Safety culture and power: interactions between perceptions of safety culture, organisational hierarchy, and national culture

Abstract

Practices that involve power dynamics are integral to maintaining organisational safety (e.g. speaking-up, challenging poor behaviour, admitting error, communicating on safety), and staff engagement in these is assumed to be shaped by perceptions of safety culture. These perceptions, in-turn, are associated with (1) positions within an organisational hierarchy (which makes power-related acts more or less threatening), and (2) societal values for power distance (e.g. challenging authority). With a sample of 13,573 of air traffic control staff (controllers, engineers, administrative, and management) from 21 national air traffic providers, we reconfirm the observation that managers perceive safety culture more positively than frontline staff (hypothesis 1), and that workers in countries with established values for hierarchy and power report safety culture as less positive than those from countries with low power distance (hypothesis 2). We then, for the first time, examine the interaction between these two factors, and establish that differences in safety culture perceptions between those higher in the hierarchy (management) and those lower in the hierarchy (air traffic controllers and administrative staff) are exacerbated by national contexts for large power distance (hypothesis 3). The study contributes to the literature by theorising the role of power in safety culture theory, and its influence upon safety culture perceptions. Moving forward, safety culture research and interventions may benefit from considering how power exists and manifests at the level of superior-subordinate dynamics.

Keywords: safety culture, power distance, national culture, values, organisational culture, hierarchy

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'Safety culture' refers to shared attitudes, values and perceptions towards safety held by organisational groups, with it being that assumed that safety culture is both a product and driver of risk-related practices (Choudhry, Fang, & Mohamed, 2007; Cooper, 2000; Hale, 2000; Pidgeon, 1998). The concept rose to prominence in the aftermath of the Chernobyl and Challenger accidents, and is used to characterise and measure psychological and behavioural characteristics of organisations that can lead to, or prevent, accidents. To this end, safety culture measurement, often conducted through employee surveys, is an integral part of organisational risk management in many industries (Choudhry et al., 2007; Flin, Mearns, O'Connor, & Bryden, 2000; Guldenmund, 2000) and is linked to changes in organisational policy and practice (DeJoy, 2005; Langford, Rowlinson, & Sawacha, 2000; Mannion, Konteh, & Davies, 2009).

Perceptions of safety culture are measured because they are assumed to reflect organisational activities and policies on safety, and to predict safety-related behaviours, for example, adhering to safety rules, raising safety concerns to management, and reporting safety incidents. Yet, the extent to which perceptions of safety culture are predictive of accidents is unclear, with some studies indicating safety culture perceptions predict workplace injuries (Christian, Bradley, Wallace, & Burke, 2009), and other research showing employee survey responses taken prior to organizational accidents do not always align with factors attributed with causing the accident (e.g. pressure to not report safety concerns) (Antonsen, 2009b; Kvalheim, Antonsen, & Haugen, 2016). Nonetheless, it is generally assumed that where beliefs and activities in relation to safety are shared and positive, safety culture is considered 'strong', and to indicate a reduced likelihood of safety mishaps.

Conversely, fragmented and negative perceptions indicate a 'weak' safety culture, and increased susceptibility to accidents (Christian et al., 2009; Clarke, 2000; Guldenmund, 2000; Health and Safety Commission, 1993; Singer, Lin, Falwell, Gaba, & Baker, 2009)

Yet, recent research indicates that perceptions of safety culture also reflect the structural and contextual features of an organisation, and not just institutional activities and policies on safety (Clarke, 1999; Findley, Smith, Gorski, & O'Neil, 2007; Hofstede, 1976; 1980; 2001; Hofstede, Hofstede, & Minkov, 2010; Mearns, Flin, Gordon, & Fleming, 1998; Parand et al., 2010; Prussia, Brown, & Willis, 2003; Thomas, Sexton, & Helmreich, 2003). More specifically, employee perceptions of safety culture are shaped by employee position within an organisation hierarchy (e.g. status), and the societal context within which an organisation is based (e.g. whether it is normal to challenge authority), with the role of *power distance* being central to both (Bahari & Clarke, 2013; Clarke, 1999; Findley et al., 2007; Hofstede, 1976; 1980; 2001; Hofstede et al., 2010; Li, Harris, & Chen, 2007; Lu, Lai, Lun, & Cheng, 2012; Mearns et al., 1998; Prussia et al., 2003; Reader, Noort, Shorrock, & Kirwan, 2015; Soeters & Boer, 2000). In particular, employees lower in the organisational hierarchy (i.e. with less power) often perceive activities core to safety culture (e.g. raising concerns, reporting errors) as less easy to engage in when compared to those further up the hierarchy (e.g. management) (Clarke, 1999; Findley et al., 2007; Mearns et al., 1998; Parand et al., 2010; Prussia et al., 2003; Thomas et al., 2003). Furthermore, in societies where there is a high power gradient between those with and without authority (i.e. with it not being normal to challenge those in high status roles), perceptions of safety culture tend to be less positive (particularly for practices such as incident reporting, Reader et al., 2015).

In the current paper we examine how organisational hierarchy (organisational role) and societal values (national culture) related to power distance affect perceptions of safety culture. For the first time, we test the interaction of these two effects, the purpose being to

examine and parse out the multi-faceted influence of power upon perceptions of safety culture. We conduct this study within the European Air Traffic Management industry. National Air Navigation Service Providers (ANSPs) work to direct aircraft during take-offs and landings, and expedite the flow of air traffic within and between countries. ATM is a highly standardised industry, and is especially suitable for studying interactions between occupational roles and national culture. In particular, the industry-wide requirement for a completely safe and reliable system, almost identical work practices internationally, standardisation of organisational roles, and nationally-bounded nature of ANSPs mean it is an especially well-placed industry through which to examine interactions between national culture and organisational characteristics. By examining this issue in ATM, we aim to contribute to the literature through conceptualising and empirically investigating how power distance shapes organisational safety culture.

Safety culture and power

Safety culture research often examines whether culture is a 'leading indicator' of safety, its distinction from safety climate, and the psychometric dimensions that characterise distinct forms of safety-related values and practices. In terms of safety performance, safety culture has been shown as a predictor of employee safety behaviours, and is weakly associated with employee safety incidents (Christian et al., 2009; Clarke, 2006). Cox and Flin (1998) describe the difference between safety culture and climate as akin to 'personality and mood', whereby culture refers to values, beliefs, and practices, and climate to perceptions of management commitment to safety. Both concepts are seen as to have a high overlap (e.g. due to their use of surveys), but culture is generally agreed to focus on a wider set of phenomena (e.g. incident reporting systems, organisational learning, communication, human

resources), and can be studied qualitatively and quantitatively (Mearns, Kirwan, Reader, & Jackson, 2013).

Psychological study of safety culture has identified various dimensions of safety-related values and practices important for managing risk (Mearns et al., 2013; Reader et al., 2015). These include such dimensions as management commitment to safety (management prioritisation of safety), collaborating for safety (group attitudes and activities for safety management), incident reporting (extent to which respondents believe it safe to report safety incidents), communication (whether staff are informed about safety-related issues), colleague commitment to safety (beliefs about the reliability of colleagues' safety-related behaviour), and safety support (availability of resources and information for safety management). Further details are presented in Table 1.

<INSERT TABLE 1 APPROXIMATELY HERE>

These dimensions can be assessed variously, but the most common methodology is surveys of employee perceptions of safety culture (Mearns et al., 2013). These are seen as important because they reflect how employees perceive and evaluate organisational policies, practices, priorities, and values on safety. Critically, employee perceptions of safety culture are assumed to influence safety behaviours (e.g. incident reporting), which compounds the culture (e.g. normalising a behaviour). Yet, in terms of developing a positive and shared safety culture, Antonsen (2009a) suggests that organisations rarely achieve consensus and harmony. This draws on the observation that culture is socially constructed (Frost, Moore, Louis, Lundberg, & Martin, 1991; Martin, 1992; Schein, 1992), and thus will not necessarily manifest the same nor have the same effect in different components or levels of an organisation. For example, different perspectives on organisational culture emerge due to the demarcation of organisational roles, conflicts over resources, and the exercise of power (Zaleznik, 1970).

In terms of safety culture, this indicates that employee perceptions of organisational policies, practices, and values for safety are likely to be shaped by the role of employees, their position within the organisational hierarchy (i.e. where individuals have higher or lower implied power based on their hierarchy position), and the broader social environment in which they are operating. In particular, power appears relevant. Power has been defined variously by psychology researchers. For example, many researchers describe power in terms of resource control (Keltner, Gruenfeld, & Anderson, 2003; Magee & Galinsky, 2009); others consider power in terms of relational influence (French & Raven, 1959; Raven, 1992). In either case, these are explicit theories of power with explicit measures. We consider power more implicitly in two forms: 1) that inferred from an individual's position within a hierarchy, and 2) the concept of 'power distance'. In particular, the concept of 'power distance' appears important, and is an underlying feature of many safety culture studies. This is because the practices that underpin a strong culture often involve an aspect of power, including challenging power (e.g. speaking-up to stop an unsafe act by a colleague), manoeuvring around power (e.g. anonymously reporting incidents involving those in authority), or communicating with those in power (e.g. on necessary improvements to safety systems) (Antonsen, 2012).

Often such behaviours are expected to be enacted by frontline employees – who are positioned lower in organisational hierarchies, often lower status, and not in management roles (though see Crozier, 1964, who argues that front-line workers often bypass typical power structures via subject-matter expertise and organisation) – and case study analyses of industrial accidents often identify problems in power-related practices (e.g. communication and speaking-up between employees of different status) as a causal factor in mishaps. For example, in terms of aviation accidents where first officers have been unable to challenge the behaviour of captains (National Transportation Safety Board, 2000), medical errors where

nurses speaking-up to senior clinicians might have averted patient harm (Pronovost, Wu, & Sexton, 2004), and process safety failures where front-line technical staff have felt unable to raise safety problems with management due to fear of reprisals (Reader & O'Connor, 2014). Furthermore, within the safety culture literature, it has been repeatedly shown that acts related to power distance are integral to effective safety management, and are emblematic of a safe culture (Chiang & Pepper, 2006; Helmreich, Merritt, & Wilhelm, 1999; Liu & Liao, 2013).

Yet, and perhaps surprisingly given the assumed relationship with safety practices (e.g. speaking-up), the influence of power distance upon perceptions of safety culture remains relatively underexplored. Although a small body of research has examined how perceptions of safety culture are shaped by the status of organisational roles and societal tendencies for challenging authority, there has been relatively little formal conceptualisation or empirical examination of how these different factors interact to shape perceptions of safety culture. To further this, we outline our conceptualisation and research hypotheses below.

Hierarchy position and perceptions of safety culture. First, the research literature indicates that how safety culture-related practices are perceived and enacted upon can depend upon the power associated with one's position in an organisation's hierarchy. For example, in healthcare, it is shown that nurses are more likely than clinicians to report finding it difficult to speak up on problems with patient care, and these divergent perceptions are understood in terms of their differing roles and authority status (Thomas et al., 2003).

Psychological research of safety culture shows that senior staff tend to view safety measures and risk more positively than junior staff (Mearns et al., 1998), that perceptions of safety management vary according to whether one is in a managerial, supervisory, or operational role (Clarke, 1999), and that managers have more positive perceptions of safety culture than frontline and support staff (Findley et al., 2007). Furthermore, safety culture is

poorest when manager and worker perceptions diverge (Prussia et al., 2003), with group differences potentially leading to organisational conflict, increased risk, and degraded safety performance (Findley et al., 2007). Prussia and colleagues (2003) suggested that such improvements required closer agreement between managers and workers over safety responsibility.

In terms of explaining why those in different hierarchy positions perceive safety culture differently, various factors can be identified. For example, employees in positions of differing organisational hierarchy will likely differ in terms of knowledge and experience in the organisation, with frontline staff having access to first-hand safety information and management holding an organisation-wide view on safety. Indeed, an individuals' role and position within a hierarchy shapes how they construe and communicate about events, with those higher-up in hierarchies using more abstract and positive language, compared to those lower in the hierarchy using more concrete and negative language (Magee, Milliken, & Lurie, 2010). Furthermore, there are many safety practices that involve social risks (e.g. speaking up), which may lead those in less powerful positions (i.e. placed lower in the organisational hierarchy) to view such practices as more challenging. For example, engaging in voice acts is easier for those in senior rather than junior roles (Bienefeld & Grote, 2012; Islam & Zyphur, 2005; Nembhard & Edmondson, 2006), and where there is a large authority gradient between superiors and subordinates, communication between superiors and subordinates becomes asymmetrical due to the differences in status, with the stream of information flowing top-down rather than bottom-up (Cosby & Croskerry, 2004).

When viewpoints on safety differ in such a way, and are not communicated due to hierarchical boundaries, divergences in perceptions of safety culture may emerge. For example, if frontline staff are given less opportunity to speak up and challenge superiors, then they may feel less engaged with incident reporting. Where subordinates believe that

management's communication on safety issues is too abstract, it may be perceived as insufficient. Furthermore, if subordinates feel that their superiors do not listen to their safety concerns, then they will perceive management to have less commitment to safety. Indeed, interventions to improve safety-related practices often focus on reducing power distances between senior and junior staff in order to improve communication processes. For example, training leaders to encourage junior team members to speak-up (Edmondson, 2003), using resources to increase collaboration in inter-disciplinary teams (Levina & Vaast, 2008), and ensuring leader inclusiveness (defined as words and deeds by a leader or leaders that indicate an invitation and appreciation for others' contributions) in order to improve psychological safety and engagement (Nembhard & Edmondson, 2006).

Thus, our first hypothesis intends to confirm the observation that hierarchical position (and power entwined within that position) is associated with more or less positive perceptions of safety culture. We suppose that, in the current research setting, those in more higher hierarchical positions (managers) will perceive safety culture more positively because they are less threatened by engaging in safety practices (e.g. reporting), and by virtue of their position in the organisational hierarchy will have more information on organizational efforts to improve safety, but less knowledge about the specific challenges being faced by staff. However, those positioned lower in the hierarchy (air traffic controllers, engineering staff, administrative staff) will perceive safety culture less positively due to the challenges with engaging in safety practices (e.g. speaking-up), alongside greater awareness of the specific safety challenges being experienced 'on-the-ground' (and the absence of management action).

> **H1**: Those positioned higher in a hierarchy (managers), and with the power associated with that position, will view safety culture more positively than those positioned lower in the hierarchy (frontline staff).

National values for power distance and safety culture. Second, psychological research of safety culture has shown that societal values for power distance can shape perceptions of safety culture for organisations operating in different geographical regions (Reader et al., 2015). At a societal level, the notion of power distance is conceptualised as a dimension of culture that can vary between nations. Specifically, studies of national culture have isolated several dimensions by which national culture vary. Hofstede and colleagues (Hofstede, 1976; 1980; 2001; Hofstede et al., 2010) have famously spent several years documenting cultural dimensions, of which power distance is one. National power distance specifically refers to how national, cultural and educational institutions shape shared values and behaviour with respect to the way nation-members think of and approach hierarchies and power in interpersonal contexts. National power distance is about nation-members expectations regarding the symmetry of relations, and is measured by Hofstede's Power Distance Index, where high scores reflect greater distance between superiors and subordinates and greater acceptance of hierarchy, whereas low scores reflect less distance and less acceptance of hierarchy.

In terms of theorising safety culture, national variations in power distance appear important. Nations are a key unit of shared experience due to their educational and cultural institutions that shape the values of its members (Minkov & Hofstede, 2011). Thus, national values for large power distances may influence perceptions of safety culture through shaping the willingness of those in less powerful positions to challenge authority and correct errors made by superiors, reducing the likelihood that junior staff will admit mistakes that have potential social or career-related consequences, and creating asymmetrical communication between management and subordinates (Mearns & Yule, 2009; Reason, 2016; Soeters & Boer, 2000).

The research evidence indicates safety culture is shaped by national values related to power distance. Research into organisational accidents, for example aircraft crashes, has indicated both a qualitative and statistical association between national values for power distance (usually operationalised in terms of flight crews challenging captains) and accidents (Helmreich, 1994; Li et al., 2007; Soeters & Boer, 2000). Furthermore, in considering the difficulties of applying safety climate models developed with Western samples, Bahari and Clarke (2013) have considered the influence of strong power distance values upon observations of safety climate. Also, associations have been observed between respondents' low power distance perceptions and reduced human failures in container shipping operations (Lu et al., 2012), and European geographical regions with strong power distance values have been shown to have less positive perceptions of safety culture in the Air Traffic Management industry (Reader et al., 2015).

Although strong power distance has been found with more positive perceptions of safety culture (Håvold, 2007), the weight of evidence indicates that national power distance is negatively related to safety (Bahari & Clarke, 2013; Li et al., 2007; Lu et al., 2012; Reader et al., 2015; Soeters & Boer, 2000). We suppose that strong power distance values are likely to influence safety culture through discouraging challenges to authority, reducing communication on safety, limiting opportunities to innovate on safety, and our second hypothesis seeks to reconfirm the observation that national cultural values will shape safety perceptions. Emulating the observation that power distance values in different European regions interact with safety culture in the ATM industry (Reader et al., 2015), we examine whether ANSPs in European societies with strong power distance values have less favourable perceptions of safety culture.

H2: National values for power distance will be negatively related to safety culture perceptions, such that as national values for power distance become stronger, safety culture perceptions will become more negative.

The interaction of power's manifestations. The practices that characterise a strong safety culture often involve power dynamics (e.g. challenging, negotiation, communication), and the previous hypotheses assume that engagement in these is influenced by employee perceptions of safety culture, which is in-turn influenced by 1) position within a hierarchy, and 2) national values for power distance. We examine the interaction between the latter two manifestations of power in order to understand how perceptions of safety culture are a product of organisational structures and societal values outside specific organisational policies, regulations, and institutional rules for safety. This is both important for understanding how power distance potentially shapes how safety is enacted within an organisation, and for considering how organisational and social structures shape safety culture development.

To date, there has been no examination of the interaction between the two manifestations of power examined in this study: the power associated with one's hierarchical position, and the societal values for how they enact that power. This interaction can potentially take two forms. First, national values for power distance are likely to reduce the quality of communication across a hierarchy (e.g. for challenging unsafe acts, raising safety concerns, reporting safety incidents), and therefore potentially exacerbate the divergence in safety culture perceptions between those higher and lower in organisational hierarchies because they will further reduce the sharing of perspectives and information on safety. In this first form, differences between superiors and subordinates will be greater in nations with strong power distance values and weaker in nations with weak power distance values.

Second, strong power distance values may actually have the potential to *improve* the quality of communication across a hierarchy through clarifying lines of communication (e.g. clearly stating expectations for incident reporting, developing systems for reporting information). If this is the case, the gap between superiors and subordinates for perceptions of safety culture will be smaller in nations with strong power distance values.

Although the evidence base for building a hypothesis is limited, we believe that the assumption of a main effect of national culture is more logical. This is because even if strong power distance values do clarify lines of communication, broader issues around concerns over challenging superiors, blame, meeting the expectations of managers (which may cause conflict), and responding to unanticipated situations are unlikely to be entirely negated. Consistent with Erez and Gati's model (2004), we expect national values for power distance to augment the greater power associated with a higher position in a hierarchy, and the reduced power for those in front-line roles, which shapes perceptions of safety culture.

> **H3**: National power distance values will moderate the manager-frontline staff gap in safety culture perceptions, such that safety culture perceptions of management and frontline staff will be most aligned at low levels of national power distance, and less aligned at high levels of national power distance.

Theoretical and practical relevance

The research questions posed have both theoretical and practical implications. On the theoretical implications, they speak to the development of safety culture. Specifically, it is supposed that power is not only central to the practices that are emblematic of safety culture (i.e. speaking-up behaviors), but also how people construe and construct the power dynamics that surround those practices. This indicates that safety culture is not just a product of institutional policies, safety management systems, and group dynamics, but also of more macro-level factors relating to power dynamics within institutions and broader societal

values. This is critical to understanding how safety culture develops and can be influenced, and connects to the long-standing debate around the relationship between micro and macro-level determinants of organizational culture (Molloy, Ployhart, & Wright, 2010) and the application of construal level theory to organisational research (Wiesenfeld, Reyt, Brockner, & Trope, 2017).

It is also important at a practical level, particularly for understanding how safety culture develops, is measured, and changes in societies with different values around power, and different hierarchical structures. To examine this, our study focuses on the European ATM industry, which is especially suitable for testing hypothesis 3 due to industry wide standardisation of working practices, nationally-bounded companies, occupational roles, regulation, policies, and requirement for a completely safe and reliable system.

Method

Participants

The participant data used in the current study originates from an ongoing research project to measure and monitor safety culture in the European Air Traffic Management industry. The project has run since 2006 and is coordinated and funded by EUROCONTROL (the organisation for coordinating and planning European air traffic management). Over this period, more than 30 countries have been involved in the project, with over 20,000 participants in total. As such, the dataset is large, and questions about the interaction between national culture and safety culture can be examined. For example, whether a safety culture model can be used reliably across international contexts (Reader et al., 2015), and whether safety culture benchmarking should take into account national values for uncertainty avoidance (Noort, Reader, Shorrock, & Kirwan, 2015). In this paper we draw on a dataset of 13,616 ANSP employees based in 21 ANSPs, across 21 European countries (one ANSP per country). Survey responses were collected between 2011 and 2015 via online surveys. We do not include data prior to this because of significant changes to the survey instrument (Mearns et al., 2013). For purposes of data transparency, Appendix 1 reports on the two other studies utilising an overlapping data set.

In the current study, we report on the data from 13,616 respondents. Of those, 1,592 (12%) reported ‘manager’ as their primary role, 6,500 (48%) reported ‘controller’ (or other operations staff), 1,764 (13%) reported ‘engineer’, and 3,717 (27%) reported being administrative staff (or other staff). We include responses administrative and other non-operations staff in our analyses because safety culture permeates all aspects of the organisation (e.g. decisions taken in the HR department may have implications for the ways frontline staff work). Some respondents reported having no primary role (n = 43) and were not included in the analyses, bringing the final sample size to 13,573 (staff demographics

presented in Table 2). There was an average of 649 responses (*SD* = 682.07) from each of the ANSPs, for an average response rate of 55% across 17 ANSPs (unfortunately we do not have response rate data for four sites). We opt to withhold descriptive data on the specific nationalities of our respondents as it would be possible to infer the specific ANSP, compromising the organisation's anonymity (e.g. many nations have a single ANSP). In order to preserve the interests of the organisations involved, and our subsequent working relationships with those organisations, we withhold nationality data and do not present safety culture data paired with organisational descriptive data.

<INSERT TABLE 2 APPROXIMATELY HERE>

Measures

Safety culture. Recent work (Reader et al., 2015) demonstrated the psychometric properties of a safety culture questionnaire tool for European ATM. The survey was developed as part of a multiple method approach (literature review, interviews, focus groups, incident analyses), where preliminary data collected with early versions of the tool were subject to exploratory and confirmatory factor analyses (Mearns et al., 2013). The survey items cover a large range of safety culture issues specific to ATM, and the six underlying dimensions iterate well established themes within the safety culture literature more generally (management commitment to safety, collaboration for safety, incident reporting, communication, colleague commitment to safety, and safety support). After further testing and refinement, the final model identified six dimensions of safety culture relevant to ATM across Europe (management commitment to safety, collaboration for safety, incident reporting, communication, colleague commitment to safety, and safety support; see Table 1). The current version of the safety culture questionnaire tool comprises 19 Likert items (1: strongly disagree; 5: strongly agree). A safety culture score is calculated by averaging

participants' scores on each of the six safety culture dimensions, where higher scores represent more positive perceptions of safety culture within the organisation.

Hierarchical position. We consider individual power through hierarchies and by studying occupational roles, which we assume manifest power phenomena. Our survey collects information about what respondents consider to be their primary role. Responses to this item are coded as one of four possibilities: (1) managers; (2) controllers (and other operations staff); (3) engineers; or (4) administrative staff. This breakdown allows us to compare differences in perceptions between managers (implicit higher power) and three different groups comprising frontline staff (implicit lower power). Coding is decided by either consulting the organisation's survey representative or, where the survey representative was unavailable, by relying on expert controller knowledge regarding job role terminology.

National power distance. We consulted Hofstede's Power Distance Index (PDI; Hofstede et al., 2010) and assigned participants a power distance score based on the nation in which they primarily work. It is important to note here that participants may have national cultural origins that are distinct from the PDI value assigned to them (participants were not asked their national cultural background for reasons of anonymity and brevity). The PDI measures the extent to which power differences within society and societal institutions (organisations, family units, etc.) are accepted by less powerful members.

Hofstede uses four questions to calculate the PDI that can be found in the 2013 version of the Values Survey Model (Hofstede, Hofstede, Minkov, & Vinken, 2013). The first two ask respondents how important it is for them to have a boss (direct superior) they can respect, and for them to be consulted by their boss in decisions involving their work (items 2 and 7 respectively; 1: of utmost importance, 5: of very little or no importance). The third asks respondents how often subordinates are afraid to contradict their boss (item 20; 1: never, 5: always). The final asks respondents to indicate the extent to which they agree with

the statement that an organisation structure in which subordinates have two bosses should be avoided at all cost (item 23; 1: strongly agree, 5: strongly disagree). The PDI is then calculated using the following formula

$$PDI = 35(m07 – m02) + 25(m20 – m23) + C(pd)$$

In the formula, m02 is the mean score for item 02, etc., and C(pd) is a constant (positive or negative) that depends on the nature of the samples. The index usually has a range of about 100 points. The four power distance items were found to load on onto a common factor related to issues of power and inequality.

These items, along with many others, were part of employee opinion surveys at the multinational firm, IBM. The value in this dataset comes from a combination of two things: (1) that responses are from approximately 50 different national sites around the world, and (2) the respondents were well matched on several dimensions (i.e. work, SES, family life) that makes national comparisons quite clear. The above formula was applied to responses in the IBM dataset, allowing a rank-ordering of nations based on their inhabitants' average responses to the PDI questions (Hofstede et al., 2010). We assign these PDI values to participants based on the nation they primarily work in.

Procedure

All data were collected via online surveys, except at seven smaller sites where paper-based surveys were used. Surveys were organised by EUROCONTROL in partnership with the management in each ANSP, with the survey data being collected by the study authors. Participants reported basic information about their work (organisational department, occupational role, location), before answering questions about the organisation's safety culture. Study results were reported back through a report and series of focus groups in each institution. Ethical clearance was granted by the ethics board at the London School of Economics. The nature of our data is sensitive for both individuals recording their

perceptions within an organisation, and the organisations themselves. To ensure their anonymity we do not record demographic details (e.g. age, gender) as these alone can be enough to identify some participants. We could report such data as an average, but we have found participants sometimes prefer to not fill out the survey when questions like these are included. We also do not report on the demographic detail of the ANSPs (e.g. organisational size, national context) as, again, this could be enough to compromise the organisation's identity.

Data Analysis

Bayesian statistics. Calculating Bayes factors allows for clearer interpretation of null results. With traditional null hypothesis significance testing (NHST), a *p*-value gives the probability of the data occurring if the null hypothesis was true; that is, how often the data occur by chance if there was no effect in the first place. We should not, however, assume a non-significant result counts as evidence for the null (as much as we sometimes like to). Or more simply, we should not confuse 'absence of evidence' with 'evidence of absence' (Heather, 2014). A Bayes factor, however, represents the weight of evidence for the alternative hypothesis vs. the null hypothesis. Thus, while NHST allows two possible conclusions (reject the null or there is insufficient evidence to reject the null), a Bayesian perspective allows three: 1) there is strong evidence for the alternative; 2) there is strong evidence for the null; 3) the data are insensitive with respect to the null and alternate hypotheses. Frequentist and Bayesian analyses will often show considerable agreement in interpretation, except in the case of null results - frequentist statistics cannot allow for meaningful interpretation of null results, whereas Bayesian statistics can.

Bayesian linear regressions allow us to say how many times better a particular model accounts for the data against a comparison model by evaluating the relative size of each models' Bayes factor. In this case, we are interested in the relative change in performance

that a model including interaction terms has over a model without (see Etz, 2015). Thus, each section reports the overall amount of variance accounted for by the model (conventional linear regression), relative performance of the model (Bayesian linear regression), and parameter estimates.

Analysis plan. We conducted linear multiple regression to determine the amount of variance in safety culture perceptions accounted for by the full model and the individual predictors. For this regression, we simultaneously entered hierarchy position (testing H1), national power distance (testing H2), and the interaction term (testing H3). We also calculated a Bayesian linear multiple regression with the same predictors so that we could compare the relative performances of variations in the model. Finally, we conducted simple slopes analyses to examine the effect of national power distance values on each level of the hierarchy position variable, that is, on each of managers, controllers, engineers, and administrative staff.

Preliminary analyses. Here we report preliminary analyses ahead of the focal analyses. Both Kolmogorov-Smirnov and Shapiro-Wilk tests of normality determined the distribution of safety culture scores was normally distributed (K-S statistic (df=12) = .193, p =.200; S-W statistic (df=12) = .954, p = .699). As this is a very large dataset, the ability for any one observation to influence the regression analysis is low. Consequently, all observations have a Cook's Distance score below .002, suggesting no observations were particularly influential. Visual inspection of the P-P plot for standardized residuals revealed a linear relationship between the predictors and the outcome. The correlation between power distance and hierarchy position was not large enough to violate the multicollinearity assumption (r = .087, p < .001). Of potential concern, however, was that the predictors were more strongly correlated with each other (r = .087) than with the dependent variable (hierarchy position: r = -.037; power distance: r = -.047). Multicollinearity often occurs when

two independent predictors actually tap the same latent construct. It is difficult, however, to interpret *this* multicollinearity because it is unclear how national power distance and hierarchical position would tap into a similar latent construct.

Results

Moderation analysis

All analyses were conducted in R. To test our moderation analyses, we conducted both conventional linear regressions and Bayesian linear regressions via the BayesFactor package (v0.9.12-2, Morey, Rouder, & Jamil, 2015).

We entered hierarchy position, national values for power distance, and interaction terms as predictors, with safety culture as the outcome variable, for all regressions. We describe this as the full model. The organisational role variable was dummy coded with the manager category as the reference. Thus, there were three dummy coded hierarchy position variables: managers vs. controllers, managers vs. engineers, and managers vs. admin staff.

Hypothesis 1. Hierarchy position accounted for a significant amount of variance in the full model. Thus, hypothesis 1 was supported. Each dummy coded variable was a significant predictor in the model, with controllers (b = -.240, p < .001), engineers (b = -.405, p < .001), and administrative staff (b = - .212, p < .001) all having lower perceptions of safety culture than managers. A model with the group factor only performed $BF_{10} = 4.71 \times 10^{82}$ (±0%) times better than an intercept-only model at explaining the data. The probability density distributions for each organisational role is visually represented by violin plots in Figure 1.

<INSERT FIGURE 1 APPROXIMATELY HERE>

Hypothesis 2. National power distance values also accounted for a significant amount of variance in the full model (b = -.006, p < .001), supporting hypothesis 2. That is, safety

culture appeared to diminish with increasing amounts of power distance scores. A model with the power distance variable only performed $BF_{10} = 7.15 \times 10^{72}$ (±0.01%) times better than an intercept-only model but was the poorest performing predictor compared to all other models. A power distance only model performed $BF_{10} = 6.59 \times 10^{9}$ (±0.01%) times poorer than an organisational role-only model, $BF_{10} = 1.78 \times 10^{89}$ (±2.25%) times poorer than a main effects-only model (a model including both the organisational role and power distance variables), and $BF_{10} = 2.46 \times 10^{101}$ (±0.69%) times poorer than a full model (including the interaction). The main effect of power distance is represented visually in Figure 2.

<INSERT FIGURE 2 APPOXIMATELY HERE>

Hypothesis 3. The data analysis indicated support for Hypothesis 3, for which we were interested in the relative performance of a full model, including the interaction terms, compared to a main-effects only model. The main effects model accounted for a significant amount of variance, $R^2 = .056$, $F(4, 13{,}564) = 199.40$, $p < .001$, as did the full model, $R^2 = .061$, $F(7, 13{,}561) = 125.50$, $p < .001$. There was a significant increase in variance accounted for by including the interaction term, $R^2_{ch} = .005$, $F(3, 13{,}651) = 25.52$, $p < .001$. Specifically, the interaction terms for the managers vs. controllers and managers vs. engineers were significant (controllers: $b = -.024$, $p = .017$; engineers: $b = .006$, $p < .001$), whereas the interaction term for administrative staff was not significant ($b = <.001$, $p = .970$). In Bayesian model comparison, the full model performs $BF_{10} = 1.37 \times 10^{12}$ (±2.25%) times better than a main effects-only model. Indeed, the full model was the best performing model configuration. The interaction is visually represented in Figure 3 and regression coefficients are provided in Table 3.

<INSERT FIGURE 3 APPROXIMATELY HERE>

<INSERT TABLE 3 APPROXIMATELY HERE>

Simple slopes. We examined the simple slopes of power distance values on safety culture for each level of the hierarchy position variable. The safety culture perceptions of managers (b = -.006, t = -6.97, p < .001), controllers (b = -.008, t = -15.22, p < .001), and administrative staff (b = -.006, t = -11.28, p < .001) were all negatively affected by increasing national power distance values. Interestingly, engineers appear unaffected by national power distance values, as their levels of safety culture perceptions were constant across all levels of power distance (b < .001, t = -.057, p = .954).

Exploratory analyses. Visual inspection of the results led us to question whether the interaction was driven solely by the engineers, whose safety culture perception seem almost entirely unaffected by national values for power distance. To check for this, we removed engineers from the sample and re-ran the model comparison for the full model vs. the main effects-only model.

With the engineers removed, the main effects model accounted for a significant amount of variance, R^2 = .062, F(3, 11,801) = 261.80, p < .001, as did the full model, R^2 = .063, F(5, 11,799) = 159.90, p < .001. As with the sample including the engineers, the interaction term led to a significant increase in variance, R^2_{ch} = .001, F(2, 11,799) = 6.68, p = .001. While the interaction term was significant according to conventional frequentist methods, Bayesian model comparison suggests the main effects model actually performed comparably, only performing nominally better than the full model by BF_{10} = 1.19 times (±2.38%). Thus, the influence of the interaction is substantially reduced once engineers have been removed from the sample. The interaction term for the controllers was again significant (b = -.002, t = -2.35, p = .019), where the slope for the controllers was steeper than for managers, suggesting that controllers' safety culture perceptions are more affected by power distance. The interaction term for the administrative staff was not significant, suggesting that the effect of national values for power distance on administrative staff's safety culture

perceptions were not significantly different to safety culture perceptions reported by managers. Regression coefficients for the analyses without engineers are presented in Table 4.

<INSERT TABLE 4 APPROXIMATELY HERE>

Discussion

Summary of findings

Our approach to power distance in safety culture is informed by the observation that many safety acts and practices inevitably involve the navigation of power dynamics, and that perceptions of safety culture shape how people engage in these behaviours. Yet, these perceptions in-turn were hypothesised to be influenced by the power distances between levels in organisational hierarchies (Hypothesis 1), and national differences in approaching power differentials and hierarchy (Hypothesis 2). These are elements not typically included in assessments of safety culture, and our analysis supported both hypotheses, which is consistent with past research. We then, for the first time, examined the interaction between these effects in order to establish whether nations with greater power distance values also have greater divergences in perceptions of safety culture between levels of hierarchy (Hypothesis 3).

We interpret our data as showing that the effect of an individual's position within an organisational hierarchy has on their safety culture perceptions is moderated by the extent to which hierarchies are nationally normative. The gap in safety culture perceptions between management and frontline staff, while existing at low levels of national power distance for some organisational group comparisons, is greatest at high levels of power distance, especially for engineers and controllers (but not administrative staff).

Theoretical implications

The data reported in this manuscript align with multi-level conceptualisations of culture (Erez & Gati, 2004). According to Erez and Gati (2004), culture is both multilevel and dynamic, with proximal levels of culture providing context for each other through both top-down and bottom-up processes. They propose a cultural hierarchy, with organisational culture nested within national culture. We suppose this creates variations in how safety culture is perceived and understood within an organisation, with hierarchies and power distance increasing 'differentiation' and 'fragmentation' in safety culture, whereby multiple interpretations arise according to factors such as identity, professional role, and interactions with others (Martin, 1992). Our work, for the first time, reveals that variations in how organisational culture is viewed can be attributed to an interaction between internal (i.e. organisational hierarchy) and external (i.e. national) factors.

Indeed, our results demonstrate the value in considering the different levels of organisational culture through which power operates. We show that national values for power distance are more relevant for controllers than they are for engineers, and that they have a more negative effect on controllers' safety culture perceptions than managers and administrative staff. Thus, the interaction of national power distance and power derived by position within an organisation appears important for how safety culture perceptions emerge for the different organisational roles. Yet, although we cannot directly test a multi-level conceptualisation with the data available (see limitations section below), multi-level conceptualisations of culture do not provide guidance on how to consider the multiple cultural forces acting on an individual. The nested nature of Erez and Gati's model suggests simply that adjacent levels of culture interact, without describing the individual's experience of those cultures. For example, the extent to which national culture can influence individuals may be called into question given its relatively small effect size in comparison to that of the

hierarchy position variable. This latter variable might be considered more proximal and salient to employees, with one's organisational role having a greater impact upon perceptions of safety culture than characteristics associated with national culture.

One approach that can inform on this issue is a social identity approach (Haslam, 2004; Postmes & Branscombe, 2010; Tajfel & Turner, 1986). This is used to consider and explore values and behaviours (i.e. culture) arising from multiple group memberships. Social identity theory posits that individuals' values, values, and behaviours are determined by the extent to which individuals internalise their meaningful group memberships: for example, a professional role or national identity. The impact of any given level of culture in a hierarchy might depend on the individual's level of identification with that cultural group. Obviously, the workers in our sample appear to be managing multiple group memberships at once. Where a social identity perspective would be useful is in accounting for the individual differences within groups. Thus, we believe there is value in future work marrying together cultural dimensions theory with social identity approaches in order to fully understand the effect of culture on individuals.

Theoretical data guiding practical understanding

An unexpected finding was that engineers were mostly unaffected by national cultural values for power distance. That is, once we removed the engineers from the sample the effect of the interaction terms was reduced, though still significant. A Bayesian comparison of the relative performance of the main effects-only model with the full, interactive model showed that the two models performed comparably. Thus, the inclusion of the interaction terms, while accounting for significantly more variance, seems to add little interpretational value, especially considering the large sample size.

The results for the engineers forced us to consider why they seemed at odds with the managers, controllers, and admin staff, who all displayed a negative relationship between

their safety culture perceptions and national power distance. We informally presented these data to other ATM workers (including engineers) and asked if they could help us understand why engineers seemed unaffected by national values for power distance. One anecdote was offered several times and happens to fit well with the theory. Several workers suggested that engineers are unaffected by national values for power distance because they are usually the subject matter experts, meaning they often work independently from their immediate supervisor. Whereas controllers are often supervised by other controllers or former controllers who know the job intimately, the supervisors of engineers might have little specific knowledge for how a particular system should operate. If managers must defer to engineers because engineers are the subject matter experts, then there is less opportunity for power distance and hierarchies to affect engineers. While these anecdotes do not constitute scientific evidence, they do provide both a platform by which to interpret our data, and a direction with which to pursue further research. If true, the above speculation only highlights the need to consider a multi-method approach when conducting organisational research to best capture the unique perceptions of culture that arise from the interaction of organisational structures and national cultures.

While the above suggestions are speculative, there are some results in the management literature of the 1980s that lend support to the notion. For example, levels of autonomy and goal congruence are more important for engineers (and scientific personnel) than other staff in explaining rates of retention (Sherman, 1989). Engineering managers must motivate their workforce toward innovative results, which may lead to an unstructured organisational environment (Thamhain, 1983). Indeed, a key concern for managers of engineers has historically been the simultaneous regulation of engineers' autonomy and control in order to promote innovation, while still producing measurable and effective outcomes (Feldman, 1989). So, it remains feasible that, where engineers' work requires

creativity and innovation, managers of engineers may be more 'hands-off' than managers of other workers, whose work requires less creativity. Beyond this, our data show that engineers have a different relationship with their organisations than frontline staff. Indeed, the characteristics of engineers' work, or how they are positioned appear to show a separate cultural layer for engineers. Indeed, Crozier's conceptualisation of power in *The Bureaucratic Phenomenon* (1964) highlights how control of uncertainty, skills, or knowledge by lower ranked workers can bypass typical power hierarchies. This is an important principle for understanding safety (or organisational) culture more broadly, in that much of safety-critical work happens away from the frontline. It may be that there are groups working in other safety-critical industries that share characteristics of engineers (e.g. work characteristics, position within the organisation), which would reveal much about the organisation's culture. This becomes especially important when considering that characteristics of engineers' work appear to override national cultural effects.

Practical implications

Our research demonstrates that a one-size-fits-all approach to safety culture is insufficient, in that neither hierarchy positions nor national culture wholly explain the variance in safety culture perceptions. It is only through examining how national cultural contexts influence the power dynamics of an organisation that a full understanding of organisational culture can be captured. Indeed, our results demonstrate that national culture appears to differentially affect different organisational roles, with controllers being the most affected, managers and administrative staff similarly affected, and engineers unaffected. This highlights the need for any organisational interventions targeting power to take into account the various ways in which different organisational roles interact with their superiors. As mentioned above, we have learned since running our analyses that engineers might have greater freedom for self-guided work and might have less interaction with their supervisors

than controllers do. The extent to which a superior and subordinate interact would then necessarily be important when evaluating effects of national cultural values for power distance – if there is little interaction then there is little opportunity for power to affect the subordinate. Thus, future safety culture interventions would do well to consider the existing values and protocols between superiors and subordinates to account for existing power dynamics relating to safety behaviours.

Limitations and future directions

A number of limitations require discussion. Much of our thinking about power distance and its effect on safety culture relies on the assumption that power distance creates asymmetrical communication flows. We speculate that communication is bi-directional between management and frontline staff in weak power distance contexts, but becomes uni-directional in strong power distance contexts because management takes limited input from frontline staff. Indeed, there are several large-scale international surveys about the relationship between culture (e.g. shared values) and manager-subordinate relationships (Smith, Peterson, & Schwartz, 2002; Smith, Peterson, Thomason, The Event Meaning Management Research Group, 2011; Van de Vliert & Smith, 2004). Yet, we did not investigate specific relationships, and did not include any measure of communication flow (or capture behaviours), principally because it was outside the scope of the project when it began. To examine this further, a logical first step would be to establish experimentally that power and hierarchies creates an asymmetry of communication, which itself leads to diverging perceptions between levels of the hierarchy.

A further limitation of this work is that it fails to take into account the dynamic nature of social identities. We have shown evidence for cultural effects on organisational perceptions but what would be most interesting would be a comparative study of social identities (e.g. national identities, organisational identities, job-role identities), documenting

how salient each is (e.g. the extent to which controllers primarily identify as controllers), and how predictive they are of safety culture perceptions. This work would greatly contribute to the understanding of culture as a superordinate entity above group-level dynamics. Mixed effects (or multilevel) modelling would greatly aid the interpretation of such a study. In our case, an ideal mixed effect model would have entered hierarchy position and national power distance as fixed effects, then allowed the effect of national power distance on safety culture to vary (random slope of national power distance) according to levels of the ANSP variable (random intercept of ANSP). Unfortunately, due to the organisation of ANSPs across Europe, there is usually only one ANSP per nation, meaning that our national power distance and ANSP variables are essentially transforms of each other and the above described model does not make sense.

Finally, the nature of our data may be problematic in two ways. First, the data are cross-sectional and can result in bias in the outcome measures. This is a particular problem when the characteristics of missing data differ from non-missing data. Indeed, the reasons for missing data in surveys of safety culture are potentially highly enlightening. Second, the self-report nature of our safety culture survey is a limitation of our study because of social desirability, common method bias, lack of predictive ability, and potential minimal participant insight on the issues being examined. Nonetheless, self-report remains an essential component of how safety culture is psychologically measured, as employee espoused values and knowledge on safety are an integral element of culture, and surveys allow for the large-scale collection of these. In particular, for issues such as power, perceptions of power-related practices are integral to the phenomena being investigated, however alternative (e.g. more behavioural) measures might also have been incorporated and associated with survey data. For example, incident reporting data, communications data, procedures for supporting staff to

raise safety concerns, and behavioural observations are perhaps more indicative of the underlying assumptions around poor culture, and the acts that demonstrated it (Schein, 1992).

Conclusions

For the first time, we have demonstrated that safety culture perceptions are affected by the interaction of national values for power distance and power conferred by position within a hierarchy. This contributes to the literature by theorising the role of power in safety culture theory, and examining how it manifests and potentially determines safety culture. It highlights the importance of considering how power exists and manifests at the level of superior-subordinate dynamics when assessing and attempting to change organisational safety culture.

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Appendix: Data transparency table

Data transparency table.

Reader, Noort, Shorrock, & Kirwan, 2015	Noort, Reader, Shorrock, & Kirwan, 2016	Current manuscript
17 European countries	21 European countries	21 European countries
10,717 respondents	13,616 respondents (additional 2,899)	13,616 respondents
Primarily reported at regional level	Reported at the de-identified ANSP (country) level	Reported at occupation level (managers, controllers, engineers, admin), at de-identified ANSP (country) level, and at the interaction level.
Distinguishes between managers and controllers	Reports data collated across all workers	Distinguishes between managers, controllers, engineers, admin
Uses 6-factor safety culture model	Uses 6-factor safety culture model	Uses 6-factor safety culture model
Uses Hofstede 5-factor model to link national culture with safety culture, and to test for regional differences in safety culture.	Uses single Hofstede factor (uncertainty avoidance) to test benchmarking technique.	Uses single Hofstede factor (power distance) to understand the role of power in safety culture research.

Table 1.

Safety culture dimensions for European Air Traffic Management (ATM). Reproduced from Reader, Noort, Shorrock, & Kirwan (2015).

Dimension	Definition	Relevance for Safety Management	Example Questionnaire Items
Management commitment to safety	Extent to which management prioritize safety	Indicates organisational prioritization of safety within an ANSP	• My manager is committed to safety • My manager takes action on the safety issues we raise • My manager would always support me if I had a concern about safety
Collaborating for safety	Group attitudes and activities for safety management	Indicates normative behaviours and attitudes among ANSP staff toward safety	• Other people in this organisation understand how my job contributes to safety • People who raise safety issues are seen as troublemakers • There are people who I do not want to work with because of their negative attitude to safety • My involvement in safety activities is sufficient
Incident reporting	Extent to which respondents believe it is safe to report safety incidents	Essential for identifying system weaknesses and learning	• People who report safety related occurrences are treated in a just and fair manner • Voicing concerns about safety is encouraged • We get timely feedback on the safety issues we raise
Communication	Extent to which staff are informed about safety-related issues in the ATM system	Important for ensuring staff are aware of system changes that might shape safety-related activities	• Information about safety related changes within this organisation is clearly communicated to staff • We learn lessons from safety related incident or occurrence investigations • I have good access to information regarding safety incidents or occurrences within the organisation • There is good communication up and down the organisation about safety
Colleague commitment to safety	Beliefs about the reliability of colleagues' safety-related behaviour	Highlights reliability of ANSP staff for engaging in safety activities	• Everyone I work with in this organisation feels that safety is their personal responsibility • I have confidence in the people that I interact with in mu normal working situation • My colleagues are committed to safety
Safety support	Availability of resources and information for safety management	Indicates active support within the institution for maintaining safety	• We have sufficient staff to do our work safely • People in this organisation share safety related information

Table 2.

Demographics of staff across 21 Air Navigation Service Providers (ANSPs). Reproduced from Noort, Reader, Shorrock, & Kirwan, 2016.

ANSP	Managers	Controllers	Engineers	Administrative	Total (role missing)
1	128	1258	270	419	2075
2	29	311	45	131	516
3	11	47	27	44	129
4	13	105	18	41	177
5	416	536	78	583	1613
6	41	319	35	315	710
7	58	172	146	127	503
8	22	83	31	62	198
9	9	128	24	30	191
10	35	71	71	15	192 (3)
11	10	71	11	2	94 (5)
12	36	361	83	36	516 (35)
13	244	904	290	678	2116
14	46	252	74	100	472
15	30	86	31	30	177
16	9	48	16	50	123
17	21	91	63	151	326
18	39	226	51	76	392
19	42	379	0	113	534
20	72	231	55	107	465
21	281	821	345	607	2054
	1592	6500	1764	3717	13573 (43)

Table 3.

Full model vs. main effects model regressions with full sample.

		Coefficient	*t*	*p*
Full model	Constant	4.062	82.403	<.001
	Power distance	-0.006	-6.140	<.001
	Managers vs. Controllers (D1)	-0.241	-4.407	<.001
	Managers vs. Engineers (D2)	-0.405	-6.137	<.001
	Managers vs. Admin staff (D3)	-0.211	-3.631	<.001
	Power distance * D1	-0.002	-2.380	.017
	Power distance * D2	0.006	4.576	<.001
	Power distance * D3	<.001	0.038	.967
	Model: R^2 = .061, F(7, 13561) = 125.50, p < .001			
	Interaction: R^2_{ch} = .005, F(3, 13,561) = 25.52, p < .001			
Main effects model	Constant	4.078	175.32	<.001
	Power distance	-0.006	-19.46	<.001
	Managers vs. Controllers (D1)	-0.360	-18.50	<.001
	Managers vs. Engineers (D2)	-0.123	-5.13	<.001
	Managers vs. Admin staff (D3)	-0.209	-10.07	<.001
	Model: R^2 = .055, F(4, 13,564) = 199.40, p < .001			

Table 4.

Full model vs. main effects model regressions with engineers excluded.

		Coefficient	*t*	*p*
Full model	Constant	4.062	81.384	<.001
	Power distance	-0.006	-6.064	<.001
	Managers vs. Controllers (D1)	-0.241	-4.352	<.001
	Managers vs. Admin staff (D2)	-0.212	-3.586	<.001
	~~Power distance~~	~~-0.006~~	~~-6.064~~	~~<.001~~
	Power distance * D1	-0.002	-2.350	.019
	Power distance * D2	<.001	0.038	.970
	Model: R^2 = .063, F(5, 11799) = 159.90, p < .001			
	Interaction: R^2_{ch} = .001, F(2, 11,799) = 6.68, p = .001			
Main effects model	Constant	4.128	169.553	<.001
	Power distance	-0.007	-20.805	<.001
	Managers vs. Controllers (D1)	-0.361	-18.375	<.001
	Managers vs. Admin staff (D2)	-0.210	-9.992	<.001
	Model: R^2 = .062, F(3, 11,801) = 261.80, p < .001~~Power distance~~			~~<.001~~
	~~-0.007~~			
	~~-20.805~~			
	~~Model: R^2 = .062, F(3, 11,801) = 261.80, p < .001~~			

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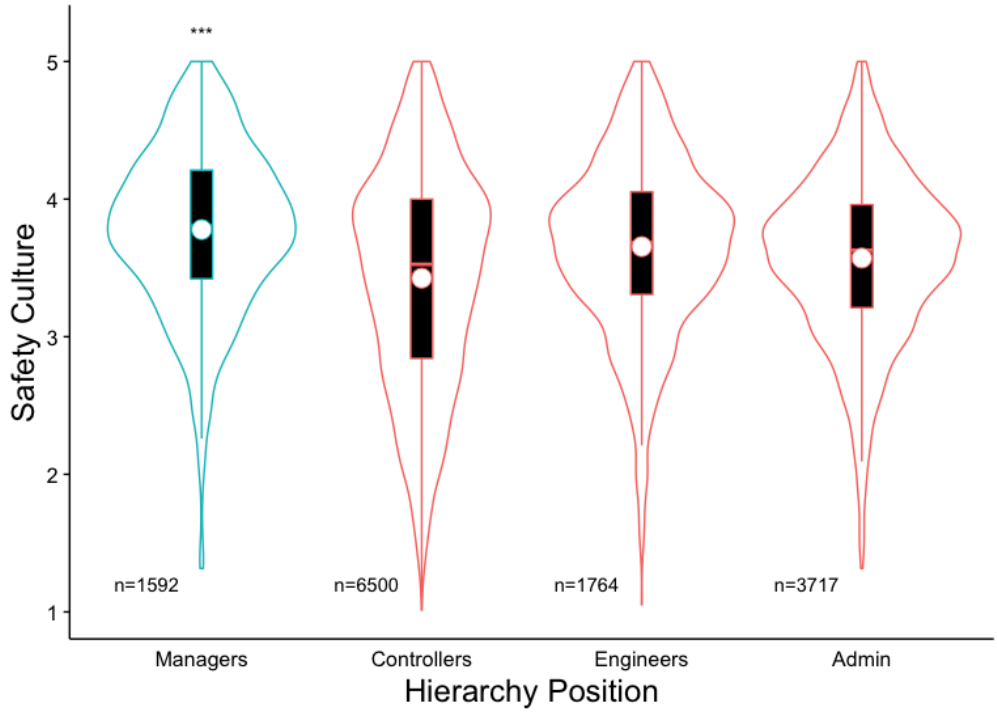

Figure 1. Violin with box plots demonstrating the main effect of hierarchy position on safety culture perceptions. Violin plots are probability density distributions. Boxplots show 25th, 50th, and 75th percentiles, inter-quartile range, and mean (represented by white circle) safety culture scores.

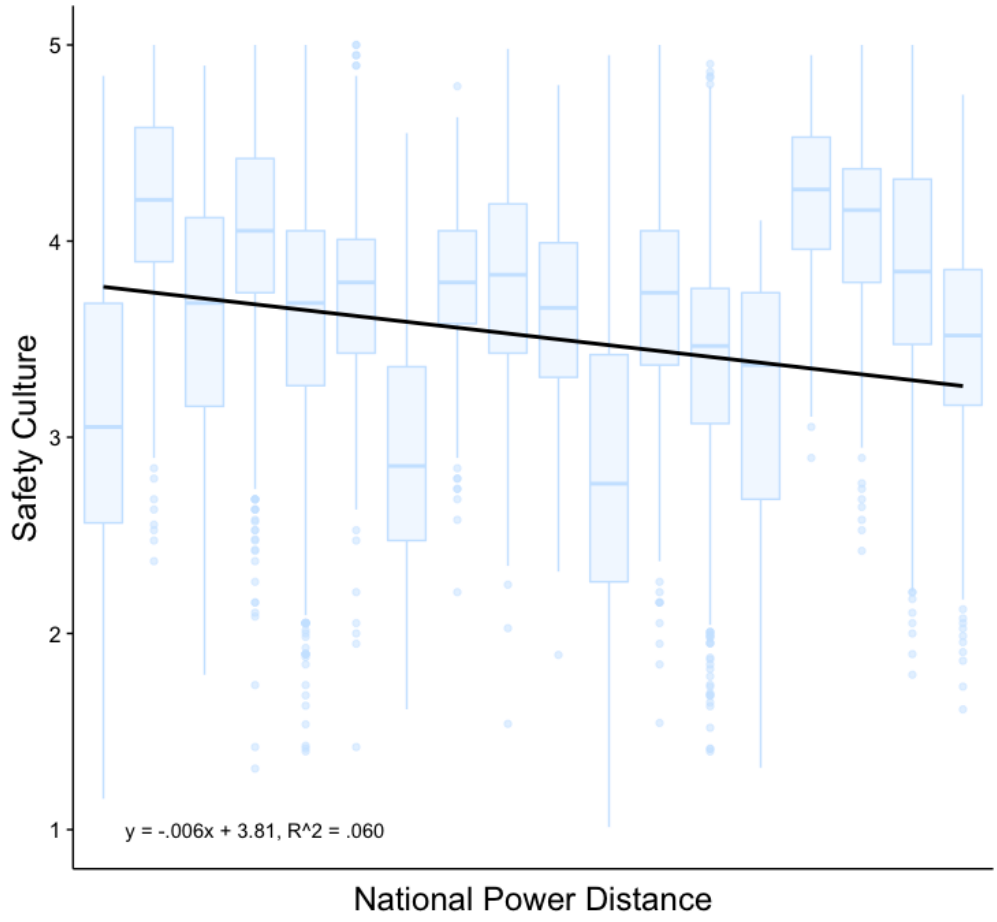

Figure 2. Main effect of national power distance on safety culture. X-axis values are increasing from left to right. Specific x-axis values are not included to maintain anonymity of the organisations that we work with.

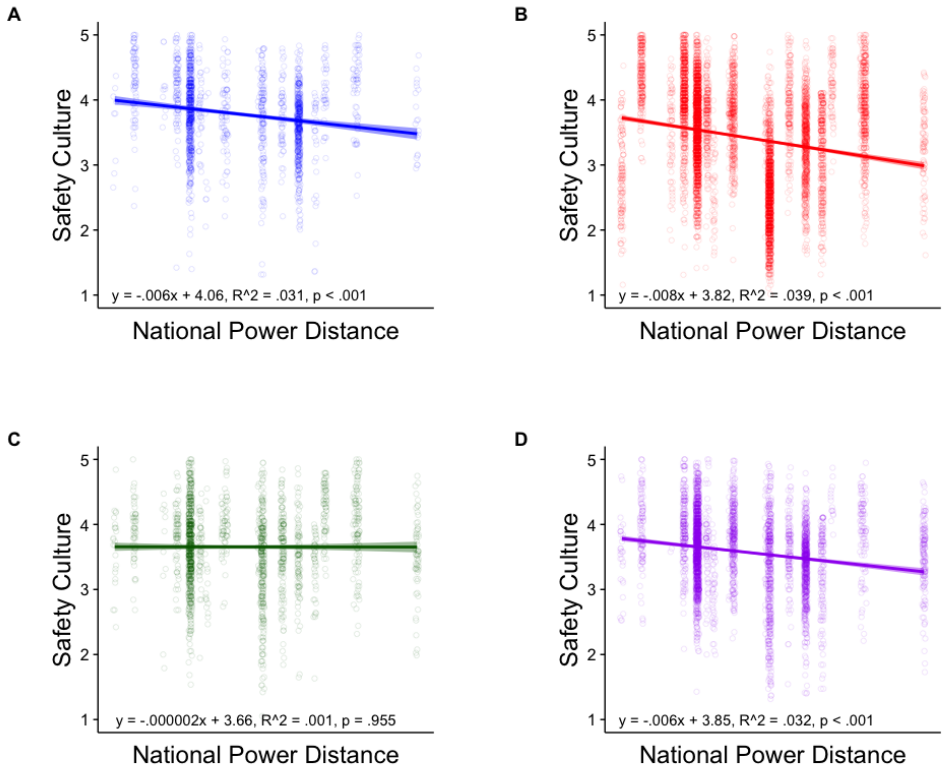

Figure 3. The interactive effect of hierarchy position and national power distance on safety culture perceptions. **A**. Managers. **B**. Controllers. **C**. Engineers. **D**. Administrative staff. Specific x-axis values are not included to maintain the anonymity of the organisations we work with.

Figure List.

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