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What we talk about when we talk about HSE and culture – A mapping and analysis of the academic discourses

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ABSTRACT

This paper is an extensive review of 229 papers addressing HSE (Health, Safety and Environment) and culture published between 1992 and 2013. The review has been conducted in order to analyse how "culture" has been conceptualised, and whether there is a relation between these conceptualisations and the authors' experience base. The review of the papers has been supported by a statistical analysis of data obtained by a structured and systematic registration of information from papers addressing "culture" and "HSE". Bivariate correspondence analysis has been used as the statistical method in order to explore possible associations between the constructed categorical variables. The statistical analysis reveals that different cultural perspectives are associated with the professional background of the authors and the research designs that have been applied. Our findings confirm much of the critique that has been addressed regarding the use of culture as a concept. The review shows that the literature first and foremost addresses safety. An overwhelming majority of the published research has been conducted in North America, Europe and Australia. We argue that this represents a bias in the research that contributes to inaccurate generalisations and conclusions, especially related to discussions regarding "bad" or "sound" cultures. Some perspectives on culture are dominant, such as the conceptualisation of culture as: 1) shared and aligned perceptions and attitudes, 2) culture as an ideational entity, and 3) culture as one factor among several factors that influence Health, Safety and/or Environment. Relatively few papers conceptualise culture as: 4) holistic metaphor, used in order to denote the systemic relations that influence HSE or as, 5) something that develops in the interaction between people within a particular organisational context. Finally, interpretative approaches, taking the perspective of the actors, are marginal.

1. Introduction

Culture has been used as a concept to describe, analyse and improve different aspects of HSE (Health, Safety and Environment) since the 1980s. Within the safety literature, it seems to be an established fact that the concept of "safety culture" was first coined in the report on the Chernobyl disaster in 1986. The use of the concept of culture may, however, be traced back to the work of Turner (1978). Since then, scholars have struggled to come up with a common definition of the concept (see e.g. Cox & Flin, 1998; Hale, 2000; Guldenmund, 2000; Haukelid, 2008; Antonsen, 2009a; Edwards et al., 2013; Reiman & Rollenhagen, 2014). The lack of any common stringent definition seems to be a recurring theme. Despite this, culture has been used as concept in relation to e.g. regulations (see e.g. Bye et al., 2016; Kongsvik et al., 2016; Antonsen et al., 2017), investigations (see e.g. Bye et al., 2016; Antonsen et al., 2017), safety assessments (see e.g. Schöbel et al., 2017), and safety improvement initiatives (see e.g. Nielsen, 2014; Nævestad et al., 2018), and there have been numerous attempts to measure the concept (see e.g. Guldenmund, 2000, 2007). Despite the lack of consensus regarding definitions, we feel confident in stating that culture has been appropriate to represent safety-related knowledge, either declared or tacit, that has been difficult to express by the use of other concepts, both among researchers as well as among practitioners within different industries.

Several review papers regarding "safety culture" have previously been published. Among the most commonly cited are Cox and Cheyne (2000), Guldenmund (2000), Richter and Koch (2004), Choudhry et al. (2007), Haukelid (2008), and Edwards et al. (2013). The overall ambition of this present paper is to scrutinise the history of the use of "culture" within the research literature. This has been performed in order to discuss the validity of the concept-analysing phenomena relevant for HSE issues.

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This paper does not focus on the definition of culture *per se*, but rather on the authors themselves and the social context of their research. This is due to a hypothesis that the variation in the use of culture may be associated with different sub-communities of safety researchers, defined by the area of profession, research design, type of industry studied, national/regional affiliation, and the particular region where the study has been conducted. In this paper we explore these possible relationships, and try to determine which conceptualisation of culture has been dominant. Furthermore, we have mapped which concepts of culture are associated with normative papers, in order to identify the main references used by practitioners in their quest to improve HSE culture within their respective industries.

The background of this research is a research project studying the consequences of the introduction of a paragraph into the Norwegian petroleum regulations that require "an HSE culture" that includes "all phases and activity areas shall be encouraged through continuous work to reduce risk and improve health, safety and the environment" (Petroleum Safety Authority Norway, 2001). The acronym HSE summarises areas of management responsibilities that are conceived to constitute related functions within an organisation. Alternative acronyms for these areas of management in use include EHS (see e.g. Sugiyama et al., 2008) and SHE (see e.g. Hale and Hovden, 1998). There are several related acronyms that encapsulate and constitute different portfolios of management responsibilities. These include, for example, HSEQ (Health, Safety, Environment and Quality), HSSE (Health, Safety, Security, and Environment), HSSEQ (Health, Safety, Security, Environment and Quality). A related term and acronym to HSE - but not as comprehensive - is OHS (Occupational Health and Safety). The use of HSE seems to be a conventional acronym used within several European industries, especially oil and gas, as well as some parts of the onshore process industry. Furthermore, it is reasonable to believe that there are different conventions between countries.

HSE culture is not a very common term and construct. While "safety culture" is a recognised concept within international literature, "health culture" and "environment culture" are not (Bye et al., 2016). Despite this, there are some examples in the literature where the term "HSE culture" has been used as a concept (e.g. Hudson et al., 2002; Hudson, 2007; Buell, 2006; Tharaldsen et al., 2008; Høivik et al., 2009; Haghighi et al., 2013; Mohammadfam et al., 2015). An example of this application is Hudson's use of the terms "HSE culture" and "HSE culture ladder" (Hudson et al., 2002; Hudson, 2007). Moreover, the relationship between "culture" and "HSE" – without using the juxtaposition of "HSE culture" – has been addressed by several researchers. This body of publications forms the basis for this present review.

Due to limitations in paper length combined with the comprehensive amount of data, this paper first and foremost presents some descriptive results, findings and core characteristics of the dataset in addition to central questions derived from these findings. In order to map the papers, we have answered the following research questions:

1. Who writes about this combination of HSE and culture?
2. Are the texts addressing health, safety and/or environment?
3. What types of methods have been used in studying "HSE culture"?
4. What are the most frequent used core references on culture?
5. What does "culture" denote?
6. To what extent are the papers normative?

The main scientific contributions and originality of this paper is that we try to map out a possible relationship between the conceptualisation of culture and the social context of the research by the use of a stringent statistical analysis of a sample of literature.

The remainder of the paper is structured as follows: Section 2 describes the materials and the research method. Sections 3 presents the results. Section 4 gives an overall summary of the results, combined with a brief discussion. Section 5 presents the final conclusions.

2. Materials and methods

2.1. Materials and methods

This paper presents and discusses the results of a content analysis where we have tried to explore explicit and covert features related to a corpus of texts. We have applied a semiotic approach in this study. This implies that we try to elucidate the difference between sign, reference and meaning, relying on the theoretical assumption that the relation between the sign (form) and the signified (meaning) is arbitrary (Saussure, 1974) following techniques presented by Bernard (2011). We began by analysing the actual use of the sign "culture" in texts written by and for researchers working on health, safety and the environment. This means that we have identified academic publications where the sign "culture" has been used in relation with HSE in recognised journals, which have been collected, and categorised against a refined codebook. The coded information has then been analysed through the use of appropriate statistical methods.

2.2. Sampling/Corpus of texts

The sample of papers has been obtained by using the search engines Science Direct, Google Scholar, and the combination of the signs of "culture" and "HSE" as keywords. In other words, we have identified only those papers that use both the signs "culture" and "HSE". The choice of these keywords is made in order to primarily capture papers which relate "culture" to HSE, i.e. papers that are assumed to address health, safety and/or the environment, not only safety, or occupational safety for that matter. The implication of this choice is that papers that are using the juxtaposed "safety culture", but the term HSE, will not be included in the sample. Secondly, the sample will contain papers that use the term "culture" without using the prefix "safety". Our sample may therefore partly be seen as a subset of the more voluminous population of papers using the term "safety culture", as well as papers addressing "culture" and "HSE" without necessarily addressing "safety". This means that the sample can be used to analyse how the construct of culture has been used in literature that addresses HSE. However, we cannot generalize our findings to also apply to the voluminous amount of literature that deals with "safety culture" without using the term HSE.

The sample is limited to the time period of 1992–2013. This means that eventual changes in the use of "culture" within the last 5 years are not reflected in our sample. We have excluded some of the more obviously irrelevant results. An example of an excluded article was one that used "culture" juxtaposed with bacteria, i.e. "bacteria culture", which is obviously not relevant for inclusion in our sample. The final sample consisted of 229 papers, of which 203 were journal papers and 26 were conference papers.

2.3. Coding information into variables

A set of variables was defined and constructed in order to obtain coded information from the papers, making it possible to conduct statistical analysis. The majority of the variables were categorical, but some were string variables that could be transformed into nominal categorical variables after the information had been obtained (Table 1). A few variables, such as the year since publication and number of citations, are numeric variables measured at a ratio level.

In order to categorise the papers with regard to the potential variation in the meaning of "culture", we chose to rely on four different culture taxonomies using different classification criterions; (1) "The extent of the communities", 2) "Integrated or differentiated" 3) "Level of abstraction", and 4) "Location of culture" (Variable nr.11–14 in Table 1). The taxonomy based on *the extent of the communities* as the classification criterion, consists of only two categories: 1) the social group as a nation, or 2) the social group as an organisation. This

Table 1
Variables used in the analysis.

	Type of variables	Variable name	Type of variable	Reliability evaluation
1	Publication	Name of paper	Categorical	high
2		Year of publication	Numerical	high
3		Number of citations	Numerical	high
4	Author information	Area of profession	Categorical	high
5		National/regional affiliation of the author	Categorical	high
6	Method	Type of industry studied	Categorical	high
7		Area of the world where the study has been conducted	Categorical	high
8		Research design	Categorical	high
9	Conceptualisation of culture	Definition of culture	String	high
10		Author used as core reference on culture	Categorical	high
11		"The extent of the communities"	Categorical: (1) National (2) Other communities (organisations, groups, etc.) (3) Unknown	medium
12		"Within or between communities"	Categorical (1) Integrated (2) Differentiated (3) Both integrated and differentiated (4) Unknown (5) Unknown	medium
13		"Level of abstraction"	Categorical (1) Culture as one factor/coordinate concept among others (2) Culture as a metaphor for «system dependencies» (3) Unknown	medium
14		"Location of culture"	Categorical (1) ideational system (2) Social system (3) Unknown	medium
15	The emphasis on HSE	"Aspects of HSE addressed"	Categorical (1) Health (2) Safety (3) Environment (4) Combination of two aspects (5) Health, Safety and Environment (6) Unknown	high
16		"Descriptive or normative"	Categorical (1) Descriptive (2) Normative (3) Both normative and descriptive (4) Unknown	high

categorisation refers to the discourse regarding national/regional cultural differences and safety (see e.g. Lamvik & Bye, 2004; Mearns & Yule, 2009).

The *integrated or differentiated* taxonomy divides between the use of "culture" to denote: 1) something that is homogenously shared among members of a defined social group, and 2) controversies, diversity and variation within a defined social unit (see e.g. Martin, 1992; Richter and Koch, 2004; Haukelid, 2008; Reiman & Rollenhagen, 2014).

The classification criterion for the *level of abstraction* taxonomy is based on the discussion of whether culture is to be considered as a factor among other factors, or as a holistic term that signifies something that is *inherent in any social system* (see e.g. Alvesson and Berg, 1992; Alvesson, 2002). This distinction may be seen as corresponding to the conceptualisation of the difference between "culture" as something organisations *have*, and "culture" as something organisations *are* (see e.g. Cooper, 2000).

The *location of culture* taxonomy relies on the typology provided by Allaire and Firsirotu (1984) which differentiates between perspectives conceptualizing culture predominately as an ideational system and those conceptualizing culture predominately as a social system. An ideational system perspective implies an orientation towards mental images, beliefs and attitudes of individuals, often supported by the use of analytical concepts such as e.g. world views, mental models, schema, scripts, etc. A social system perspective emphasizes how (human) practices are constituted, altered and maintained with references to features and characteristics of the social context of those practices. As discussed by e.g. Shore (1998), these two perspectives are not necessarily contradictory and mutually exclusive. However, we have used this distinction to evaluate what the authors are primarily focusing on when they write about culture.

The coding of the papers was conducted by a team of researchers. In order to evaluate the reliability of the data associated with the different variables, we conducted a test coding where the assessors had to obtain data from a common set of publications. The individual assessments were compared qualitatively in order to evaluate the inter-reliability. The results showed that the reliability was questionable when it came to the four variables regarding the conceptualisations of culture.

The problem with these variables is that they require a relatively thorough interpretation process by the ones who do the categorisations. Following this first test coding and the evaluation of the inter-reliability, the assessors made another attempt to obtain data from a common set of publications. The following qualitative evaluation of the inter-reliability indicated an improvement that was considered sufficient in order to conduct the assessment and use the data in the following analysis.

The reliability of the data regarding variables, i.e. name of authors, year of publication, journal, author discipline, nationality of the authors, number of references, branch of industry, region of the world, methods applied, the formal definition of "culture", the aspects of HSE that are addressed and whether the text is normative or not, are considered as high (Variable nr.1–10 and 15–16 in Table 1). The reliability of the data related to the variables regarding the meaning of the term "HSE culture" is weaker due a possible lack of accuracy between different researchers (Variable nr.11–14 in Table 1).

2.4. Statistical analysis

To inspect basic features of the data we calculated descriptive statistics such as frequencies and contingency tables. These analyses gave us information about the authors of the text concerning, for example, their profession, nationality, geographic area of the research, number of references, definitions of culture, etc.

We carried out simple correspondence analysis with standard symmetrical biplots in order to identify possible relations between categories of two discrete variables. The advantage of correspondence analysis is that it is especially suited for the analysis of large contingency tables with many categories (Clausen, 1998) and for exploratory rather than confirmatory approaches (Hjellbrekke, 1999). Checking for the significance of the relationships can be achieved by performing a chi-square test. In addition, the correspondence analysis provided information as to what degree the different values of the variables contribute to the relationship.

Statistics regarding correspondence analysis include, inertia, correlation coefficient, chi-square and eigenvalues. Inertia signifies the total variance explained by the dimensions (i.e. the fitted table's total variance explained). The square root of the total inertia equals the correlation between the variables used to form the table. A rule of thumb is that the correlation should be above 0.2 in order to be deemed sufficient for analysis (Bendixen, 1995). Chi-square is the preferred method of testing statistical significance in correspondence analysis. Eigenvalues are proportions of the total inertia explained by a particular dimension.

A potential problem when dealing with large contingency tables is categories with low frequencies. The case of low expected frequencies has generated considerable debate amongst researchers. A common rule of thumb is that the number of expected frequencies below five should not exceed 20% of the cells in the contingency table (Field, 2009). However, when using correspondence analysis as an exploratory tool, we check whether the low frequency categories influence the two-dimensional solution as a primary indicator of the low frequency problem. Low frequency categories tend to be outliers, but they are often not large contributors to the dimensions. In these cases, we check whether the outliers can be thought of as having lesser importance for the analysis, and can therefore be treated as supplementary points, or if they are important for the interpretation. Furthermore, since our study conducts a population-based analysis, our main goal is not statistical inference, but rather to explore the defining features of our present dataset.

Interpretation of correspondence analyses in this study is performed by: a) interpreting the dimensions using the graph along with inertia, eigenvalues and the categories' contribution to the dimensions (i.e., is there a concept that seems to define the categories on both sides of a dimension), and b) projecting lines of column categories perpendicularly onto a straight line between a row point and the origin (see example in Fig. 1 below).

On the left side of the origin, we see that "Business & Administration" is the most frequent category in the row category "Descriptive". Furthermore, in descending order, "Social sciences", "Health", and "Psychology" have a higher than total percentage of frequencies within "Descriptive". On the other side of the origin (i.e., lower than total percentage of frequency), we find "Engineering & Technology". However, it is important to underline the fact that even though "Engineering & Technology" is located farthest away from "Descriptive", this does not mean that no papers from this discipline are descriptive in the use of the word culture. As seen in the contingency table, in fact 19.8% of the papers are "Descriptive" – but the total percentage for all other disciplines is much higher, hence the location on the graph.

To help guide the interpretation, we take the categories' contribution to the dimensions into account. For a particular dimension we divide 100 (percent) by the number of categories within the row

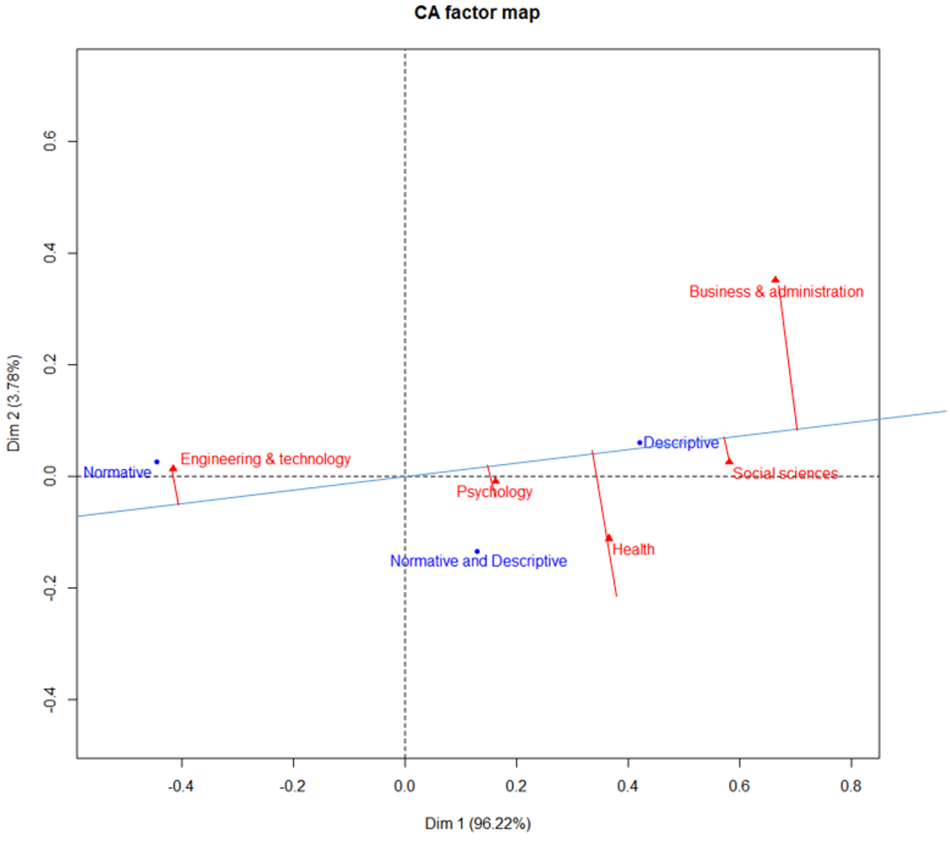

Fig. 1. Example of correspondence analysis with interpretation lines.

(column) variable to find the average contribution *by chance*. By comparing a single category's contribution to the dimension with the average contribution by chance, we can conclude whether or not this particular category is helpful in interpreting the graphical solution (Bendixen, 1996).

3. Results

3.1. Who writes about "HSE" and "culture"?

One obviously important factor in the different ways in which authors understand and use the concepts of culture and HSE, is their original background that form the basis of their writings. The fields of HSE (and especially that of safety) are multidisciplinary and, as we show in Bye et al. (2016), the concept of culture can have different referents in various contexts. Thus, it is of interest to describe the origin of the authors both in terms of geographical, professional and industrial contexts.

3.2. Profession of the authors and area of industry

The largest category of authors (42%, n = 96) are educated within the field of engineering and technology, holding different engineering degrees (chemical engineers, construction engineers, etc.). Researchers with a background in psychology (presumably organizational psychologists) account for 29% of the papers (n = 67), while 14% of the papers are written by authors from different branches of health science (n = 32), such as medical science, public health, physiotherapy, occupational hygiene, pharmaceuticals, etc. Moreover, 10% of the papers (n = 22) have different types of social scientists (except organizational psychologists) as the corresponding author (including social anthropology, geography, philosophy and sociology), and 3% of the papers are written by authors with a background in the fields of business and administration (n = 7). Finally, five papers (2%) had authors with other or unknown professions. These numbers do not take into account that the majority of the papers involve several authors, potentially with different professional backgrounds.

A total of 26% of the papers (n = 59) focus on different sectors of transportation systems (aviation, railroad, shipping, road transportation). Approximately 23% of the sample (n = 53) consists of papers having the oil and gas industry as the area of research. The nuclear industry is the subject of 8% of the papers (n = 18), while a further 30% of the papers (n = 68) is from diverse areas of industry, including healthcare, manufacturing, construction, mining, chemicals, pharmaceuticals, fire-fighting, fishing, defence, agriculture, and service. Finally, 14% of the papers do not address any specific industry. These papers present theories that are not contextualised to any specific activity or industry.

The test results regarding associations between the profession of the author and the area of industry were non-significant[1], indicating that there are no large differences in the distribution of professions across industries when speaking of "HSE" and "culture".

3.3. Geographical origin of the authors

More than 60% (n = 138) of the papers are written by an author, or a group of authors, who are affiliated with European research institutions, companies or governmental bodies. In total, European authors are involved in 64% of the papers, with 15.7% (n = 36) of the papers having been written by North American authors. Broken down to nation-states, it is clear that a few nations dominate the picture; the US, Canada and the UK provide most papers. Based on this picture it is obvious that "HSE" and "culture" are treated academically in a few specific regions.

[1] chi square test: $X^2 = 18.415$, df = 16, $p > .05$

Table 2
Categories of year and area of industry – Eigenvalues, inertia and contributions of the categories.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.07	0.05	0.12
Rows' contribution	1992–1999	55.19	36.51	
	2000–2006	42.78	35.70	
	2007–2013	1.03	27.79	
Columns' contribution	Generic	19.86	54.55	
	Nuclear	27.75	2.96	
	Oil and gas	28.87	5.21	
	Other	0.01	31.16	
	Transportation	23.52	6.12	

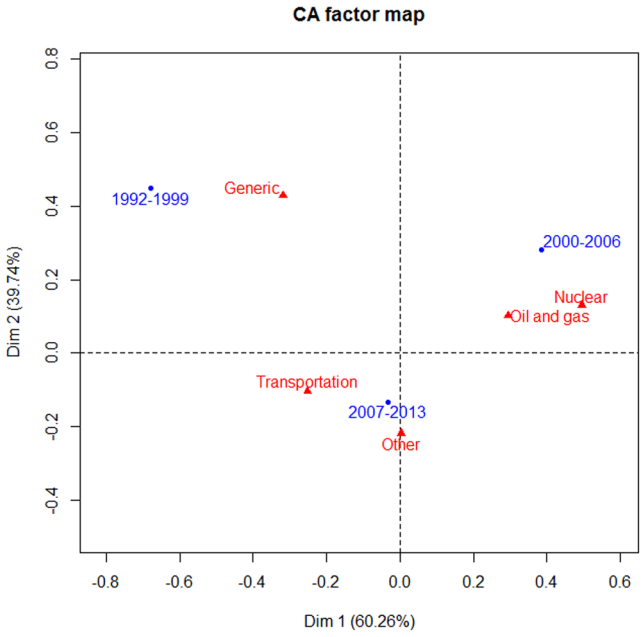

Fig. 2. Correspondence analysis between categories of year and area of industry.

3.4. The geographical area of the research

Of the papers, 42% are based on studies conducted in Europe. The second largest geographical region is North America (9%), followed by Australia (6.1%). The second largest category is, however, papers that are not based on any specific geographically situated study. As many as 67 papers (29%) do not build on any study in a specified geographical area. If we only consider those papers that are based on research in a

Table 3
Culture and HSE.

Category	Frequency	Percentage
Health	4	1.7
Health and Environment	1	0.4
Health and Safety	26	11.4
Health, Environment and Safety	21	9.2
HSE as neither Health, Environment or Safety	4	1.7
Safety	173	75.5
Total	**229**	**100.0**

Table 4
Research design and profession of the main author.

	Profession of the main author (N and%)					
Years	Business & administration	Engineering & technology	Health	Psychology	Social sciences	Total
Quantitative	1	28	18	30	4	81
	14.3%	29.2	56.3%	44.8%	18.2%	36.2%
Qualitative - Case	0	22	1	2	1	26
		22.9%	3.1%	3.0%	4.5%	11.6%
Qualitative - Other methods	1	4	3	5	5	18
	14.3%	4.2%	9.4%	7.5%	22.7%	8%
Combination of quantitative and qualitative methods	2	9	4	11	2	28
	28.6%	9.4%	12.5%	16.4%	9.1%	12.5%
Review	3	28	6	17	10	64
	42.9%	29.2%	18.8%	25.4%	45.5%	28.6%
Non-empirical	0	5	0	2	0	7
		5.2%		3.0%		3.1%
Total	7	96	32	67	22	224
	100%	100%	100%	100%	100%	100%

specific geographical area, 80.2% stems from research in Europe, North America, and Australia. Only 20 papers are based on data from Asia (12), South America (4), the Middle East (2), and Africa (2).

3.5. Popularity within different areas of industry

Based on a notion that the popularity of "safety culture" has fluctuated within areas of industry, starting in the nuclear sector in the aftermath of the Chernobyl accident, and subsequently being the focus of the offshore oil and gas sector, we tested if there were any associations between areas of industry and specified time periods. The test proved to be significant,[2] and the associations were further explored by the use of correspondence analysis. The explained variance (inertia) in the correspondence model is 12% (Table 2).

The bi-plot (Fig. 2) shows that the period of 1992–1999 is associated with papers addressing no specific industry. The following time period, 2000–2006, is associated with research within the nuclear and oil and gas industries. The time period from 2007 to 2013 is associated with transportation and other industries.

3.6. Are the texts addressing health, safety and/or environment?

Although the authors of the papers use the terms "HSE" and "culture", they first and foremost discuss safety (Table 3) and – to a much lesser degree – health. "Culture" primarily functions as a term denoting conditions that influence the safety level and/or occupational health within organizations. A relationship between "culture" and "environment" is specifically addressed in only one of the papers in our sample.

3.7. Which methods have been used in studying "HSE culture"?

By categorising the sample with respect to the use of data sources, the largest category is papers that rely on quantitative data (49%, n = 112), either entirely or in combination with qualitative data. The second largest category consists of papers that are based on reviews of other publications (29%, n = 66), while 19% (n = 44) are based entirely on qualitative methods and 3% are non-empirical (n = 7).

Surveys are the most commonly used data source within the sample. Of the papers, 87 (38%) rely entirely or partly on survey data[3]. Other quantitative data used are records of incident/accident data (n = 30) and data obtained using quasi-experiments (n = 4).

Qualitative methods used in combination with quantitative methods include literature reviews, case descriptions and interviews.

Among the 44 papers relying only on qualitative data, 26 are case descriptions (case studies). Only 8% of the papers (n = 18) are based entirely on interviews and/or the use of ethnographic methods.

3.8. Research design by discipline

Table 4 shows that Engineering & Technology dominates the "Qualitative – Case" category, whereas Psychology and Health have the highest frequencies in "Quantitative".

A possible association between papers with particular research designs and professions was tested, and the results were significant, but the test violated a statistical assumption[4]. Correspondence analysis was conducted to further explore the associations. The explained variance in the correspondence model is 19%[5] (Table 5).

The biplot (Fig. 3) shows that "Qualitative – Case" and "Non-empirical" are associated with "Engineering & Technology". The research design "Qualitative – other methods" is associated with Social sciences and Business & Administration. On the other hand, "Quantitative" research design and "Combination" (combination of quantitative and qualitative methods) are associated with "Psychology" and "Health".

3.9. Research design by area of industry

Table 6 shows that papers related to no specified industry (generic) are the highest represented of the categories regarding "Review", with 64.5%. Papers related to all the other areas of industry are most highly represented in the category of quantitative research design.

The chi-square test for research design by area of industry proved to be significant[6]; however, being subject to a potential low expected frequency problem[7]. The total explained variance (inertia) in the

[2] Chi square test: $X^2 = 26.305$, df = 8, $p < .01$.

[3] Of the papers, 61 are based solely on survey data and 26 are based on survey data in combination with other data (e.g. accident data).

[4] Chi square test: $X^2 = 46.381$, df = 20, $p < .05$. 16 cells (53.3%) had an expected count below 5. The minimum expected count was 0.22.

[5] The main contributors to the dimension 1 are "Qualitative - Case" and "Engineering & Technology". On the second dimension, "Quantitative" and "Social Sciences" are the main contributors, with "Review" and "Qualitative – Other methods" also contributing more than by chance.

[6] Chi square test: $X^2 = 53.706$, df = 20, $p < .01$.

[7] Since the chi square test had a potential problem with low expected frequencies, and non-empirical has low frequencies, non-empirical should be considered as an outlier with a high contribution to the solution. For this reason, we chose to conduct a correspondence analysis treating "Non-Empirical" as a supplementary category.

Table 5
Research design and profession of the main author - Eigenvalues, inertia and contributions of the categories (correspondence analysis).

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.12	0.07	0.19
Rows' contribution	Combination	4.78	0.27	
	Non-empirical	9.03	1.45	
	Qualitative - Case	66.03	0.02	
	Quantitative	9.26	41.29	
	Review	0.19	26.01	
	Qualitative - Other methods	10.71	30.97	
Columns' contribution	Business & administration	3.61	11.46	
	Engineering & technology	56.47	0.06	
	Health	0.60	0.28	
	Psychology	17.75	8.19	
	Social sciences	5.56	66.10	

Correlation coefficient 0.44.

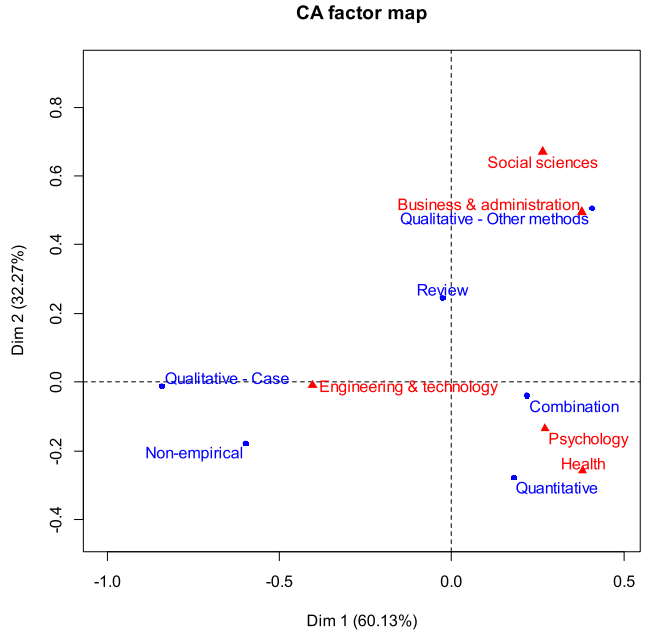

Fig. 3. Correspondence analysis between research design and profession of the main author.

Table 6
Research design and area of industry.

	Area of industry (N and%)					
Research design	Generic	Nuclear	Oil and gas	Transport	Other	Total
Quantitative	5	7	15	31	26	84
	16.1%	38.9%	28.3%	52.5%	38.2%	36.7%
Qualitative - Case	1	2	11	3	9	26
	3.2%	11.1%	20.8%	5.1%	13.2%	11.4%
Qualitative - Other methods	2	0	5	5	6	18
	6.5%		9.4%	8.5%	8.8%	7.9%
Combination of quantitative and qualitative methods	1	1	7	8	11	28
	3.2%	5.6%	13.2%	13.6%	16.2%	12.2%
Review	20	5	14	11	16	66
	64.5%	27.8%	26.4%	18.6%	23.5%	28.8%
Non-empirical	2	3	1	1	0	7
	6.5%	16.7%	1.9%	1.7%		3.1%
Total	31	18	53	68	59	229
	100%	100%	100%	100%	100%	100%

Table 7
Research design and area of industry - Eigenvalues, inertia and contributions of the categories.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.12	0.05	0.17
Rows' contribution	Combination	9.05	1.89	
	Non-empirical	*	*	
	Qualitative - Case	2.18	68.15	
	Quantitative	19.82	27.86	
	Review	68.46	0.58	
	Qualitative - Other methods	0.49	1.52	
Columns' contribution	Generic	80.39	3.94	
	Nuclear	0.16	1.45	
	Oil and gas	0.16	51.30	
	Other	4.67	2.29	
	Transportation	14.61	41.02	

Correlation coefficient: 0.41
* Supplementary point

correspondence model is 17%[8] (Table 7).

The biplot from the correspondence analysis (Fig. 4) indicates an association between "Review" and "Generic" and non-empirical in this direction to some degree. "Oil and gas" seem to be associated with "Qualitative - case" as research design, and "Transportation" with "Quantitative" research. Other areas of industries are associated with "Qualitative-other methods" and the combination of qualitative and qualitative research.

3.10. What are the most frequently used core references?

A main finding is that there is considerable variation in the choice of main reference with regard to culture (see Table 8). In 73 publications (32%) the core references for culture are unique or used as core references in only one other paper in the sample. The most frequently used core references when addressing "culture" are different publications of Reason, Schein and Hofstede (years excluded here). However, 54 papers (24%) do not use any preferred core references linked to the use of the term

[8] The main contributors to dimension 1 are "Review" and "Generic", and thereafter "Quantitative". On the second dimension "Qualitative – Case", "Quantitative", "Oil and gas" and "Transportation" are the categories defining the graphical solution.

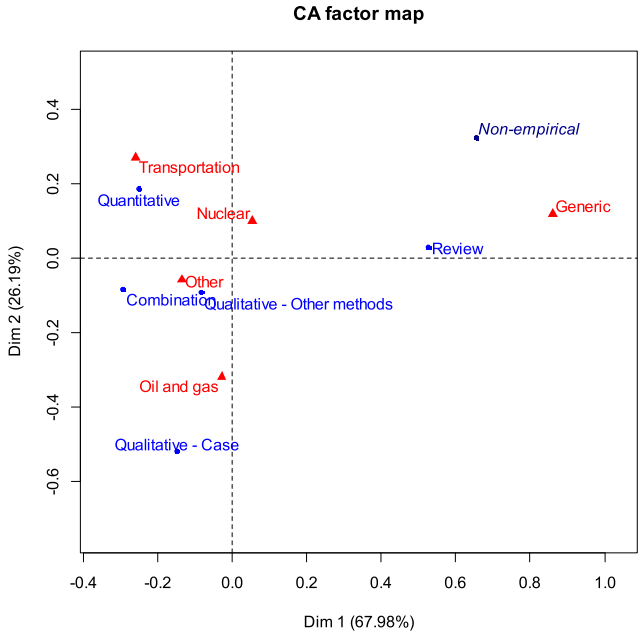

Fig. 4. Correspondence analysis between research design and area of industry, Non-empirical as supplementary category.

Table 8
Core reference used in three or more papers.

Category	Frequency
Reason (1998, 2000)	19
Schein (1985)	17
Hofstede (1980)	13
Cox & Flin (1998)	6
Geertz (1973)	6
Guldenmund (2000)	6
Zohar (1980)	6
ACSNI (1993)	4
Cooper (2000)	4
Grote & Künzler (2000)	3
Hale & Hovden (1998)	3
Hudson (2001, 2007)	3
IAEA (1991, 1992, 2002)	3
Pidgeon (1991, 1998)	3
Turner (1978)/Turner & Pidgeon (1997)	3
Westrum (1993)	3
Others	73
No main reference	54
Total	**229**

"culture". One explanation is that 17 of these papers are review papers where the authors do not rely on one or several specific formal definitions on culture. However, the remaining 37 papers (16%) do address "culture" without a reference to support any definition of culture.

3.11. The most cited papers

Different from above, where we have identified all the core references that are used in three or more articles, we look here at the 20 most frequently cited papers in our sample; 10 of them are theoretical discussions (Pidgeon & O'Leary, 2000; Hudson, 2003), or reviews of other papers (Guldenmund, 2000, 2007; Cooper, 2000; Glendon & Stanton, 2000; Sorensen, 2002; Lund & Aarø, 2004; Flin, 2007; Choudhry et al., 2007). Five of the papers use quantitative data obtained by surveys (Williamson et al., 1997; Grote & Künzler, 2000; Lee & Harrison, 2000; O'Dea & Flin, 2001; Carthey et al., 2003), or accident data bases (Carthey et al., 2003). Two papers combine survey data with qualitative methods (Cox & Cheyne, 2000; McDonald et al., 2000), and three are based entirely on qualitative data (Richter and Koch, 2004; Parker et al., 2006; Hudson, 2007).

When considering solely the papers with more than 10 citations (n = 116), 46 (40%) do not present any new empirical data (Table 9). These are reviews or non-empirical papers.

3.12. What does "culture" denote?

In 129 of the papers in the sample, the author(s) provide(s) a single formal definition of what they consider to be "culture". In seven papers the author(s) presents different formal definitions without preferring one definition over the other. These seven papers are all reviews of the use of culture in other papers. As many as 93 papers in the sample (41%) use the term "culture" without presenting any formal definition. The extent of the use of the term "culture" varies considerably among these 93 papers. The limited use of the term in some papers made it impossible to classify 18 of the papers according to three of the taxonomies ("integrated or differentiated", "level of abstraction", and "location of culture") regarding the meaning of "culture".

3.13. "Culture" and the extent of the communities

Only 29 (12%) of the papers address "national culture" and conditions associated with communities larger than a defined formal organisation. Of these papers, 16 have been conducted within the industrial context of transportation, and address driving habits that are attributed to "culture", and work practices and/or safety performance among seafarers of different nationalities. The remaining 13 papers are spread across several industries, such as construction and building, industrial production, oil and gas and health. The most frequently cited papers addressing national culture are Radin et al. (1996), Mearns and Yule (2009), Horlick-Jones (1998), Mohamed et al. (2009), and Hayakawa et al. (2000). The papers addressing "national culture" seem to use "culture" to explain variations in behaviour between defined social groups.

3.14. "Culture" as integrated or differentiated

A majority of 61% of the papers use "culture" to address features that are shared and "common" within a specified community. In 51 of the papers (22%) the authors use term the "culture" in a manner that implies that it is a phenomenon that varies to some extent within a specific community. This means that the authors address, for example, variations in practices, beliefs and opinions within a community. In 140 (61%) of the papers culture is treated as something that is integrated and common throughout a specified community. The reviewers were

Table 9
Total citations by research designs.

Citations	Combination	Non-empirical	Qualitative - Case	Quantitative	Review	Qualitative - Other methods	Total
No citations	4 (14.3%)	1 (3.6%)	8 (28.6%)	7 (25%)	6 (21.4%)	2 (7.1%)	28 (100%)
1–10 citations	12 (14.1%)	3 (3.5%)	15 (17.6%)	32 (37.6%)	17 (20%)	6 (7.1%)	85 (100%)
11 and more citations	12 (10.3%)	3 (2.6%)	3 (2.6%)	45 (38.8%)	43 (37.1%)	10 (8.6%)	116 (100%)
Total	28 (12.2%)	7 (3.1%)	26 (11.4%)	84 (36.7%)	66 (28.8%)	18 (7.9%)	229 (100%)

Table 10
Level of abstraction and profession of the main author and culture as abstraction or factor.

	Profession of the main author						
Level of abstraction	Business & administration	Engineering & technology	Health	Psychology	Social sciences	Unknown	Total
Holistic	2	4	2	6	14	2	30
	28.6%	4.2%	6.3%	9.0%	63.6%	40%	13.1%
Factor	2	71	17	48	3	1	142
	28.6%	74.0%	53.1%	71.6%	13.6%	20%	62.0%
Both perspectives	0	6	5	7	2	1	21
	0%	6.3%	15.6%	10.4%	9.1%	20%	9.2%
Unknown	3	15	8	6	3	1	36
	42.9%	15.6%	25.0%	9.0%	13.6%	20%	15.7%
Total	7	96	32	67	22	5	229
	100%	100%	100%	100%	100%	100%	100%

Table 11
Level of abstraction and profession of the main author - Eigenvalues, inertia and contributions of the categories.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.29	0.04	0.33
Rows' contribution	Both perspectives	0.00	0.04	
	Factor	17.65	13.62	
	Holistic	82.25	4.10	
	Unknown	0.10	82.24	
Columns' contribution	Business & administration	4.04	39.06	
	Engineering & technology	10.81	0.03	
	Health	0.49	34.32	
	Psychology	2.06	23.50	
	Social sciences	82.60	3.09	

Correlation coefficient: 0.57.

not able to use categorise 35 (15%) of the papers, using the "integrated or differentiated" taxonomy.

To assess whether there were significant effects regarding the association between papers with an integrated or differentiated view of culture and respective profession of the main author and area of industry, we used the chi-square tests. Both tests proved non-significant[9].

3.15. "Culture" and level of abstraction

When the papers are categorised according to the "level of abstraction" of culture the majority of the papers (62%, n = 142) conceptualise culture as some kind of factor, among other factors, that have an influence on human behaviour and safety performance. Of the papers, 30 (13%) advocate a holistic concept of culture (i.e. a metaphor for "system dependencies"), while 21 papers (9%) use the term culture to denote both "a factor among other factors", and a "system of interrelations". The reviewers were not able to categorise 36 (16%) of the papers according to "level of abstraction" taxonomy. The reason for this was that culture was not explicitly defined and briefly used as term in the texts.

3.16. Level of abstraction by discipline

Table 10 shows that the conceptualisation of culture as a factor is most common among those papers written by authors from engineering and technology (74%), psychology (72%) and health (53%). Holistic conceptualisation of culture is more common among those papers written by authors with a background in the social sciences (64%) and business and administration (29%).

The correspondence analysis (see Table 11 and Fig. 5) shows that there are some associations between the level of abstraction of the concept of culture and the professions of the researchers[10]. The total variance explained (inertia) is 33%. As we can see by the dimensions, the main effects of these associations are explained by one dimension (29% of variance explained). For this dimension, the most contributing categories are "Holistic" and "Social sciences". The category "Unknown" in Profession of the main author is removed for this analysis.

By inspection of the correspondence analysis biplot (Fig. 5), we see that "Holistic" and "Social sciences" are closely tied together, both deviating from the other points[11]. The main results from the correspondence analysis are that "Holistic" seems to be a perspective more associated with "Social sciences" than other professions, and that there is an association between the factor "perspective on culture" and papers with an engineer or psychologist as the corresponding writer.

Test of associations between level of abstraction and areas of industry was also conducted but the result was not significant[12]

3.17. Location of "culture"

By using the "location" taxonomy of culture, 135 of the papers (59%) were allocated in the category named "ideational system", i.e. the use of "culture" to denote phenomena that we also denote as "attitudes", "values", "opinions", "views" and ways of thinking.

Moreover, 18 of the papers (8%) belong to the category where culture functions as a term to denote a kind of social system of interdependencies, and 28 papers (12%) have been allocated to the category where "culture" denotes the products (i.e. work practices, patterns of interaction, values, language, etc.) of a sociocultural system of interdependencies. The reviewers were not able to categorise 48 of the papers (21%) according to this taxonomy.

3.18. Location of culture by discipline

Table 12 shows that the conceptualisation of culture as something ideational is most common among those papers written by authors with

[9] Chi-square test - Profession of the main author: X^2 = 14.289, df = 12, p > .05, chi square test - Area of industry: X^2 = 15.192, df = 12, p > .05.

[10] Chi-square test:X2 = 77.696, df = 12, p < .01. The expected frequencies were in nine (45%) of the cells, above the common rule of thumb. The results of the significance test should therefore be interpreted with caution.

[11] They are both outliers in the sense that they are located more than one standard deviation from the origin. Since they both are, in a strict sense, outliers, they should be considered to be suppressed or treated as supplementary points (Bendixen, 1996). However, based on the fact that they are important for the interpretation of the variables, and that this is a population-based study, we chose to retain the categories.

[12] Chi square test:X2 = 12.109, df = 12, p > .05.

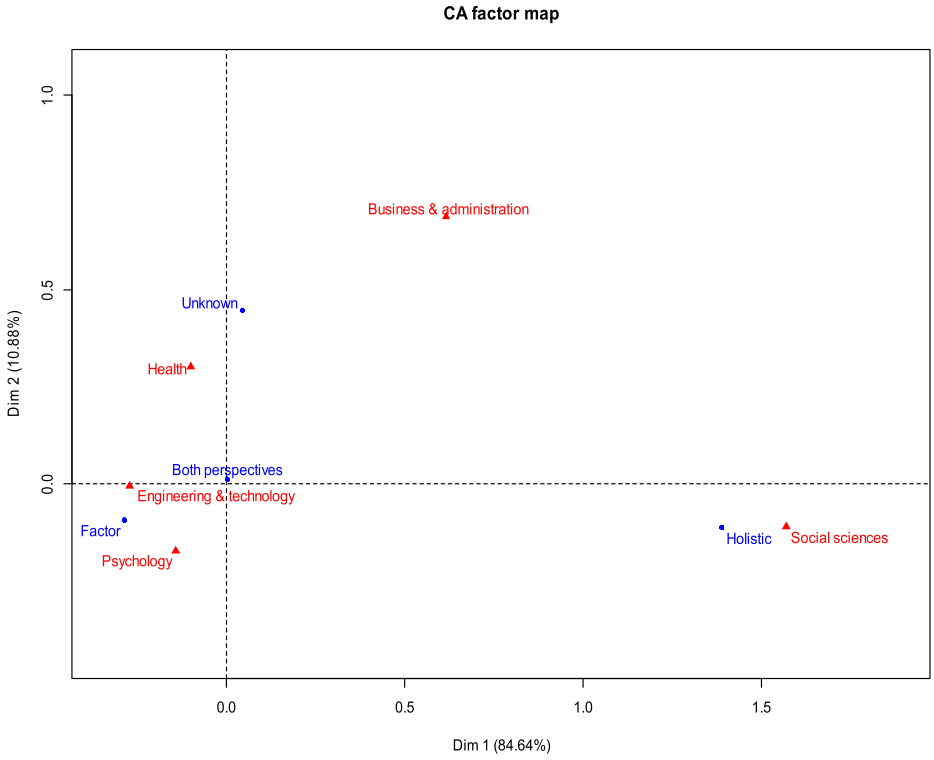

Fig. 5. Correspondence analysis of level of abstraction and profession of the main author.

Table 12
Location of culture and profession of the main author and "location" of culture.

	Profession of the main author						
Location of culture	Business & administration	Engineering & technology	Health	Psychology	Social sciences	Unknown	Total
Ideational	4	49	21	50	8	3	135
	57.1%	51.0%	65.6%	74.6%	36.4%	60%	59%
Social	1	16	4	11	13	1	46
	14.3%	16.7%	12.5%	16.4%	59.1%	20%	20.1%
Unknown	2	31	7	6	1	1	48
	28.6%	32.3%	21.9%	9.0%	4.5%	20%	21.0%
Total	7	96	32	67	22	5	229
	100%	100%	100%	100%	100%	100%	100%

background in Psychology (75%), Health (66%), Business and administration (57%), and Engineering and technology (51%). Considering culture a "social system" is most common among papers written by social scientists[13] (59%).

The correspondence analysis shows there are some associations between the location of culture and the professions of the main author[14]. The total explained variance (inertia) in the correspondence model is 17%[15] (Table 13).

The biplot (Fig. 6) shows that culture as something "Social" and "Social sciences" are closely associated. "Unknown" is most frequently associated with "Engineering & Technology" and Business & Administration" whereas "Ideational" is closest to "Psychology" & "Health".

Table 13
Location of culture and profession of the main author - Eigenvalues, inertia and contributions of the categories.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.11	0.06	0.17
Rows' contribution	Ideational	3.67	37.41	
	Social	70.98	8.93	
	Unknown	25.35	53.67	
Columns' contribution	Business & administration	1.00	0.49	
	Engineering & technology	11.12	34.63	
	Health	3.72	1.90	
	Psychology	0.16	57.89	
	Social sciences	84.00	5.09	

Correlation coefficient: 0.41.

[13] Organizational psychologists not included.
[14] The chi square test: X2 = 38.174, df = 8, p < .01.
[15] The main effects of these associations are explained by dimension 1 (11% of variance explained). The most contributing categories for this dimension are "Social" and "Social sciences". On the second dimension, "Ideational" and "Unknown", "Engineering & Technology" and "Psychology" are the contributing categories.

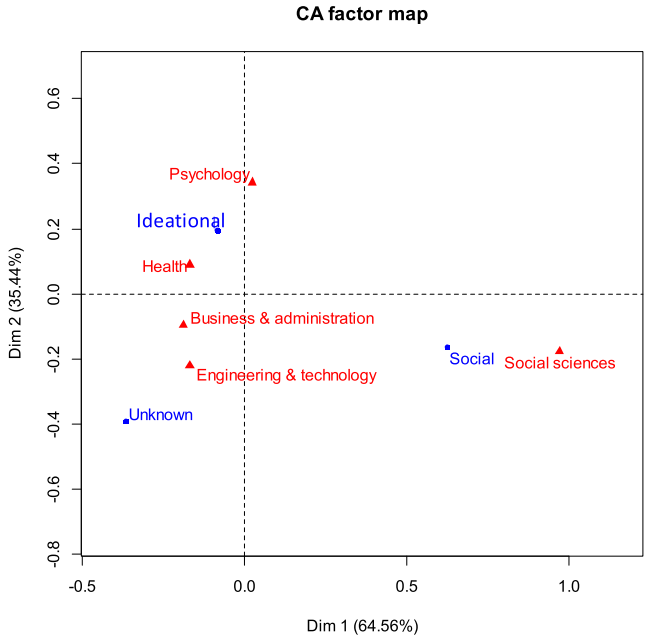

Fig. 6. Correspondence analysis of Location of culture by Profession of the author.

Table 15
Location of culture and research design - Eigenvalues, inertia and contributions of the categories.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.08	0.02	0.10
Rows' contribution	Ideational	35.21	5.84	
	Social	5.20	74.71	
	Unknown	59.59	19.45	
Columns' contribution	Combination	24.87	1.10	
	Non-empirical	0.11	9.16	
	Qualitative – Case	29.07	37.08	
	Quantitative	16.36	9.27	
	Review	27.67	19.28	
	Qualitative - Other methods	1.92	24.11	

Correlation coefficient: 0.32.

be related to a Ideational location of culture. Moreover, we see that papers based entirely on case study descriptions seem to be more difficult to classify in terms of location of "culture".

Associations between location of culture and areas of industry were also tested and the results were not significant[17].

Table 14
Location of culture and research design.

	Research design						
Location of culture	Quantitative	Qualitative- Case	Qualitative - Other methods	Combination of quantitative and qualitative methods	Review	Non-empirical	Total
Ideational	58	11	11	22	29	4	135
	69.0%	42.3%	61.1%	78.6%	43.9%	57.1%	59%
Social	13	4	5	4	18	2	46
	15.5%	15.4%	27.8%	14.3%	27.3%	28.6%	20.1%
Unknown	13	11	2	2	19	1	48
	15.5%	42.3%	11.1%	7.1%	28.8%	14.3%	21.0%
Total	84	26	18	28	66	7	229
	100%	100%	100%	100%	100%	100%	100%

3.19. Location of culture by research design

Conceptualisation of culture as a ideational feature is most common in published papers, regardless of research design (Table 14). The conceptualisation of culture predominately as a constituted practice in relation to characteristics of the social context is most common in research designs, based entirely on qualitative methods other than case descriptions, in reviews and in non-empirical research. The authors' conceptualisation of culture is most difficult to identify when qualitative case descriptions are used as the only method for the research.

The correspondence analysis shows there are some associations between the location of culture and research design.[16] The explained variance (inertia) in the model is only 10% (Table 15). The main contributors to the dimension 1 is "Ideational" and "Unknown", as well as "combination", and both of the qualitative categories.

The graphical biplot (Fig. 7) shows that both Quantitative and Combination (use of both quantitative and qualitative methods) seem to

3.20. To what extent are the papers normative?

A total of 95 of the papers (41.5%) in the sample were normative recommendations on how to improve the HSE records of an organisation, without including comprehensive descriptions of obtained data. A total of 53 of the papers (23.1%) presented results from the analysis of obtained data, followed by some recommendations on how to improve HSE records. However, 81 of the papers (35.5%) did not present any normative representations, but were entirely descriptive, oriented towards the findings from the analysis conducted.

3.21. Descriptive or normative by the profession of the authors

Table 16 shows that entirely descriptive papers are most common among those where the main author has a background in Business and administration (71.4%), Social sciences (59.1%), Health (46.9%) and Psychology (46.9%). Entirely normative papers are most common among those where the main authors have a background in Engineering and technology (60.4%).

The correspondence analysis yielded significant results regarding

[16] Chi square test: $X^2 = 23.485$, df = 10, $p < .01$. 27.8% of the cells had an expected frequency of 5, which may confound the results.

[17] Chi square test: $X^2 = 10.034$, df = 8, $p > .05$.

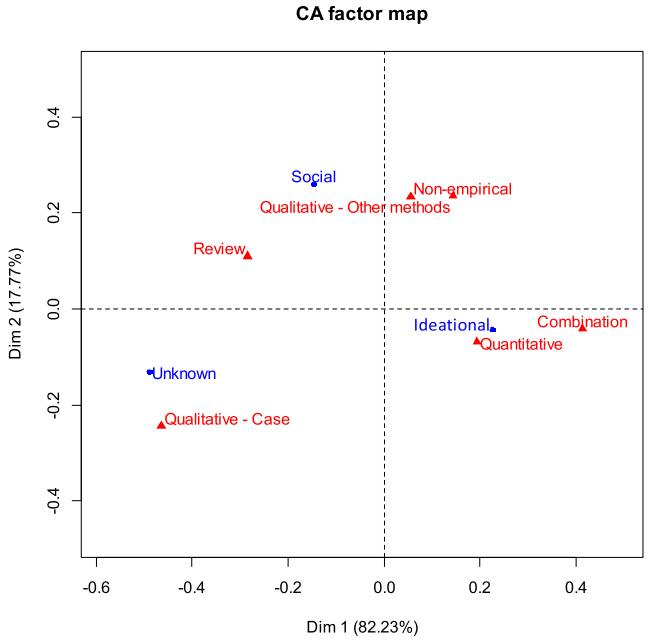

Fig. 7. Correspondence analysis of location of culture and research design.

the association between the location of culture and the profession of the main author[18], and the total explained variance is 16%[19] (Table 17).

The biplot (Fig. 8) shows "Descriptive" and "Social sciences", as well as "Business and administration", are closely associated. On the left-hand side of the x-axis, we see that "Engineering and technology" is linked to papers with normative content. "Health" and "Psychology" are more associated with a combination of descriptive and normative style of writing.

3.22. Descriptive or normative by research design

An entirely descriptive style of writing is most common among publications based entirely on "Qualitative - other methods" (interviews and/or ethnographic methods) (Table 18). A normative writing style is most common among papers based on qualitative case descriptions (69.2%) and among review papers (47%).

The correspondence analysis and the test of associations proved to be significant [20], with an explained variance of 15% (Table 19).

In the graphical biplot (in Fig. 9 we see that Qualitative – other methods seem to be associated with being Descriptive, while Qualitative case and Non-empirical are related to Normative (Fig. 9).

3.23. Descriptive or normative by area of industry

Of the papers coded as "Descriptive", there are no apparent deviations from either industry from the total percentage of 35.4% (Table 20). As for the "Normative" category, 64.2% of these are from the Oil and Gas industry, and only 22% from Transportation. Moreover, the opposite trend is present regarding papers coded as "Normative and Descriptive". Here, the Oil and Gas industry have produced only 5.7% of the papers, as opposed to the total number of papers, which is 23.1%.

The test of associations was significant[21]. The explained variance was 11%[22] (Table 21).

The biplot (Fig. 10) shows that "Normative" and "Oil and Gas" are associated, both being strong contributors to the x-axis. Similarly, "Transportation" is related to "Normative and Descriptive", both contributing to the definition of the right-hand side of the axis.

4. Discussion

In the following discussion we have tried to summarise and outline some possible implications for the discourse regarding the concept of culture, based on our findings connected to hallmarks of the authors addressing "HSE" and "culture" and their conceptualisations of culture.

4.1. Authors addressing "HSE" and "culture"

Our analysis shows that only nine of the papers in our sample do not address safety when writing about culture and HSE. A majority of 75.5% of the papers only address safety, not health or environment. This implies that the majority of publications addressing "culture" and "HSE" seem to represent a subset, or are consistent with publications addressing "safety culture".

Judging from our sample, a large majority of the papers have authors that are either situated in Europe, North America or Australia (80%). This is also reflected in the geographical regions where the empirical research has been conducted. More than 80% of the empirical papers rely on data obtained in Europe, North America or Australia.

If we follow the assumption and research results which support that safety cultures vary between different geographic areas and nationalities (see e.g. Hansen et al., 2002; Lamvik & Bye, 2004; Håvold, 2005; Lamvik & Ravn, 2006), this means that the discussions in the majority of the papers are based on and limited to European, Australian and North American realities. This represents a bias in the research that may contribute to (to the extent that these are made) inaccurate generalisations and conclusions. Inaccurate generalisations may also be enhanced when we consider that only 29 (12%) of the papers address "national culture". Together this may contribute to a somewhat reductionistic discourse within the community of HSE research, an issue especially relevant when addressing normative aspects through the use of the notion of "good" or "bad" "cultures".

Most of the papers in our sample are written by researchers with a background in engineering and technology (42%) or psychology (29%). Social scientists account for 10% of the papers. This distribution is relevant since we find several significant differences between researchers of different professional backgrounds and how the research on culture and HSE is conducted and represented. It should be noted that one of the tests did not adhere to statistical assumptions of the chi-square test. Nevertheless, the correspondence analysis revealed that psychologists, together with authors with a background in health, tend to primarily rely on quantitative research designs, where researchers with a background in engineering and technology are more inclined to conduct case studies. Researchers from business and administration and other social sciences (social anthropology, sociology, human geography) tend to rely on interviews and ethnographic methods. This may contribute to a discourse dominated by questions related to individual perceptions and attitudes (survey-based research designs), as well as predominately *etic* case descriptions (from the perspective of the observer). Research designed in order to grasp and interpret the perspective of the subject

[18] Chi square test: $X^2 = 34.507$, df = 8, $p < .01$, n = 225.

[19] The main effects of these associations are explained by one of the dimensions (15% of variance explained). For this dimension, the most contributing categories are "Descriptive", "Normative", "Engineering and technology" and "Social sciences". For this analysis, the category "Unknown" is excluded.

[20] Chi-square test: $X^2 = 33.657$, df = 10, $p < .01$. A potential problem with low expected frequencies was also present in this analysis. In essence, the association between Normative or Descriptive and research design seems to be largely explained by that all Non-empirical studies and 69.2% of the studies using solely case are coded as Normative.

[21] Chi square test: $X^2 = 25.854$, df = 8, $p < .01$.

[22] The effects of these associations are explained by only one dimension, with "Normative" and "Normative and Descriptive", "Oil and Gas" and "Transportation" as the most commonly contributing categories.

Table 16
Cross tabulation of Normative or Descriptive and Profession.

	Profession of the main author						
Normative or descriptive	Business & administration	Engineering & technology	Health	Psychology	Social sciences	Unknown	Total
Descriptive	5	19	15	28	13	1	81
	71.4%	19.8%	46.9%	41.8%	59.1%	20%	35.4%
Normative	1	58	7	22	3	4	95
	14.3%	60.4%	21.9%	32.8%	13.6%	80%	41.5%
Descriptive and normative	1	19	10	17	6	0	53
	14.3%	19.8%	31.3%	25.4%	27.3%	0%	23.1%
Total	7	96	32	67	22	5	229
	100%	100%	100%	100%	100%	100%	100%

Table 17
Normative or Descriptive and Profession - Eigenvalues, inertia and the variables' relative contributions to the dimensions.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.15	0.01	0.16
Rows' contribution	Descriptive	42.8	21,49	
	Normative	54.52	4,85	
	Normative and Descriptive	2.68	73,66	
Columns' contribution	Business & administration	9.31	66.33	
	Engineering & technology	50.18	1.28	
	Health	12.84	30.88	
	Psychology	5.33	0.51	
	Social sciences	22.34	1	

Correlation coefficient: 0.40.

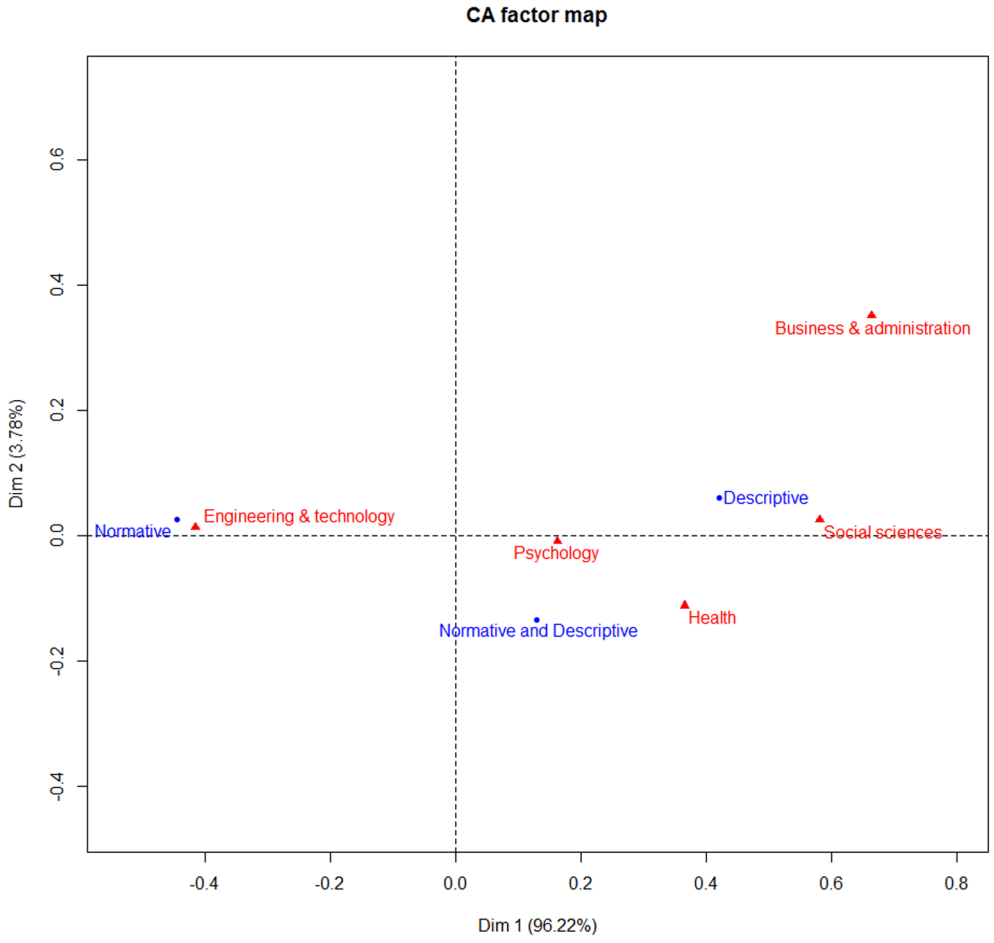

Fig. 8. Correspondence analysis of Normative or Descriptive and Profession.

Table 18
Crosstabulation of Normative or Descriptive and Research design.

	Research design						
Normative or descriptive	Quantitative	Qualitative-case	Qualitative - Other methods	Combination of quantitative and qualitative methods	Review	Non-empirical	Total
Descriptive	37	6	11	9	18	0	81
	44.0%	23.1%	61.1%	32.1%	27.3%		35.4%
Normative	28	18	2	9	31	7	95
	33.3%	69.2%	11.1%	32.1%	47.0%	100%	41.5%
Descriptive and normative	19	2	5	10	17	0	53
	27.8%	7.7%	27.8%	35.7%	25.8%		23.1%
Total	84	26	18	28	66	7	229
	100%	100%	100%	100%	100%	100%	100%

Table 19
Normative and/or Descriptive and Research design - Eigenvalues, inertia and the variables' relative contributions to the dimensions.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.13	0.02	0.15
Rows' contribution	Descriptive	28.98	35.65	
	Normative	58.30	0.22	
	Normative and Descriptive	12.72	64.13	
Columns' contribution	Combination	2.93	38.58	
	Non-empirical	33.71	0.83	
	Qualitative – Case	27.43	13.76	
	Quantitative	8.45	15.16	
	Review	3.20	21.50	
	Qualitative - Other methods	24.28	10.18	

Correlation coefficient: 0.39.

(see e.g. Haukelid, 2008; Richter and Koch, 2004; Dekker, 2016; Carim et al., 2016) seems to be somewhat marginal within the research communities. In general, there has been a lack of studies of actual work practice (Carim et al., 2016) situated in particular organisations, in interactions with a particular technology (Reiman & Rollenhagen, 2014) and accompanied by the sensemaking of the involved actors (Haukelid, 2008).

An additional noteworthy finding regarding the choice of methods is that 28% of the papers are reviews of other papers. Among the papers that are based on original data, excluding the reviews and the non-empirical papers (31%), around half of them (53%) are based entirely on quantitative data. This typically means different statistical analysis of questionnaires measuring "culture", but also includes to some extent the use of different types of event data. Only 12% of the total sample use quantitative data, questionnaire data and event data, in combination with qualitative data obtained by interviews and/or ethnographic methods, while 22% of the total sample relies entirely on qualitative data, i.e. case studies, interviews and ethnographic methods. This distribution is relevant in relation to the discourse on whether quantitative methods and measurements of culture by the use of surveys is expedient or not (see e.g. Guldenmund, 2007; Haukelid, 2008).

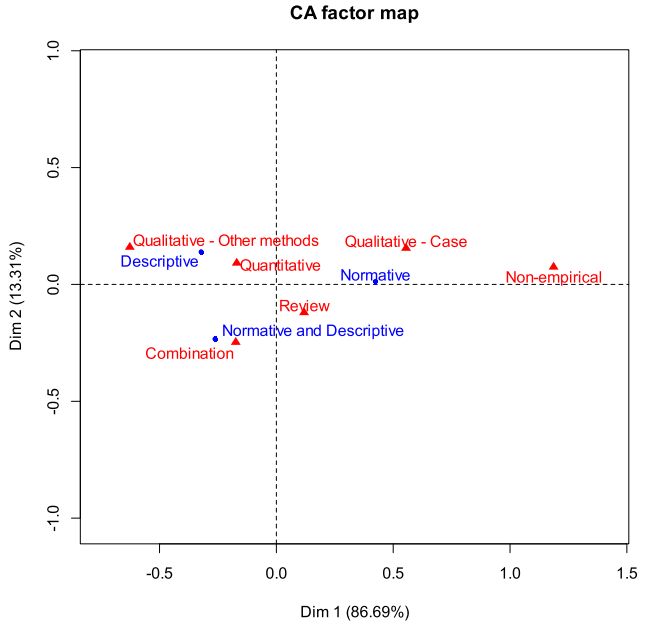

Fig. 9. Correspondence analysis of Normative or Descriptive and research design.

4.2. Conceptualisation of culture

A somewhat large proportion of the papers contain the concept of culture without presenting a formal definition (41%), or where the term is used in a rather vague and imprecise way that makes it difficult to interpret what the authors are actually trying to denote. As mentioned above, we found it difficult to categorize the articles according to the

Table 20
Cross tabulation of Normative or Descriptive and Area of industry.

	Area of industry					
Normative - descriptive	Generic	Nuclear	Oil and gas	Transport	Other	Total
Descriptive	9	6	16	25	25	81
	29.0%	33.3%	30.2%	42.4%	36.8%	35.4
Normative	14	6	34	13	28	95
	45.2%	33.3%	64.2%	22.0%	41.2%	41.5%
Descriptive and normative	8	6	3	21	15	53
	25.8%	33.3%	5.7%	35.6%	22.1%	23.1%
Total	31	18	53	59	68	229
	100%	100%	100%	100%	100%	100%

Table 21
Normative or Descriptive and Area of industry - Eigenvalues, inertia and the variables' relative contributions to the dimensions.

		Dimension 1	Dimension 2	Total (Inertia)
	Eigenvalues	0.11	0.00	0.11
Rows' contribution	Descriptive	4.29	60.34	
	Normative	49.14	9.37	
	Normative and Descriptive	46.57	30.29	
Columns' contribution	Generic	0.07	56.99	
	Nuclear	3.69	21.12	
	Oil and gas	55.91	3.44	
	Other	0.01	7.53	
	Transportation	40.31	10.92	

Correspondence coefficient: 0.33.

cultural taxonomy we have used. This finding may partly reflect that culture is incorporated as a part of everyday language of both the authors and readers, making it possible of "getting away" without defining it.

Although the works of Reason, Schein and Hofstede (altogether 21% of the sample) are used as a core reference more frequently than other authors, there is a wide variety in the sample. A total of 35 of the papers in the sample (15.3%) use "culture" as a concept without any reference to any author.

In 61% of the papers "culture" seems to be used to denote something that is shared, aligned and common among a defined group of people. These findings are relevant in relation to the discourse regarding the conceptualisation of culture as integrated, differentiated or fragmented (see Martin, 1992; Richter and Koch, 2004; Haukelid, 2008; Reiman & Rollenhagen, 2014).

In most of the papers (62%) "culture" is treated as one factor among other factors that explain a phenomenon. "Culture" is used as a holistic analytical metaphor in only 13% of the papers. Our findings indicate that the use of culture as an analytical metaphor is under-represented, and there are no statistically significant differences across industries.

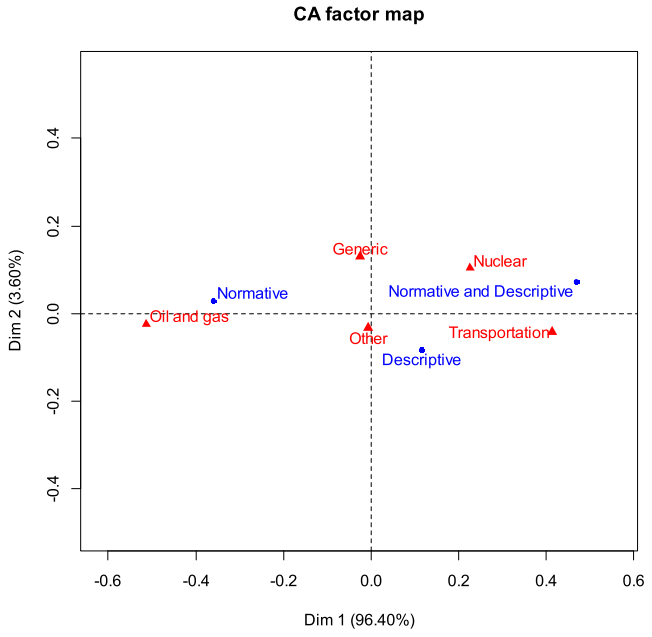

Fig. 10. Correspondence analysis of Normative or Descriptive and Area of Industry.

The correspondence analysis between professions of the authors and conceptualisation of culture revealed that authors with a background in psychology (assumingly mainly organizational psychology) or engineering and technology are associated with a conceptualisation of "culture" as a factor. Furthermore, there is an association between a holistic perspective and authors with a background in social sciences. Our correspondence model explains 33% of the variation in the sample.

When categorising the papers on how the authors "locate" culture, we found that 59% tend to treat culture as an ideational phenomenon, whereas 20% conceptualised it as something social (interaction between actors in a socio-technical context). As the biplot of the correspondence analysis showed, the "ideational" was associated with researchers with a background in psychology or engineering and technology, whereas "social" was associated with social sciences. There is also an association between locations of culture and research design, but the explained variance is only 10%. This implies that for most papers regardless of research design, one can find different conceptualisations of "location of culture". However, some of the categories clearly stand out, for example was "ideational" associated with a quantitative research design. The finding that location of culture was related to research design is relevant for the discussion on whether culture is "something organisations have", or "something organisations are" (see. e.g. Cooper, 2000; Antonsen, 2009b), and the potential of using "culture" to perform holistic socio-technical analysis (Reiman & Rollenhagen, 2014). Our findings support Reiman and Rollenhagen's (2014) view that there has been a lack of more systemic viewpoints on safety within the mainstream safety culture discourse.

4.3. Normative orientation

Around 65% of the papers contain normative recommendations about how to improve HSE records and/or the "culture". The rest of the sample consists of entirely descriptive papers, representing findings from research activities. As many as 41.5% of the papers are lacking a comprehensive description of empirical data, being predominately normative-oriented. However, with a somewhat low explained variance (16%), the correspondence analysis reveals a statistically significant association between predominately normative-oriented papers with no or limited descriptions of empirical data and authors with a professional background in engineering and technology. Social science is associated with non-normative papers. There is also a statistically significant relation – with low explained variance (15%) – between how normative the authors are and the research design. Predominately normative papers are associated with non-empirical research design and case studies. Furthermore, with even less explained variance (11%) there is an association between area of industry and how normative the authors are. The correspondence analysis revealed that predominately normative papers are associated with the Oil and Gas Industry, and predominantly normative and descriptive studies are primarily associated with the Transportation Industry.

5. Conclusions

Our statistical analysis based on a "stocktaking" of papers addressing "culture" and "HSE", confirms much of the critique that has been addressed regarding the use of culture as a concept within safety research. Correspondence analyses have in this study been utilised in order to explore direct relationships between various aspects of the research conducted on "culture" and "HSE". Some perspectives seem to dominate. These include the conceptualisation of culture as shared and aligned perceptions and attitudes, more or less neglecting the differentiation and fragmentation perspectives. Papers where culture is conceptualised as something ideational are dominant, and there are relatively few papers that conceptualise culture as something that develops and maintains in the interaction between people within a particular organisational context. Interpretative approaches, taking the

perspective of the actors, seem to be somewhat marginal within culture and HSE research.

We find that different cultural perspectives are associated with the professional background of the authors and research designs, and that the discourse has been dominated by researchers with a professional background in psychology and engineering and technology. A somewhat large proportion of the predominately normative papers lack a comprehensive description of empirical data.

It should be noted that most of the correspondence analyses we have conducted, we found moderate effect sizes between the variables. Consequently, there is much unexplained variance in the analyses. This implies that even though we have found significant associations between conceptualisations of HSE culture and e.g. profession, several of the categories have "average" frequencies. Nevertheless, most of the analyses were highly significant, indicating clear tendencies of association.

A majority of the published research has been conducted in North America, Europe and Australia, which we argue represents a bias in the research that may contribute to incorrect generalisations and conclusions. In summary, our findings reveal some challenges in how culture has been conceptualised, and that there is a research gap in terms of the knowledge regarding "culture" and HSE outside the western world.

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References

ACSNI, 1993. Organising for Safety. Advisory Committee on Safety of Nuclear Installations, ACSNI Human Factors Study Group, Third Report, H.M. Stationery Office, Norwich.
Allaire, Y., Firsirotu, M.E., 1984. Theories of organizational culture. Org. Stud. 5 (3), 193–226.
Alvesson, M., 2002. Understanding Organizational Culture. SAGE.
Alvesson, M., Berg, P.O., 1992. Corporate Culture and Organizational Symbolism: an overview. de Gruyter studies in organization, 34.
Antonsen, S., 2009a. Safety culture assessment: a mission impossible? J. Contingencies Crisis Manage. 17 (4), 242–254.
Antonsen, S., 2009b. Safety culture and the issue of power. Saf. Sci. 47 (2), 183–191.
Antonsen, S., Nilsen, M., Almklov, P.G., 2017. Regulating the intangible. Searching for safety culture in the Norwegian petroleum industry. Saf. Sci. 92, 232–240.
Bendixen, M., 1995. Compositional perceptual mapping using chi-squared tree analysis and Correspondence Analysis. J. Market. Manage. 11, 571–581.
Bendixen, M., 1996. A practical guide to the use of correspondence analysis in marketing research. Market. Res. On-Line 1 (1), 16–36.
Bernard, H.R., 2011. Research Methods in Anthropology: Qualitative and Quantitative Approaches. Rowman Altamira.
Buell, R.S., 2006. Creating a culture to deliver sustainable HSE performance. SPE Projects, Facilit. Construct. 1 (03), 1–8.
Bye, Rolf Johan; Rosness, Ragnar; Røyrvik, Jens Olgard Dalseth, 2016. 'Culture' as a tool and stumbling block for learning: The function of 'culture' in communications from regulatory authorities in the Norwegian petroleum sector. Saf. Sci. 81.
Carim Jr, G.C., Saurin, T.A., Havinga, J., Rae, A., Dekker, S.W., Henriqson, É., 2016. Using a procedure doesn't mean following it: a cognitive systems approach to how a cockpit manages emergencies. Saf. Sci. 89, 147–157.
Carthey, J., de Leval, M.R., Wright, D.J., Farewell, V.T., Reason, J.T., 2003. Behavioural markers of surgical excellence. Saf. Sci. 41 (5), 409–425.
Choudhry, R.M., Fang, D., Mohamed, S., 2007. The nature of safety culture: A survey of the state-of-the-art. Saf. Sci. 45 (10), 993–1012.
Clausen, J.A., 1998. Life reviews and life stories. In: Giele, J.Z., Elder, G.H. (Eds.), Methods of Life Course Research: Qualitative and Quantitative Approaches. Sage.
Cooper Ph. D, M. D., 2000. Towards a model of safety culture. Saf. Sci. 36(2), 111-136.
Cox, S.J., Cheyne, A.J.T., 2000. Assessing safety culture in offshore environments. Saf. Sci. 34 (1–3), 111–129.
Cox, S., Flin, R., 1998. Safety culture: philosopher's stone or man of straw? Work Stress 12 (3), 189–201.
Dekker, S., 2016. Just Culture: Balancing Safety and Accountability. CRC Press.
Edwards, J.R., Davey, J., Armstrong, K., 2013. Returning to the roots of culture: A review and re-conceptualisation of safety culture. Saf. Sci. 55, 70–80.
Field, A., 2009. Discovering Statistics Using SPSS. Sage publications.
Flin, R., 2007. Measuring safety culture in healthcare: A case for accurate diagnosis. Saf. Sci. 45 (6), 653–667.
Geertz, C., 1973. The interpretation of cultures Vol. 5019 Basic books.
Glendon, A.I., Stanton, N.A., 2000. Perspectives on safety culture. Saf. Sci. 34 (1), 193–214.
Grote, G., Künzler, C., 2000. Diagnosis of safety culture in safety management audits. Saf. Sci. 34 (1–3), 131–150.
Guldenmund, F.W., 2000. The nature of safety culture: a review of theory and research. Saf. Sci. 34 (1–3), 215–257.
Guldenmund, F.W., 2007. The use of questionnaires in safety culture research–an evaluation. Saf. Sci. 45 (6), 723–743.
Haghighi, M., Alimohammadi, I., Zarie, F., Yekefalah, D., 2013. Assessment health, safety & environment culture in an oil refinery based on Geller model. Iran. J. Health Ed. Health Promot. 1 (3), 47–56.
Hale, A.R., Hovden, J., 1998. Management and culture: the third age of safety. A review of approaches to organizational aspects of safety, health and environment. Occupat. Injury: Risk Prevent. Intervent. 129–165.
Hale, A., 2000. Culture's confusions. Saf. Sci. 34, 1–14.
Hansen, H.L., Nielsen, D., Frydenberg, M., 2002. Occupational accidents aboard merchant ships. Occup. Environ. Med. 59 (2), 85–91.
Hayakawa, H., Fischbeck, P.S., Fischhoff, B., 2000. Traffic accident statistics and risk perceptions in Japan and the United States. Accid. Anal. Prev. 32 (6), 827–835.
Haukelid, K., 2008. Theories of (safety) culture revisited—An anthropological approach. Saf. Sci. 46 (3), 413–426.
Hjellbrekke, J., 1999. *Innføring i korrespondanseanalyse* [Introduction to correspondence analysis]. Fagbokforlaget, Bergen.
Hofstede, G., 1980. Culture's consequences: National differences in thinking and organizing. Sage, Beverly Hills, Calif.
Horlick-Jones, T., 1998. Meaning and contextualisation in risk assessment. Reliab. Eng. Syst. Saf. 59 (1), 79–89.
Hudson, P.T.W., 2001. Safety management and safety culture: the long, hard and winding road. Occupat. Health Saf. Manage. Syst. 3–32.
Hudson, P., 2007. Implementing a safety culture in a major multi-national. Saf. Sci. 45 (6), 697–722.
Hudson, P., 2003. Applying the lessons of high risk industries to health care. BMJ Quality Saf. 12 (suppl 1), i7–i12.
Hudson, P.T., Parker, D., van der Graaf, G.C., 2002. The hearts and minds program: understanding HSE culture. Safety and Environment in Oil and Gas Exploration and Production. Society of Petroleum Engineers.
Høivik, D., Moen, B.E., Mearns, K., Haukelid, K., 2009. An explorative study of health, safety and environment culture in a Norwegian petroleum company. Saf. Sci. 47 (7), 992–1001.
Håvold, J.I., 2005. Safety-culture in a Norwegian shipping company. J. Saf. Res. 36 (5), 441–458.
IAEA, 1991. Safety Culture (Safety Series No 75- INSAG-4). International Nuclear Safety Advisory Group, International Atomic Energy Authority, Vienna.
IAEA, 1992. The Chernobyl Accident: Updating of INSAG-1. (Safety Series.75-INSAG-7), International Safety Advisory Group, International Atomic Energy Agency, Vienna.
IAEA, 2002. Safety culture in nuclear installations. Guidance for use in the enhancement of safety culture. IAEA-TECDOC 1329, International Atomic Energy Agency, Vienna.
Kongsvik, T., Gjøsund, G., Vikland, K.M., 2016. HSE culture in the petroleum industry: Lost in translation? Saf. Sci. 81, 81–89.
Lamvik, G.M., Bye, R., 2004. National culture and safe work practice—a comparison between Filipinos and Norwegian seafaring professionals. In: Probabilistic safety assessment and management. Springer, London, pp. 1315–1321.
Lamvik, G.M., Ravn, J.E., 2006. National culture and safety performance - offshore drilling, in: Soares and Zio (Eds.), Proceedings of the European Safety and Reliability Conference 2006 (ESREL 2006), Taylor & Francis Group, London, pp. 363-371.
Lee, T., Harrison, K., 2000. Assessing safety culture in nuclear power stations. Saf. Sci. 34 (1–3), 61–97.
Lund, J., Aarø, L.E., 2004. Accident prevention. Presentation of a model placing emphasis on human, structural and cultural factors. Saf. Sci. 42 (4), 271–324.
Martin, J., 1992. Cultures in Organizations: Three Perspectives. Oxford University Press.
McDonald, N., Corrigan, S., Daly, C., Cromie, S., 2000. Safety management systems and safety culture in aircraft maintenance organisations. Saf. Sci. 34 (1–3), 151–176.
Mearns, K., Yule, S., 2009. The role of national culture in determining safety performance: Challenges for the global oil and gas industry. Saf. Sci. 47 (6), 777–785.
Mohamed, S., Ali, T.H., Tam, W.Y.V., 2009. National culture and safe work behaviour of construction workers in Pakistan. Saf. Sci. 47 (1), 29–35.
Mohammadfam, I., Nikoomaram, H., Faridan, M., 2015. Evaluation of health, safety and environment (HSE) culture. Int. J. Occup. Hygiene 5 (1), 1–5.
Nielsen, K.J., 2014. Improving safety culture through the health and safety organization: A case study. J. Saf. Res. 48, 7–17.
Nævestad, T.O., Hesjevoll, I.S., Phillips, R.O., 2018. How can we improve safety culture in transport organizations? A review of interventions, effects and influencing factors. Transport. Res. Part F: Traffic Psychol. Behav. 54, 28–46.
O'Dea, A., Flin, R., 2001. Site managers and safety leadership in the offshore oil and gas industry. Saf. Sci. 37 (1), 39–57.
Parker, D., Lawrie, M., Hudson, P., 2006. A framework for understanding the development of organisational safety culture. Saf. Sci. 44 (6), 551–562.
Petroleum Safety Authority Norway , 2001 . Regulations relating to Health, Safety and the Environment in the Petroleum Activities and at certain Onshore Facilities (the framework regulations), 31 August 2001 . Petroleum Safety Authority Norway.
Pidgeon, N.F., 1991. Safety culture and risk management in organizations. J. Cross Cult. Psychol. 22 (1), 129–140.
Pidgeon, N., 1998. Safety culture: key theoretical issues. Work Stress 12 (3), 202–216.
Pidgeon, N., O'Leary, M., 2000. Man-made disasters: why technology and organizations (sometimes) fail. Saf. Sci. 34 (1–3), 15–30.

Radin, U.R., Mackay, M.G., Hills, B.L., 1996. Modelling of conspicuity-related motorcycle accidents in Seremban and Shah Alam, Malaysia. Accident Analy. Prevent. 28 (3), 325–332.
Reason, J., 2000. Safety paradoxes and safety culture. Injury Control Saf. Promot. 7 (1), 3–14.
Reason, J., 1998. Achieving a safe culture: theory and practice. Work Stress 12 (3), 293–306.
Reiman, T., Rollenhagen, C., 2014. Does the concept of safety culture help or hinder systems thinking in safety? Accid. Anal. Prev. 68, 5–15.
Richter, A., Koch, C., 2004. Integration, differentiation and ambiguity in safety cultures. Saf. Sci. 42 (8), 703–722.
Saussure, F., 1974. Course in general linguistics. Owen, London.
Schein, E.H., 1985. Organisational culture and leadership: A dynamic view. Jossey-Bass, San Francisco, CA.
Schöbel, M., Klostermann, A., Lassalle, R., Beck, J., Manzey, D., 2017. Digging deeper! Insights from a multi-method assessment of safety culture in nuclear power plants based on Schein's culture model. Saf. Sci. 95, 38–49.
Shore, B., 1998. Culture in mind: Cognition, culture, and the problem of meaning. Oxford University Press.
Sorensen, J.N., 2002. Safety culture: a survey of the state-of-the-art. Reliab. Eng. Syst. Saf. 76 (2), 189–204.
Sugiyama, H., Hirao, M., Fischer, U., Hungerbühler, K., 2008. Activity modeling for integrating environmental, health and safety (EHS) consideration as a new element in industrial chemical process design. J. Chem. Eng. Jpn. 41 (9), 884–897.
Tharaldsen, J.E., Mearns, K.J., Knudsen, K., 2008. January). A comparative study of HSE-culture on the Norwegian continental and UK continental shelves. Safety, and Environment in Oil and Gas Exploration and Production. Society of Petroleum Engineers.
Turner, B.A., 1978. *Man-Made Disasters*, (first edition). Wykeham Publications.
Turner, B.A., Pidgeon, N., 1997. *Man-Made Disasters*, (second edition). Butterworth-Heinemann.
Westrum, R., 1993. Cultures with requisite imagination. In *Verification and validation of complex systems: Human factors issues*. Springer, Berlin, Heidelberg, pp. 401–416.
Williamson, A.M., Feyer, A.M., Cairns, D., Biancotti, D., 1997. The development of a measure of safety climate: the role of safety perceptions and attitudes. Saf. Sci. 25 (1–3), 15–27.
Zohar, D., 1980. Safety climate in industrial organizations: theoretical and applied implications. J. Appl. Psychol. 65 (1), 96.