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The relationship between national culture and safety culture: Implications for international safety culture assessments

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In this article, we examine the relationship between safety culture and national culture, and the implications of this relationship for international safety culture assessments. Focussing on Hofstede's uncertainty avoidance (UA) index, a survey study of 13,616 Air Traffic Management employees in 21 European countries found a negative association between safety culture and national norm data for UA. This is theorized to reflect the influence of national tendencies for UA upon attitudes and practices for managing safety (e.g., anxiety on risk; reliance on protocols; concerns over reporting incidents; openness to different perspectives). The relationship between UA and safety culture is likely to have implications for international safety culture assessments. Specifically, benchmarking exercises will consistently indicate safety management within organizations in high UA countries to be poorer than low UA countries due to the influence of national culture upon safety practices, which may limit opportunities for identifying and sharing best practice. We propose the use of *safety culture against international group norms* (SIGN) scores to statistically adjust for the influence of UA upon safety culture data, and to support the identification of safety practices effective and particular to low or high UA cultures.

Practitioner points

- National cultural tendencies for uncertainty avoidance (UA) are negatively associated with safety culture.
- This indicates that employee safety-related attitudes and practices may be influenced by national culture, and thus factors outside the direct control of organizational management.
- International safety culture assessments should attempt to determine the influence of national culture upon safety culture in order that benchmarking exercises compare aspects of safety management and not national culture.

- Safety culture against international group norms (SIGN) scores provide a potential way to do this, and can facilitate the identification of best practice within countries operating in a low or high UA cultural cluster.

Safety culture refers to the norms, values, and practices shared by groups in relation to risk and safety (Cooper, 2000; Pidgeon, 1998). Within safety-critical industries (e.g., nuclear energy, oil and gas, aviation), safety culture assessments with cross-sectional surveys are used to identify trends that are promotive (e.g., shared beliefs on risk) and problematic (e.g., lack of incident reporting) for safety management (Carroll, 1998; Ek, Akselsson, Arvidsson, & Johansson, 2007; Fuller & Vassie, 2001; Lee & Harrison, 2000). Through further investigation, opportunities for interorganizational learning are identified (e.g., sharing best practice) and used to improve safety culture (Lee & Harrison, 2000; Mearns, Whitaker, & Flin, 2001; Sexton *et al.*, 2006). The globalized nature of many high-risk industries means that safety culture assessments are increasingly conducted at an international level (Reader & O'Connor, 2014; Sorra & Dyer, 2010; Taylor, 2010). Yet research indicates that safety culture within an organization may be influenced by national cultural tendencies to avoid the anxiety caused by risky and ambiguous situations (called 'uncertainty avoidance'; Hofstede, Hofstede, & Minkov, 2010). This has implications for how the results of international safety culture assessments are analysed and interpreted. In the current study, we explore this relationship through reporting on an investigation of safety culture in the international Air Traffic Management (ATM) industry. We theorize the relationship between national culture and safety culture, and investigate this through exploring the associations between national tendencies for uncertainty avoidance (UA) and safety culture. We then consider the implications of this relationship for international safety culture assessments, and propose that the association between UA and safety culture be taken into account when benchmarking safety culture data from organizations based in countries with diverse national cultures.

Safety culture

Safety culture is generally understood to be a safety-related facet of organizational culture (Guldenmund, 2000), and conceptualizations of safety culture within the organizational psychology literature focus on how shared norms and values shape safety practices. Surveys are often used to evaluate safety culture (Conchie, Donald, & Taylor, 2006; Huber, 1991; Reason, 1997), and these typically measure organizational employee responses to a number of latent dimensions, for example the commitment of management to safety, the support given by an organization (e.g., resources) to improve safety, incident reporting practices, collaborative activities to improve safety, and communication on safety (Reader, Noort, Shorrock, & Kirwan, 2015). Where responses to such dimensions are shared and positive across an organization, safety culture can be conceptualized as 'strong', and to have a positive influence upon safety (e.g., people can raise safety concerns; Guldenmund, 2007, 2009, 2010; Joyce & Slocum, 1984; Smith, Dugan, Peterson, & Leung, 1998). Conversely, negative, opposite, or fragmented perceptions can indicate a 'weak' safety culture, which renders individuals and organizations susceptible

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to workplace injuries and safety incidents (e.g., risk-taking; Beus, Payne, Bergman, & Arthur, 2010; Christian, Bradley, Wallace, & Burke, 2009; Clarke, 2010; Nahrgang, Morgeson, & Hofmann, 2011; Singer, Lin, Falwell, Gaba, & Baker, 2009). Through providing insight on the safety practices of employees and managers, safety culture survey data are used to evaluate the effectiveness of organizational safety management strategies (e.g., on reporting safety incidents), and to identify strengths and areas for improvement.

In describing safety culture, it is necessary to reflect on its relationship with safety climate. This is because the distinction between safety culture and climate is an ongoing subject for debate, and is relevant to considering how national culture influences organizational safety (Guldenmund, 2000; O'Connor, O'Dea, Kennedy, & Buttrey, 2011). Broadly, safety climate refers to the 'surface features of the safety culture (. . .) at a given point in time' (Flin, Mearns, O'Connor, & Bryden, 2000, p. 178), and focuses on employee beliefs in relation to management commitment to safety (DeJoy, 2005; Guldenmund, 2000, 2007; Zohar, 2010). Safety climate is generally considered to be narrower and more precisely defined than safety culture, and focuses on the prioritization of safety over other possible targets (Zohar, 2010). Safety culture encapsulates a wider set of constructs (e.g., collaborating on safety, knowledge on safety, incident reporting practices, communication on risk) and can utilize a variety of measurement techniques, including surveys, observations, focus groups, and incident analyses (Griffin & Neal, 2000; Guldenmund, 2010; Mearns & Flin, 1999; O'Connor *et al.*, 2011). This has led to safety culture being critiqued as a 'fuzzy' concept (Clarke, 2000), and the difference between safety culture and safety climate has been likened to the difference between 'personality' and 'mood' (Cox & Flin, 1998). Critically, safety culture is conceptualized as being reflective of enduring organizational, professional, and societal practices (Guldenmund, 2000; Helmreich & Merritt, 1998), and this means it may be influenced by national culture. This distinguishes it from safety climate, which captures more changeable beliefs about the current organizational prioritization of safety.

Yet, to date, the relationship between national culture and safety culture has received relatively little attention in the occupational psychology literature. In particular, there is a need to better theorize how national culture might influence safety culture, and to consider implications of this for safety culture assessments. For example, if employee safety-related beliefs and practices are influenced by national culture, this indicates that safety culture data may reflect both aspects of safety management and the societal tendencies of the country where employees are based (which are external to an organization). This raises questions over how safety culture data from different countries can be compared to identify problems in safety management and opportunities for learning. To explore this, we develop a theoretical framework for how national culture might influence safety culture.

The relationship between national culture and safety culture

The need to examine the relationship between national culture and safety culture has been recognized for some time within the occupational safety literature (Clarke, 1999). Specifically, the 'general' organizational culture literature is instructive (Kirkman, Lowe, & Gibson, 2006), and shows organizational culture to be influenced top-down by a range of societal factors, for example national culture, language, training, progression systems, access to economic resources, and political environment (Boroditsky & Schmidt, 2000; Chunlin, Chengyu, & Boben, 1999; Erez & Gati, 2004; House, Hanges, Javidan, & Dorfman, 2004; Johnstone & Kanitsaki, 2006; Linell, 2009).

In particular, researchers have examined the relationship between organizational culture and the five dimensions of national culture outlined by Hofstede (2001): Power distance, collectivism, uncertainty avoidance (UA), masculinity, and long-term orientation. Within this model, a country's citizens are conceptualized as developing a shared set of core values and practices (e.g., through education, political and economic systems, religion, media) that influence and normalize how people behave and think. These are theorized to transfer into organizational life (e.g., through behavioural habits, norms on contradicting those in authority, rewarding individual or collective performance), and to implicitly shape organizational culture and behaviour. Research using Hofstede's model provides supports for this conceptualization (although it is critiqued; McSweeney, 2002; Tsui, Nifadkar, & Ou, 2007). For example, the survey responses of individuals to Hofstede's cultural dimensions are shown as more similar within country than between countries (Hofstede, 2002; Minkov & Hofstede, 2012a,b), organizational culture and behaviour in multinational organizations are shown to vary according to the national cultural norms of the countries where operations are based (Kirkman *et al.*, 2006; Schwartz, 1999), and where management practices are congruent with national culture, organizational units are found to perform more effectively (Newman & Nollen, 1996).

Thus, in considering the relationship between national culture and safety culture, a similar model to that outlined by Hofstede (2001) might be adopted. National cultural tendencies that develop within a society, and implicitly shape employee beliefs and work behaviours, might also be expected to influence safety-related norms, values, and practices. For example, national norms on power distance may determine how junior colleagues communicate with managers on safety (e.g., challenging risk management strategies), and tendencies for UA may influence willingness to engage in situations with uncertain social consequences (e.g., admitting an error, organizational change). As indicated in the organizational culture literature (Hofstede, 2001; Hofstede *et al.*, 2010; House *et al.*, 2004), this relationship is likely to depend on the pattern of national cultural tendencies within a given country, their strength, and their concordance with the espoused values and practices of an organization.

Although not extensive, safety research supports the notion that national culture may influence safety culture. For example, differences in national cultural tendencies (e.g., UA, long-term orientation) have been associated with variations in safety outcomes and employee behaviour within global industries and multinational companies in domains such as construction, shipping, and energy (Lu, Lai, Lun, & Cheng, 2012; Mearns & Yule, 2009; Spangenberg *et al.*, 2003). Most promisingly, a growing body of research has examined associations between safety culture and Hofstede's (2001) dimensions of national culture. While this work observes associations between safety culture and different dimensions of national culture (e.g., power distance), a consistent relationship has emerged between safety culture and UA. To reiterate, UA refers to the extent to which people in a society try to minimize anxiety caused by risky and ambiguous situations (Hofstede *et al.*, 2010). For example, research in Pakistan has shown associations between self-reported UA and awareness of safety issues (Mohamed, Ali, & Tam, 2009), and studies with Norwegian seafarers have found correlations between self-reported UA and attitudes about safety improvements and conditions at work (Håvold, 2010). Furthermore, a high UA culture has been indicated to reduce the effectiveness of safety training (14 countries, in multiple industries) due to it increasing the focus of employees on structured scenarios and less on alternative scenarios (Burke, Chan-Serafin, Salvador, Smith, & Sarpy, 2008), and in the aviation industry, national norms on high UA have been negatively associated with perceptions of safety culture (Reader *et al.*, 2015).

The nature and directionality of the above relationship has not been fully explained. However, it might broadly be reasoned that citizens within a given country develop shared norms on UA, and that these influence the safety-related practices of employees, and thus perceptions of safety culture. For example, shared tendencies for high UA might be expected to lead to (1) less innovation and greater reliance on static procedures and protocols for managing ambiguous and dynamic safety scenarios (Helmreich, 1999), (2) reduced willingness to engage in social acts that have ambiguous and possibly socially threatening consequences (e.g., admitting error, speaking-up) (Soeters & Boer, 2000), (3) less flexibility to act on new and emerging risks, for example in terms of changing strategies and re-allocating resources (Waarts & Van Everdingen, 2005), (4) a feeling of chronic unease due to concern over aspects of risk management that are beyond the control of a given actor's ability – for example where one must rely on another person to manage safety (Fruhen, Flin, & McLeod, 2013), and (5) reduced tolerance of diverse opinions on how to manage safety (Hofstede, 1983).

Thus, through applying Hofstede's (2001) model, a conceptualization of how safety culture is influenced by national culture can be developed. Yet, the specific interactions between the different dimensions of safety culture and national cultural tendencies such as UA remain unaccounted for. Furthermore, the implications of this relationship for international safety culture assessments are unspecified. Chiefly, a question arises over whether, if trends in safety culture data reflect national cultural tendencies that are external to an organization, it is necessary to take into account this relationship when comparing safety culture data from units or organizations operating in different countries?

The current study

In the section above, we considered how national culture might influence safety culture, and identified a growing literature on its relationship with UA. We explore this further through reporting on a study conducted within the European ATM industry, and describe the two key foci of the study below.

The relationship between UA and safety culture

The first aim of the study is to examine the relationship between national cultural tendencies for UA and safety culture. We do this through an international study of safety culture in the high-risk industry of European ATM. ATM relates to the expeditious flow of aircraft in flight or operating in the manoeuvring area of an airport' (Ek & Arvidsson, 2012, p. 82), and mishaps have potentially catastrophic consequences (e.g., the 2002 Überlingen mid-air collision in 2002). Most countries in Europe have one prominent national Air Navigation Service Provider (ANSP), and these are typically staffed by domestic staff (e.g., controllers, engineers), with safety practices being shaped by European (i.e., EASA, EUROCONTROL) and country-specific (i.e., Civil Aviation Authorities) regulations, and organizational and national characteristics (e.g., traffic complexity, resources, team structure, local norms; Eißfeldt, Heil, & Broach, 2002). With Europe progressing towards a universal ATM system (a 'single sky'), ensuring a strong and positive safety culture across all nations within an ATM system is essential for ANSPs to work together to safely coordinate flight traffic (Ek & Arvidsson, 2012; Lofquist, 2010). Safety culture assessments are utilized as a way to assess the safety management of ANSPs in different countries, and are used to identify concerns and opportunities for improving safety management.

Table 1. Dimensions for Air Traffic Management (ATM) safety culture survey

Dimension	Definition
Management commitment to safety (three items; $\alpha = .86$)	Measures the extent to which management are committed to safety, and is indicative of organizational prioritization of safety within an ANSP
Collaborating for safety (four items; $\alpha = .58$)	Measures group attitudes and activities for safety management, and is indicative of normative attitudes and behaviours amongst ANSP staff towards safety
Incident reporting (three items; $\alpha = .81$)	Measures the extent to which respondents believe it is safe to report safety incidents, which is essential for identifying system weaknesses and opportunities for learning in ANSPs
Communication (four items; $\alpha = .82$)	Measures the extent to which staff are informed about safety-related issues in the ATM system, and is important for ensuring ANSP staff are aware of system changes that might shape safety-related activities
Colleague commitment to safety (three items; $\alpha = .71$)	Beliefs about the reliability of colleagues safety-related behaviour, and is indicative of the reliability of ANSP staff for engaging in safety- activities
Safety support (two items; $\alpha = .56$)	Availability of resources and information for safety management, and is indicative of active support within an ANSP for maintaining safety

Note. ANSP, Air Navigation Service Provider.
The ATM safety culture survey was developed through an iterative series of interviews, observations, incident reports, and systematic literature, and the items have been previously published (Reader *et al.*, 2015).

To investigate the relationship between UA and safety culture, we examine for associations between ANSP (i.e., country level) safety culture data collected in 21 countries and independent national norm data on UA. To measure safety culture, we use a six-dimension safety culture survey that has been tailored for use in ATM and shown as having good psychometric properties when utilized in ANSPs within four culturally distinct regions of Europe (North, East, South, West; please see Table 1).

Prior to examining associations between ANSP safety culture data and UA, it is first necessary to ensure that the safety culture survey used to collect data from ATM staff functions equivalently in the different countries included within the study. This is important for establishing that data from different ANSPs are comparable, with previous research showing that safety culture survey tools do not necessarily function equivalently in diverse cultural environments. For example, safety culture models established in Western settings function poorly when tested in different cultural environments (Bahari & Clarke, 2013), and participants from diverse cultural backgrounds respond differently to latent questionnaire dimensions (Cigularov, Lancaster, Chen, Gittleman, & Haile, 2013). Cross-national psychometric equivalence can be established through multigroup confirmatory factor analysis (MGCFA) whereby the psychometric model underlying a safety culture questionnaire is shown to function reliably and consistently in all of the countries sampled (Cheung & Rensvold, 2002; Horn & McArdle, 1992). Thus, we first test the psychometric equivalence of the six-dimension ATM safety culture model for each of the 21 national ANSPs included in this study (Hypothesis 1).

Having tested the functional equivalence of the safety culture model, we examine whether the responses to the safety culture survey in the 21 ANSPs are associated with

independent national cultural norm data on UA for the countries in which the ANSPs are based (Hofstede *et al.*, 2010; House *et al.*, 2004). Specifically, we predict that low UA will be associated with more positive safety culture scores, and outline below the expected relationship for each safety culture dimension.

Management commitment to safety.   This dimension refers to the extent to which ANSP employees consider management to prioritize safety. As indicated by national culture research, low UA cultures tend to be less focussed on using procedures to control risk and more tolerant of diverse opinions (Hofstede, 1983). It might therefore be expected that in such cultures, ANSP managers will be more willing to seek out and encourage novel safety problems and solutions, and will be open to opinions and suggestions different to their own. Because these are indicative of management prioritization of safety, we hypothesize that *management commitment to safety* will be more positive in ANSPs in low uncertainty avoidant countries (Hypothesis 2a).

Collaborating for safety.   This dimension refers to group attitudes and activities for safety management, and refers to collaboration within and between ANSP teams (e.g., controllers collaborating on safety with engineering staff). In low UA cultures, people tend to be more comfortable with opinions that contradict the group and potentially cause embarrassment, and are less likely to be constrained by protocols and procedure (Helmreich, 1999; Merkin, 2006). Such tendencies are arguably important for groups to raise problems about safety performance (e.g., highlighting errors), and for innovating on safety across the ANSP (e.g., developing new ways of working between safety and engineering). Thus, we hypothesize that *collaborating for safety* will be more positive in ANSPs in low uncertainty avoidant countries (Hypothesis 2b).

Incident reporting.   This refers to the extent to which respondents feel psychologically safe to report safety incidents. National culture research shows that activities that deviate from the norm and potentially indicate poor performance tend to cause less anxiety in low UA cultures, with there generally being reduced concern over the consequences of reporting mistakes (Schultz, Johnson, Morris, & Dyrnes, 1993). Because such tendencies are critical to reporting incidents in ATM, we hypothesize that *incident reporting* will be more positive in ANSPs in low uncertainty avoidant countries (Hypothesis 2c).

Communication.   This refers to the extent to which stakeholders are informed and engaged in system-related changes in the ATM system. As indicated by national culture research, low UA cultures tend to be more comfortable with uncertainty and change, and organizational communication is less constrained by protocol or boundaries (Shane, 1995; Van Muijen & Koopman, 1994). It might therefore be expected that in such cultures, ANSP employees will be less concerned about change, with communication generally being two-way and more open (e.g., through consultations, opportunities to raise problems). Thus, we hypothesize *communication* will be more positive in ANSPs in low uncertainty avoidant countries (Hypothesis 2d).

Colleague commitment to safety.   This refers to beliefs about the reliability of colleagues' safety-related behaviour. In low UA cultures, people tend to be more tolerant of behaviours and opinions different to their own, and less concerned about the activities of others and risks that they cannot control (Barr & Glynn, 2004; Hofstede, 1983). Concordant with such tendencies, it might be expected that ANSP staff in low UA cultures are less concerned about the reliability of their colleagues' safety-related behaviour. Thus, we hypothesize that *colleague commitment to safety* will be more positive in ANSPs in low uncertainty avoidant countries (Hypothesis 2e).

Safety support.   This refers to the availability of resources and information for safety management. National culture research shows that low UA cultures tend to be less constrained by rules and protocols (Koopman *et al.*, 1999; Shane, 1995), and in such cultures, it might be expected that there is greater flexibility for ANSPs to provide resources and information for safety (e.g., greater autonomy for ANSP managers in how resources are allocated). Thus, we hypothesize that *safety support* will be more positive in ANSPs in low uncertainty avoidant countries (Hypothesis 2f).

Implications of a relationship between UA and safety culture for international safety culture assessments

The second aim of this study is to consider the challenges posed by a relationship between UA and safety culture for international safety culture assessments, and to examine whether as a solution to these, national variations in UA might be taken into account when comparing safety culture data from different countries. To recap, safety culture assessments are used to detect potential problems and best practice in safety management. They do this through identifying weak and strong performing units and organizations, and recognizing opportunities for interorganizational learning where practice can be shared to improve safety (Mearns *et al.*, 2001). This is often performed through 'benchmarking' units and organizations against one another to normalize and compare data (Bhutta & Huq, 1999; Moriarty & Smallman, 2009; Watson, 1993), and safety culture benchmarking is commonplace within many safety-critical industries (Evans, Glendon, & Creed, 2007; Lee & Harrison, 2000; Mearns, Whitaker, & Flin, 2003; Nieva & Sorra, 2003). Yet, if a relationship between UA and safety culture is established, two key challenges emerge in terms of benchmarking safety culture data from units and organizations in different countries.

The first challenge is that a negative association between safety culture and UA is likely to skew the results of international benchmarking exercises. Specifically, operations in low UA countries will consistently report a stronger safety culture than those in high UA countries. This is problematic, as benchmarking will in part reflect the influence of national cultural tendencies (that are outside the control of an organization) upon safety beliefs and practices. This has implications for the operations that are identified as having the 'weakest' and 'strongest' safety culture (and by implication safety management system), and the actions that arise from this (e.g., for allocating resources, changing procedures, instituting training). It is also likely to 'reify' safety culture, with organizations in high UA countries being constantly ranked lowest, and improvements in their safety practices not being reflected in re-surveys due to them appearing minor in the context of the wider data set (which is influenced by wider and stable societal structures).

The second challenge is that a negative association between safety culture and UA is likely to limit the identification of opportunities for sharing best practice (Mearns *et al.*, 2001). For example, organizations in low UA cultures that are constantly identified as strong performers may appear to have little to learn from organizations in high UA cultures. Furthermore, practices that are identified as 'best' in one cultural setting may not transfer well to another. For instance, research in multinational companies shows that the effectiveness of safety policies depends in part on their appropriateness to the wider national cultural environment in which they are enacted (Janssens, Brett, & Smith, 1995). Similarly, the extent to which safety practices developed by organizations in low UA countries (e.g., for incident reporting) will be effective in high UA cultures may depend on the appropriateness of these practices to wider cultural norms.

We propose that a potential solution to these challenges is to develop 'clusters' of countries with comparable norms on UA in order that safety culture can be assessed against the context of national cultural tendencies. Evaluating safety culture in UA clusters norm-groups (e.g., low and high) would provide the following benefits. It would avoid benchmarking exercises resulting in skewed findings whereby they present an overly optimistic assessment of safety management (because safety culture is in part a function of national cultural tendencies outside the control of management) at organizations in low UA countries when they are compared against high UA countries (and vice versa). Furthermore, ensuring countries are compared against culturally similar countries will allow for relative comparisons of poor and good practices in safety management that would be otherwise undetected (because they would not stand out in the wider data set). This would facilitate the identification and sharing of best practices specific to a particular cultural context. Through comparing safety culture within UA-related clusters, insight can be provided on practices favourable and challenging to safe operations within a high or low UA setting (Janssens *et al.*, 1995; Michael & College, 1997; Robert, Probst, Martocchio, Drasgow, & Lawler, 2000). For example, safety-related practices that are identified within best-performing organizations in a high UA setting (e.g., policies for ensuring anonymity in incident reporting) can be better understood in terms of why they are effective (e.g., they address anxiety caused by high UA), and shared amongst countries with similar belief structures. Such practices may be less relevant to low UA settings (e.g., where staff are less concerned about anonymity in reporting), with their utility being masked within a larger benchmarking exercise (where safety practices are not considered in terms of societal context, and all ANSPs are compared).

We examine this in ATM, and identify clusters of ANSPs with comparable tendencies for UA. Consistent with the national variations on tendencies for UA described by Hofstede (2001), we expect that clusters of comparable ANSPs (in terms of safety culture) can be identified according to the national norm data for UA for the countries in which ANSPs are located. Having identified clusters of countries that group together, we will then 'scale' safety culture assessment scores in a way that captures and reflects national variations in UA. To do this, we develop *safety culture against international group norm* (SIGN) scores, which are safety culture scores transformed into *z*-scores (Mearns, Flin, Gordon, O'Connor, & Whitaker, 2000; Mearns *et al.*, 2001), and present the relative position of an organization within a cultural cluster. SIGN scores highlight variations against a group norm (e.g., half-standard deviations) on a normal distribution, and signal a relative position of safety culture strength rather than a direct comparison of raw scores. This is an approach applied in many fields and emerges from the cognitive intelligence

literature (i.e., IQ scores) where cross-national variations and longitudinal improvements can confound intelligence scores (Cattell, 1934, 1943; Cicchetti, 1994; Flynn, 1987, 1999; Naglieri, 2003). Through applying SIGN scores to analyse safety culture data in clusters of countries, the context of measurement can be integrated into the interpretation of scores. This means safety culture data are re-scaled to fit a given cultural context, with the assessment of safety culture being directed towards learning between organizations and regions. In the current study, we apply the SIGN scores to examine the relative strength of safety culture amongst ANSPs units in countries with different national cultural tendencies.

Method

Participants

A total of 13,616 ANSP employees based in 21 European countries returned a safety culture survey between 2011 and 2014. This was part of a wider ongoing investigation of safety culture in European ATM, with over 30 countries being investigated to date. To ensure anonymity at an ANSP level, general demographic data (i.e., age, gender) were not collected. Participants were classified as having one of four general roles: Operational staff ($n = 6,500$), management ($n = 1,592$), engineering ($n = 1,764$), or administration ($n = 3,717$). A small number of participants ($n = 43$) reported no primary role but were still taken up in the analyses. Demographic statistics of the survey sample are summarized in Table 2.

Air Navigation Service Providers varied in size ($M = 650$; $SD = 680$). Due to political sensitivities of European ATM, and to ensure continued support of ANSPs in future

Table 2. Demographics showing staff groups across 21 Air Navigation Service Providers (ANSPs)

ANSP	Operational staff	Managers	Engineers	Admin	Total (role missing)
1	1,258	128	270	419	2,075
2	311	29	45	131	516
3	47	11	27	44	129
4	105	13	18	41	177
5	536	416	78	583	1,613
6	319	41	35	315	710
7	172	58	146	127	503
8	83	22	31	62	198
9	128	9	24	30	191 (3)
10	71	35	71	15	195 (3)
11	71	10	11	2	99 (5)
12	361	36	83	36	551 (35)
13	904	244	290	678	2,116
14	252	46	74	100	472
15	86	30	31	30	177
16	48	9	16	50	123
17	91	21	63	151	326
18	226	39	51	76	392
19	379	42	0	113	534
20	231	72	55	107	465
21	821	281	345	607	2,054
Total	6,500	1,592	1,764	3,717	13,616 (43)

research, we are unable to report specific countries involved. Doing this would compromise the anonymity of the ANSPs.

Procedure and measures

Safety culture surveys were distributed electronically and/or through paper-and-pen at 21 ANSPs. This depended on local preference, and there were no differences found between the data collected through the different methods. Surveys were part of a mixed-methods investigation of safety culture, whereby they were distributed to staff, and then, the results were discussed with staff in workshops and interviews (depending on the size of organization there was 24–60 hr of focus group activity). Focus groups resulted in a set of safety recommendations being developed for each ANSP, in coordination with their safety management team. The method for this has been previously described (Mearns *et al.*, 2013).

The survey tool used to collect safety culture data was iteratively developed through a series of safety culture investigations prior to 2010 (Mearns *et al.*, 2013). These included staff interviews and workshops, discussions with safety managers, pilot testing, and exploratory and confirmatory factor analyses. The survey reflects a range of safety culture issues specific to ATM, and the six underlying dimensions iterate well-established themes within the safety culture literature (Guldenmund, 2007). We have presented the items and characteristics of the dimensions elsewhere (Reader *et al.*, 2015). Questionnaires were translated and back translated (or partially translated, depending on the usage of English within the ANSPs) into the national language(s) of the ANSPs.

Analysis

The relationship between UA and safety culture

The psychometric equivalence of the ATM safety culture survey tool was examined across 21 ANSPs using AMOS 19 (Hypothesis 1). This was tested for occupational groups (operational staff, management, engineers, administration) and ANSPs. Missing data were replaced across these groups using EM estimation (Enders, 2003), and steps for MGCFA in the measurement equivalence literature were followed (Chen, Sousa, & West, 2005; Ployhart & Oswald, 2004; Vandenberg & Lance, 2000). After testing whether the model fits independently in each group, equivalence was established by testing the cross-national equivalence of the model across all ANSPs. While this is sometimes regarded as sufficient for establishing model equivalence across groups (Chen *et al.*, 2005), further steps tested first- and second-order factor loadings, latent means and correlations and, finally, residual and measurement errors. Goodness of fit for the model was indicated by the RMSEA ($<.08$ a moderate fit; $<.06$ a good fit) and CFI. To adjust for underestimated CFIs when RMSEAs for the independence model are small (i.e., $<.158$; Kenny, 2014), and reduce the chance of a type 1 error (i.e., false rejection), CFIs were interpreted at $\geq.90$ (for a good fit), and $\geq.85$ (for a moderate fit). Model comparison was based on ΔCFI $> .1$.

To establish whether low UA was associated with more positive safety culture scores on the six dimensions of the safety culture survey tool (Hypothesis 2a–f), disaggregated country-level data on national cultural values (Hofstede, 2001) was associated with individual-level safety culture scores using Pearson correlations.

Taking into account national variations in UA when benchmarking safety culture data
To establish national cultural clusters, a two-step cluster analysis (with SPSS version 21; IBM Corp, 2012) was conducted at the ANSP level. Two-step cluster methods examine whether units cluster together so that countries in group A are more similar to countries in group A on UA than to countries in group B, etcetera (Zhang, Ramakrishnon, & Livny, 1996). Independent and readily available data at the country level from Hofstede's UA Index (Hofstede, 2001) was used to cluster the 21 countries in this study. Clusters were evaluated based on their average silhouette width (ASW; i.e., extent of distinctiveness and overlap between clusters), which is calculated as $SW_i = (b_i - a_i)/\max(a_i, b_i)$. An ASW of ≥.6 are indicative of reasonable clusters (Kaufman & Warner, 1990; Wiechmann, 2008). An ANOVA tested for variation in UA between clusters.

To construct a scale for analysing safety culture data in the context of national cultural norms, SIGN scores were generated by calculating z-scores for each safety culture dimension within each cultural cluster, with $z = (x - \mu)/\sigma$. Weights were applied proportionally to account for ANSP size differences within their cluster, with π_k = % of ANSP in the population/% of ANSP in sample. To ease interpretation, calculated z-scores were set to 100 and standard deviations to 15 to form SIGN scores. Qualitative data from survey free text comments and follow-up workshops with ANSP staff were used to further illustrate the utility of taking into account variations in UA when interpreting safety culture data.

Results

The relationship between UA and safety culture

The MGCFA indicated that the safety culture assessment tool holds moderately to good across all 21 ANSPs (Hypothesis 1 supported). A small RMSEA was found for the independence model (RMSEA = .048 [.048–.049]), indicating underestimation of CFIs. CFIs suggested the model fitted the data well for 12 ANSPs (CFIs ≥ .90), and moderately for nine ANSPs (CFIs ≥ .85). Combined with RSMEAs, the results suggested four ANSPs to have weakest fit (moderate CFIs with RMSEAs > .08, for ANSPs 1, 13, 14 and 21). Next to underestimated CFIs, this weaker fit was likely explained by constraints put on the model to sufficiently identify the model (i.e., second-order constraints and correlations were held constant across ANSPs). Still, even considering these constraints, further analysis indicated that the model held across ANSPs (CFI = .90; RMSEA = .02 [.02–.02]) and that first- and second-order factor loadings are equivalent across groups (ΔCFI < .1). However, constraining item means decreased model fit (ΔCFI = −.2), indicating that individual items had different scores across ANSPs. Constraining factor variances and residual errors did not significantly reduce model fit, but constraining measurement variances did. While CFIs dropped below .85 from step 4 onwards, this established psychometric equivalence of the safety culture assessment tool across Europe. In particular, it is indicated that the model and first- and second-order factor loadings are equivalent across groups, justifying mean comparisons of safety culture. Model fit indices are summarized in Table 3.

Correlational analyses indicated that UA was associated negatively with safety culture dimensions, and regression analyses indicated that UA was a significant predictor for safety culture ($r > |-.13|$, ps < .001). Specifically, this was the case for management commitment to safety, $\beta = -.16$; $F(1, 13614) = 363.77$; $p < .001$: Hypothesis 2a supported, collaborating for safety, $\beta = -.23$; $F(1, 13614) = 750.41$; $p < .001$: Hypothesis 2b supported, incident reporting, $\beta = -.23$; $F(1, 13614) = 732.51$; $p < .001$:

Table 3. Model fit indices of within and across 21 Air Navigation Service Providers (ANSPs)

Analysis	ANSP	χ^2	df	χ^2/df	CFI	ΔCFI	Compare	RMSEA	90% CI RMSEA	
0	1	392.45	143	2.74	.86			.100	.088	.111
	2	1764.74	143	12.34	.93			.074	.071	.077
	3	305.89	143	2.14	.90			.076	.064	.088
	4	432.88	143	3.03	.92			.063	.056	.070
	5	540.88	143	3.78	.90			.077	.070	.084
	6	298.96	143	2.09	.91			.076	.064	.088
	7	253.80	143	1.78	.88			.066	.053	.080
	8	242.72	143	1.70	.90			.074	.058	.090
	9	405.87	143	2.84	.93			.063	.056	.070
	10	295.31	143	2.07	.85			.093	.078	.109
	11	480.02	143	3.36	.93			.065	.059	.072
	12	447.16	143	3.13	.88			.081	.072	.089
	13	2033.51	143	14.22	.86			.091	.087	.094
	14	1035.67	143	7.24	.85			.094	.089	.099
	15	491.48	143	3.44	.92			.070	.063	.076
	16	428.03	143	2.99	.90			.071	.064	.079
	17	1816.82	143	12.71	.89			.074	.071	.077
	18	477.31	143	3.34	.92			.066	.060	.073
	19	284.30	143	1.99	.87			.071	.059	.083
	20	1569.51	143	10.98	.91			.070	.067	.073
	21	253.87	143	1.78	.89			.089	.071	.107
1	All	13253.19	3,003	4.41	.90			.017	.017	.017
2		15164.19	3,263	4.65	.88	.0	2 vs. 1	.017	.017	.018
3		16092.50	3,323	4.84	.87	.0	3 vs. 2	.018	.018	.018
4*		33718.10	3,703	9.11	.70	−.2	4 vs. 3	.026	.026	.026
5*		33718.10	3,703	9.11	.70	.0	5 vs. 4	.026	.026	.026
6*		33718.10	3,703	9.11	.70	.0	6 vs. 5	.026	.026	.026
7		36390.55	3,823	9.52	.68	.0	7 vs. 6	.027	.026	.027
8		37695.41	3,943	9.56	.67	.0	8 vs. 7	.027	.026	.027
9		55790.76	4,323	12.91	.49	−.2	9 vs. 8	.031	.031	.032

*Similar model constraints.

Table 4. Pearson correlations between uncertainty avoidance (UA) and safety culture scores

	Management commitment to safety	Collaboration for safety	Incident reporting	Communication	Colleague commitment to safety	Safety support
UA	−.16	−.23	−.23	−.18	−.13	−.17

Note. *P*s (two-tailed) < .001, *n* = 13,616.

Hypothesis 2c supported, communication, $\beta = -.18$; $F(1, 13614) = 472.65$; $p < .001$: Hypothesis 2d supported, colleague commitment to safety, $\beta = -.13$; $F(1, 13614) = 230.15$; $p < .001$: Hypothesis 2e supported, and safety support, $\beta = -.17$; $F(1, 13614) = 409.62$; $p < .001$: Hypothesis 2f supported. Pearson correlations are summarized in Table 4.

Taking into account national variations in UA when benchmarking safety culture data
A cluster analysis revealed two cultural clusters for UA across Europe. A two-step cluster analysis indicated two distinctive clusters, one with high UA (12 ANSPs; $n = 6,957$;

Table 5. Mean and standard deviations for the low and high uncertainty avoidance (UA) clusters

Safety culture dimension	High UA cluster		Low UA cluster		Total	
	M	*SD*	*M*	*SD*	*M*	*SD*
Management commitment to safety	3.78	0.99	3.97	0.82	3.88	0.91
Collaboration for safety	3.44	0.73	3.61	0.69	3.53	0.71
Incident reporting	3.33	0.98	3.56	0.88	3.45	0.94
Communication	3.39	0.92	3.56	0.78	3.47	0.85
Colleague commitment to safety	3.93	0.69	3.99	0.66	3.96	0.68
Safety support	3.46	0.95	3.65	0.87	3.55	0.92

Note. ANSP = Air Navigation Service Provider.
High UA cluster = 12 ANSPs ($n = 6,957$); low UA cluster = 9 ANSPs ($n = 6,959$).

Table 6. Safety culture and SIGN scores (with *SD*) in a high and low uncertainty avoidance (UA) cluster for 'collaboration for safety' and 'incident reporting'

Cluster	ANSP	Collaboration for safety		Incident reporting	
		Raw	SIGN	Raw	SIGN
High UA	1	2.89 (0.80)	89 (16)	2.42 (1.00)	86 (15)
	2	3.39 (0.78)	99 (16)	2.82 (1.00)	92 (15)
	3	3.47 (0.67)	101 (14)	3.36 (0.82)	101 (13)
	4	3.16 (0.57)	94 (12)	2.71 (0.81)	91 (12)
	5	3.63 (0.59)	104 (12)	3.28 (0.79)	99 (12)
	6	3.65 (0.66)	104 (14)	3.44 (0.79)	102 (12)
	7	3.52 (0.64)	102 (13)	3.57 (0.73)	104 (11)
	8	3.71 (0.61)	106 (12)	3.99 (0.70)	110 (11)
	9	3.09 (0.73)	93 (15)	3.00 (0.95)	95 (14)
	10	3.83 (0.59)	108 (12)	4.25 (0.59)	114 (9)
	11	3.31 (0.71)	97 (15)	3.41 (0.98)	101 (15)
	12	3.64 (0.75)	104 (15)	3.64 (0.89)	105 (14)
	Total	3.44 (0.73)	100 (15)	3.33 (0.98)	100 (15)
Low UA	13	3.11 (0.54)	89 (12)	3.26 (0.77)	95 (13)
	14	3.75 (0.60)	103 (13)	3.78 (0.69)	104 (12)
	15	3.57 (0.55)	99 (12)	3.65 (0.63)	101 (11)
	16	3.15 (0.72)	90 (16)	2.54 (0.83)	83 (14)
	17	3.30 (0.62)	93 (13)	3.01 (0.83)	91 (14)
	18	3.65 (0.56)	101 (12)	3.60 (0.70)	101 (12)
	19	4.09 (0.55)	111 (12)	4.25 (0.57)	112 (10)
	20	4.11 (0.57)	111 (13)	4.19 (0.62)	111 (11)
	21	3.76 (0.62)	103 (13)	3.81 (0.73)	104 (12)
	Total	3.61 (0.69)	100 (15)	3.56 (0.88)	100 (15)

Note. ANSP = Air Navigation Service Provider.
High UA cluster = 12 ANSPs ($n = 6,957$); low UA cluster = 9 ANSPs ($n = 6,959$).

M = 87.22; SD = 6.17) and another with low UA (nine ANSPs; n = 6,959; M = 47.62; SD = 15.40). This solution with two clusters resembled a reasonable structure, ASW = .6, and an ANOVA indicated that the difference in UA between the clusters was large, $F(1, 13614)$ = 39407.22, p < .001, η^2 = .74. Furthermore, the low and high UA clusters varied significantly on all safety culture dimensions, $F(1, 13614)$ > 163.28, p < .001, η^2 = .012–.075. Descriptive statistics for the UA clusters are summarized in Table 5.

To scale for international safety culture data, SIGN scores were calculated relative to an ANSP's cultural cluster in order to incorporate the effect of national culture into the safety culture scores (see Table 6). To illustrate this, we focus on the use of SIGN scores for the dimensions of incident reporting and collaborating for safety, as these were found to be the safety culture dimensions with the strongest association with UA.

First, for benchmarking safety culture, the incident reporting data shows ANSPs to score differently in terms of 'raw' safety culture scores, yet similarly in terms of the relative performance within a cultural cluster. For example, ANSP 3 (M = 3.36; SD = 0.82) in the high UA group scored lower on incident reporting than ANSP 15 (M = 3.65; SD = 0.63). Yet when norm data on UA was taken into account, the ANSPs have similar SIGN scores (101). Qualitative survey comments and follow-up workshops with ATM staff (e.g., controllers) illustrated why this might be the case. Specifically, both ANSPs were small, and had comparable safety systems for incident reporting (e.g., anonymous, with de-individualized feedback being provided to learn from incidents). However, in the high UA group, participants tended to be more concerned on disrupting the work of colleagues, anxious about the embarrassment of potentially being identified from the incident report, and uncertain on how the external regulator would assess them. Arguably, these reflect broader societal factors (i.e., anxiousness on how incidents will be perceived by colleagues) rather than concerns about the incident reporting system itself (i.e., that those who report incidents will be treated fairly). Thus, while the raw scores do represent differences in beliefs about incident reporting, the 'SIGN' scores reflect the observation that the incident reporting systems were actually similar in both ANSPs (i.e., one was not 'weaker' than the other), with differences in perceptions potentially being explained by broader societal tendencies for UA rather than problems in incident management.

Second, in terms of facilitating the sharing of best practice, Table 6 indicates that ANSPs can have similar raw scores, but perform differently in terms of relative position within a cultural cluster. For example, ANSP 5 (M = 3.63; SD = 0.95) in the high UA group and ANSP 15 (M = 3.57; SD = 0.83) in the low UA group had similar scores in terms of raw safety culture scores, but their corresponding SIGN scores varied (i.e., 104 and 99, respectively). This indicated that in relation to their cultural cluster, ANSP 5 performed well in the high UA group and ANSP 15 less so in the low UA group. Survey comments and follow-up workshops indicated that in the low UA group, technical and administrative systems did not support collaboration on safety as well as they might do (e.g., developing and instituting safety protocols with colleagues from different departments). However, in the high UA group, participants were empowered and encouraged by management to collaborate on safety (e.g., raising safety issues in teams). Thus, while the raw scores indicated similar results for the dimension of collaborating for safety in ANSP 5 and ANSP 15, the SIGN scores indicated potential opportunities for sharing best practices within a cultural cluster that would have remained otherwise unidentified, with practices appearing relevant to the cultural context of the cluster within which the ANSP was based (but not necessarily relevant to the other cluster).

Discussion

Through showing national norms for UA to be associated with safety culture in national ATM organizations, we have found support for a theorization of how national cultural tendencies influence safety culture. Furthermore, through developing *safety culture against international group norms* (SIGN) scores to statistically control for the influence of UA upon safety culture data, we have proposed a new technique for supporting the identification of safety practices effective and particular to different national cultures. We consider the implications of the study below.

Theoretical implications

Researchers have previously considered the possibility for a relationship between UA and safety culture (Burke *et al.*, 2008; Håvold, 2010; Helmreich & Merritt, 1998; Mohamed *et al.*, 2009). We investigated this through a multicountry study, and our findings indicate a relationship between UA and safety culture. This supports the notion that safety culture should be understood as a concept shaped by broader cultural phenomena such as national culture. Across a sample of 13,616 employees based in 21 national ANSPs, we found tendencies for UA to be negatively associated with positive responses to the six survey dimensions of safety culture.

Although this relationship was only associative, it seems more likely that national cultural norms for UA (which are generalized from a nation's population) influence safety culture in ANSPs (i.e., an organization within that nation) than the reverse. Utilizing previous work investigating national culture and organizational culture (Hofstede *et al.*, 2010; Kirkman *et al.*, 2006), we theorized that national cultural tendencies for UA that develop within a society will implicitly influence employee safety practices. This appears to occur through two intertwining mechanisms. First, national tendencies for UA shape safety-related practices (e.g., the openness of management to opinions different to their own) which in turn influence perceptions of safety culture (e.g., management commitment to safety). Second, national tendencies for UA shape the attitudes of staff towards safety-related practices (e.g., anxiety over the embarrassment of making an error) and these influence responses to the safety culture survey (e.g., on incident reporting). Future research should attempt to further establish the directionality and mechanisms through which UA influences safety culture (e.g., through qualitative or longitudinal work).

At a broader level, the study findings indicate that alongside sociotechnical perspectives from the engineering and cognitive sciences, safety culture research needs to be more informed by cultural psychology. In comparison with affiliated fields of inquiry such as risk research (Lupton, 1999), safety culture research uses a limited range of cultural theory and methods. Indeed, safety culture might be conceptualized to include issues of power and national cultural norms (e.g., Antonsen, 2009; Choudhry, Fang, & Mohamed, 2007; Edwards, Davey, & Armstrong, 2013; Haukelid, 2008), and may also benefit from applying cultural theories of risk (Douglas, 1992), perspectives on risk society (Beck & Van Loon, 2000; Giddens, 1999), systems theories (Mele, Pels, & Polese, 2010), and governmentality (Foucault, Burchell, Gordon, & Miller, 1991).

Yet, conceptualizing safety culture in this way also raises questions over how safety culture can be changed. For example, if safety culture is in part reflective of societal practices and habits for communicating and acting (Aarts & Dijksterhuis, 2003; Berger & Luckmann, 1966), to what extent do organizations have influence over the safety-related

practices and beliefs of employees (e.g., where safety practices are counterintuitive to societal norms (Berry, 1997))? Schein (1992) argues that organizations can change permanently via temporal acceptance of novel practice (or changes to practice), and this indicates that organizations may be able to surpass cultural barriers to safety through favouring and rewarding practices that underpin safety.

Practical implications

The relationship between UA and safety culture was argued to generate at least two practical challenges for international safety culture assessments. First, it is likely to skew the benchmarking of units or organizations based in different countries. Survey assessments of organizations with 'strong' and 'weak' safety cultures will tend to favour operations in low UA countries. Yet, because safety culture scores partly reflect tendencies for UA, this may provide a consistently optimistic or pessimistic impression of organizations operating in low and high UA countries. Second, safety practices in some countries may be specific to solving a problem in a particular cultural context, and benchmarking exercises should attempt to identify and understand such practices in order to facilitate learning. To examine this, we performed a cluster analysis using norm data on UA for the countries involved in the study. This revealed high and low clusters of countries for UA. We then calculated *safety culture against international group norms* (SIGN) scores to allow for relative inspections and interpretations of safety culture data.

Comparisons of low UA and high UA ANSPs for incident reporting showed that ANSPs could score quite differently in terms of raw scores, yet perform equally in their cultural grouping (with attitudes towards incident reporting appearing to be influenced by UA rather than differences in safety management). Conversely, ANSPs could have similar raw scores for collaborating on safety, but quite divergent SIGN scores (indicating them to be performing differently within their cultural cluster). This allowed for the safety performance of ANSPs to be understood within a cultural context (i.e., against peer countries with similar cultures), and for best practices related to those contexts (e.g., empowerment in high UA settings) to be identified and potentially shared. Thus, SIGN scores may provide a useful way to consider the influence of national culture upon safety culture when benchmarking internationally. Crucially, ignoring the relationship between UA and safety culture will mean benchmarking exercises do not take into account the structural influence of national cultural tendencies external to safety management upon safety practices. This is important, as one of the indicators of a good safety culture may be the extent to which safety policies and practices are aligned to national cultural environments (Janssens *et al.*, 1995). Where management practices contradict national cultural norms or political environments (e.g., reducing job security in high UA countries), employees can respond negatively and be less understanding of organizational policy (Debus, Probst, König, & Kleinmann, 2012; Michael & College, 1997; Robert *et al.*, 2000). Yet, devising safety policies specific to particular countries necessitates diversity in safety management, and this presents challenges for industries such as ATM, where standardization and predictability of operations are essential.

Overall, the SIGN score methodology appears a promising way to take into account the relationship between national culture and safety culture when conducting international safety culture assessments. However, further research is required and the technique is preliminary. For example, the added value of SIGN scores in terms of predicting safety outcomes is yet to be demonstrated, SIGN scores do not differ radically from raw safety culture scores (although the relative performance of an ANSP against other ANSPs does

change), and a more systematic evaluation of the SIGN score methodology for facilitating organizational learning on safety is required. Future work will investigate this.

Limitations

This study has some noteworthy limitations. It is important to remember that quantitative measures only provide a proxy for safety culture. Safety culture is assessed from trends in the survey data, yet this data does not specify exactly where a culture is strong or weak (e.g., as indicated by safety performance data). Furthermore, while a subset of safety culture (i.e., safety climate) has been associated with outcomes (Clarke, 2010), questionnaire data on perceptions of beliefs and commitment of managers and colleagues do not fully capture deeper layers of culture (Geertz, 1994). The extent to which the safety culture measure used in this study is distinct from safety climate is unclear. Other approaches (e.g., observations) provide contextualized 'thick descriptions' and describe tacit knowledge underlying practices, and should supplement survey data examining culture. We encourage future research to address triangulation in international contexts, and although we did collect qualitative data, in-depth analysis of this was beyond the scope of the article.

Furthermore, while SIGN scores transform raw safety culture data to include national culture, the conditions under which they may be appropriate to employ vary. For example, in some cases differences between units in cultural clusters were small (e.g., for colleague commitment to safety), indicating the relationship between safety culture and national cultural dimensions to vary in strength. Other national cultural tendencies may be relevant (e.g., power distance), and our study relied on norm data from the GLOBE study to measure national culture, and this may not be reflective of the ATM sample. This approach has been critiqued (Tsui *et al.*, 2007), with theorists questioning the extent to which societies develop universal tendencies that can be measured (McSweeney, 2002). To understand how tendencies for UA influence safety culture, more behavioural and human performance focussed analyses are required.

In terms of taking into account UA when benchmarking safety culture, a number of other scenarios might also be considered. For example, where multiple units are based within a country, it might be assumed that units have a similar national culture (and thus the same score on Hofstede's independent norm scores for UA), and national culture would not be used to explain differences. Furthermore, where national norm data are not available to researchers, or organizations are staffed by highly multicultural workforces (for example expatriates), it may be useful to measure UA within the organizations being studied.

Lastly, crucial to the notion of international safety culture benchmarking is the assumption that measurement equivalence can be established. Where it is not established, it may mean that survey data cannot be meaningfully compared across countries and that benchmarking should remain internal. This speaks to the importance of developing measurement tools that address the universal safety concerns of organizations and industries operating internationally. Despite sufficient model fit indices being established for our own safety culture model, results indicated that for some ANSPs further refinements might benefit the model. This might be explained by lower Cronbach's alphas for collaborating for safety and safety support. In the light of ongoing refinements to the model, this is expected to improve and we will address this in future research.

Conclusion

Through extending Hofstede's conceptualization of how national cultural tendencies develop and influence organizational culture to the domain of occupational safety, we hypothesized a relationship between UA and safety culture. The analysis of data collected within the European ATM industry supported this relationship, with significant theoretical and practical implications for the conduct of safety culture research in cross-cultural settings. Further research is required to establish the directionality and mechanisms underlying the relationship between national culture and safety culture, and to examine the benefits of taking this relationship into account when conducting international safety culture research.

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