose responsibility is to coordinate safety development. The total number of responses was 579, representing about 58 % of all employees, meaning that the response rate of the survey was very high.

5. Results

The clustering of the results was made by the SOM method (Kohonen, 2003), which allows the presentation of multidimensional questionnaire data in two dimensions. Similar safety culture instances (data vector with 17 current and target values) are mapped close together and dissimilar instances apart. SOMs create visual representations of safety culture asymmetries. These asymmetries can be exploited as guiding themes of which features of safety culture require immediate actions. The information gained can also be used to prioritize development efforts within companies. Here the SOM suggests three different clusters in the dataset, Figure 1. The nature of each cluster is described below in Table 1.

Table 1: Description of clusters

Cluster	Description
Red (Left)	The best cluster with the highest values. Safety training, Support and encouragement, Safety awareness and responsibility, Leadership, Safety policy, Management, Atmosphere, Efficacy of the safety actions, Co-operation and Flow of information are at high levels. Safety attitudes, Safety directions and regulations, Working environment and Learning by doing are at medium and high levels. Resourcing for safety, Organization's openness to new ideas and Creating new knowledge also contained low and medium values in addition to high values.
Blue (Middle)	This is the middle cluster with the medium values. Safety awareness is at a high level. Safety training, Management, Flow of information, Efficacy of the safety actions, Leadership, and Safety policy are at high and medium levels. Support and encouragement, Safety attitudes, Working environment, Co-operation, Safety directions and regulations and Learning by doing are at medium level. Organization's openness to new ideas, Atmosphere, Resourcing for safety and Creating new knowledge are at medium and low levels.
Yellow (Right)	The cluster with the lowest values. All the concepts are at medium or low levels. Creating new knowledge is at a low level.

Table 2 shows the instance distribution in the clusters. It shows how different companies are situated in the three clusters.

Table 2: Instance distribution in the clusters

Red	Blue	Yellow	
85	235	269	Current
468	96	25	Target

Table 2a: Instance distribution in the clusters; Colour (Current – Target)

Company	Red	Blue	Yellow	Company	Red	Blue	Yellow
A	4 – 13	7 – 4	7 – 1	H	3 – 19	10 – 7	13 – 0
B	3 – 8	5 – 1	1 – 0	I	5 – 56	27 – 8	34 – 2
C	1 – 3	2 – 5	5 – 0	J	7 – 62	28 – 8	37 – 2
D	3 – 28	10 – 7	29 - 7	K	17 – 82	48 – 19	40 – 4
E	5 – 31	21 – 10	16 – 1	L	2 – 14	13 – 11	13 – 3
F	0 – 2	3 – 3	2 – 0	M	4 – 9	2 – 0	3 – 0
G	27 – 125	52 – 11	62 – 5	N	4 - 16	7 – 2	7 – 0

In Figure 1 we can see three clusters in the dataset: Red (left), Blue (middle) and Yellow (right). As an example, company A's current (_c) and target (_t) instances are presented.
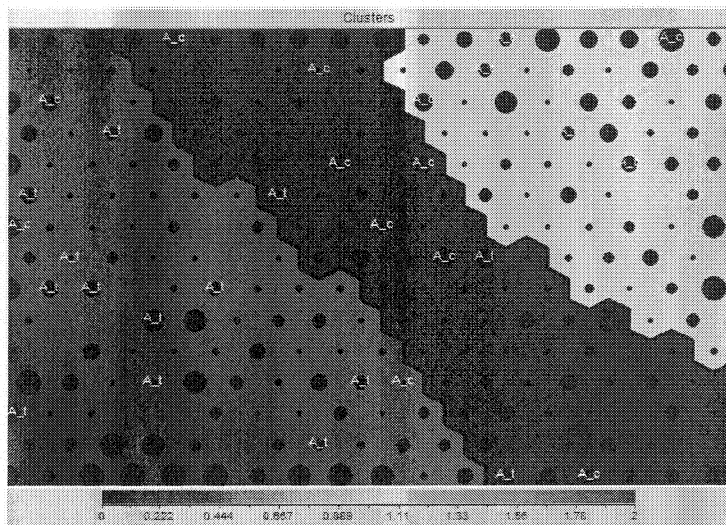

Figure 1: The SOM above suggests three clusters in the dataset

Figure 2 shows that the leftmost cluster contains high values for the concept, the middle cluster contains medium values for the concept and the rightmost cluster contains low values for the concept. As an example, company N's instances are displayed. We can see that everyone in company N is aiming for high values and that some perceive the current reality as being low.
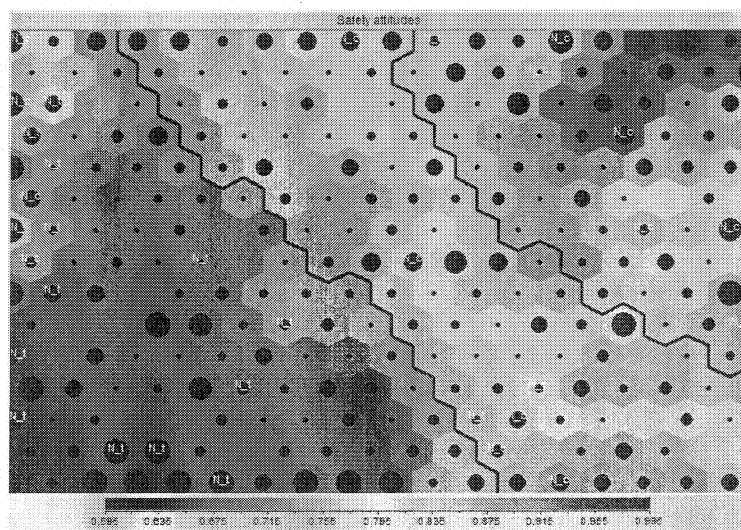

Figure 2: SOM of Safety attitudes concept in the dataset

Figure 3 -*Creating new knowledge* shows us that there are not many high values for the concept. In fact, most of the current values are low, and most of the target values are also low or medium. These values quite clearly show that there is an acute problem with this concept in these companies. As an example, company G's values are shown.

In the same Figure 3 - *Organization's openness to new ideas,* we can see that the cluster with the highest values on the left also has many low and medium values. This means that some people's views on this concept in the dataset vary a lot. The majority target high values, but there are also people whose target levels are low. As an example, company I's instances are presented.
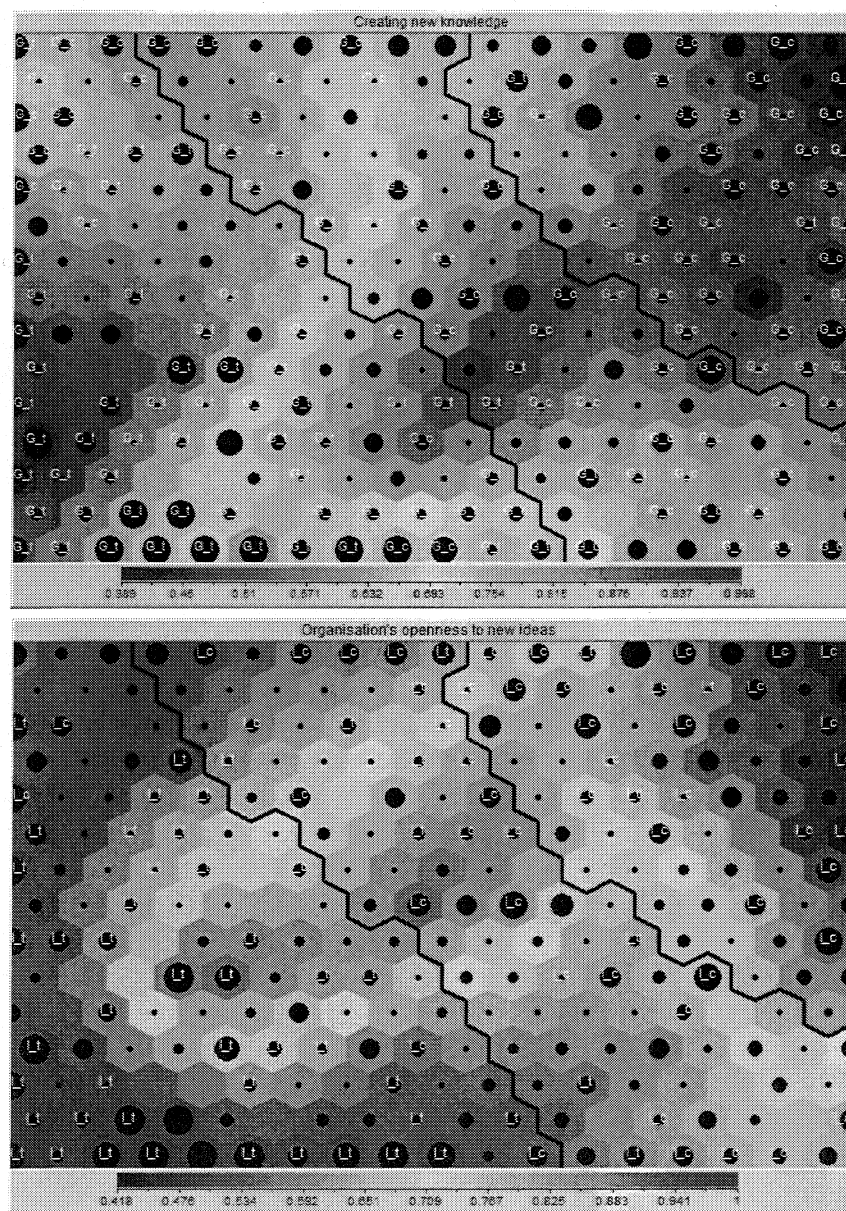
Figure 3: SOMs of the concepts Creating new knowledge and Organization's openness to new ideas

Executives and managers receive bottom-up information concerning the current state of their company's safety culture. They also obtain information on how their people perceive the future state of the safety culture in the company. This information helps executives and managers to decide how to delegate, integrate, co-operate and empower their people to strengthen the current safety culture and move the culture according to the wishes of the people and to align requirements from top-down to bottom-up. This kind of collective perception, analysis, and synthesis can change the safety culture in a positive direction. The application and methodology created can help decision-makers in this way with this complex aspect of management and leadership. The results also show how each company is positioned among all the companies that participated.

6. Discussion

These results clearly draw attention to those concepts that require further attention in the companies concerned. However, these results alone do not tell how improvement can be made. Knowledgeable interpretation of the results is needed to determine what steps should and could be taken in each

company. In-depth analysis of the dataset concerning "highlighted" concepts and participatory discussions with stakeholders in the company are the next steps.

The SOM allows a dataset to be looked at in an exploratory manner. SOM provides us with a holistic overview of the dataset, and also allows us to examine the dataset concept by concept without concerns about data precision. In this research, we can see that there are two concepts that need closer examination in the companies involved: *Creating new knowledge* and *Organization's openness to new ideas*. These concepts are very important elements in developing safety culture in companies. If insufficient attention is paid to them, the efforts made concerning other concepts may be watered down. All the other concepts in the dataset show quite a consistent effort towards high levels. Another noticeable point in the dataset is the fact that there are two small companies among the 14 that do not clearly aim for high values.

This research has been well accepted in the participating companies – the high response rates also indicate this – and the results have led to practical targeted development actions in the companies. This research is ongoing and new companies are welcome to join the research.

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