The London School of Economics and Political Science

Human Factors in Financial Trading: An investigation of error, non-technical skills and culture

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DECLARATION

I certify that this thesis, presented for examination for MPhil/PhD degree at the London School of Economics and Political Science, is solely my own work except for where clearly indicated (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

Meghan P. Leaver

ABSTRACT

The financial crisis of 2008 was the most severe crisis since the great depression: millions of jobs and billions of pounds of household income were lost, resulting in pervasive unemployment, inequality and a rise in suicide rates (Barr et al., 2012). The failure exhibited complex organisational properties, such as tight coupling (e.g. the bankruptcy of Lehman Brothers triggered the collapse of other key organisations), the prioritisation of production over safety (e.g. profit over the wellbeing of clients) and a collective inaction to heed early warning signs (e.g. surrounding credit derivative swaps).

Yet, research in the financial sector has failed to capture critical information on how the behaviours and practises (e.g. systemic rate rigging) within the industry eroded risk management processes, and led to organisational failure (Power, Ashby, & Palermo, 2013; Ring, et al., 2014). This thesis draws on human factors theory and methodology that have successfully been applied in other high-risk domains (e.g. aviation) and applies them to a financial trading organisation to investigate whether human factors approaches help understand error in the financial trading domain.

To achieve this, four articles and three additional chapters have been developed for this thesis. Chapter 1 (introduction) conceptualises financial trading as a high-risk organisation and considers the implications of this for the domain, and the field of human factors. Chapter 2 (Article 1, published in *Journal of Risk Research*) conducts a systematic literature review of 19 studies in financial trading in order to establish the relevance of non-technical skills theory to the domain. Chapter 3 reports on the development of a methodology for capturing

operational incidents within a financial trading firm: the Financial Incident Analysis System (FINANS). Chapter 4 (Article 2, published in *Human Factors*) uses FINANS to analyse 1,000 incidents and reveals the human factors issues that underlie operational incidents (e.g. 1% of trades are erroneous and the most common causes are slip/lapse and problems in situation awareness and teamwork). Chapter 5 (Article 3, under review at *Human Factors*) analyses a further 1,042 operational incidents and establishes the role of human skills for capturing error and indicates financial traders to be the ‘last-line of defence’ for preventing incidents. Chapter 6 (Article 4, published in the *Journal of Business Ethics*) analyses ten high-profile trading mishaps in the UK, and shows safety culture problems in each as underlying the failures. Chapter 7 reviews each study and discusses the findings, implications and limitations of each. Chapter 8 concludes that the application of human factors concepts in financial trading generates meaningful insight into how risk is managed in this domain, and extends human factors research into a previously unexplored environment.

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I would also like to thank colleagues in the department of Psychological and Behavioural Science, whose curiosity and penchant for theoretical conversation widened my intellectual capacity. In particular, my IPOC colleagues – Kevin, Mark and Brett, who spent valuable time going over new ideas, pushing forward methodological inquiry and making this process significantly more interesting.

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THESIS FORMAT

The format for this thesis is a PhD-by-publication, with human factors theories and methodologies being applied to financial trading through a series of discrete research papers (Chapters 2-6). The context and implications of these studies are drawn together through an introduction (chapter 1), critical discussion (chapter 7), and conclusion (chapter 8).

Chapter 1 (introduction) conceptualises financial trading as a high-risk organisation and considers the implications of this for the domain, and the field of human factors. Chapter 2 (Article 1, published in *Journal of Risk Research*) conducts a systematic literature review of 19 studies in financial trading in order to establish the relevance of non-technical skills theory to the domain. This is common approach to investigating human factors issues in other industries, and reveals the viability and utility of applying non-technical skills concepts to financial trading. Chapter 3 reports on the successful development of a novel methodology for capturing operational incidents (errors) within a financial trading firm: the Financial Incident Analysis System (FINANS). Through analysing 1000 FINANS incidents using a human factors taxonomy (based on article 1), Chapter 4 (Article 2, published in *Human Factors*) shows human factors issues to frequently underlie operational incidents, and to cause substantial losses. Specifically, the analysis reveals 1% of trades to be erroneous and the most common causes of operational incidents to be slip/lapse (e.g. fat fingers) and problems in situation awareness (e.g. attention) and teamwork (e.g. coordination).

Chapter 5 (Article 3, under review at *Human Factors*) examines how trading errors might be minimised, and analyses a further 1,042 operational incidents in order to establish the role of human skills for capturing and averting error. Focussing on near misses, it shows that 96% of errors (52% of which are caused by slip/lapse) are averted through the non-technical skills of financial traders (in particular teamwork and situation awareness). Consistent with more recent theorisations in the human factors literature (in particular "Safety II"), it indicates financial traders to be the 'last-line of defence' for preventing incidents, with organisational culture being essential to providing the motivation and environment for doing so. Chapter 6 (article 4, published in the *Journal of Business Ethics*) examines this further, and establishes safety culture theory as an overarching framework through which to explain risk-related activities in financial trading. This study analyses ten recent high-profile trading mishaps in the UK, and shows safety culture problems (e.g. related to management commitment to safety) in each as underlying the failures; this counters prevailing narratives that focus on unethical 'rule breakers' rather than systemic problems.

Chapter 7 is a critical discussion of the thesis and reviews each study (aim) undertaken within this PhD and discusses the findings, implications and limitations of each study (aim). Chapter 8 draws together the main findings from each research study. It concludes that the application of human factors concepts in financial trading generates meaningful insight into how risk is managed in this domain, and extends human factors research into a previously unexplored, complex socio-technological environment.

I served as the principal investigator, data analyst and primary author for each journal article, with Dr. Tom Reader serving as a secondary author and research supervisor. Each preface includes details as to the proportional contribution of each author. I solely authored all other sections of this thesis.

The overall aim of this PhD is to apply human factors theories and methodologies to financial trading. This is intended to yield original insights and methodologies for managing risk in financial trading, and to extend human factors concepts into previously unchartered domains. This chapter first provides the personal context to the PhD, and then delivers a description of the financial trading domain. It then reviews financial trading literature in order to situate the current research, and then considers the integration of financial trading into human factors literature. Finally, based on the initial review, a series of macro- and micro-level research questions are outlined.

1.1 Personal statement

In the fall of 2012, a little over two years into my professional placement with the participating organization (a medium-sized commodity trading company), I approached senior management about the potential opportunity to build a tool to capture human-driven incidents that were occurring on the trading floor. Routinely, we were encountering the same set of incidents, typically driven by a poor shared understanding and lack of communication between the trading department teams that were dependent upon each other to achieve successful transactions, but we did not possess a means of collecting, monitoring, analysing and learning from these incidents. What I had been observing for some time was that dangerous preconditions would go unnoticed or be 'worked around' because of the inherent difficulty in handling the bulk of information in out-of-date systems and a constantly changing set of conditions on the trading floor. The incident could be so complex, vague or dynamic that the information available at any one time would be dispersed across several teams and locations, meaning that when the risk teams tried to make sense of the problems, they found that individuals and teams often held contrasting and changing interpretations of the same situation. I became instantly fascinated with how to capture and manage the relevant information and create a means for the organization to learn from it.

In my privileged role on the trading floor I have seen first-hand the cost of human error, yet incidents have not been investigated in a systematic way. Moreover, the issues that crop up in a single trading floor are not dissimilar to the issues that underpin more critical incidents, like those of the recent and highly publicised trading misconduct scandals (e.g. LIBOR rigging and mis-selling). For this reason, I am interested in improving how incidents can be collected and learnt from. With support from the participating organization, I began to investigate a way in which we could collect the incidents we were observing on the floor and construct an ambient, holistic form of measurement embedded within the organization.

The work undertaken in this thesis is driven by a professional capacity (e.g. informing organizational risk management, generating feedback to the organization on current issues and delivering interventions), as well as an intellectual drive (e.g. developing a methodology and a philosophy for how risk should be managed in financial trading, and contributing to the field of organizational psychology and human factors).

1.2 Financial trading

The trading environment is where products (e.g. equities, short-term, long-term, options) are bought and sold by financial traders in order to manage investment portfolios and generate profit for investment banks, energy companies and brokers. Trading requires an ability to anticipate market trends (i.e. for buying and selling) and negotiate large wholesale trades, and due to the sums of money and time-pressure involved in trading, it is a well-paid but stressful occupation. It is inherently risky, with reward systems incentivizing risk-taking that results in profit. Whilst this should reward analytical decision-making processes, profit can also emerge from 'noise trading' (irrational and erratic trading activities that reflect somewhat random decision-making), which in turn can negatively influence 'rational' trading (and therefore penalize logical decision-making).

The trading floor itself is a large, noisy and socio-technological space wherein traders (and support teams) watch monitors and interact by phone, internal chat systems or in small groups. Each desk is intentionally grouped as a specialized desk (e.g. the teams are divided according to the financial instrument or commodity that they trade or support, such as equities, bonds, natural gas, coal etc.) and it is the successful interactions across these heterogeneous desks that underlie organizational performance (Beunza, 2004).

The spatial configuration of the trading floor is standardized across most trading houses to provide the socio-spatial resources to promote a situated awareness or sense making capabilities (Beunza, 2004; Hicks, 2004). Workstations are in close proximity in order to allow traders to communicate with each other without leaving their individual workstation. In terms of joint activity, traders typically cycle between working alone and in collaborative teams; they monitor other desks' activity, share information, work with spatially distributed team members via phone and interpret the 'noise' of the floor (Hicks, 2004; Willman, Fenton-O'Creevy, Nicholson, & Soane, 2006).

1.3 Scoping literature review

This section conducts a preliminary review of the existing literature in order to identify instances where human factors concepts have been either applied, or recognized as relevant, to the financial trading domain. This literature review was non-exhaustive[1]; however this was done in order to permit a better understanding of human error and failure in the financial trading domain through the lens of industry 'experts', and to position this work's contributions into the broader literature on error analysis in financial trading.

In terms of a description of the literature that has been identified and reported on, the literature broadly exists within the realms of management studies and behavioural economics, with editorials and articles most popularly found in management journals such as *Management Science*, *Academy of Management*, *Human Relations*, *Harvard Business Review, Journal of Management Studies, Journal of Finance, Journal of Behavioural Decision Making* and *Journal of Behavioural Finance*, or risk management related journals such as *Regulation and Governance* and *Journal of Risk Research*. Both being relatively new domains of academic scholarship, the majority of the papers deemed relevant were published after 1990, with a clear uptick in impressionistic editorials and case study analysis following the financial crisis of 2008 and subsequent cases of trading misconduct.

[1] A systematic literature review of existing empirical studies of non-technical skills in financial trading is presented in Chapter 2.

In regards to specific areas of study, there is a notable bias towards retail banking, with topics varying from consumer decision making, e-banking and trust, judgements around loans/mortgages and, more broadly, critiques regarding the effectiveness of emerging regulation, audit and compliance strategies. The literature search filtered out non-trading domains and the final body of literature that remained essentially fell into one of two theoretical foci: behavioural economics or regulation and governance. A tertiary batch of literature that tended to focus on highly generic cross-sectional data on leadership styles (e.g. transformational versus transactional leadership). However, the leadership literature was greatly decontextualized and the results were primarily derived from case study analysis of large banking institutions, and therefore less directly relevant to the trading domain and the aims of this work.

1.3.1 Behavioural economics literature

The first set of work that was examined sits in the behavioural economics domain. Behavioural economics rejects the rational actor model of neoclassical economics and instead promotes the idea that actors are 'boundly rational'.

Bounded rationality. Bounded rationality refers to how perfectly rational decisions are often not feasible in practice due to certain limitations (e.g. cognitive resources, intractable decision problems, time pressure), and therefore traders often must compensate for this by making less than optimal decisions (Simon, 1991).

This theory attempts to account for the behaviours that underpin financial failure and scandals through the application of psychological concepts to understand financial decision-making. For example, literature that positions itself within this body of work tends to focus on decontextualized micro-aspects of decision-making, such as the heuristics and biases in decision-making with non-expert participants (e.g. students) (Awamleh & Gardner, 1999; Bantel & Jackson, 1989; Geyery & Steyrer, 1998; Howell & Hall-Merenda; Lee, Cheng, Yeung, & Lai, 2011; Shahin & Wright, 2004; Singh, 2008). A key paper by Garling and colleagues summarizes this body of literature and its impacts in the general financial services domain well, ultimately presenting the argument that financial markets overtax the actors' capacity to make rational judgements and decisions – and that cognitive bias (overconfidence, over-optimism, influences of nominal representation) underpins the behaviours and practices observed in cases of misconduct across the financial domain (Garling, Kirchler, Lewis, & van Raaij, 2009).

Information 'gaps'. The idea that traders operate within bounded cognitive fields is repeatedly acknowledged in the literature, where several articles point to problems in the distribution and interpretation of critical information as underpinning poor decision-making. For example, studies suggest that perhaps key information about trades and activity is not available to central team members who could understand its significance, and that this leads to 'gaps' in knowledge within and between the teams (e.g. front office and middle office) (Fenton-O'Creevy, Nicholson, Soane, & Willman, 2003; Michel, 2007). These 'gaps' in information have a range of identified causes such as non-participatory decision-making leading to groupthink of senior management and traders in determining risk tolerances, human-machine interface design flaws (e.g. information not made available in a digestible way to the operators) and procedural drift (e.g. the modelling of risk within the financial institutions is too mechanic, with human input all but removed from the decision-making process) (Hicks, 2004). It is argued that these processes that led to the creation of information 'gaps' are compounded by the intangible and complex nature of financial products, where vast amounts of uncertainty and information vacuums exist (Beunza, 2004; Willman et al., 2006).

Moral hazards. Finally, some studies draw upon the 'moral hazards' problem in explaining the extreme decision-making observed in financial trading. Meaning, where self-interested parties expose their market counterparts to excessive amounts of risk, they argue that this is because the risk-taking party does not bear the full costs associated with the activity, yet does gain all of the associated benefits (Dowd, 2009; Edmonds, 2007).

Limitations. Although the psychological concepts explored in the behavioural finance literature do possess some explanatory value and have been seminal in terms of documenting decision-making heuristics, for example by Kahneman and Tversky (Kahneman & Tversky, 1979; Kahneman, Slovic, & Tversky, 1982; Kahneman & Tversky, 1972; Tversky & Kahneman, 1974, 1981; Tversky & Kahneman, 1973), their practical implications for financial trading are somewhat limited. In fact, relatively few of the studies empirically explore the behaviours in-situ, and therefore their findings are relatively decontextualized. The methods, materials and settings of such experimental work do not accurately replicate 'real-world' trading environments (i.e. ecological validity), and therefore their findings can be difficult to operationalize (Brewer, 2000; Kahneman & Klein, 2009). Such work shows the importance of cognitive biases and affective influences in shaping trading decisions (e.g. overconfidence, optimism, loss aversion), albeit in a relatively decontextualized way (e.g. ignoring expertise, situational constraints and organizational environment). Therefore, whilst laboratory-style studies are useful for outlining broad principles on decision-making in high-stakes finance, the work in this thesis is geared to working with 'in-situ' research and methods adapted to a more ecological approach (Cacciabue & Hollnagel, 1995).

1.3.2 Regulation and governance literature

A second set of literature that aims to conceptualize failures in the financial trading industry is regulation and governance literature. This set of literature conceptualizes error in the financial domain as the product of a lax set of accounting standards and internal compliance regimes. This body of literature argues that repeated cases of misconduct might also be understood as a result of 'Thatcherite' reformist policies (e.g. reduced role of government in regulatory oversight) and the proliferation of self-regulation across the industry. Topics generally focused on are audit cultures, corporate governance structures, economic policy, credit failure, monetary policy and organizational restructuring (Cumming, Dannhauser, & Johan, 2015; Power, 2009). The methods used in these studies primarily relied on cost-benefit analysis and post-hoc case study analysis of misconduct and impressionistic accounts of post-financial crisis phenomena (e.g. explorations of why macro-economic models failed, and historical anecdotes of financial crisis and ethical drift).

Applications. Practical interventions aimed at improving risk management that are generated from this body of research include the mining of large amounts of trade data (e.g. for portfolio compression and reconciliation); third-party trade matching (e.g. a third party matches the trades between two counterparts to ensure all trades are booked into the individual organizations' portfolios); the emergence of targeted corporate governance codes (e.g. the Bank of England Senior Management Regime, SMR); new areas of work driven by legislation such as Basel II, MFID and EMIR (e.g. operational compliance teams); and a more central role for the Financial Conduct Authority (UK). The aims of increasing regulation are standardization, transparency, predictability and a reduction in acts of misconduct (e.g. fraudulent practices) (Edmonds, 2007; House of Commons Treasury Committee, 2009).

Limitations. Other high-risk industries that have similarly reacted to cases of failure and human error with increasing regulation and enhanced oversight (e.g. aviation and healthcare) have suffered from the 'bureaucratization of safety' that undermines organizational ability to reach a desired state of safety (Dekker, 2014). Aspects of the 'bureaucratization of safety' include the snowballing proceduralization of risk (undermining critical thinking in deference to procedures), the proliferation of out-of-date rules, a drain on organizational resources and greater difficulty capturing contextual sensitivities (e.g. nuances and changes in tools, insights and experiences) (Amalberti, 2001). These effects also manifest in the financial trading domain, where trading houses transact hundreds of trades daily across thousands of licensed counterparts, meaning the sheer volume of data to be processed can overwhelm the local capacity (e.g. drain on the resources) of regulators. Also, the technology and financial instruments used in the finance domain are continually evolving and adapting in order to maintain competitive advantage in a globalized market – this is remarkably challenging for a regulator, who is generally less informed about the day-to-day business of trading houses and therefore less equipped to stay up-to-date on the latest tools and technology, leading to difficulty in capturing the contextual nuance.

Therefore, although increasing regulation may lead to a short-term modification of organizational behaviours and practices (e.g. new operating procedures, creation of oversight teams and dedicated whistle-blower posts), the solutions put forth in this literature are superficial and do not target the deeper-held beliefs and environmental factors (e.g. culture) that support and promote the behaviours and practices that lead to error.

1.3.3 Summary

Following a scoping review of both sets of relevant and existing literature, it is evident that neither sets of literature offer the methodological tools to understand in-situ error data or the theoretical concepts to identify and synthesize the observed behaviours and practices that lead to and capture error in the trading domain. Therefore, this thesis looks to work in other risky domains (e.g. high-risk organizations) to identify a theory or set of concepts to guide the investigation.

1.4 High-risk industries

This section aims to examine the potential benefits of taking a human factors approach to financial trading. It does this by comparing some of the core 'features' of financial trading to other high-risk industries, and through this reflecting on the concepts and methodologies that might be useful for understanding and improving risk management in financial trading.

1.4.1 The investigation of financial trading using human factors methods

In other high-risk work domains, for example aviation, military and healthcare, in-depth analyses of the specific behaviours important for risk management within a given occupation are driven by human factors theory. Usefully, human factors theory offers a range of methodological tools (e.g. questionnaires, critical incident techniques, interviews) to understand in-situ error data, and provides theoretical frameworks for exploring how the behaviours and practices identified through error analysis underpin organizational performance.

Human factors methodology is relevant to the financial trading domain because it is used to manage problems that are similar in nature in other high-risk domains, and thus offers a way of organizing, analysing and better understanding the operational trading incidents that are reported. Also, the results of human factors analysis have led to interventions and training programmes for improving safety across a wide variety of high-risk domains and could be usefully adapted to the financial trading domain (Flin, O'Connor, & Crichton, 2008; Weigmann & Shappell, 1997). Moreover, human factors theory, and organizational psychology more generally, provides access to a wider field of literature to draw on to explain the behaviours observed on the floor.

Notably, human factors approaches typically investigate safety in safety-critical organizations (e.g. nuclear, aviation, healthcare), where risk is engineered out of the system in order to achieve the desirable 'state of safety'. Comparably, financial trading must also ensure that risk is continually managed and reduced where possible, and similarly, systemic problems in human performance can place the organization and wider social and economic system at risk. Yet dissimilarly, the success of financial trading organizations also hinges on a level of overt risk-taking by traders (as this leads to a competitive advantage). For example, judgement is essential to making effective trading decisions, and with every trade there is the possibility of loss and profit.

1.4.2 Financial trading as 'ultra-resilient'

Financial trading organisations are consistent with Amalberti's (2013) description of an 'ultra-resilient' organization. These are organizations where risk-taking is essential to success, and rather than engineering risk out of a system (e.g. through automation), it is managed through understanding and continually improving the employee skills required for effective performance (e.g. decision-making) whilst also ensuring systems are designed to reduce the likelihood of error (Amalberti, 2013). Defining financial trading organisations in this way is helpfully frames any further human factors investigations.

In fact, drawing upon the safety profiles work developed by Amalberti et al (2013), finance can be situated within the greater HRO (high-risk organization) literature, usefully enabling the comparison of the financial trading domain to other high-risk domains (see figure 1).

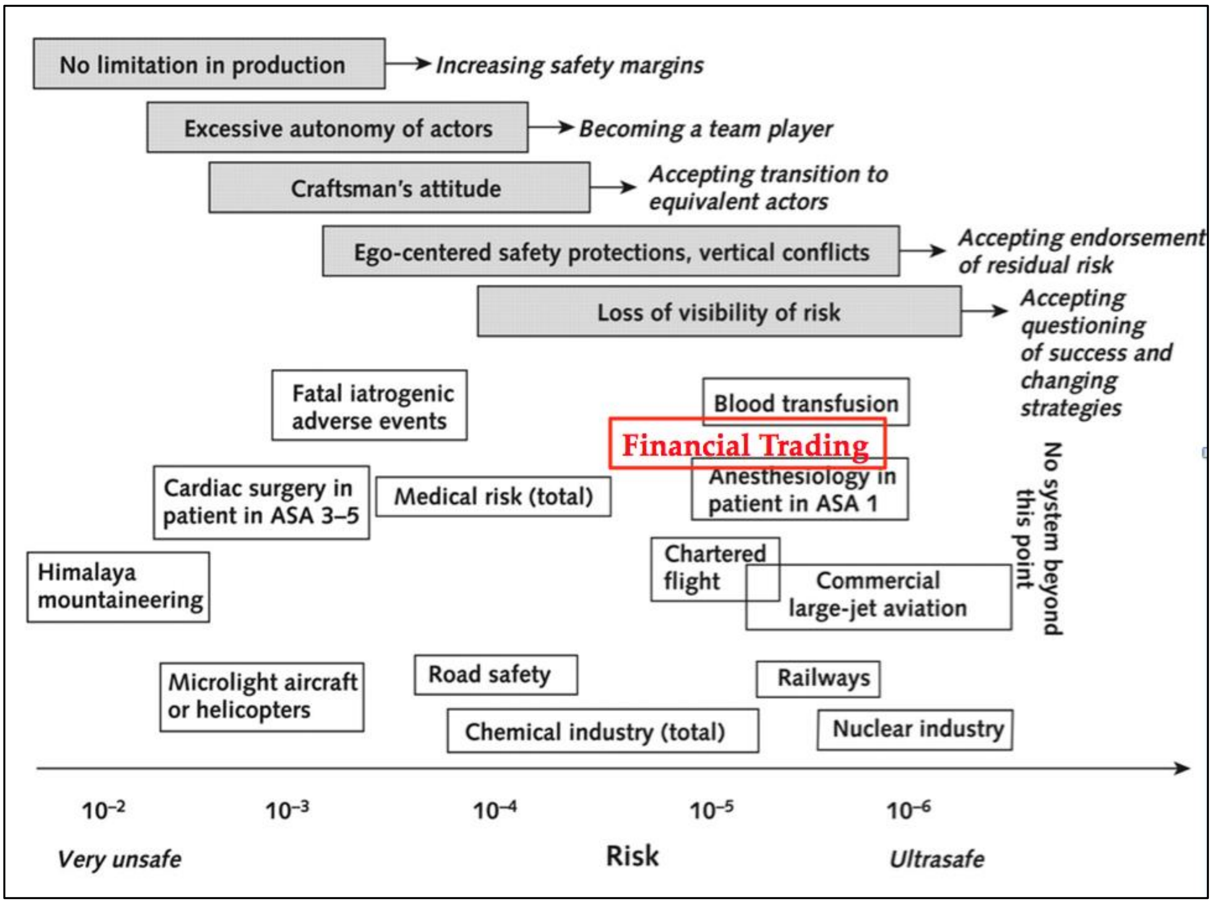

Figure 1: 'Riskiness' of Financial Trading, adapted from (Amalberti, Auroy, Berwick, & Barach, 2005) and based on data from studies 2 and 3

Figure 1 illustrates the 'riskiness' of trading activity, and provides a descriptive risk profile of the domain compared to other established high-risk domains. Reflecting on the nature of the financial trading context, the domain possesses unique properties, where there is a trade-off between authorized, deliberate risk-taking (e.g. creating trading opportunities) and undesirable risk (e.g. unauthorised risk-taking and people risk). The organization expends ample energy in sustaining the balance of high productivity (e.g. creating trading opportunity, generating revenue) whilst maintaining ultra-high levels of safety (e.g. daily modelling and measuring of value-at-risk, market volatility and changes in market and credit risk exposure).

Incidents in the trading domain are defined as ‘operational incidents’. Operational incidents are situations where trading activity results in an avoidable financial loss (e.g. making a trade without assessing market-related risk), or compliance failures (e.g. breach of trading limits) which place the integrity of the financial organization at risk even if no loss has occurred (e.g. overexposure to volatile markets: (Zhao & Olivera, 2006)). The organization’s adaptive capacity to detect (e.g. cross check of roles) when an operational incident occurs (e.g. a trading breach) is key to maintaining a resilient safety profile and limiting failure.

Importantly, the classification of ‘ultra-resilient’ situates financial trading within high-risk research and provides evidence to expand the set of domains considered as ‘high-risk’ to include financial trading. This justifies adopting a human factors approach within this domain.

1.4.3 The significance of conceptualizing financial trading as a high-risk industry

This shift in the conceptualization of finance importantly moves away from regulatory-based models and towards more human-centred models of error analysis, such as those employed in the human factors and safety domain. This reconceptualization is novel in the financial trading domain, yet parallels can be made between the recent work in other socio-technological domains such as cyber security, which has identified the relevance of human factors theory and advocated a more humanist framework to better understand and improve safety (Dekker, 2014).

The traditional conceptualization of ‘safety’ in human factors has long been considered as a state where the number of things that can go wrong is as low as possible. From this perspective, the purpose of ‘safety’ or risk management is to ‘measure’ and ‘manage’ safety through the inspection of failures. This works well in tractable systems, where the common factor is the breakdown, failure or malfunctioning of machinery or technology with more obvious and generally linear cause-effect relationships (e.g. accident models).

Yet the modern economy (e.g. of which financial trading is a part), and the technical and socio-technical systems that are attributed to it, continues to innovate and is shaped by increasingly powerful information technology – this means that systems and work environments have progressively become more intractable (Hollnagel, Wears, & Braithwaite, 2015). More precisely, automation and new technologies have resulted in new roles, decisions and vulnerabilities, while staff is also faced with new levels of complexity, adaptation and constraints. This means that methods and models of traditional systems (e.g. tractable systems) are less able to deliver the necessary and desirable ‘state of safety’ that these organizations seek.

1.4.4 Summary

Although not a safety-critical industry, the risks posed by the financial domain can be equally as disastrous as those observed in other risky domains. The failure of the financial industry in 2008 and subsequent trading misconduct scandals have had far-reaching societal consequences. At a national level, the monetary impact was widespread and required government bailouts of unprecedented proportions (850 billion GBP) (National Audit Office, 2010), which in turn led to pervasive austerity measures and curtailed government spending on social structures (e.g. hospitals, education). At the societal level, millions of jobs and billions of pounds of household income were lost, resulting in persistent unemployment and escalating levels of inequality and poverty.

The socio-technical complexity and intractability of financial trading is reflective of the changing economic landscape – where rapid technological change redefines the relationship between people and systems, transforms work processes and practices and increases the operational requirements of operators. Existing theoretical work has identified the need for a 'New Era' of human factors research that challenges the prevailing worldview (e.g. safety as a focus on what goes wrong) and promotes a more humanist interpretation of safety (e.g. safety as a focus on what goes right) (Dekker, 2014).

Financial trading would benefit from being a high-risk domain subject to human factors analysis. This is because human factors approaches are useful for understanding recurrent and systemic problems in risk management and can lead to insight on the number and types of incidents occurring within an organisation, their consequences, and the complex network of issues (e.g. errors, skill gaps, resources) that underpin them. Furthermore, reconceptualizing finance through the application of human factors challenges the field of human factors to engage with a non-traditional (e.g. high-risk, but not safety-critical) domain. In doing this, aspects of the prevailing worldview in human factors 'safety' thinking and financial risk management practices might also be re-imagined.

1.5 Research aims

Thus, human factors theories and methodologies appear conceptually relevant and practically useful for explaining and improving risk management in financial trading; however, this remains to be established. This is examined in the current PhD through investigating and applying two of the most commonly used concepts within human factors literature: *non-technical skills* and *safety culture*.

First, non-technical skills relate to the behaviours and abilities of operators that can both cause and protect against failures to manage risk. This is important for understanding both how operational incidents are generated (e.g. human error), and also how they can be averted. In high-risk industries (e.g. aviation, nuclear, healthcare) that face similar challenges to financial trading (e.g. stress, complexity, risk, severe consequences for failure), human factors research has investigated the non-technical skills (e.g. teamwork) of operational staff essential for performance. In-depth analyses of behaviours and tasks are used to support the analysis of critical incidents (e.g. to understand the causes of human error), and to identify the context specific skills that underpin effective performance for a given task or situation. Analyses can lead to the change or redesign of working environments and tasks (e.g. technology, culture, protocols) in order to support non-technical skills, or the design and implementation of assessment and training packages (e.g. teamwork, hazard identification) for improving behaviour and performance (Helmreich, Anca, & Kanki, 2010; O'Connor et al., 2008).

Second, safety culture theory is used to examine how the organizational environment shapes the way people behave and think in relation to risk. This is important for understanding the conditions under which risk in financial trading can be effectively managed. Although different approaches exist to theorize and measure organizational culture (Cameron & Quinn, 2005; Erez & Gati, 2004; Hofstede et al., 1990), safety culture has become the dominant theory used to understand how cultural factors determine risk practices in industries that must balance competing demands of productivity and safety (Glendon & Stanton, 2000; Nordlöf et al., 2015). This is because safety culture explains how social environments directly influence risk practices, and because problems in safety culture often underlie mishaps within other high-risk domains (e.g. aviation, healthcare, energy). Although financial trading is not a safety-critical industry, mishaps are highly damaging for organizations and economies, and their causes (e.g. managerial pressure to increase profit, ineffective procedures) are similar to those in other high-risk industries (Leaver & Reader, 2017).

Through utilizing these concepts, the following primary research aim is addressed: to investigate whether human factors approaches help understand error in the financial trading domain. To elaborate on this primary aim, the following sub-aims are posed, with each aim being explored through an empirical study;

1. To establish whether non-technical skills are critical to risk management in financial trading (Study 1)
2. To develop a methodology for capturing operational incidents within financial trading, and drawing on this (Study 2),

3. To examine the human factors issues (and in particular non-technical skills) underlying operational incidents within financial trading (Study 3)

4. To investigate whether operational incident reports contain data important for understanding how operational incidents are averted (Study 4)

5. To establish the utility of safety culture for understanding risk-related activities in financial trading (Study 5)

We examine these specific research aims in greater depth below. Through addressing them, this thesis examines whether risk management in financial trading can be improved through adopting human factors theories and methods, with approaches for doing this being outlined and tested. Furthermore, it explores the idea that – because of the causes and consequences of failures in financial trading – the industry should be conceptualized as a high-risk industry, with implications for policy and research. This will expand the types of domains of interest to human factors researchers, with financial trading being a particularly complex domain due to the importance of both risk-taking and risk management for organizational success.

1.5.1 Description of the research aims

The structure of this thesis is that a chapter will broadly map onto each of the research aims outlined above. Each aim is addressed through an empirical study. In aggregation, these attempt to reconceptualize financial trading as a high-risk industry. Each aim is reviewed below.

Aim 1. Establishing whether non-technical skills are critical to risk management in financial trading

The first aim of this thesis is to establish whether non-technical skills are critical to risk management in financial trading. This is important, because it investigates the principle that the behaviours and skills of human operators can both create and prevent risk within financial trading. This is an integral part of human factors approaches to managing risk in other industries, and establishing whether financial trading also shows these features is a first step to reconceptualizing it using human factors concepts.

This aim is addressed in chapter 2 (article 1) through a systematic review of studies reporting on non-technical skills and behaviours in the financial domain. The study i) identifies 'real-world' (e.g. non-laboratory) research reporting behavioural data in financial trading; ii) examines and reports on data on non-technical skills (and other human factors issues) found to underpin good or poor performance and risk management in financial trading; and iii) considers the quality and coverage of research investigating non-technical skills in financial trading and provides a scope for future research. The insertion of financial trading in the non-technical skills literature is novel, and accesses a set of literature that previously had not been considered in this domain. Furthermore, it tests the wider principle that human factors concepts, and in particular non-technical skills, are important for understanding risk-management in financial trading, and thus should be more formally applied.

Aim 2. Developing a methodology for capturing operational incidents within financial trading

The second aim of this thesis is to develop a methodology for capturing and then analysing operational incidents in financial trading. The generation of a robust methodology is essential so that data can be retrieved on error and non-technical skills. To achieve this, the development of a system for capturing, monitoring and analysing operational incidents in the financial trading domain is described. The work in this chapter defines 'operational incidents' in financial trading as trading activity that results in an avoidable loss (e.g. making a trade without assessing market-related risk) or compliance failures (e.g. breach of trading limits), which place the integrity of the financial organization at risk even if no loss has occurred (e.g. overexposure to volatile markets: (Zhao & Olivera, 2006).

This study is reported in chapter 3 'Development of an Incident Collection Tool'. The methodological work described here forms the core of the PhD thesis. Specifically, the chapter recounts the design, development and early testing of an operational incident collection and analysis tool for financial trading: the Financial Incident Analysis System (FINANS). Notably, within financial trading there is no precedent for incident reporting in terms of either methodology for collecting incident data, defining and understanding what constitutes an incident, or informing organizational learning initiatives. Therefore the extension of human factors methodology to the financial trading domain is novel, and provides the opportunity to empirically evidence the premise that human factors theory and concepts are relevant in the trading domain and that risk management is improved through the application of human factors concepts.

Aim 3. Examining the human factors underlying operational incidents within financial trading

The third study of the thesis presented in chapter 4 examines i) the frequency and consequences of operational incidents in financial trading; and ii) the role of non-technical skills and other human factors issues as contributors to them. Through the process of analysing incidents, the reliability and validity of the FINANS methodology is tested.

This aim is addressed in a two-part study presented in chapter 4 (article 2). The study reports on the application of the FINANS, which was designed to achieve three goals: first, to provide a standardized method for collecting data on operational incidents that occur on the trading floor; second, to develop a reliable method for analysing and extracting human factors-related contributors to operational incidents; and third, to provide practical insight into how these contributors might be ameliorated. This study marks an expansion of current empirical and theoretical applications of incident reporting and human factors theory to a high-risk (but not safety-critical) domain. Furthermore, the work undertaken in this chapter reconceptualizes the way financial trading is considered, providing key evidence to the social and cognitive nature of error in this domain.

Aim 4. Investigating whether operational incident reports contain data important for understanding how operational incidents are averted

The fourth aim of the thesis is to examine what can be learnt in terms of the skills and systems important for avoiding operational incidents. This is important because it demonstrates that the skills of human operators can both create and prevent error within financial trading, and empirically establishes that incident data contains relevant human factors information important to understanding how incidents are captured and detected. Moreover, this research also shows how data from incident monitoring systems can be analysed in a fashion more consistent with averting error. This resonates with the safety II literature, which examines the good practice for mitigating, rather than reducing, error.

This aim is addressed in chapter 5 (article 3) “Near Misses in Financial Trading: Skills for Capturing and Averting Error”. This chapter examines the utility of near-miss data to identify the core social-psychological skills that are used to capture and ameliorate error. As near-misses regularly occur in financial trading, the study aims to identify opportunities for organizational learning through examining the recovery mechanisms that led to the detection of incidents before failing. Specifically, the study reports on three sets of analyses. First, the assessment of the reliability of coding for the human factors skills that capture and ameliorate error on the trading floor is analysed in order to ensure the coding consistency and robustness. Second, the study identifies the frequency with which various human factors skills cause – and for the first time in human factors literature – ameliorate near misses. To achieve this, a frequency analysis of the coded incidents is undertaken. Third, an analysis of the skills and systems used to detect and prevent error and the causes of error together, the purpose of which is to illustrate how the skills that cause error and the skills that ameliorate error may interrelate. This work reconceptualizes finance through the application of human factors, and challenges the field of human factors to engage with a non-traditional (e.g. high-risk, but not safety-critical) domain. In doing this, aspects of the prevailing worldview in human factors ‘safety’ thinking and financial risk management practices might also be re-imagined (e.g. supplementing a focus on what goes wrong with a focus on what goes right).

Aim 5. Establishing the utility of safety culture for understanding risk-related activities in financial trading

The final aim of the thesis is to examine whether risk management in financial trading can be understood from a safety culture perspective.

At this point, the research in this thesis expands beyond the focus on non-technical skills and human error, and considers the wider system within which behaviour occurs. This is important, because behaviours in relation to risk do not occur within a vacuum; they are a product of wider norms, values and institutional systems (Chen, Sawyers, & Williams, 1997; Kaptein, 2011; Saini & Martin, 2009). Understanding how the macro-level trading environment might shape micro-level risk-related behaviours of traders is critical for intervention and change. It is also important for conceptualizing financial trading as akin to other high-risk industries.

This aim is addressed in Chapter 6 (article 4) entitled "Safety Culture in Financial Trading: An Analysis of Trading Misconduct Investigations". In this chapter, safety culture theory is applied to conceptualize and explain failures to manage risk within financial trading in a standardized way, using FCA Final Notices. Identifying the human factors that underpin error in the trading domain on their own cannot ensure that failure will be avoided. The analysis of the human factors that underpin operational incidents must be layered with an understanding of the culture within the organization; it is meaningless if the culture of the organization is not incentivized to act on the information provided from the analysis.

Furthermore, the chapter counters narratives focusing on traders who are unethical 'rule breakers', and emphasizes the value of a systematic approach, whereby safety culture theory is used to explain why risky behaviours in financial trading occur. This work demonstrates that safety culture shapes how operators behave and think in relation to risk, and this is central to understanding the conditions under which risk in financial trading can be effectively managed.

1.5.2 Summary

The work undertaken in this thesis reconceptualizes how we understand financial trading (and financial services more generally) in terms of human factors, and it also contributes to the expansion of human factors theory through its application to the financial trading domain. The Financial Incident Analysis System (FINANS) developed and tested within this thesis not only allows us to test and provide evidence to this premise, but also delivers a contextualized description of the behavioural nature of the problems in financial trading and illuminates how these are often a product of environmental factors such as culture.

Furthermore, the application of human factors theory in financial trading challenges the field to engage with a non-traditional (e.g. high-risk, but not safety-critical) domain. This will expand the fields of interest to human factors researchers, with financial trading being a particularly complex domain due to the importance of both risk-taking and risk management for organizational success. The application of human factors concepts in this industry generates meaningful and novel insight into how safety is managed in a complex socio-technological domain.

2. Non-technical Skills

2.1 Preface

The first aim of this thesis is to establish whether non-technical skills are critical to risk management in financial trading. This is important, because it investigates the principle that the behaviours and skills of human operators can both create and prevent risk within financial trading. This is an integral part of human factors approaches to managing risk in other industries, and establishing whether financial trading also shows these features is a first step to reconceptualizing it using human factors concepts.

This aim is addressed in study 1 through a systematic review of studies reporting on non-technical skills and behaviours in the financial domain (chapter 2). The literature review presented in chapter 2 (article 1) entitled "Non-technical Skills for Managing Risk and Performance in Financial Trading" has three aims: i) identify ecologically valid (or 'real-world') research studies investigating the relationship between non-technical skills and performance within the domain of financial trading; ii) examine the data on the non-technical skills found to underpin good or poor performance in financial trading and to report on this data in order to provide a first-stage overview of the non-technical skills (NTS) important for performance on the trading floor and iii) consider the quality and coverage of research investigating NTS in financial trading and identify potential areas for future research.

The insertion of financial trading in the non-technical skills literature is novel, and accesses a set of literature that previously had not been considered in this domain. Furthermore, it tests the wider principle that human factors concepts, and in particular non-technical skills, are important for understanding risk management in financial trading, and thus should be more formally applied.

The results of the systematic literature review are presented and grouped into two categories: the cognitive skills (e.g. situation awareness, decision making) and social skills (teamwork, leadership). Whilst not a comprehensive guide to non-technical skills in financial trading, the framework captures and presents existing knowledge. Arguably, the cognitive and social skills are inherently intertwined and do not sit distinctly apart. However, for the sake of creating a structured framework to draw upon, they are presented separately.

The journal article (article 1, "Non-technical Skills for Managing Risk and Performance in Financial Trading") that follows was authored by Leaver and Reader (2015) and published in the *Journal of Risk Research*. Leaver designed and carried out the case study and systematic literature review, authored the main drafts and contributed to roughly 80% of the content. Reader provided key supervisory assistance, editorial suggestions and contributed to roughly 20% of the content. Three anonymous reviewers provided helpful feedback, suggested edits and ultimately approved the article for publication.

The *Journal of Risk Research* has an impact factor of 1.34 and is currently ranked 29/96 (social sciences, interdisciplinary).

Abstract

Recent financial incidents have been found to be caused, in-part, by human factors-related issues in financial trading (e.g. leadership and decision-making). Yet, there has been relatively minimal application of human factors research to understand effective risk management in financial trading. In other high-risk environments, the non-technical skills (i.e. leadership, decision making, situation awareness, teamwork) of organisational actors performing risk-related roles are examined in order to specify the behaviours and standards required for safe activity. This study i) identifies 'real-life' (i.e. non-laboratory) research studies investigating the relationship between non-technical skills and performance within financial trading, ii) examines and synthesises data on the non-technical skills found to underpin good or poor performance, and iii) considers the quality and coverage of research investigating non-technical skills in financial trading, and identifies potential areas for future research. Twenty studies were reviewed, and a qualitative association between non-technical skills and performance in financial trading established. The review found a range of decision-making (e.g. heuristics and biases, intuitive DM, emotional regulation) and leadership skills (e.g. setting standards, monitoring behaviour, encouraging speaking-up) to have been identified as essential for the management of risk in financial trading environments. Furthermore, situation awareness (e.g. information search and assessment strategies, vigilance, identifying 'noise' data) and teamwork (e.g. avoiding 'role' conflict, communication between traders) were found to often be essential for good risk-management, yet remain less explored within the literature, and should be the focus of future research. Non-technical skills are essential for effective risk management within the financial sector, yet further field research is required to examine the context-relevant behaviours that underpin safe activity. This will facilitate the development of evidence-based systems for assessing and training non-technical skills competencies.

Introduction

Effective risk management in financial trading [1] relies on a combination of technical and non-technical skills. Non-technical skills (NTS) are the social (teamwork, leadership) and cognitive skills (situation awareness, decision-making) that underpin the effective performance of individuals and teams working in complex and risky organisational settings (Flin, O'Connor, and Crichton 2008). Due to the importance of good communication and decision-making in financial trading, non-technical skills are identified as essential for effective risk management in this setting (Fenton-O'Creevy et al. 2003; Hicks 2004; Kahn and Cooper 1996). This is similar to other industries that manage risk, yet in financial trading the meaning of 'risk' can differ somewhat. In financial trading, risk refers to activities that lead to losses, or threaten the stability of the organisation (but not physical damage) as well as the opportunity that can be realised from activity. More specifically, '*operational risk*' involves the operating mechanisms of the market and organisation (e.g. failure of the trading software), and '*behavioural risk*' is the risk that the staff will either commit an error or engage in behaviour that results in financial losses (Willman et al. 2002). Thus, the ability of financial traders to cope with *operational risk* (i.e. to cope with the environment) and avoid *behavioural risk* (i.e. decision-making errors) underlies organisational performance.

In high-risk industries (e.g. aviation, nuclear, healthcare) that face similar challenges to financial trading (e.g. stress, complexity, risk, severe consequences for failure), human factors research has identified the non-technical skills that are essential for effective risk management. This work is used to support the analysis of critical incidents, the assessment of non-technical competencies, and training to enhance staff skills (Kanki, Helmreich and Anca 2010; O'Connor

[1] For the purpose of this review, the term financial trading refers to "high stakes trading activities" and is associated with investment banking, and financial and commodity trading activities (including the trading support domains) where the failure of the institution would cause catastrophic social, political, economic damage.

et al. 2008a). Within financial trading, interventions and solutions for improving risk management have tended to focus on regulation and management rather than human-factors related issues (Hutter and Power, 2005; Power, 2004). Yet, research has long shown how psychology shapes financial decision-making (Tversky, Kahnemen and Choice, 1981). In this article, we review research investigating the non-technical skills that underpin the effective performance and management of risk in financial trading. We focus primarily on the role of the 'traders' who make high-risk decisions (e.g. buying and selling assets) within financial organisations. The purpose is to examine current knowledge on non-technical skills within the trading environment, to place, interpret, and synthesise this within a non-technical skills framework, and to identify future areas of investigation.

Human factors and financial trading

As discussed above, human factors approaches to managing organizational risk may provide useful insight for understanding performance in financial trading (Sutcliffe, 2011). In-depth analyses of the specific behaviours important for risk management within high risk work domains such as aviation, military and healthcare (e.g. according to working environment and role) have led to interventions and training programmes for improving behavioural safety (Weigmann and Shappell 2005; Flin, O'Connor and Crichton 2008). Yet, analogous frameworks do not exist within the domain of financial trading.

However, recent and high-profile incidences within financial trading have exemplified the vulnerability of the financial sector to human factors related problems, and the need for a better understanding of human performance. In particular, catastrophic problems in the performance of traders have led to financial institutions receiving large fines, billion dollar losses, and huge reputational damage. Recent cases have included rogue trading on stock futures at Societe

General in 2008 (resulting in -£3b in losses and fines) (Clark 2012), the manipulation of the Libor rates (foreign exchange markets) at UBS, RBS, and Barclays in 2011 (-£300m) (Enrich 2012), money laundering at HSBC in 2012 (-£1.2b) (Smythe 2013), and electricity price rigging at JP Morgan (-$405m). Whilst such incidences have typically been seen as caused by 'rogue traders' (employees making unauthorized trades on behalf of their institution) and organisational cultures which facilitate poor behaviour (e.g. rewarding recklessness, little oversight), investigations also reveal a range of non-technical skill problems in the trading environment. For example, managers failing to lead and monitor behaviour on the trading floor, traders incorrectly interpreting risk-related data, poor communication between traders on critical information pertaining to trades (e.g. risk exposure), and traders not taking action on identifying irregular trading activities by colleagues.

To further illustrate, table 1 outlines some of the human factors problems recently identified by the Senate Subcommittee investigative report (2013) into the JP Morgan Chase rogue trading scandal in 2012. This is generally considered to be one of the most serious recent financial trading scandals of modern times. It resulted in a loss of $1B (USD) in paid fines, $9.2B in legal fees, a proposed wide ranging settlement figure of $20B (USD), and serious reputational damage to the financial industry (Schwartz and Silver-Greenberg, 2012; Silver-Greenberg and Craig, 2012). It was caused by traders recklessly staking billions of dollars on the performance of derivative credit default swaps.

Table 1: Human factors issues identified in the JPMorgan trading scandal of 2012

Key Events	Human Factors problems
Jan 2012: Inaccurate speculation by the trading desk regarding the default (bankruptcy) of Eastman Kodak. Nine days of straight losses followed, with traders attempting to hold onto trades in a falling bond market, resulted in a total loss of £50M.	Poor anticipation and recognition of the risks associated with position taking. Overconfidence and a clear lack of understanding of market volatility and direction (resulting in risk not being hedged).
Jan – Mar 2012: Accumulation of outsized positions in the credit default swap market (CDS) and incorrect speculation on bond defaults by the trading desk left the organisation grossly overexposed to market fluctuations. CDS positions were not unravelled in time, and a market crash in Europe meant the risk could not be hedged quickly enough. As losses accrued, traders attempted to cover them up, leaving the bank further exposed. Losses totalled at least $2bn.	Poor coordination of activities between trading staff, and failures to exchange information following a "trading spree", led to an oversized trading position (leaving the bank overly exposed to market volatility). Failures to accurately evaluate risk in the bond market underlay the failure to close the trading position before massive losses were incurred. Trading limits were repeatedly breached by the trading desk, yet no disciplinary action was taken by leadership. Failure by the trading desk to respect or recognise the long term impacts of breaching trading limits. Failure by the risk control team to understand the risk posed by the CDS position, and lack of agreement within the team on whether to take action (resulting in inertia).
Jan 2012 - Ongoing: Software problems led to an inability to retrieve accurate pricing, with up to 80% of traders experiencing technical and functional limitations in trading activities. Traders adjusted their prices 'experientially' rather than using reliable and consensus based market prices, with the market value being distorted.	Inconsistent access to vital benchmarking price information led to problems in decision making for active traders (e.g. a lack of accurate information). A lack of standardisation in trading decision-making processes, and manipulations of pricing mechanisms, and led to inaccurate representation of trading positions, which further compromised decision-making.
Apr 2012: Large losses were realised by the Chief Investment Officer (CIO), however no remedial action was taken by senior management to curtail aggressive trading patterns.	The losses and problems in trading patterns were not considered a major issue by senior management, and they remained unaware of the frequency and magnitude of poor trading activity. Breaches in trading limits were regular and not punished, meaning the standards on trading limits were not respected by trading teams or management.
May 2012: Failures in providing full information on the trading scandal to regulators resulted in increased speculation and a loss of confidence in the firm	Poor oversight by organisational leadership on the on-going failure. Poor coordination between organisational leadership and traders. Problems by senior management in assessing the severity of the situation, and in coordinating with the regulator.

Consistent with models used to explain organisational accidents (Reason, 1990, pp202), a range of active (e.g. traders ignoring trading limits, poor coordination between trading desks) and latent (e.g. software problems, poor organisational culture) failures were identified in the US Senate Subcommittee report (2013) into JP Morgan Chase. Problems in non-technical skills were central, for example, failures by traders to accurately assess, remain updated on, and judge the derivative credit default swap (CDS) market, and poor decision-making by traders (e.g. on responding to the losses) and senior management (e.g. on downplaying the problems) throughout the incident. Furthermore, failures in teamwork and communication between teams (e.g. trading desks, management and the trading floor support teams) and within teams (e.g. whether to take action on suspect trading in the risk control teams) were critical, exacerbated the crisis, as did a lack of leadership on both the trading floor (e.g. for not punishing trading limit breaches) and senior management (e.g. in retaining awareness of trading activities).

Such activities can be understood using non-technical skills theorem relating to situation awareness, decision-making, teamwork, and leadership. To respond to organisational crises in other industries, human factors research have utilised NTS theory to develop behavioural assessment and training programmes, with positive results in terms of attitudes towards risk, enhanced learning, and behavioural change (Salas et al. 2000; Salas et al. 2006). However, in finance, interventional analyses tend to be compartmentalised; involving the segregated collection of information about uncertainties and lacking the social and collective beliefs about risk taking and control (Beck 1992; Hutter and Power 2005). Additionally, interventions also tend to focus on regulation rather than the embedded human-factors related issues within the industry (Hutter and Power 2005; Slovic 1972; Power 2004).

However, as the focus on 'risk culture' within financial organisations increases, it is recognised that human factors approaches are potentially valuable for explaining and avoiding critical failures (Young 2011; Power 2011; Ashby, Palermo and Power 2012). In discussing the 2008 financial crisis, Power (2011) observes; "*The scale of interconnectivity that increased prior to the crisis had 'normal accident' properties, in the sense that the complexity of chains of claims and claims on claims made the 'counterparty risk' of collateralized debt obligations practically unknowable and beyond control*" (Power 2011, 30). This focus on interconnectivity within systems and institutions illustrates how activity in financial organisations must be understood from a human factors perspective, with failure occurring due to a mixture of increasing market uncertainty coupled with poor risk management and coordination at the operational level (internal controls, auditing, procedures and capital). Crucially, it emphasises the need to develop a better understanding of the behaviours required for effective performance at the operational level of financial organisations – i.e. the trading environment (LaPorte 2007).

The trading environment

The trading environment is where products (e.g. equities, short-term, long-term, options) are bought and sold by financial traders in order to manage investment portfolios and generate profit for investment banks and brokers. Trading requires an ability to anticipate market trends (i.e. for buying and selling) and negotiate large wholesale trades, and due to the sums of money and time-pressure involved in trading, it is a well-paid but stressful occupation. It is inherently risky, with reward systems incentivising risk-taking that results in profit, and profit can emerge from 'noise trading' (irrational and erratic trading activities), which in turn can negatively influence 'rational' trading (and therefore penalising logical decision-making). The trading floor itself is a large, noisy and high technology filled space wherein traders (and support teams) watch monitors and interact by phone, internal chat systems or in small groups. Each desk is intentionally grouped as a specialised desk (e.g. the teams are divided according to the financial instrument or commodity that they trade or support such as equities, bonds, natural gas, coal etc.) and it is the successful interaction across these heterogeneous desks that underlie organisational performance (Beunza and Stark 2004, see figure 1).

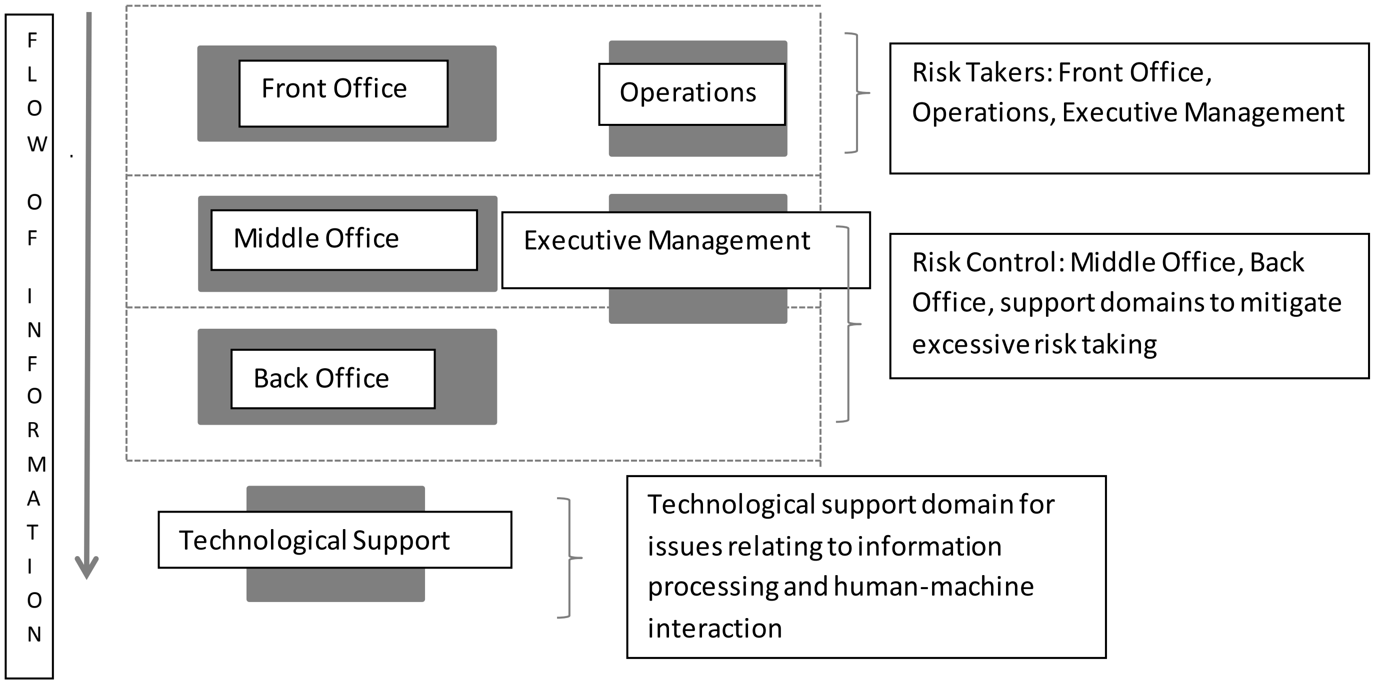

Figure 1: Typical Trading Floor Layout

The spatial configuration of the trading floor is standardised across the settings so as to provide the socio-spatial resources to promote a situated awareness, or sense making capabilities (Beunza and Stark 2004; Hicks 2004). Traders typically cycle between working alone and in collaborative teams; they monitor other desks activity, share information, work with spatially distributed team members via phone and interpret the 'noise' of the floor (Hicks 2004; Willman et al. 2006). The floor is an intensely social space where the close proximity of the workstations allows traders to communicate to each other without leaving their individual station. Thus, good non-technical skills are integral to effective risk management both in terms of avoiding errors (e.g. situation awareness, decision-making) that result in large losses, and ensuring that teams of traders work effectively together and are able to identify and act on irregular or poor performance.

Non-technical skills in financial trading

Non-technical skills (NTS) are the cognitive and social skills that complement a worker's technical skills, and underpin safe performance in high-risk environments (Flin 2003). Table two presents the definitions for the key non-technical skills identified and utilised in the NTS research literature (Flin, O'Connor and Crichton 2008), and to initially frame our focus on the non-technical skills essential for effectively managing people risk in financial trading.

Table 2: Principle Non-Technical Skills Definitions

NOTECHS Principle	Definition
Situation Awareness (SA)	A dynamic, multifaceted construct that involves the maintenance and anticipation of critical task performance events. Individuals monitor and perceive information within the task environment, interpret this information within the context of their wider knowledge, and then anticipate ahead. The NTS literature specifies activities associated with SA as gathering information, interpreting information and anticipating future state (Flin et al 2008, pp.17). The definition of SA is still undergoing academic debate regarding the meaning in terms of the mechanisms and models of the cognitive processes.
Decision Making (DM)	The process of reaching a judgement or choosing an option, sometimes called a course of action, to meet the needs of a give situation. DM is often interwoven with situation awareness processes, as individuals base decisions on their understanding of a particular task environment. The NTS literature specifies activities associated with decision-making as defining problems, considering options, selecting and implementing options, and evaluating decision success (Flin et al, 2008, pp41). Conditions for DM can vary in relation to time pressure, task demands, feasibility of options and what level of constraint, support and resource exists for the decision maker (Flin et al, 2008, pp41).
Teamwork (TW)	Coordination amongst a group of people with different expertise who have to cooperate on the same tasks, and must form a shared understanding of their activities, roles, and norms of behaviour. The NTS literature specifies activities associated with teamwork as; supporting others, solving conflicts, exchanging information and co-ordinating activities (Flin et al, 2008, pp93). Common understandings of the shared tasks are fundamental to achieve an efficient team outcome. Group process models are used to illustrate how individual differences, leadership and team structures affect team behaviour (Flin et al, 2008, pp95).
Leadership (LD)	Team member, who coordinates the work of others, motivates, sets standards, and provides vision. The NTS literature specifies activities associated with activities associated with leadership as using authority, maintaining standards, planning and prioritising, managing workload and stress (Flin et al, 2008, pp129). They are tasked with directing and coordinating the activities of team members, assessing performance, motivating and planning. The thoughts and behaviours of others in the team are influenced by the team leader's ideas and actions).

The history of non-technical skills research is grounded in several high-risk industries, but especially in aviation. To reduce pilot errors caused by problems in social (e.g. team coordination) and cognitive (e.g. vigilance) performance, human factors researchers pioneered the use of non-technical skill assessment and training systems. These systems detail the non-technical skills and behaviours crucial for safe in-flight operations, and create taxonomies of the behaviours indicative (e.g. communication as indicative of teamwork) of a particular skill (Wiener 1993; O'Connor 2007). Assessments of behaviour are then used to appraise the skill proficiencies of operators, and to identify training requirement. NTS assessment and training systems have now been developed for many different industries (Byrdorf 1998; Flin 1996; Helmreich and Shaeffer 1994), and are based on theory relating to social and cognitive psychology. Systems are developed to reflect the contextual demands of a working environment (e.g. the operating theatre, maritime command deck), and to reflect the skills and behaviours required to fulfil a specific role (e.g. anaesthetist, first officer). Thus, to provide a fine-grained analysis of the non-technical skills essential for financial trading, behaviour must be understood within the context and nature of taskwork on the trading floor.

Yet, to date, non-technical skill assessment and training systems have not been developed for financial trading. Nonetheless, there is growing consensus within the financial literature on the importance of non-technical skills for managing risk (Garling 2009, LaPorte, 1996, Shefrin 2008; Ramanujam and Goodman 2003, 2010, 2011; Power 2010; Etzioni 2009, Akerlof and Shiller 2008; Shleifer 2000), and experimental research in finance has identified a variety of psychological heuristics and biases to influence decision-making in finance (Fox, Rogers and Tversky; 1996; Shattuck and Miller 2006).

Thus, there is a requirement to more formally describe and outline the key non-technical skills (and behaviours indicative of them) essential for managing risk within financial trading. The process of identifying non-technical skills important for performance in a work domain typically begins with a literature review (Reader et al. 2006). This allows for key research findings on non-technical skills to be integrated, and for an initial non-technical skills framework to be outlined. To date, there has not been a literature review of the non-technical skills important for managing risk in financial trading, and in this article we review research investigating non-technical skills within *real-life* contexts in the financial trading environment. We emphasise *'real-life'* because a large experimental literature, led by ground-breaking research by psychologists such as Tversky and Kahneman (1986; 1973; 1981) and Kahneman and Tversky (1972; 1973; 1979; 1984) and Kahneman, Slovic and Tversky (1982), has documented numerous heuristics and biases to influence financial decision-making. Although the algorithms and principles derived from these studies are hugely interesting, they can be difficult to operationalize within real trading environments (Kahneman and Klein 2009).

In financial trading, correlations between hypothetical decision-making for financial scenarios and decisions for live market transactions are poor (Lo, Repin, and Steenbarger 2005), and behaviours in the financial environment are shaped by a range of contextual factors (e.g. pressure, rewards systems, risk, and stress), with traders using a variety of information sources (e.g. spread sheets, databases, publications, colleagues, news features) to assess and predict future trading scenarios and likely decision events (Hicks 2004). Investigations of non-technical skills typically focus on how context-specific behaviours and activities of operators relate to risk and safety. This is in order that non-technical skill assessment and training tools reflect the working environments in which they are used, and can be associated with good or poor outcomes (i.e. that they are not generic). To do this it is necessary to examine in detail how task context and social environments shape activity, and how behaviour in turn shapes organisational risk (Rasmussen 1986; Vicente 2002; Woods 1994; Hutchins 1995; Klein 1989). Although this review focuses upon 'real-life' research, it is notable that the experimental literature on decision-making in finance has been reviewed extensively elsewhere (e.g. Garling 2009). Such work shows the importance of cognitive biases and affective influences in shaping trading decisions (e.g. overconfidence, optimism, loss aversion), albeit in a relatively decontextualized way (e.g. ignoring expertise, situational constraints, and organisational environment).

Therefore, whilst laboratory-style studies are useful for outlining broad principles on decision-making in high-stakes finance, this review focuses on research of a more ecological nature (Cacciabue and Hollnagel 1995). Specifically it focuses on research investigating non-technical skills and the management of risk in financial institutions (e.g. case studies, qualitative research, and observational studies).

Literature review aims

The current literature review examines research on non-technical skills within the trading environment so that the behaviours and non-technical skills associated for effective and safe performance can be described. The literature review has three aims.

First, to identify 'real-life' research studies investigating the relationship between non-technical skills and performance within the domain of financial trading. Second, to examine data on the non-technical skills found to underpin good or poor performance in financial trading, and to synthesise this data in order to provide a first stage overview of the non-technical skills important for performance on the trading floor. Third, to consider the quality and coverage of research investigating non-technical skills in financial trading, and to identify potential areas for future research.

Method

The literature review was performed through the following steps:

1. *Identification of relevant research papers* on non-technical skills in real-world financial trading environments.
2. *Data extraction* of methodological and non-technical skill related information from the selected papers.
3. *Data synthesis* to outline and summarise knowledge on non-technical skills within trading settings.

Identification of relevant research papers

The search strategy for the literature review was as follows. Research papers within a number of academic databases (EconLit, SocIndex, Web of Knowledge, Business Source Complete, SciVerse and PsycINFO.) were identified using the following keywords: <u>human factors, decision making, situation awareness, leadership, teamwork, nontechnical skills, trading, finance, failure, and banking, stress management, fatigue</u>. These terms were chosen based on their applicability to the subject and relevance to the aims of the review. These databases were chosen based on their scope of peer reviewed literature and their relevance to the topic search terms. Search date restrictions for this review were defined all available peer reviewed literature published in a peer reviewed journal or book after 1970.

Within the initial research stage, titles and abstracts were inspected in order to identify whether articles contained primary or secondary data on non-technical skills within a financial trading context. Context specific refers to studies which took place in a financial trading floor or, a high simulation trading floor environment. In regards to the study criteria, studies were excluded if they contained data from laboratory studies and did not use professionals working in the financial trading domain (high reliability simulated environment studies were considered). During this stage, studies were collected regardless of the type of methodology used (e.g. no methods restrictions); however primary and secondary data sources were noted by the researcher as an indicator of study quality. Titles were screened, as were key words and abstracts of the articles. Full text articles were retrieved for those studies appearing to meet the criteria, as well as for those where the title, key words, abstract gave insufficient information for immediate conclusion. Upon retrieval of the text, the eligibility of the study was determined by an additional reviewer. The first author is a finance expert studying human factors and the second reviewer is an established human factors and non-technical skills expert. Figure 2 reports the literature review process.

Stage 1: Initial Search
<u>Electronic Search</u>: EconLit, Web Knowledge, Swetwise, SocINDEX, SciVerse, PsychINFO, Business Source Complete
<u>Keywords</u>: Title or abstract contain trading **OR** *banking* **OR** *finance* **AND** *human factors* **AND** *non-technical skills* **AND** *situation awareness* **AND** *teamwork* **AND** *leadership* **AND** *decision making*
<u>Limitations</u>: Articles in English and published after 1970
<u>Results</u>: 652

Stage 2: Screening of results
<u>Filter:</u> Titles examined for relevance to the topic, Relevance of abstract examined in order to assess information presented in the study
<u>Filter</u>: no biases, heuristics, loss aversion, quantitative risk measurement
<u>Results:</u> 67

Stage 3: Filters applied
<u>Setting:</u> Real world research environment, not a lab simulation
<u>Context</u>: Expertise in trading finance
<u>Results:</u> 20

Figure 2: Literature search strategy

Data Extraction

A range of data was extracted from the selected articles in order to characterise studies (e.g. methods) and generate data on non-technical skills. This included the following:

i. *Study characteristics*. The type of data collected, the study setting, the use of expert or novice participants, and the methods used for data collection

ii. *Non-technical skills related content*. Data within each article (e.g. on behaviour) on activities within financial settings that were consistent with any of the four non-technical skills outlined in table 2 were extracted.

iii. *Study outcomes*. Where possible, associations between data on non-technical skills and performance outcomes in financial settings were extracted.

Data synthesis

Non-technical skills data were sorted and labelled according to the NTS categorises described in table 2 (situation awareness, decision making, teamwork, leadership). Data were then sorted and placed within a table of results presenting key findings for each study. Then, for all of the studies, data was grouped according to non-technical skill category, and synthesised to create a prototype non-technical skills framework. This summarises and amalgamates key findings from the literature review. The purpose of the framework is to consolidate the existing literature as well as highlight the limitations (or gaps) and the opportunity for future improvement / continued research.

Results

Research papers selected for review

Of the 67 articles that met the research criteria, 20 studies were identified as having investigated non-technical skills in a financial setting using primary in-situ or high fidelity simulated study methods. All studies were peer reviewed articles. The data collection methods used for the (20) studies included in the review varied; (four case study based, six interview based, four questionnaire survey, one longitudinal content analysis, three ethnographic studies, one simulated environment (trading games) and one biofeedback analysis). Of the 20 studies, all were executed in the high stakes financial domain (banking, investment, trading), although one study compared behaviour between staff in the banking sector to a hospital setting (Ramanujam and Goodman 2010). An overview of the characteristics of the reviewed studies, their sample data (where applicable), methods and key findings are presented in table 3.

Table 3. Summary of findings from the systematic literature review

Authors	Study Aims	Methods	Key Findings	Data on non-technical skills and performance in financial trading			
				Situation Awareness	Decision Making	Teamwork	Leadership
Sefrin and Statman 1985	Investigates whether traders realise the occurrences of losses differently than gains.	Method: Secondary data analysis Domain: Trading and investment banking Details: Utilises secondary data from Schlarbaum *et al*. (1978) on stock trading history and aggregates data on mutual fund trades where transaction costs were negligible to illicit information on decision making and financial outcomes.	Loss aversion found to impact DM in uncertain trading conditions (e.g. for keeping losses too long).	Not Reported	Heuristics and biases, specifically the disposition effect, negatively influence trading decisions (e.g. the tendency to sell winners too quickly and hold on to losers).	Not Reported	Not Reported
Hartzmark 1991	Investigated traders ex-ante predictions and ex post realisations to elicit the influence of biases and heuristics on trading behaviour.	Method: Secondary data analysis Domain: Financial trading Details: CFTC (Commodity Futures Trading Commission) end-of-day reports on the commitments of large traders were analysed to extract information on the relationship between decision making techniques and trading performance.	Finds traders to not have a specific skill to consistently earn profits, with chance being a determining factor.	Not Reported	Predictions in the market can made randomly, yet result in better than average trader performance (for a period of time). Feedback on trading is difficult to recognise due to "noise" in the financial markets, which influences the ability to take future decisions.	Not Reported	Not Reported
Roberts and Libuser 1993	Explores the utility of High-Reliability Organisation (HRO) principles in trading.	Method: Case study Domain: Finance (trading support domains) Details: Case studies of two banks are presented from the perspective of HRO and error theory.	Identifies the following principles for teams reducing their exposure to error and risk in trading: flexible decision making, appropriate checks and balances, and authority and accountability.	Not Reported		A lack of segregation and clarity for team roles (e.g. in audit and loan departments) creates incentives to hide mistakes (e.g. bad loans), failures to occur, and team members to have conflicting roles (which result in a loss of	Leadership reward schemes for aligning success with high-risk strategies result in conflicting risk and performance goals, with risk-taking being encouraged and the long-term organisational stability threatened.

						objectivity and poor team coordination).	
Menkoff 1998	Investigates how traders exploit and use different information types to make decisions under uncertainty.	Method: Questionnaire Survey Domain: Financial trading Details: Survey of 92 banks in Germany to illicit information on how 'rational' traders use non-fundamental analyses to exploit 'less rational' noise traders.	Finds non-fundamental market information types (e.g. beliefs and sentiments) to influence both rational and not fully rational actors in market decision making.	Noise (erratic and irrational) traders cause risk by (potentially) driving the price away from the market fundamental value (actual value), with non-fundamental information becoming internalised within rational traders (negatively shaping their comprehension and anticipation of the market).	Decision-making for 'rational' actors is shaped by non-fundamental information.	Not Reported	Not Reported
Sheaffer, Richardson, and, Rosenblatt 1998	Investigates the utility and validity of an early warning framework to detect critical failures in trading.	Method: Case study Domain: Financial trading Details: The Barings Bank collapse in 1995 is examined for failures to detect early warning signs.	Demonstrates the importance of chief decision makers acknowledging the existence of early warning signs as an antecedent to the bank's collapse.	The lack of attention to financial indicators leads to a poor understanding of the risk associated with trading positions	Top-down decision-making reduces important input from the sharp end team members on strategic decisions.	Poor or unclear communication procedures between teams leads to increased uncertainty on information (e.g. on definitions of financial tools). Unclear responsibilities and poor information sharing result in team conflict.	Leadership that creates a culture of fear for error or incident reporting results in warning data being overlooked or ignored by traders.
Willman et al. 2001	Explores how traders utilise market knowledge to make decisions.	Method: Semi Structured interviews Domain: Investment banking Details: Interviews of 118 experienced traders and 10 managers in 4 banks.	Finds traders to believe that technical information is not enough for effective decision-making, quasi-scientific information also being utilised.	Not Reported	Traders learn decision-making strategies through 'doing', however this can generate noise trading information (e.g. on irrelevant market information, or on effective behavioural strategies) that overly influences decision-making.	Not Reported	The management priority of advocating output (£) over communicating long term strategy may lead to management problems (such as traders hiding losses).
Willman et al. 2002	Examines the management of traders in financial markets from the perspective of agency and prospect theory.	Method: Semi Structured interviews Domain: Investment banking Details: Interviews of 118 experienced traders and 10 managers in 4 banks.	Finds trading mangers to focus on avoiding losses rather than making gains, with trader performance and behaviour being influenced by the intensity of monitoring and incentive structures.	Not Reported	Behavioural rather than performance-based evaluation of traders increase risk adversity in decision-making Low supervision when losing money can result in greater trader risk-taking	Not Reported	Managers increase their monitoring of traders when they are losing money, and generally give significant autonomy and trust during the remaining periods.

Lo and Repin 2002	Investigates the roles of rationality and emotion in the governance of financial markets.	Method: Biofeedback analysis Domain: Financial trading Details: The physiological responses of 10 traders were measured during high and low trading activity in live sessions.	Find trader rationality in decision making is shaped by emotions associated with changing markets.	Not Reported	Decisions made under uncertainty and high-pressure are influenced by emotive responses (e.g. physiological changes) to the context, with trader fallibility to overconfidence and previous decisions being increased.	Not Reported	Not Reported
Beunaza, and Stark 2002	Analyses the organisation of trading floors to examine how special factors influence awareness and learning.	Method: Ethnographic and interview study Domain: Financial trading Details: Ethnographic study of a wall street trading room (160 persons) with follow up interviews with managers.	Demonstrates how the social aspect of trading aid developing an understanding of the sophisticated market instruments.	Traders need awareness (a "sense") of the market, and knowledge on how to utilise financial tools appropriately combine with their reading of the market. Situation awareness is supported by the socio-spatial attributes of the trading floor.	Not Reported	Not Reported	Not Reported
Ramanujam, Goodman 2003	Investigates errors in financial organisations through applying HRO theory.	Method: Case Study Domain: Financial trading Details: Explores error and organisational culture in the collapse of Barings bank	Argues Baring bank collapse illustrates the susceptibility of HRO's to latent errors and poor organisational culture.	Overly routinized tasks reduce vigilance to identifying problems, and led to latent errors that remained unidentified by the organization.	Narrow definitions of risk and trading options heighten the likelihood of error and poor decision making	A lack of segregation of team member duties and poor team coordination creates extreme risk through reducing information sharing and creating conflicting demands.	A lack of monitoring and leader vigilance on trader activities results creates opportunity for poor trading activities. Failures to maintain and demonstrate standards heightened the likelihood of error/risk taking.
Fenton-O'Creevy et al. 2003	Examines how perceptions of control influence the performance of traders.	Method: Questionnaire Domain: Financial trading Details: Survey of 107 traders in 4 UK investment banks on influencers of decision making.	Indicates traders to operate in conditions whereby unrealistic perceptions of control may be supported, and vary according to individual.	Not Reported	Situational pressure such as stress, time pressure, and competition influence decision-making strategies and performance relating to financial instruments, with traders believing they have greater levels of control over trading outcomes than they actually do (illusions of control are exacerbated by stress levels).	Not Reported	Not Reported
Hicks 2004	Investigates how a user centric (human – centric) design approach can enhance trader' performance.	Method: Interviews and observations on the trading floor Domain: Financial and commodity trading	Finds improvements in trading to occur through analysing trader workflow and improving	Traders cycle between working alone and in small and distributed teams (2-3 people) in order to maximise	Decision-making strategies are based on previous experiences of traders, with precise numbers being less	The segregation of responsibilities between the teams ensures controls over procedures and standards (such as	Teams with autocratic head trader have fewer interactions, and less input from novice traders on system problems (e.g.

		Details: Two case studies, examining how technological design shape activity on the trading floor.	ergonomics (data display).	information gathering and time management. Effective traders maintain awareness of trading patterns and their trading health through constantly searching their trading books.	relevant, and traders seeking patterns based on previous experiences of market movement.	execution, validation and confirmation occurring in separate departments)	software design) and strategy of the trading desk which limits performance.
Lo, Repin and, Steenbarger 2005	Investigates the links between emotions and rationality in trading performance.	Method: Questionnaire Domain: Financial trading Details: Examination of how emotion influences the decision making of 80 volunteer day traders.	Finds extreme emotional responses (in response to loss) as be counterproductive for trading performance.	Not Reported	Trader performance is linked to emotional state, with extreme emotional states leading to reduced rational decision making and lower performance outcomes.	Not Reported	Not Reported
Willman et al. 2006	Investigates organisational influences upon noise trading behaviours.	Method: Semi Structured interviews Domain: Investment banking Details: Interviews of 118 experienced traders and 10 managers in 4 banks focused on how noise on the trading floor influences performance.	Shows organisational culture to influences trader risk appetite and individual behaviour.	Trader's base decision on assumptions of the market (alongside quantitative information), for example anticipations of sentiment in price fluctuations and their impact on trading performance.	Unclear bonus structures lead traders to develop riskier trading strategies which are based on inferred hypotheses regarding payment calculations.	Coordination on interbank activity allows traders to positively influence market asset prices, and achieve higher output. Bonus structures that are team or individually focused positively influence the level of risk tolerated in the team's strategy (e.g. higher bonus tend to be given to greater risk taking teams)	Managers monitor trading more closely when they are aware of losses occurring, however grant considerable autonomy when making gains.
Michel 2007	Examines how cognition is influenced by uncertainty in investment banking.	Method: Ethnographic and questionnaire study Domain: Investment banking Details: Two year ethnographic study in two banks (with 84 formal interviews, 48 days of observation, 136 formal semi structured questionnaires, and 120 informal interviews).	Establishes different modes of cognition (e.g. deductive versus inductive) are required for performance in different types of financial organisations.	To manage uncertainty in understanding trading scenarios, junior actors utilise other employees or resources such as a spreadsheet in order to establish 'cues' that will determine decision-making	Not Reported	Uncertainty management tools change patterns of communication within teams	Not Reported
Cheng 2007	Investigates how overconfidence effects trading performance in the open outcry (visual, verbal, interactive) and the electronic trading (less interactive, more	Method: Simulation of trading games Domain: Trading Details: Electronic stock trading games in the trading pits of Singapore with 50 trainee traders.	Finds trader interactions lead to increased overconfidence, with overconfident traders tend having relatively poor performance.	Not Reported	More experienced traders show better self-awareness (e.g. more realistic perception of their exposure to the market) and trading performance due to a	Not Reported	Not Reported

	individual centric) settings				reduced level of overconfidence influencing decision-making. Overconfident traders do not tend to have well diversified portfolios because they believe too strongly in their stock picks.		
Ramanujam and Goodman 2010	Explores the existence and outcomes of latent errors in the banking system	Method: Case Study Domain: Investment banking Details: Identifies human factors underlying errors at an investment bank, and compares to a hospital	Demonstrates how trading organisations experience major adverse outcomes as a result of underlying human factors issues in their operations	Not Reported	Not Reported	Effective role divisions and team coordination act as a control mechanism to ensure traders follow rules and helps to limit systemic risk in the organisation. A lack of coordination between the member departments (e.g. internal audit and account reconciliation processes) results in poor teamwork and performance..	Failures of management to ensure trading rules are followed potentially allow and unknowingly facilitate irregular and dangerous trading activities (e.g. trading and settling simultaneously).
Hensman and Sadler-Smith 2011	Explores 'signalling' and managerial decision making techniques in the financial setting.	Method: In-depth semi-structured interviews Domain: Investment Banking Details: Interviews with 15 executives to examine how intuition influences decision making under uncertainty.	Presents a conceptual framework to understand the influence of intuition in managerial decision making in the financial sector, particularly in uncertain conditions.	Not Reported	For complex, uncertain, and time-pressured decisions, experiences and "gut feelings" are utilised to identify optimal decisions (e.g. where there are two equally plausible options)	Individual and intuitive decisions require cooperation with other stakeholders in order to implement the decisions, and to validate and ensure they are best fit solutions.	Managers set standards for good decision-making in order to demonstrate and achieve expected performance outcomes, although this can limit participation and input of team members
Mention, 2011	Investigates associations between incident reporting and management culture in finance	Method: Longitudinal content analyses Domain: Investment banking Details: Nine years' worth of data was analysed	Identifies growing awareness in the need for strong management process and the role of corporate culture in trading	Awareness and recognition of reporting rules resulted in improved internal control (IC) reporting	Not Reported	Not Reported	Directive and strong management is important for setting standards and encouraging internal control reporting
Fenton-O'Creevy, et al. 2011	Investigates emotional influencers upon trader decision making	Method: Semi Structured interviews (Extended from Willman et al. 2006) Domain: Investment banking Details: Interviews of 118 experienced traders	Illustrates how different strategies for different emotional regulation have material influence on trader performance and behaviour.	Not Reported	Traders who regulate their emotions (e.g. in anticipating and controlling emotional responses) before they influences behaviour perform better than those whose behaviour and	Not Reported	Not Reported

	and 10 managers in 4 banks focused emotion and decision-making		expression is shaped by emotion (response-focussed). This is because 'response-focussed' traders are less able to reflect critically on intuitive based decisions (which may or may not be accurate).	

Of the (54) studies not included in the final selection, many did not investigate non-technical skills in real-life settings, and instead focused on decontextualized micro-economic aspects of decision making, or on heuristics and biases in decision-making with non-expert participants (e.g. students). Other studies excluded were those based in retail banking, or those reporting highly generic cross-sectional data on leadership (e.g. transformational leadership) in financial organisations not specific to trading environments, and without fine-grained behavioural analyses (Awamleh and Gardner 1999; Lee et al. 2011; Singh 2008; Bantel and Jackson 1989; Geyer and Streyrer 1998; Howell and Hall-Merenda 1999; Shahin and Wright 2004). Additionally, the studies extracted on stress and fatigue was primarily in the retail banking sector and indicate that although these factors play an important role in decision making, traders don't perceive stress and fatigue as influential in their task performance. One study was found that links stress to reduced capacity for decision making in financial trading however no empirical study was completed and it was therefore not included in this review (Oberlechner & Nimbade, 2005).

Non-technical skills and performance in financial trading

In the sections below we consider cognitive and social non-technical skills.

Cognitive skills and performance in financial trading

The sections below summarise and discuss the key findings reported in table 3 relating to the non-technical skills of situation awareness and decision-making, which in HF research are essential for identifying, mitigating, and controlling risk in a range of high-risk settings.

Situation Awareness

Situation awareness refers to the "maintenance and anticipation of critical task performance events" in order that "potential problems can be corrected before they escalate" (Shrestha et al. 1995, 52). SA is generally considered to have three levels: perception, comprehension, and anticipation (Endsley 1995). Eight of the 20 studies (40%) covered an aspect of situation awareness. Of the selected studies, two ethnographic studies, two case studies, two interviews, one longitudinal content analysis, and one questionnaire investigated the concepts of situation awareness. All of the studies considered SA from the perspective of attention and situational recognition.

Perception. Situation awareness related findings highlight the importance of traders perceiving and attending to task-related information. For example identifying financial cues that provide insight into trading positions, and maintaining a "sense" of the wider market in order that decisions are appropriate (Sheaffer, Richardson, and Rosenblatt 1998; Beunza and Stark 2004). A range of information sources are used to maintain and develop SA, such as trading screens, spreadsheets, trading books, and other trading team members, with the arrangement of the trading floor and ergonomics influencing attention and information gather activities (Beunza and Stark 2004; Hicks 2004; Michel 2007). Vigilance to risk-related data is shaped by the extent to which task are routinized, with traders actively seeking out cues that determine trading strategies, and a lack of attention to risk increasing instances of error (Ramanujam and Goodman 2003; Michel 2007). Additionally, the time that is available to integrate and update information, as well as assess new risks is key to maintaining situation awareness.

Comprehension and anticipation. In terms of comprehending informational cues, and anticipating ahead, the review identified some examples of this. Traders are found to base decisions on their anticipations of price fluctuations and their comprehension of markets, and better comprehending of situations and rule-systems increases instances of internal control reporting (Willman 2006; Mention 2011). Traders seek out patterns of information (consistent with previous experience) that are indicative of particular market conditions and likely successful trading strategies (Hicks 2004). Furthermore, Menkoff (1998) indicates that 'noise' traders (who engage in erratic and illogical trading patterns) negatively influence how 'rational' traders comprehend the market (if they cannot distinguish 'fundamental' from 'non-fundamental' information), with the ability to identify 'noise' being critical. Furthermore, ensuring trading teams understand and share insight on risk is critical (Mention 2011), and Michel's (2007) ethnographic research highlights how cognition and understanding is distributed and shared across people and structured tasks (e.g. the use of complex spreadsheets).

Decision making

D*ecision making* refers to the selection of options (either by the leader on behalf of the team or amongst the members of a team) through the integration of information and perceptions from the members of the team (Klein and Zsambok 1997). It is highly associated with SA, as arguably decision-making is seen as the 'end product' of situation assessment. 15 of the 20 (75 %) extracted papers explored the NTS concept of decision making. Of the 15 papers, two case studies, six interviews, three questionnaires / survey, one simulation, one biofeedback and two quantitative data comparison were completed.

Intuitive and experience-based decision-making. Several of the research studies highlighted the importance of intuitive and experience in trader decision-making. As discussed in the previous section on SA, trading strategies are often based on previous experience, with traders using seeing out patterns of information (consistent with previous experience) indicative of likely successful decision strategies (Hicks 2004). In particular, within complex, uncertain, and time-pressured situations, successful traders report utilising intuitive feelings to make decisions (Fenton-O'Creevy et al. 2011). Furthermore Willman et al (2006) describe how, due to the organisational context (e.g. time pressure, level of uncertainty, riskiness), traders decisions are partially led by their underlying market assumptions, which are driven by non-technical variables such as experience and sentiment (Willman et al. 2006). Yet, the extent to which intuitive decisions are appropriate is shaped by a number of factors. For example, traders who learn decision-making through "doing" can integrate noise data into their strategies, and extreme emotional states are found to lower decision-making capability, with the ability of traders to regulate their emotions and reflect dispassionately on chosen courses of action, shaping their performance (Lo, Repin and, Steenbarger 2005; Fenton-O'Creevy et al. 2011).

Rationality. Consistent with the experimental psychology literature, the role of rationality and heuristics and biases have also been explored in real-life trading. The 'rational' decision-making processes of traders have been found to be influenced by 'non-fundamental' information and emotional factors. Above average trader performance can be produced by random (i.e. non-rational) market predictions, and trader performance has been associated with emotional state (Hartzmark 1991; Menkoff 1998; Lo, Repin and, Steenbarger 2005). For example, using biofeedback processes in a study of day traders, Lo, Repin and, Steenbarger (2005) illustrate that emotional arousal is a significant factor in real time financial decision making and assessments of risk (for both novice and expert actors). A number of the cognitive heuristics and biases commonly identified in the behavioural economics literature are also found to negatively influence trader performance. For example, in terms of picking winners and tendencies for loss aversion (e.g. a preference to sell successful assets, and hold onto those that lose money) (Sefrin and Statman 1985), 'illusions of control' (which increase under stress in decision-making outcomes despite challenging trading conditions (Fenton-O'Creevy et al. 2003)), and overconfidence in decision-making abilities (e.g. in not maintaining diverse stock profiles) (Lo and Repin 2002; Cheng 2007). Such factors are found to be shaped by emotional states and experience, yet solutions or interventions for reducing the impact of heuristics and biases in trading appear relatively few, and may benefit from approaches used in other disciplines (Croskerry, 2003).

Collaborative decision-making. Decision-making research has focussed on how social aspects of trading environments shape performance. A lack of collaborative decision making (e.g. top down decision making) has been associated with poor performance outcomes in finance (Shaeffer, Richardson and, Rosenblatt 1998). Common themes in the reviewed studies include demonstrating the influence of communication pathways in organising team decision making. Hierarchy was found to influence trading decision-making outcomes (e.g. how non collaborative decision making is linked to ineffective team decision making), for example Ramanujam and Goodman (2003) explore the idea that the nature of the HRO (as hierarchical) influences the organisations ability to balance risks and outcomes. A top down strategy leads to poor strategic decision making for financial organisations, for example to enter into a new market activity that leads to large losses (Ramanujam and Goodman 2003). Yet overall, the research literature provides relatively little insight into the communication pathways that underlie collaborative decision-making remain.

Summary

Consistent with the long history of psychological research investigating financial decision-making, research on cognitive non-technical skills demonstrates their importance for financial trading. Application of the situation awareness concept to interpret research findings shows how effective traders gather information (i.e. information sources, search strategies), using this to understand the task environment (i.e. the market, the trading environment), and to think ahead (i.e. anticipate market changes and the effect of individual trading). Such processes influence decision-making, with a number of studies highlighting the often intuitive nature of trader decision-making. Yet, decision-making processes are influenced by a number of factors, including emotional responses, heuristics and biases, and collaboration with colleagues. Detailed examinations of human error in trading decision-making were not found (e.g. causes and consequences, wider trend patterns), and data on aspects of SA and decision-making were quite general (e.g. task-analysis techniques were not applied to understand risk and cognition at different stages of the trading process). Examples of potential interventions to improve SA were identified (e.g. ergonomics, floor space), however interventions to improve decision-making were not identified. Interestingly, collaboration in decision-making was seen as important for being developing SA and for ensuring effective decisions, and the following section considers the role of teamwork and leadership in financial trading.

Social skills and performance in financial trading

The sections below summarise and discuss the key findings reported in table 3 relating to the non-technical skills of teamwork and leadership. In work environments where risk is partly managed through collaborative activities, the communication, collaboration, and leadership of groups is integral to successful performance.

Teamwork

Teamwork refers to a “distinguishable set of two or more people who interact, dynamically, interdependently, and adaptively toward a common and valued goal / objective / mission, who have each been assigned specific roles or functions to perform and who have a limited life-span of membership” (Salas et al. 1992, 4). Of the research literature identified, eight of the 20 (40%) papers explored teamwork in financial trading, often as an influencing factor on the occurrence of error. Of these articles, four were case studies, three were interview studies and one was an ethnographic study (and questionnaire).

Team roles. Much of the research on teamwork focussed on how team roles shape behaviour and performance. Specifically, several papers focussed on the influence of ‘role segregation’ (e.g. team member role clarity and congruent team goals). Ramanujam and Goodman (2003) and Roberts and Libuser (1993) found a lack of role segregation in financial teams to result in extreme risk exposure for the organisation (e.g. a lack of segregation in the audit and loan departments resulted in errors being more likely to be hidden). Furthermore, a lack of role segregation was found to lead to poor team coordination and performance (Ramanujam and Goodman 2003; Roberts and Libuser 1993), for example in financial institutions which have trading operations that are either co-located or in distributed work settings (e.g. a head office in London and a satellite office in Singapore). Such dislocation means that the trading activities of the institution may be located in Asia, whereas the oversight and funding operations are located in Europe, with poor performance occurring due to poor operational coordination and temporal gaps in activity (Ramanujam and Goodman, 2003).

Coordination and communication. As described above, clarity and interdependencies upon traders with different roles is a key influencer of trading performance. Underlying this is the way in which trader roles shape communication and coordination. Poor communication is seen as undermining performance, with the analysis of the Barings Bank collapse showing poor or unclear communication procedures creating uncertainty on how information is interpreted, and team conflict on its management (Shaeffer, Richardson and, Rosenblatt 1998). Patterns of communication are found to be shaped by how uncertainty is managed, and bonus structures shape (e.g. individual or team) strategies (Willman et al. 2006, Michel 2007). Hicks (2004) observed that trader performance is linked to the recognition of the trader as a team member, as energy and financial trading organisations are complex socio-technical systems that are risk and performance critical. An overly strong reliance on automation can undermine team coordination and communication (e.g. for sharing risk-related information), and communication between different organisational departments (e.g. internal audit and account reconciliation) is especially critical (Hicks 2004; Ramanujam and Goodman 2010). Furthermore, for managerial decision to be optimal they require cooperation and validation from other stakeholders, highlighting the importance of interactions between traders and management (Hensman and Sadler-Smith 2011).

Leadership

Leadership in operational work settings (i.e. the trading floor) refers to how team member are directed, coordinated, and motivated to achieve organisational goals (Salas, Burke and, Cannon-Bowers 2000; Flin, O'Connor and Crichton 2008). The literature review highlighted the importance of effective leadership for ensuring the performance of financial trading teams. 10 of the 20 (50%) papers explored an element of leadership. Of these papers, four were case studies, five interviews, and one longitudinal content analysis that explore the concepts of leadership.

Leadership structures. Studies of leadership in the financial domain were often focussed upon the hierarchical nature of organisational leadership. For example, authoritarian structures are generally found to inhibit knowledge sharing within hierarchy trading system (e.g. between the trading floor and management), and to promote a culture of fear of reprisals that leads to a reduced ability within the organisation to detect early warning signals in the lead up to organisational failures (i.e. traders feel unable to highlight problems observed in the trading floor) (Mention 2011; Shaeffer, Richardson and, Rosenblatt 1998; Hensman and Sadler-Smith 2011). Top-down leadership structures that encourage and reward high levels of risk taking implicitly penalise more conservative strategies, potentially threatening organisational stability (Roberts and Libuser 1993). Such factors are of increasing interest to regulator and researchers in risk culture (Power 2011).

Leadership strategies. Research in the trading environment shows organisational and operational leaders to employ a range of strategies in managing trading teams. For example, in an investigation of noise trading behaviour, Willman et al. (2001; 2002; 2006) explored how leadership behaviours vary according to the situational factors experienced by the trading team. They observed that way leaders monitor and adhere to procedures is directly linked to the incoming revenue of the team (e.g. if the team is making money, team leaders monitor less closely the activities and risks of the team members). This illustrates the ‘contingent’ nature of team leadership in the financial setting, whereby leadership behaviours can be adapted according to the situation. This is broadly consistent case studies of financial scandals whereby management are shown as reluctant to interfere in teams they perceive to be performing exceptionally well, yet are actually covering-up substantial losses (Willman et al. 2002).

Furthermore, finance research has shown how the leadership style of the team leader influences team work outputs as well (Hensman and Sadler-Smith 2011; Hicks 2004). Specifically they show that executive leadership in the financial setting is typically autocratic. Employing a longitudinal study, Mention (2011) observes that strong, inclusive management (democratic style) is a crucial factor in challenging the culture of a fear of reprisals and leads to better reporting of error. Ramanujam and Goodman (2003) explore this further citing that the lack of leader vigilance and monitoring (e.g. a lack of leader inclusiveness) leads to increased likelihood of deviation from standards and procedures and subsequently elevated instances of error. Shaeffer, Richardson and, Rosenblatt (1998) further argue that leadership style in finance is seen as "complacent, inward looking, indecisive and paranoid" resulting from a lack of leader inclusivity (autocratic style executive management) and crucially, this leads to the incubation of error in the organisation.

Leader Engagement. Available research shows that a lack of engagement between management and the operational actors promotes the incubation of error. Sheaffer, Richardson and, Rosenblatt (1998) highlight how errors are incubated in the financial organisation due to a culture of reprisals and elimination of input from the sharp ends actors. As frontline team actors were alienated out of the decision making process, valuable information and warnings were ignored (e.g. senior management were unaware of the accumulation of risks in the Asian trading activities). In a time of stress, senior organisational members choose make key decisions autocratically, eliminating key information from the organisations junior players. This research is consistent with decision making style investigations in other high risk fields such as emergency services, military and aviation. The junior members of the organisation reported that the dominant top down decision making process inhibited them from reporting errors (Roberts and Libuser 1993).

Summary

Research on the associations between social skills and performance in financial trading indicate the importance of teamwork and leadership for risk management and optimal decision-making. Factors such as role definitions and conflict, communication strategies within and between organisational departments, and coordination influence performance. In turn, teamwork and risk-taking activities are influenced by leadership structures and strategy. Yet, despite the importance of teamwork and leadership for performance financial trading, research on these concepts is arguably scant. For example, the specific communication and coordination strategies that underpin effective trading and risk management are not described, nor are the aspects of operational team leadership (e.g. managing resources, motivating team members, planning) found critical for performance in other domains (Burke et al. 2007). The role of teamwork problems as a precursor to trading incidents remains unexplored, with concepts such as team cognition (e.g. for understanding team strategies), shared situation awareness, and conflict being potentially useful concepts for understanding the performance of financial traders.

Data synthesis to develop an initial non-technical skills framework

In order to summarise key findings on the non-technical skills important for performance in financial trading, table 4 synthesises the research literature described in table 3. Whilst not a comprehensive guide to non-technical skills in financial trading, the framework captures and presents existing knowledge.

Table 4: Non-technical skills and performance in financial trading

Non-technical skill category	Skills important for effective trading performance

Situation Awareness	• Constantly searching for new information in order to update market assessments • Use of a wide variety of information sources to support SA (e.g. trading screens, spreadsheets, trading books, and other trading team member) • Attention and integration of new information and recognition of risk, amount of available time to assess risks • Increased vigilance during highly-routinized tasks to avoid slips and lapses • Ability to distinguish 'noise' data • Methodical utilisation of information cues to anticipate trading scenarios and predict market behaviour and risk – monitoring conditions and re-interpreting SA if they change
Decision Making	• Use of experiential and intuitive decision-making strategies • Emotional regulation for dispassionately selecting courses of action • Ensuring 'noise' data does not negatively influence the evaluation of information and selection of decision-making strategies • Avoiding overconfidence, loss aversion, and illusions of control, as key influencers of decision-making (biases) • Utilisation of the team to assess and reflect on decision-making strategies
Teamwork	• Clear understanding of team member roles and responsibilities on the trading floor • Segregation of team member roles where they create conflict • Team coordination during shared tasks, and between different parts of the trading floor • Communication and information sharing on trader decision-making • Shared understanding amongst traders for risk-related information and procedures
Leadership	• Monitoring of team member decision-making • Allowing autonomy in trader decision-making where performance is effective • Ensuring standards are maintained, and procedures followed • Encouraging input from team members in problem solving, developing decision-making strategies, and conflict resolution • Avoiding reward structures that incentivise high-risk taking strategies • Encouraging speaking-up and reporting of critical incidents

Discussion

Whilst psychological concepts have long been applied to understand financial decision-making, operator performance in financial trading remains relatively unexplored from a human factors perspective. The current literature review indicates that through adopting and applying the 'non-technical skills' paradigm to interpret research on the performance of financial traders, useful insights can be made for understanding the factors that influence performance, and the potential for intervention to improve risk management. In particular, the decision-making strategies of successful traders can be understood from utilising both cognitive theory on situation awareness (e.g. information gathering strategies, comprehension of complex market data, course of action), and also social psychology theory on the teamwork processes that support effective performance (communication, coordination) and leadership strategies that shape activity.

In understanding why trading errors and risk-taking occur, the adoption of non-technical skills theory appears especially useful. Furthermore, in developing interventions, NTS theory potentially provides a more psychologically based method for improving trader performance. For example, rather than focussing on strategies for minimising cognitive heuristics and biases that influence decision-making (Crosskerry 2003), intervention strategies can focus on improving trader' situation awareness and decision-making through focusing upon team processes. Additionally, as public interest in the behaviour and actions of traders is growing, the formal assessment of human factors and non-technical skills could inform future regulation in this domain.

Overall however, it might be argued that research investigating the non-technical skills that shape performance in financial trading is relatively embryonic. In comparison to domains such as aviation and healthcare (Leonard and Graham 2004; Helmreich 2000), thorough descriptive analyses of the human factors issues underlying critical incidents in financial trading are required so that a better understand of the specific causal and system factors underlying error can be developed. Task analyses may also be useful for identifying the specific risks associated with different stages in the trading process, and for precisely describing the cognitive (e.g. specific information patterns used for effective decision-making) and social skills (e.g. communication on risk) that underpin effective trading performance.

Limitations and future research

The literature review has a number of limitations. First, the literature review search strategy may have failed to capture relevant papers with important NTS-related information. Often, the studies identified in the literature review did not focus on non-technical skills explicitly (e.g. situation awareness), rather they contained data that appeared relevant to NTS concepts was extracted. Other publications with data relevant to non-technical skills, but not reported using the terminology of the strategy, may have been missed. Second, the focus on non-technical skills meant that other factors underlying critical incidents in financial trading were not explored. These include political, regulatory and technical features (such as the human machine interaction failures) of the trading environment that might shape activity. Third, the methodologies applied to investigate activity in trading were very diverse. They included interviews, surveys, case studies, bio-feedback, and longitudinal analyses of financial performance. Whilst diversity in research methodology avoids problems such as common method bias (Podsakoff et al. 2003), there are limitations with each, and the extent to which results can be compared is debatable. The design and sampling strategy of each study are divergent (e.g. the interviews conducted are measured qualitatively to elicit the behavioural patterns in team performance outcomes, whereas the biofeedback methods are deigned to focus on the quantitative outcomes of statistical analysis), and there are challenges in comparing research findings. Fourth, there is potential for bias in the analysis of research studies. In particular, data on non-technical skills (e.g. situation awareness) was extracted from papers that did not focus on these topics (e.g. a case study analysis). This means a level of data re-interpretation has occurred, and there is a need for future research to explicitly focus on non-technical skills and performance in financial trading.

Table 4 presents an initial framework of the NTS factors found to shape performance in financial trading. Further research (error analysis, task analysis, observational studies of performance, examinations of effective leadership behaviours) are required to develop a comprehensive framework. For example, Weigmann and Shappell (2005) remind us that incident investigation in a high risk setting should consist of five components; a human factors investigation system, a database, data analysis, data driven research and development of effective remedial actions. Classifying the nature of the events that occur is an important step in understanding the underlying weaknesses in the system. Such a model requires the balance of simple and broader categories for the accident reporting and coding forms. The application of NTS concepts to understand performance in financial trading will facilitate this type of investigation, and will contribute to developing error and performance models tailored to the context of financial trading. In turn, such data will be useful for supporting the development of tools (e.g. observational systems for assessing non-technical skills and providing feedback) for evaluating and improving non-technical skills on the trading floor.

Conclusions

The utility of human factors approaches for improving our understanding of performance in financial trading is increasingly recognised. However, to date, the methods and theories used to understand and improve operational risk management in other high-risk industries have not been fully applied to financial trading. In particular, in organisational settings where a combination of cognitive and social behaviours are critical for avoiding and managing error, non-technical skills theorem has been used to understand and improve the behaviours and abilities of front-line staff. In this literature review, we have demonstrated the importance of non-technical skills in the trading environment, with a combination of social and cognitive skills being found to underpin trader performance. Yet, NTS research remains at an embryonic stage within financial trading, and there is a need to better understand the specific behaviours and cognitive strategies that underpin effective trader performance. This will provide an empirical basis for the development of contextually specific interventions for reducing error and improving performance.

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3. Development of the Operational Incident Log

The second aim of this thesis is to develop a methodology for capturing and then analysing operational incidents in financial trading. The generation of a robust methodology is essential so that data on error and non-technical skills can be retrieved. To achieve this, the development of a system for capturing, monitoring and analysing operational incidents in the financial trading domain is described in the following chapter.

3.1 Introduction

Studies of major organizational accidents (e.g. Chernobyl disaster, Kings Cross fire accident) indicate that many risks remain hidden, go unnoticed or are misunderstood for long periods of time before an accident. Significantly, the collection and interpretation of incident data has the potential to identify a range of warning signs (J. Reason, 1997; Turner, 1994; Vincent, Taylor-Adams, & Stanhope, 1998). Identifying problems, interpreting what they mean and then learning from them are essential aspects of organizational life (Pidgeon, 1991). For example, Van de Shaaf (1991) argues that near-miss data and the reporting of minor incidents increases the available information and provides a better understanding of how to prevent further accidents (Van der Schaff, 1991). Yet incident reporting can be challenging due to fear of disciplinary action, attitudes that error is 'inevitable' and a more general culture of blame. The management of error in socio-technical systems requires the acceptance of error with equal consideration given to the individual human behaviour (e.g. the observed risky practices) and the factors that influence the behaviour (e.g. the culture within the organization that supports or undermines safe or risky practices) (Waring, 2005; Waterson et al., 2015).

Therefore, it is essential that an organization creates a 'safety culture' in order to overcome these barriers.

Within financial trading, there is no precedent for incident reporting in terms of either methodology for collecting incident data, defining and understanding what constitutes an incident, or informing organizational learning initiatives. This chapter aims to tackle the first of these issues by describing the methodological process of designing, refining and implementing a data collection tool to capture incident data in the financial trading domain. This is an essential first step in retrieving data that is key to identifying the non-technical skills that underpin error.

3.2 Literature review

The section below identifies a set of literature that guided the development of the incident reporting system described in this chapter. The features and lessons learned from the application of incident systems that have been applied in other high-risk domains is described, the aim of which is to inform the development of a similar tool in the financial trading domain.

3.2.1 Incidents in financial trading

Chapter 2 shows that non-technical skills are important for managing risk in financial trading. Effective traders have good technical and non-technical skills that allow them to quickly sort through large amounts of information in order to exploit market volatility and make judgments about the future state of market conditions. However, the complexity and pressure of trading leads to errors and risk taking. This combination can result in 'incidents', whereby trading activity results in an avoidable financial loss (e.g. making a trade without assessing market-related risk) or compliance failures (e.g. breach of trading limits), which place the integrity of the organization at risk even if no loss has occurred (e.g. overexposure to illiquid markets). Crucially, such events are typically not caused by rogue traders (employees making unapproved financial transactions) but by systemic problems across an organization (e.g. failure of the system to generate breach reports) that impair human performance. Table 1 presents a few examples of incidents that have been interpreted using the non-technical skills framework presented in study 1. The data in Table 1 provides contextualized examples of the type of reports that are collected through FINANS in order to provide a clearer conceptualization of what error looks like in the trading domain. Furthermore, the incidents provide evidence of the underlying human factors that influence the occurrence of error, as well as the human factors that assist in the detection of error.

Table 1: Example data of potential reported incidents

Example Incidents	Key human factors problems identified in the cases
A middle office analyst sent a request to the trading systems (TS) team to set up a new rule (as systems rights and access rules do not permit them to carry out this change) for a specific type of financial contract to be downloaded so that it would no longer create a physical position in the book. The rule did not work the first time, however middle office (risk analyst) spotted it during a procedural check. The rule did not work the second time and the front office (trader) spotted it. This could have created an incorrect physical position.	Failure of the TS team to gather enough relevant information (SA) Poor coordination of shared task work (TMWK) between the TS and MO teams in obtaining shared goals (e.g. working system) Poor systems maintenance and testing (HCI) Good attention (SA) to procedural work by the MO and FO teams
Middle office (MO) saw a loss during their morning procedures that created a discrepancy of 93,000 (GBP) between the database and their independent (manual) check. MO looked into reasons for this loss and saw that the estimation on a particular deal had moved from the day before (the deal was in the past and therefore should not change). After discussing with the trading systems team, it was discovered that this was due to the book crashing and the opening failing, which in turn caused the parameters on the estimation for the route to be deleted from the beginning of the month. This meant that the book was using the previous version of the parameters that were out of date and hence the estimation was incorrect leading to inaccurate estimation of the interest rates in the risk position. This would have been easily spotted and discovered if MO had access to the database that stores that previous day's data (a system defence to be used when these issues happen), however it was not available as it had been refreshed and displayed what the live book was displaying. The estimation was fixed by entering the correct parameters for the route for the reference day of the beginning of the month. The formula then recalculated and gave the correct estimation, making back 93k£ (e.g. P&L neutral).	Good gathering and interpretation of information skills by the middle office (SA) Communication and coordination of shared tasks between the TS and MO teams (TMWK) as well as knowledge sharing between the teams (TMWK) Seeking advice on a decision (DM) System maintenance and use of tools (HCI)
Front office (trader) modified their shared freight file without explicitly notifying middle office (MO) about it. Therefore, MO's estimation of the P&L for the freight curves was incorrect for several days. Because there is only a small risk position, it was difficult to spot (e.g. it generates very little P&L). The discrepancy was finally	Poor communication of shared task work and knowledge between the teams (TMWK)

noticed when the two curves diverged enough that it was obvious in the P&L estimation (e.g. MO's estimation was not in line with the freight desks estimation).	Interpretation of information (SA) to detect the error
The coal operations team sent a shared email asking middle office (MO) to link a sale to a purchase in the book. When MO checked the volumes for the purchase in the book they discovered only a quarter of the specified volume was booked (25%), after checking the shared email history and speaking to Front office they found out that FO did not ask MO to update the book correctly for the full volume and instead only 75% of the volume was booked, hence 25% of the volume was not entered into the book. This missing volume was added by MO and then linked to the sale volume. The issue was resolved quickly as the full volume was agreed with the counterpart hence it was only missed in the book. However, if this was not agreed with counterpart and FO only assumed it was, then the desk would have oversold (e.g. too much risk). Another issue is the risk was incorrectly represented hence the hedging done by the desk was also wrong. This led to a within day P&L impact.	Communication and coordination of shared task work between the teams (TMWK), discovered through communication and gathering of relevant information (SA)
A formula in the book is contractually specified as: a * X + b. where b is the freight component as per the technical specifications of the concerned vessel. The contract was booked with a fixed b where it should be a variable depending on X and other components. The formula was booked by MO and detected by MO when they had a handover of tasks the following day and the formula and contract was second-checked by another middle officer.	Lack of gathering of relevant information when checking the contract parameter against the book information (SA) Coordination of shared task work (during handover of task work) led to the detection of the problem (TMWK)

The incidents provided in Table 1 helpfully contextualize the type of reports that the Incident Reporting Form (IRF) described in this chapter collects. These reported incidents will be drawn on throughout the chapter to help illustrate the information the tool aims to collect and the output of the human factors framework used to analyse each incident.

The way an organization deals with incident data reveals a lot about its risk management strategy. In other words, we can infer the safety maturity of an organization by investigating how it deals with incident data For example, organizations that actively seek out previous experiences of error in an effort to ensure they do not happen again (e.g. foster a learning culture), or an organization where staff routinely document and communicate the experience of error to enable learning (e.g. foster a reporting culture).

Incident data also reveals the granular descriptions of behaviour within the organization, such as deviance to local procedures. Incident reporting systems usefully collect this data, and once analysed it helps to reveal patterns and descriptions of the conditions that lead to error (e.g. too many workarounds due to ill-fitting procedures). Once the data is aggregated, the patterns and analysis can be used to inform risk management decisions, improve training and foster organizational learning and awareness. This identification of trends reveals critical process ‘weaknesses’ and ‘strengths’ and is essential to improving risk management in the financial trading domain, and this begins with the collection of incident data.

Before describing the incident reporting form and collection database developed in this thesis, the following section reports on the relevant and available literature on incident collection in other high-risk domains. This is important because this was drawn upon as inspiration whilst developing the incident reporting form and database, and the literature set out below informed key decisions that were taken in the initial design phase of the incident reporting form.

3.2.2 The purpose of incident collection

The purpose of collecting incident data is to gather information (e.g. error and near-miss data) that is present in the day-to-day life of high-risk organizations, in order to learn from previous experiences and improve organizational performance and safety.

Developing an incident collection tool is crucial because it equips the organization with a means of centrally gathering data on risk-related problems (e.g. mishaps, errors, human-computer interface issues) experienced by staff. This data can be used to identify the types and sources of problems within and across the organization (e.g. slips, knowledge-based errors, rule-based errors), error types (e.g. active or latent) and the antecedents to failure, all which helps to reveal problems in the system design or procedures (Rasmussen et al., 1981; Reason, 1990; Zhao & Olivera, 2006). Moreover, if strong feedback is shared with the participants, these systems promote the ability to self-assess, share knowledge and learn from error, and promotes the resolution of conflict within the organization (Carroll, 1998; Johnson, 2002; Kaplan, 2003). In order to achieve this, the organization must gather reliable, insightful and organic (derived from the frontline actors) incident data using an incident reporting form.

3.2.3 Incident collection in other high-risk domains

Theories of error developed in aviation and other high-risk domains suggest that errors are likely to occur in all complex systems. Given this projection, the reporting of incidents, including both failures and near-misses, is increasingly seen as an essential component for improving safety. Domains with established incident reporting procedures, such as aviation, benefit in several ways from the additional analytical and theoretical insight. For example, greater insight into the relative proportion of particular classes of 'human error' (e.g. teamwork, decision making, situation awareness) assists the organization in directing resources (e.g. systems augmentation, targeted training), as well as identifying the barriers that prevent adverse situations from developing into a major incident (e.g. near-miss cases). Additionally, feedback from incident reporting systems can be shared with staff to promote participation and engagement. Finally, these lessons can be shared across industries to promote the establishment of standards and common solutions (e.g. sharing of lessons learned) to routinely observed issues.

Similarly, financial trading is a highly complex and risky industry that would benefit from the collection and analysis of incidents. Recent large-scale failures across several organizations in the financial trading domain (e.g. UBS, Libor and JPMorgan) resulted in multi-billion dollar fines, and extensive investigations into their causes have revealed human factors-related issues in managing risk. For example, the investigation of trader performance has highlighted the importance of non-technical skills (e.g. communication, attention) and human-computer interface issues for influencing performance in financial trading (Leaver & Reader, 2015). This outcome is similar to many other high-risk sectors (e.g. aviation, nuclear power), yet relatively little is known about the link between human factors related problems and incidents in trading.

The existing human factors literature provides an empirically-tested and theoretically-driven foundation for developing an incident reporting system in the financial trading domain. In fact, incident reporting systems have been used extensively to identify and understand safety problems in a number of high-risk domains.

For example, the Aviation Safety Reporting System (ASRS; developed by the Federal Aeronautics and Space Administration) is a voluntary and confidential incident reporting system used by pilots and engineers (via a web-based platform) to report near-misses and incidents (Billings & Reynard, 1984; Helmreich, 2000). This data is then used to understand the role of employees and systems in detecting and coping with incidents, and to identify systemic and growing threats to safety. In other industries, for example healthcare, incident reporting systems have also become relatively commonplace, although they are generally not as developed in comparison to aviation (Itoh, Omata, & Andersen, 2009; Wu, Pronovost, & Morlock, 2002). For example, in healthcare staff often experience cultural barriers in reporting incidents, effectively contributing to poor attitudes on incident reporting that can limit institutional learning (Anderson, Kodate, Walters, & Dodds, 2009; Waring, 2005).

The methodology being developed for financial trading draws on the experiences of previous error researchers across other high-risk domains, such as aviation, rail and healthcare, to frame the development of an incident collection system in the financial domain. Systems that have successfully collected, analysed and reported on errors and near-misses, such as the ASRS, were used as inspiration for the incident reporting form and database described in this chapter.

3.2.4 Review of existing incident reporting systems

A review of existing incident reporting systems in other domains (below) reveals the common characteristics of successful systems and identifies where system deficiencies exist. For example, it reveals that incident data tends to be collected through two mechanisms. First, through automatic and mandatory systems (e.g. computer monitoring systems in aviation, observable mishaps) which lead to a formal incident investigation. Second, through voluntary staff incident reporting systems. This typically involves staff completing a narrative text and/or structured report on incidents they observed or participated in.

Incident reports usually contain information on the types of events that took place (e.g. mechanical, procedural), the personnel involved (e.g. identifying the teams), the activities leading to the incident (e.g. behaviours), and how the event was detected (e.g. system, observation). Depending on the industry and organization, incident reports can be anonymous or identified, and can supplement existing monitoring systems (e.g. near-miss data in aviation) or be the primary source of data on mishaps.

Importantly, researchers on incident monitoring have argued that systems require the following properties: they must have strong procedures for capturing incidents (e.g. independent, with non-punitive results); generate high-quality data (e.g. freeform narrative of the event promotes a broader, more ecological explanation of the event); and be underpinned by strong analytics – for example, where experts interrogate the data and generate meaningful insights on the types of incidents that occur and root causes (Mahajan, 2010). Finally, to ensure these insights are utilized, robust feedback and learning mechanisms are required (e.g. for developing interventions, sharing lessons learned across the organization).

In order to extract valid insights and promote organizational learning within the financial trading domain, there is a requirement to better understand and adopt the specific aspects of incident reporting systems featured in the literature. Incident reporting systems are a key source of information on the development of a new tool in the financial trading domain where no robust system for the collection of incident and near-miss events exists.

In deciding on the format for the incident reporting form in financial trading, the experiences of other error researchers were taken into account, such as those identified above, and particularly those in the aviation, rail and healthcare domains. Below, the characteristics of three systems across three different domains that served as inspiration for the development of an incident reporting form and collection system in the financial trading domain are examined.

Aviation. Incident collection and analysis research is primarily rooted in the aviation domain, where millions of reports have been collected since the establishment of error collection tools in the 1980s (Billings, 1998; Billings & Reynard, 1984; Shappell & Wiegmann, 2001). Two reporting systems operate simultaneously in the aviation domain: one mandatory system with the primary purpose of holding providers accountable and focused on errors that result in serious injury or death; and a second system – the Aviation Safety Reporting System (ASRS) – with the goal of quality improvement, which is voluntary and focused on the collection of near-miss data in order to identify potential vulnerabilities within the system.

The ASRS is credited with helping to improve the safety of airline travel in the USA over the past three decades. For example, according to the Federal Aviation Administration, the risk of dying in a domestic jet flight was 1 in 2 million (1967-1976) and fell to 1 in 8 million by the 1990s, due in some part to the benefits of accident analysis and the introduction of human factors interventions (e.g. incident reporting, team training). Below, some of the primary characteristics of the ASRS that have been used to frame the development of a tool in the financial domain are discussed.

The ASRS is a voluntary, confidential reporting tool that is maintained by the National Aeronautics and Space Administration (NASA) and funded by the Federal Aviation Association (FAA). The purpose of the ASRS is to collect, de-identify, catalogue and analyse incident reports based on human factors concepts such as: relevant conditions preceding an incident, causal/contributing factors, chain of events, and the processes that led to the detection of an incident (Beaubien & Baker, 2002; Billings, 1998; Sarter & Alexander, 2000). The ASRS provides separate reporting forms for pilots, air traffic controllers, cabin crews and mechanics. Each form contains a series of fields that describe the relevant conditions (e.g. type of flight, phase of flight, weather) that immediately preceded the incident. Space is also provided for a text-based narrative so that the reporter can provide additional details, such as causal/contributing factors, the chain of events and suggestions for preventing the event's recurrence. The incident narratives are stored as text (Beaubien & Baker, 2002).

There are several lessons from the ASRS that informed the development of a similar system in financial trading. Firstly, the importance of consensus amongst stakeholders in designing the system and the use of set categories. In defining the categories, experts from within the participating organization were consulted on variables such as detection mechanisms, risk types and departments involved (in order to capture the migration of error across the floor). Moreover, lessons regarding the provision of feedback from the ASRS – in the form of database search requests and quick turnaround data analyses distributed to internal stakeholders across departments –

were considered in the development of the incident reporting system in the financial domain, with the aim of investigating unsafe practices, planning corrective action and learning from the incidents.

The UK-based version of a similar reporting tool, known as the Confidential Human Factors Incident Report Program (CHIRP), was also incorporated to frame the development of the incident reporting system in financial trading. Similar to the ASRS, operational staff submit the reports voluntarily and de-identified feedback by newsletter, summary statistics and topics of interest are distributed to the participants to encourage further contribution. Uniquely, this system includes an exhaustive glossary to classify and code the textual information, which helps to establish consistent feedback across domains. This aspect is considered within the development of the financial incident analysis system; however, due to the low number of reports in the database it was not found to be applicable. Nevertheless, the addition of a glossary of terms could enhance the coding ability of the tool in future iterations.

Lastly, the Australian version (Confidential Aviation Incident Reporting, CAIR) was also considered, as it is similar to the previous two systems but with a focus on systems and procedures as opposed to individual events. The concepts coded in this system do not distinguish between an accident and an incident (similar to Reason, 1990), but take a more complete approach at the systems level (e.g. no primary or contributory causes). After considering the requests of organizational management within the participating organization (who are interested in the categorization of causes to highlight process weaknesses and strengths), it was decided to take a finer-grained approach to identifying the primary and contributory causes in the data analysis.

The purpose of the incident collection tools outlined above (ASRS, CHIRP and CAIR) is to allow the user to identify broad safety trends and process weaknesses (e.g. procedural and technical), and this aim is shared with the incident reporting system outlined in this chapter. The systems are typically web-based, voluntary and provide textual data for analysis – characteristics that have also been adopted in the tool described in this chapter. Also, these incident collection tools are typically supplemented with a more fine-grained human error coding framework, such as the human factors analysis and classification system (HFACS), to provide a richer analysis of the human factors principles that underlie performance (Beaubien & Baker, 2002; Shappell & Wiegmann, 2001). This aspect is a key guiding principle in the development of the incident reporting system in the financial domain, as it provides evidence as to whether human factors methods and concepts are relevant in the financial trading domain.

Box 1 presents an example report from the ASRS reporting system and illustrates the lessons that can be derived from the data.

Box 1: ASRS Sample Report with interpretation
Sample Report "The aircraft never stalled, but it was literally only a few seconds/knots from doing so…My failure to maintain an adequate scan was the primary cause of this near stall incident. I relied too much on the automatic pilot and allowed myself to become distracted with my chart review. That should have been done at cruise, with the captain 'covering' for me while I had my head in the books. Also, the PNF (Pilot-Not-Flying) might have noticed the low speed sooner if he'd made his PA announcement at level-off, not in climb." (ASRS Report Number 278353). Type of Analysis: Link the flight phase – relationship between flight phases during the monitoring errors (e.g. during taxi, take-off, climb, cruise, descent, landing). Identify the consequences – adverse safety consequences from monitoring error (e.g. altitude deviations, runway incursions, departure from desired speed). The data can be benchmarked to contextualize the severity. Lessons from the analysis: The busier the crew is in non-monitoring tasks, the more likely it is that monitoring performance will decrease. Crews reported zero at most, one flight related task as being conducted – this shows that monitoring errors are not limited to high workload, multiple task periods and it implies that monitoring is a discipline, which must be practised constantly and consistently, regardless of workload. Actionable feedback: Develop a framework for improvement: management of air carriers and other aviation operations, as well as regulatory officials must realize that is it incumbent on them to provide crews with clearly thought-out guidelines to maximize their monitoring of aircraft trajectory, automation and systems. Procedures that conflict with crew monitoring must be minimized or eliminated. Flight crews must constantly exercise monitoring discipline and practise the operational guidelines designed to improve monitoring. On long-haul flights in which crew monitoring may not be sustained, particular attention should be devoted to altitude and course changes.

Inspired by the report, analysis and outcomes presented in Box 1, the incident collection form for financial trading was designed so that it would provide similar trend data. For example, the input of date and time were replicated to identify the approximate time of day the error occurred (e.g. similar to flight phase identification in the ASRS), as well as adding a text input in the form to describe the ‘possible consequences’ of the reported error. Emulating central aspects of the systems outlined above is desirable because the data that is generated from these aspects of the system can be used to identify broad safety ‘hotspots’ (e.g. altitude deviations, runway incursions, departure from desired speed) that can be targeted with tailored interventions. Moreover, the data can be used for benchmarking aspects of safety across the industry, to contextualize the severity or ‘hotspots’ and identify and prioritize key areas of improvement.

Incident reporting is well-established in the aviation domain, where robust feedback and reporting procedures promote organizational learning and permits benchmarking across the industry. In the healthcare domain, tools informed by the aviation domain have been met with some success. However, the domain has also had to tackle key issues undermining reporting and make key modifications to the systems to better reflect the specific task work in the healthcare domain. In developing a tool for the financial trading domain, these challenges and modifications revealed in the healthcare literature are considered.

Healthcare. Incident collection tools in healthcare were first established over two decades ago and were informed by similar tools in the aviation domain. Currently, incident reporting systems in the medical domain cover a wide range of the organizational sector and are established for many different types of incidents (e.g. surgical, anaesthesiology, ICU).

Unlike the aviation industry, the healthcare domain is plagued with issues of underreporting that threaten the ability of the systems to accurately quantify and measure harm reduction. Several factors underpin the reluctance to report: fear of retribution, driven by a culture of blame (e.g. high-profile cases act as a powerful disincentive to participate, stigma of whistle-blowers); the perception of additional training of staff as a burden; poor investigatory procedures (e.g. perceived utility of reporting, feedback); and increasing evidence-based medicine where errors are violations of protocol or procedures and therefore seen as punitive.

The challenges to reporting systems in the healthcare setting reveal crucial lessons that were considered when developing a system for incident collection in the financial trading domain. For example, it is observed in the medical field that only a small percentage of doctors report incidents formally. The reasons for this can be variable, such as a fear of retribution, fear of legal action or deeply entrenched beliefs in medicine that only 'bad doctors make mistakes' (Mahajan, 2010). Similarly, there is a culture of blame and stigma around whistle-blowing in the financial trading domain that deters reporting by key frontline staff. In this situation, it is essential that data input is non-punitive and independent, and that the analysis of events is administered systemically, resulting in direct action that improves safety. Improving mechanisms for incident reporting can enable greater staff participation and reduce – if not eliminate – the stigma of reporting.

Moreover, it has been noted that systems with too many closed questions do not allow for free expression of 'what actually happened', and that staff must be allowed to narrate their own version of events. Therefore an emphasis on staff testimonies is beneficial, as it promotes a more ecological description of the event and a more comprehensive understanding of the multitude of factors that link together in the evolution of an event (Mahajan, 2010). This observation was helpful in framing the initial development of the incident reporting form in the financial trading domain.

Furthermore, in the analysis, it was found that systems for incident collection in the healthcare domain draw on experts from the specialty to interrogate the data and generate meaningful learning outcomes. In anaesthesiology, the Australian Incident Monitoring System (AIMS) successfully collects and identifies anaesthesia-related incident data. Key examples from the collected incidents include drug administration errors (e.g. pharmaceutical preparation error), equipment errors (intravenous/venous line errors) and communication errors (e.g. miscommunication of the placement of a regional block). These examples identify the contributory factors such as work overload, lack of emergency procedures, fatigue, and inadequacies in the layout and processes of the system. Subsequently, this has generated improvements such as universally standard color-coded drug labelling, changes to workload management (e.g. reducing both the need to operate at night and continuous hours of work), and training (Abeysekera, Bergman, Kluger, & Short, 2005).

Rail. The characteristics of the incident collection tool (e.g. the reporting form) that were found to be relevant in the aviation and healthcare domains have similarly been found to be influential in the rail industry and have been adapted accordingly. In the UK rail domain, CIRAS (Confidential Incident Reporting and Analysis System) is the national system for reporting and analysis of railway near-misses. It was developed in 1996 as a result of an initiative by ScotRail and the University of Strathclyde, and subsequently rolled out across the entire UK rail network in 2000 (Davies, Wright, Courtney, & Reid, 2000).

In CIRAS, reports are voluntarily submitted through two avenues: by mail (using one of the CIRAS forms available in workplaces, or included with each copy of the *CIRAS Journal*) or by telephone. Once a report has been mailed or telephoned in, CIRAS staff perform a critical incident interview with each driver involved, during which detailed forced-choice questionnaire data is collected to provide technical, environmental and personal information (e.g. shift time, nature of work, weather and rail conditions) (Wright & Van der Schaaf, 2004). The CIRAS database is secure and protected, data is stored on a removable hard drive (which is kept safe overnight), and the computer itself is 'stand-alone' and non-networked (to limit the risk of hacking). Once the interview is complete, the original report form is returned to the employee and no copies are made or retained (all identifying information is redacted) (Davies et al, 2000). Although the reporting form is quite different to the incident reporting form developed for the financial trading domain (e.g. paper form versus web-based), there are similarities in the intended use of the data. For example, CIRAS maintains a log to keep track of issues that have been closed and those that remain unresolved, and this has been used in the web reporting form in the financial trading domain.

In terms of improvements, short-term corrective actions are frequently taken following the reports in CIRAS, such as the repositioning of mirrors and monitors, changes to braking procedures on disc-brake sets and the erection of barriers at illegal crossing points (Davies, Wright, Courtney & Reid, 2000). In the longer term, CIRAS offers scope for collecting generic human factors data that can provide a resource for the industry to learn from error to improve performance and safety. For example, trend data and patterns can be used to enable the industry to determine physical locations prone to error, particular times (e.g. during shifts) and conditions that underpin the occurrence of error, and error-promoting conditions (e.g. procedural inadequacy, fatigue). This data is used to exchange lessons learned within the industry and share safety solutions, in particular driver fatigue.

Although the intention of incident reporting is to improve safety and performance outcomes in high-risk domains, there are practical challenges in the administration of the systems and key limitations in the outcomes from incident analysis that have been observed across all the domains where incident reporting is on-going.

3.2.5 Incident collection: limitations and challenges observed in other domains

The use of incident reports in several high-risk domains such as aviation and healthcare is increasingly acknowledged as an important tool for organizational learning about incidents, human factors and safety (Pidgeon & O'Leary, 2000). Error reporting systems have led to the successful identification of system deficiencies across several high-risk domains, helped to identify the barriers that prevent adverse situations from developing into a major accident, and helped analysts to identify where additional support is required to guarantee the future benefit of safeguards, as well as the creation of national standards for safety. However, the extent to which this type of tool can capture a representative sample of incidents remains a topic of debate within the literature (van der Schaaf & Kanse, 2004), and the challenges within the data must be carefully considered when drawing comparisons to the financial trading domain.

Underreporting is a key weakness in the data collected from incident reporting systems. Underreporting results in a bias in the type of reported errors and reduces the organization's ability to quantify and accurately measure how risk management processes lead to improvements in safety and performance.

The reasons why underreporting is prevalent vary and are well summarized by van der Shaaf & Kanse (2004) in a systematic four-tier framework: i) *fear* (e.g. 'blame culture', litigation, disciplinary action); ii) *risk acceptance* (e.g. incidents as just 'part of the job', or a 'macho' culture that suppresses reporting); iii) *useless* (e.g. the perceived attitudes of management, lack of follow-up actions, handling the incident alone); and iv) *practical reasons* (e.g. time constraints, insufficient information, lack of incentives) (van der Schaaf & Kanse, 2004). In the scope of the current study, these four principles are relevant and underpin the future efficacy of the tool. Therefore it is critical to acknowledge the existence of these limitations in the data (e.g. interpretations of broad causality) so that the findings from the dataset are not overstated, as well as to develop a tool with these principal limitations in mind (e.g. ensure targeted and active feedback and clear procedures for data entry).

In addition to this four-tier framework, a sub-category may be the *human behaviour* limitations, such as the level of awareness of the participants (how they may not report because they don't know what the error is), and ignoring the error or covering it up (Rouse & Rouse, 1983; Sanne, 2008; Zhao & Olivera, 2006). Also, studies of human recall show that recall of events is made up of segments of recollection with gaps that may be filled with bias and extraneous information, and therefore must be treated cautiously when analysing individual narratives, which may or may not be complete (O'Connor, O'Dea, & Melton, 2007). The psychological processes in which risks and warning signs are initially identified and interpreted within the organization are complex and shaped by local norms, objectives, policies, values and knowledge (Macrae, 2009). Likewise, shared attitudes and beliefs are central pillars to an organization's safety culture (e.g. adhering to rules, tolerance of violations) and can influence the early risk-identification process, although these impacts are not yet fully understood (Mearns, Whitaker, & Flin, 2001; Pidgeon & O'Leary, 2000). Knowing this, caution was taken when interpreting the data and exploring the findings within the financial trading domain, keeping in mind the limitations that may serve to skew the data. Furthermore, lessons can be learned from how other high-risk industries have promoted positive reporting cultures, and these lessons were considered in the development of a tool in the financial domain.

Recommendations from the medical field to foster 'just' reporting practices and overcome these limitations include the provision of participant feedback, as people will only contribute to the system if they believe their contribution will be acted on (Johnson, 2002; Kaplan, 2003). The promotion of collecting near-miss data is important, as it is more frequent than 'harm' data and also carries less 'baggage' to the person reporting it, therefore it may be more open and honest (Kaplan, 2003).

In the development of an incident reporting tool in the financial trading domain, attempts to manage these concerns by de-identifying the incident data prior to analysis and ensuring that the attribution of responsibility is team-specific (e.g. individual failings are not monitored, only team failures) were undertaken. This is illustrated in the incident data provided in Table 1. The perceived attitudes of management are guided through consistent feedback (e.g. short daily reports and more in-depth monthly reports) regarding the incidents and activity on the floor and across the teams, as well as active incentivizing of operational personnel to report incidents (e.g. during bi-weekly meetings, teams who report are well-acknowledged).

Also, events identified as 'major' by the management are openly discussed in action-plan meetings, which encourage the mixed participation of the teams involved in the incident (analyst, supervisor and manager). In these meetings, representatives from all departments involved in the incident are invited to present their understanding of their role in the incident, and share ideas on how the risks migrated within the organization (e.g. lack of adequate controls, poor role definitions) and discuss solutions (e.g. fixes). This meeting also aims to re-frame prevailing norms or attitudes regarding which incidents are acceptable or unacceptable within the organizational risk appetite. Admittedly, practical constraints such as time and perceived usefulness of the meetings are challenging to manage on the individual level, as the meetings are voluntary and depending on the time of day/day of the week and severity/complexity of the incident, participation varies.

Following a review of the existing literature, consideration of the limitations that undermine the analysis of incident data and forward-planning of how to overcome the possible barriers to success, a careful process of system development guided by the principles laid out above can begin. The following section of this chapter presents the key steps in the process of the development of an incident reporting form and incident collection database ('the system').

3.3 Process of developing an incident reporting tool for financial trading

Following a review of the literature and the tools for collecting and identifying incidents that are used in other high-risk domains, the following section describes the design and development of a similar tool, adapted to the financial trading domain.

3.3.1 Collecting incident reports in financial trading

To perform an analysis of human error on the trading floor, and to isolate data on the non-technical skills required for effective performance, it was necessary to access and collect data on trading incidents. To achieve this, the author designed an incident collection tool comprised of two parts: an incident reporting form (reporting interface) and an incident database (data repository).

The practical design of the tool is driven by the principal features of incident reporting forms found in other domains and described in the first section of this chapter. For example, the collection system is voluntary, confidential and accessible on a web page on the local working stations of employees at the participating organization, and it offers drop-down menus for identifying date and time, risk type categories and teams involved. In addition, there is a freeform text box where staff generate the report in their own words. All of these features were cited in the literature as beneficial attributes to an incident reporting system.

The incident log aims to provide a methodologically sound and theoretically informed system to capture data on the human factors skills that influence error on the trading floor. The vision of the system is a voluntary, confidential mechanism for trading staff to report incidents that they observe within the working environment. The goal of data interpretation is to provide broad trend data to management to help steer the creation of guidelines, raise awareness, develop training protocols and help the organization reflect on past experience in order to improve future risk management and performance. Following the literature review in section one, the aim is to gather ecological narratives reported by expert staff that reflect the nature and complexity of error in this domain (e.g. the multitude of factors that link in the evolution and migration of error, see Table 1 for examples); to provide a reliable and standardized methodology to frame the analysis of the incidents; and to turn the reports into organizational lessons in order to generate meaningful learning outcomes.

Crucially, the constraints to reporting, the implications of underreporting on the efficacy of risk management, and the existence of cultural (e.g. norms and beliefs that management prioritize safety reporting outcomes) and human behaviour variables (e.g. gaps in recollection) as essential determinants of the success of incident reporting systems in the field have been considered prior to undertaking the collection of incident reports.

No analogous system exists; therefore, the work in this chapter develops a novel methodology to understand error in the financial trading domain through the expansion of the current human factors literature to include this domain. The first section of this study identified the key properties that make up the founding principles of the system (e.g. voluntary, non-punitive, confidential, web-based, active and targeted feedback from top to bottom of the organization). The creation of an incident reporting form and collection system in the finance domain contributes to human factors literature and finance literature. In fact, the testing of a system within the participating organization provides original empirical evidence that human factors techniques and methods can be successfully applied in the financial trading domain.

Moreover, the development of an incident collection tool in this domain offers a novel perspective to the risk management literature, offering empirical evidence that incident collection can inform risk management, and theoretical evidence that social and cognitive skills are increasingly found to be relevant in avoiding error and financial loss. The first phase of development of the system, the incident reporting form, is discussed in the following section.

3.3.2 The Incident Reporting Form (IRF)

An incident reporting form (IRF), in its most basic shape, provides a detailed record of an incident that occurs within the workplace, such as a numeric input error on a trading floor. The incident may take two distinct forms: either a *near-miss* – a narrowly avoided, unplanned incident whereby the last defensive barrier within the organization is challenged but upheld; or a *failure* – the state or condition of not meeting the desired operational outcome.

In designing the template for the IRF, the experiences of other error researchers were taken into account, particularly those of the Australian Safety Reporting System (ASRS; developed by the Federal Aviation Administration and NASA (Reynard, Billings, Cheaney & Hardy, 1986). The IRF was designed to include a narrative section to elicit a description of the incident in the reporter's own words, and a multiple-choice section (drop-down menu) to elicit contextual details about the incident regarding ‘what happened’, ‘why it happened’, ‘when and where it happened’ and ‘follow-up actions taken’.

This format of questioning is inspired by the Socratic method of dialectic investigation, whereby a series of questions and answers are used to stimulate critical thinking and draw out ideas and underlying presumptions in the respondents, in this case the trading staff’s beliefs of incident causation. This method, or ‘elenchus’, searches for general, commonly-held truths that shape beliefs, and scrutinizes them to determine their consistency with other beliefs or norms. In its most basic form, elenchus is a series of questions formulated as tests of logic and fact, intended to help a person or group to discover their beliefs about some topic (e.g. incident causation), while seeking to typify general characteristics shared by various particular cases (Vlastos, 1982).

To allow the evaluation of the incident in light of a theory of the psychological basis of human error, the drop-down menu was structured into the following key areas: type of incident, migration of risk, departmental (e.g. staff) involvement (e.g. multi-tier or single team involvement), and suggested corrective strategies.

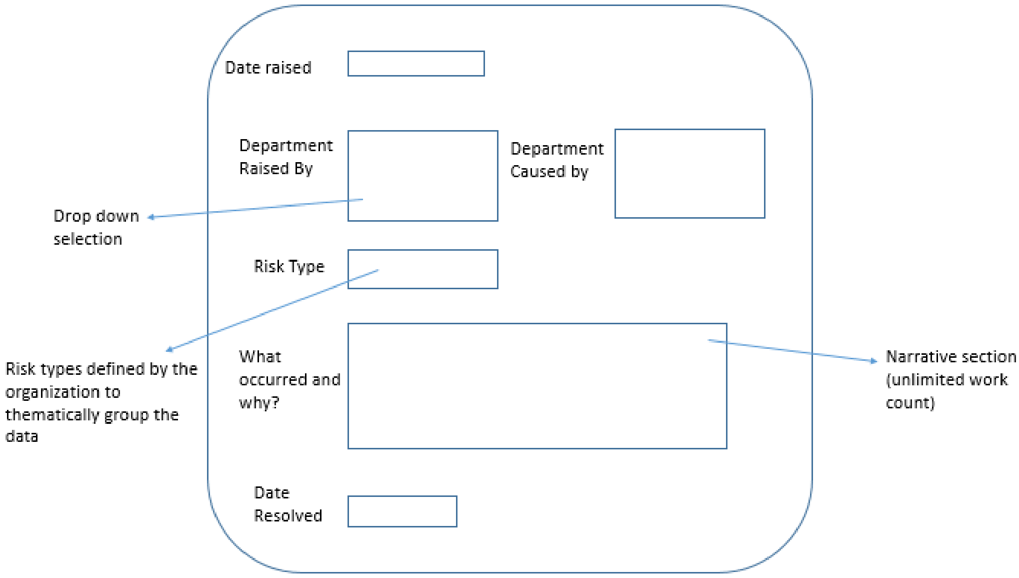

Figure 1: The interface of the incident reporting form used in FINANS

The incident collection tool developed in financial trading captures voluntary, anonymous and self-reported, typically retrospective descriptive data about a mishap or near-miss incident, and aims to group the incidents by error categories. Below, an explanation and justification for the chosen inputs in the IRF is provided.

Date caused and date resolved. Participants are asked to log the date the incident was raised. This could be the date the error was logged, or a date in the past. The date does not default to the current day and must be manually selected from the calendar. The calendar input does not allow for a date entry in the future (day + 1). The date resolved field can be left blank or filled in with the use of the select calendar. The presence of these two categories permits an analysis of when the incident is 'closed' (e.g. detected and dealt with within the day) or indicates if it remains 'open' (e.g. still unresolved).

This contributes to a better understanding of the complexity of the issue, and allows further diagnostics on the number of 'open' and 'closed' incidents within the systems in a given time period. Furthermore, each report is time-stamped in the database, which allows further analysis (e.g. emerging patterns) of when errors and near-misses occur (e.g. during peak workload hours or end of the day) in order to tailor interventions (e.g. scheduling breaks, drawing it to the attention of managers in order to re-balance workloads).

Department caused by/department raised by. These two input variables are in a drop-down format, where the participant can select multiple items. Participants can choose from a selection that includes all trading desks (e.g. grouped by commodity) and trading support teams (e.g. legal, risk control). Additionally, participants can choose local and/or disparate teams (e.g. Liquefied Natural Gas, London and Risk Control, Houston). This is valuable in terms of data analysis as it better reflects the true nature of incidents on the floor (e.g. that they typically involve several teams).

With this information, we can run diagnostics on how the risk migrates on the floor, detect patterns in causation and illustrate frequency of error origination and detection by desk. This is considerably valuable in helping to better understand breakdowns in communication and coordination between specific teams (e.g. risk control and a front office trading desk), as well as highlighting the success or weakness in certain risk management processes (e.g. maintaining standards) and recovery mechanisms (e.g. of near-misses).

Risk type. The participants are asked to classify each incident into a risk type category. This step is not mandatory and may be left blank. In determining the set of standard risk types, a diverse team of trading experts including three traders, one risk manager, three risk control team members and a business applications developer informed the choices to ensure they were reflective of the task work and working environment.

Adopting a grounded theory approach, the group of experts were asked to review a set of randomly selected incidents (n=150) and identify the types of risks (from an extensive list) that emerged from the text to determine the risk categories that they found to be relevant. From here, a set of predisposing risk categories emerged. Following this observation, a drop-down menu with six of the most commonly identified risk types (deal entry error; missing deal in the book; invoicing and confirmation issue; pricing; market parameters; and trading systems/IT bug) was generated.

The risk types usefully help to classify the broad risk trends on the floor and aid in the reporting of events and error trends to management. Importantly, the risk types are reflective of the working environment and task work specific to this domain, and in that way are easily digested by management when presented in the form of monthly reports.

What occurred and why. The expert participants are asked to provide a narrative summary of the incident in their own words in the text box provided. There are no character limits or restrictions (e.g. symbols). In fact, in some cases, the participants input calculations into the field as well as contract stipulations and financial evaluations. The provision of a free-form narrative section promotes a more ecological explanation of the events surrounding the incident, as well as providing a basis for text analysis. Using a form of content analysis, the text can be analysed and indexed in order to identify analytical categories, patterns and emerging themes on a regular basis that describe the incidents.

Feedback reports. Feedback in the form of a Microsoft SQL server report is delivered daily to stakeholders (e.g. senior management, risk managers, reporting staff members), and more in-depth analysis of the incidents is distributed monthly (e.g. thematic analysis, performance by department and risk category). The first page of the report outlines the internally approved definition of operational risk, presents the barriers to reporting that have been identified within the organization, and includes the date and key contact information.

The second page of the report reveals historical trend data by desk, risk type and trading location, both within the reporting year and year on year. The third page presents a more granular analysis of the incidents that occurred within the last three months and within each month specifically, with an analysis of three to five key events. This provides a more nuanced interpretation of the incidents, gathers information on follow-up actions and offers a human factors interpretation of each incident. Most importantly, this report is shared amongst the stakeholders to promote organizational learning, training and awareness of safety and risk on the floor (e.g. to increase perceived utility of incident reporting).

3.3.3 Incident database

The incidents collected using the incident reporting form (IRF) are stored in a database developed using Microsoft Access (2013). Access is Microsoft-based software that allows the user to create desktop databases. This software was chosen because it was readily available on the local workstations within the participating organization, and the author was relatively familiar with how to navigate it. Data is automatically assigned a sequential event number and stored in a Microsoft SQL server database for as long as the program is running. The data stored in the database can be extracted in two formats for analysis: .xls and .csv. The database is password protected and accessible only to the author and a business applications manager on a local computer.

Staff members were given a demonstration of the incident collection tool prior to rolling out the front-end interface (e.g. the IRF) via a presentation to selected trading teams and one-to-one tutorials.

3.3.4 Tutorials and training

To train the trading staff how to report operational incidents, it was decided to adopt an approach using group demonstrations and individual sessions at employee workspaces. The author led group demonstrations on the trading floor; the groups were made up of participants from the trading department (e.g. risk control training, front office training, support services training).

Trading staff were asked to recall incidents on the trading floor during a challenging, non-routine situation, as well as routine incidents that they had experienced. Each incident was discussed among the participating members and a final summary of the event was described (e.g. context, the problem narrative, identifiable solutions). The author then demonstrated to the group how to enter the incident into the IRF. A selection of the discussed incidents is included in Table 1, and is supplemented with a human factors analysis of the skills that underpin the occurrence of the error as well as the skills that helped to avert error. The extracted example (Scenario 2) from Table 1 reveals the type of incident that is reported in the log and discussed during the training:

"Middle office (MO) saw a loss during their morning procedures that created a discrepancy of 93,000 (GBP) between the database and their independent check. MO looked into reasons for this loss and saw that the estimation on a particular deal had moved from the day before (the deal was in the past and therefore should not change). After discussing with the trading systems team, it was discovered that this was due to the book crashing and the opening failing, which in turn caused the parameters on the estimation for the route to be deleted from the beginning of the month. This meant that the book was using the previous version of the parameters, which were out of date, hence the estimation was incorrect, causing a loss. This would have been easily spotted and discovered if MO had access to the database that stores the previous days results and information e, however this was not available as it had been refreshed and displayed what the live book was displaying. The estimation was fixed by entering the correct parameters for the route for the reference day of the beginning of the month. The formula then recalculated and gave the correct estimation, making back 93k£." (Scenario 2, Table 1).

This report usefully indicates the cognitive and manual process that the participant took to detect and avert the near-miss incident evolving into a realised error. Importantly, we discover how the incident was caused by a poor human-computer interface, specifically a lack of system flexibility (e.g. unavailable back-up database) and weak detection mechanism (e.g. to detect errors after a systems outage). Moreover, this example incident reveals the skills that helped to avert error – in particular, teamwork (e.g. communication and coordination of pertinent information between the teams), situation awareness (e.g. gathering of relevant information), and decision-making (e.g. seeking advice from a team member).

This type of data provides insight into how errors are averted on the trading floor through team processes, and sheds new light on the skills that support staff on the floor. In terms of risk management, this importantly supports organizational learning (e.g. in the form of staff training) as well as highlighting how barriers to failure are not necessarily system-based but team-based. Each training session was followed up with a question and answer session with the author. The author completed three group trainings on the floor with separate trading teams (e.g. risk control training, front office training, support services training). Each training session lasted approximately 1.5 hrs.

Due to the constraints of the working environment and the difficulty for all staff to attend a group training session, the author offered individual training sessions with some participants. The structure of the training was similar to the group sessions and held at the participant's workstation. All participants were given a booklet containing examples of logged incidents and instructions on how to access and log incidents.

3.3.5 Monthly reporting and feedback

A Microsoft SQL server report generated in the SQL server reporting services that builds a report that is sent out each morning (07h00 GMT) to the risk managers and supervisors, detailing the ten most recently logged incidents. Furthermore, the author publishes a monthly report that is sent by email to senior management and risk control participants. The report outlines several data metrics such as historical trends, the evolution of patterns of incidents, and feedback on solutions. The report is generally a three to four page PDF document; the first page is a title page, the second page details the historical incident analysis and the location of the incidents (e.g. which teams are reporting error and which teams are causing error), and the third and fourth page provide a text-based description of incidents that occurred within the reporting month, in addition to potential or realized solutions. Figure 2 illustrates a sample of the analytics provided in the reports.

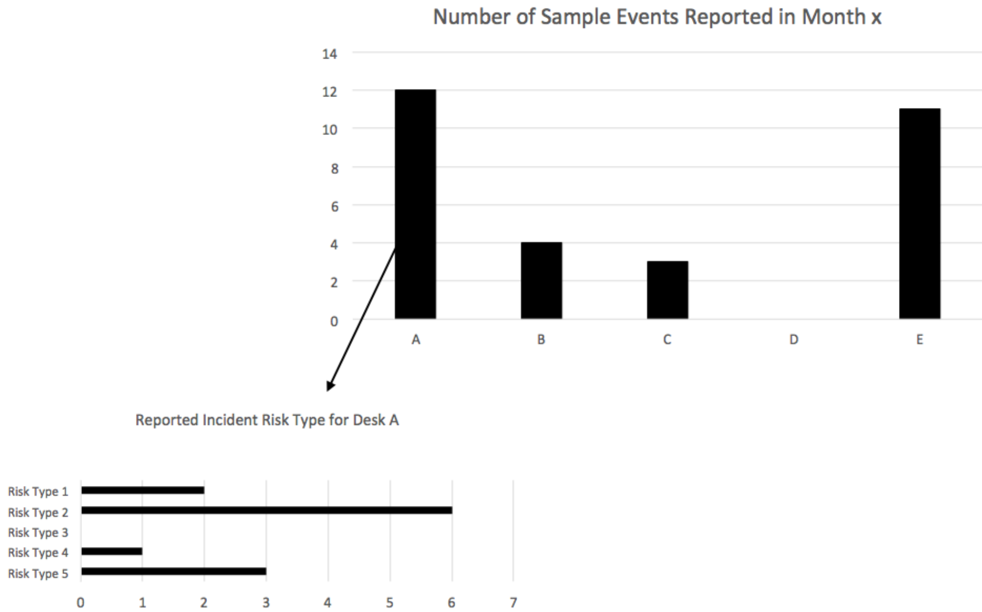

Figure 2: Sample analytics in a monthly report (Leaver, 2017).

The analytics provide a graphical visualization of the types of risks that occur on the floor and their frequency, as well as the location of the errors that are reported and the most common causal location (e.g. which desks cause most error, which desks 'capture' error).

Oftentimes, as expected, error originates in the front office (e.g. risk taking) and is ameliorated by the trading support function (e.g. back office and middle office). The reports inform management about weaknesses in the defence against error (e.g. system maintenance and complexity) and essentially provide insight into the defences that work well (e.g. team coordination and communication). The outcomes of these reports support managerial decision-making regarding team training and the distribution of resources (e.g. staffing and workload distribution, system migrations), as well as highlighting the migration of error and revealing the existence of 'safety nets' in practice and daily processes.

3.4 Conclusion

In this chapter, the development of a system for capturing, monitoring and analysing operational incidents in the financial trading domain is described. The methodological work that has been described forms the core of the PhD thesis – specifically, through the development and early testing of an operational incident and analysis tool for financial trading, the Financial Incident Analysis System (FINANS). Drawing on current literature detailing successful collection tools developed in other high-risk domains such as aviation, healthcare and rail, the features of an 'ideal' electronic reporting form and database were identified and utilized in the design and development of FINANS.

The central purpose of creating FINANS is to collect self-reported data on incidents (e.g. errors and near-misses) that occur in the financial trading domain in order to identify the core competencies (e.g. the non-technical skills) that cause or capture error on the trading floor. This type of data usefully reveals trends and broad descriptions in error occurrence (e.g. location of primary error generation, peak times for error occurrence), as well as illuminating the detection mechanisms (e.g. skills and processes that help to avert error).

Crucially, within financial trading, there is no precedent for incident reporting in terms of either methodology for collecting incident data, or defining and understanding what constitutes an incident. Therefore the methodology described here contributes to original research in this domain. Moreover, these findings can be utilized to support management decision-making and risk management more generally; for example, through actions such as the support of organizational learning initiatives (e.g. in the form of targeted staff training), the reallocation of resources (e.g. staff or capital), redistribution of workload during peak times and environmental modifications (e.g. updated seating charts to foster knowledge sharing amongst critical teams, updated workstations).

The limitations of the tool are similar to those found in other high-risk domains, principally the effects of human observer bias and the fact that every aspect of performance cannot be captured (e.g. the trading staff’s ability to self-report and report on incidents where they were involved). Critical to the effective operation of the incident collection tool is the development of an incident analysis system to analyse the events through a human factors lens.

The next study reports on the development and testing of the Financial Incident Analysis System, FINANS. FINANS is designed with two aims in mind: first, to facilitate the extraction of human factors-related (and in particular non-technical skills) data from the incident log. The second aim is to create a system that can be used by trading companies more generally to analyse trading incidents. The use of such a system is common to many industries (e.g. aviation, healthcare), where human factors specialists have developed error analysis systems for the initial capture of baseline data (i.e. on the types of factors underlying error), to be used by trained and domain-expert staff in organizations (Helmreich, Merritt, & Wilhelm, 1999; Shappell & Wiegmann, 2001).

4. Human Factors in Financial Trading: An Analysis of Incidents

4.1 Preface

The third study of the thesis presented in chapter 4 (article 2), entitled "Human Factors in Financial Trading: An Analysis of Trading Incidents", examines i) the frequency and consequences of operational incidents in financial trading; and ii) the role of non-technical skills and other human factors issues that contributes to them. Through the process of analysing incidents, the reliability and validity of the FINANS methodology is tested.

This aim is addressed in a two-part study presented in chapter 4 (article 2). The study reports on the application of the FINANS, which was designed to achieve three goals: first, to provide a standardized method for collecting data on operational incidents that occur on the trading floor; second, to develop a reliable method for analysing and extracting human factors-related contributors to operational incidents; and third, to provide practical insight into how these contributors might be ameliorated.

This is important because incident reporting helps to identify threats to safety and organizational performance, and the collection and interpretation of incident data has the potential to identify a range of warning signs. This research provides data crucial for ameliorating risk within financial trading organizations, with implications for regulation and policy.

Traditionally, human factors theory has been applied in safety-critical domains (e.g. aviation, healthcare, nuclear), and this study marks an expansion of current empirical and theoretical applications of human factors theory to a high-risk (but not safety-critical) domain. Furthermore, the work undertaken in this chapter reconceptualizes the way financial trading is considered, providing key evidence about the social and cognitive nature of error in this domain.

The journal article that follows was authored by Leaver and Reader (2016) and published in the journal of *Human Factors*. Leaver designed the study, carried out the data collection and analysis, outlined the article and authored the main drafts, contributing to roughly 85% of the content. Reader provided key supervisory assistance and editorial suggestions, and acted as a second coder for 50% of the data analysis. Reader contributed to roughly 15% of the content. Three anonymous reviewers (experts in the field of human factors) provided critical feedback, suggested edits and ultimately approved the article for publication.

Copies of participant instructions and other materials used to conduct the studies in this chapter can be found in the appendix of this thesis.

Human Factors has an impact factor of 2.219, and is ranked 29/80 in Psychology, Applied and 3/16 in Ergonomics journals.

Human Factors in Financial Trading: An Analysis of Trading Incidents

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Objective: This study tests the reliability of a system (FINANS) to collect and analyze incident reports in the financial trading domain and is guided by a human factors taxonomy used to describe error in the trading domain.

Background: Research indicates the utility of applying human factors theory to understand error in finance, yet empirical research is lacking. We report on the development of the first system for capturing and analyzing human factors–related issues in operational trading incidents.

Method: In the first study, 20 incidents are analyzed by an expert user group against a referent standard to establish the reliability of FINANS. In the second study, 750 incidents are analyzed using distribution, mean, pathway, and associative analysis to describe the data.

Results: Kappa scores indicate that categories within FINANS can be reliably used to identify and extract data on human factors–related problems underlying trading incidents. Approximately 1% of trades (n = 750) lead to an incident. Slip/lapse (61%), situation awareness (51%), and teamwork (40%) were found to be the most common problems underlying incidents. For the most serious incidents, problems in situation awareness and teamwork were most common.

Conclusion: We show that (a) experts in the trading domain can reliably and accurately code human factors in incidents, (b) 1% of trades incur error, and (c) poor teamwork skills and situation awareness underpin the most critical incidents.

Application: This research provides data crucial for ameliorating risk within financial trading organizations, with implications for regulation and policy.

Keywords: financial trading, human error, system design, risk, teamwork, situation awareness

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INTRODUCTION

Financial trading organizations buy and sell products (e.g., equities, physical commodities, financial options) in order to generate profit and optimize their portfolios. Large-scale failures (e.g., Société Général, UBS, JPMorgan) have resulted in multibillion-dollar fines from regulators and have undermined the global economy. Investigations into their causes have highlighted problems in organizational culture (e.g., risk taking) and "rogue traders" who manipulate rules and systems. Increasingly, however, the role of human factors–related issues in managing risk within financial trading are also considered, with parallels being drawn between the financial trading industry and other "high-risk" industries (Young, 2011). For example, investigations of trader performance have highlighted the importance of nontechnical skills (cognitive and social skills that underpin performance), human error (e.g., attention), and human–computer interfaces for influencing performance in financial trading (Ashby, Palermo, & Power, 2012; Fenton-O'Creevy, Nicholson, Soane, & Willman, 2003; Leaver & Reader, 2015; Willman, Fenton-O'Creevy, Nicholson, & Soane, 2002). This outcome is similar to many other high-risk sectors (e.g., nuclear power, aviation, health care), yet relatively little is known about the link between human factors–related problems and incidents in trading (e.g., how many incidents occur and the causes of them).

In this article, we report on the development and application of the Financial Incident Analysis System (FINANS). This is the first system developed to (a) collect voluntary operational trading incident reports (where trading activity results in an avoidable financial loss, for example, due to poor decision making or a compliance breach: Zhao & Olivera, 2006) from employees working on financial trading floors and (b) analyze incidents in order to identify the human factors issues reported within them. In this study, we test the reliability of FINANS and apply it to examine the nature and prevalence of incidents caused by human factors–related problems in a trading organization.

Human Factors and Financial Trading

Financial trading is an inherently complex and risky domain. Traders make high-stakes decisions within complex, large, noisy, high-pressured, and technologically advanced environments. They aim to generate profit for the organization and its stakeholders, and to do so, they must monitor market information (e.g., through screens), interact virtually and physically with other traders and stakeholders, make rapid investment decisions, and ensure that rules and procedures are followed (e.g., trading limits). Effective traders have good technical and nontechnical skills; however, the complexity and pressure of trading lead to error and risk taking (Leaver & Reader, 2015). This combination can result in "operational incidents," whereby trading activity results in an avoidable financial loss (e.g., making a trade without assessing market-related risk) or compliance failures (e.g., breach of trading limits), which place the integrity of the financial organization at risk even if no loss has occurred (e.g., overexposure to volatile markets; Zhao & Olivera, 2006). Crucially, such events are typically caused not by rogue traders (employees making unapproved financial transactions) but by systemic problems across an organization (e.g., failure of the system to generate breach reports, inaccurate reporting on risk) that impair human performance (Leaver & Reader, 2015).

Thus, financial trading is increasingly conceptualized as similar to a high-risk industry (Sutcliffe, 2011; Young, 2011), with risk constantly being monitored and, when possible, reduced. However, unlike many high-risk industries, the success of financial trading organizations hinges on overt risk taking by traders (as it leads to a competitive advantage). This feature of the domain is consistent with Amalberti's (2013) description of an "ultra-resilient" organization, where rather than engineering risk out of a system (e.g., through automation), risk is managed through improving employee skills and system design. Typically, this improvement is achieved through gathering data on mishaps and examining the role of human performance and system design in those incidents. Yet, to date, no system exists for capturing operational incidents in financial trading and analyzing the human factors–related issues that contribute to them (Leaver & Reader, 2015). To address this gap in the literature, we report on the development and application of the first tool for capturing and analyzing human factors–related operational incidents within financial trading: FINANS.

Using incident reports to investigate human factors in financial trading. Investigations into how human factors–related issues influence the management of risk within complex industries often begin with the examination of incidents (e.g., mishaps, near misses) and their causes (Barach & Small, 2000), because such analyses are useful for understanding recurrent and systemic problems in risk management. Incident-reporting systems can lead to insight on the number and types of incidents occurring within an organization, their consequences, and the complex network of issues (e.g., errors, skill gaps, resources) that underpin them. Incidents are often collected through incident-reporting systems, whereby employees submit a narrative text and/or structured report on incidents they observed or participated in. Reports describe the types of events that took place (e.g., mechanical, procedural), the personnel involved (e.g., identifying the teams), the activities leading to the incident (e.g., behaviors), and how the event was detected (e.g., system, observation). Incident reports can be anonymous or identified, can triangulate with existing monitoring systems (e.g., instrument data), or can be the primary source of data on mishaps (e.g., in health care). Crucially, to be effective, incident monitoring systems rely on good procedures for capturing incidents (e.g., independent, with nonpunitive results), high-quality data (e.g., freeform narratives that provide an ecological explanation of the event), strong analysis (through coding frameworks that identify causal factors), and robust feedback and learning mechanisms (e.g., for developing interventions, organizational learning) (Mahajan, 2010).

Incident-reporting systems have been used extensively to identify and understand safety problems in a number of high-risk industries. For example, the Aviation Safety Reporting System (ASRS; developed by the Federal Aviation Administration and National Aeronautics and Space Administration [NASA]) is a voluntary and confidential incident-reporting system used by pilots and engineers (via a Web-based platform) to report near misses and incidents (Billings, 1998; Helmreich, 2000). These data are used to understand the role of employees and systems in detecting and coping with incidents and to identify systemic and growing threats to safety. In other industries, for example, health care, incident-reporting systems have also become relatively commonplace although are generally not as developed as in aviation (Itoh, Omata, & Anderson, 2009; Wu, Provonost, & Morlock, 2002). For example, in health care, staff often experience cultural barriers in reporting incidents, and poor attitudes on incident reporting can limit institutional learning (Anderson, Kodate, Walters, & Dodds, 2013; Waring, 2005). Furthermore, in aviation, incident-reporting methodology has continuously evolved, for example, through the presence of a "callback" function that serves to gather additional information by interview prior to anonymization (NASA, 1999).

To understand and learn from incident reports, people tend to analyze them using reliable and theoretically derived taxonomies that classify the types of problems (e.g., error, skills, and systems) that contributed to an incident (Baker & Kronos, 2007; Barach & Small, 2000; Olsen, 2011; Vincent & Amalberti, 2016, Chapter 5). Such taxonomies should be tailored to the industry and should utilize human factors concepts to codify data on the types of incident experienced by operators (e.g., their technical nature, their outcomes), the workplace problems that lead to them (e.g., human–computer interfaces), and the skills and behaviors important for a work domain (e.g., in team vs. noncollaborative roles). The data collected can be used to collect headline data on incident occurrences within a given industry—for example, that in surgery, 43% of incidents involve team communication problems (Gawande, Zinner, Studdert, & Brennan, 2003) or that in military aviation, errors are more likely in rotary than in fixed-wing aircraft (Hooper & O'Hare, 2013). Furthermore, incident reporting is used to identify in-depth data on the causes of specific forms of mishap that can be used to develop interventions (e.g., new software, training), or for example, aspects of system design that lead to errors in the flight cockpit (Billings, 1999; Moura, Beer, Patelli, Lewis, & Knoll, 2016) or aspects of clinician behavior that either contributed to an adverse event (e.g., loss of situation awareness) or helped to avert it (e.g., teamwork skills; Schulz, Endlsey, Kochs, Gelb, & Wagner, 2013; Undre, Sevdalis, Healey, Darzi, & Vincent, 2007).

In summary, the incident-reporting literature highlights a number of principles for how incidents should be collected, analyzed, and used to influence safety-related practices. We apply these principles to develop a system for investigating operational incidents in financial trading.

FINANS

In the current study, we report on FINANS, which was designed to achieve three principle goals: first, to provide a standardized method for collecting data on operational incidents that occur on the trading floor; second, to develop a reliable method for analyzing and extracting human factors–related contributors to operational incidents; and third, to provide practical insight into how these contributors might be ameliorated. In the scope of this paper, we consider human factors as aspects of human performance and system design that contribute to problems in managing risk in financial trading.

FINANS comprises two parts. The first part is an "incident log" for capturing operational incidents on the trading floor. To recap, an incident in this context is an event that did lead or could have led to losses or unwanted market or credit exposure. Incidents can be wide ranging and can include technical systems failure (e.g., pricing tool failures), erroneous human input errors, misunderstandings of instructions or strategy between departments (e.g., between a trader and his or her risk department), and rule violations (e.g., late trade entry). Drawing on previous research, we use a Web-based design (Macrae, 2007; Mahajan, 2010; Wu et al., 2002). The system is accessed online, with reports being voluntary and anonymous (unless trading

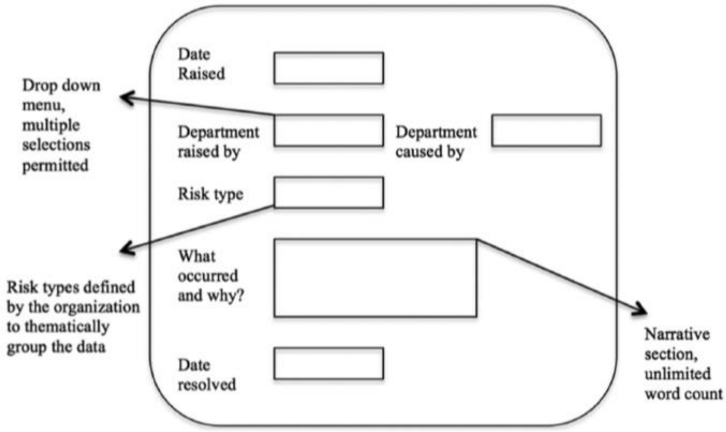

Figure 1. Graphic of the Financial Incident Analysis System (authors' own rendering).

staff wish to identify themselves) due to the generally accepted negative culture toward "whistleblowing" and admitting error in the financial trading industry (Atkinson, Jones, & Eduardo, 2012; Keenan & Krueger, 1992).

Trading staff complete a reporting form, which includes a narrative section for eliciting a description of the incident in the staff's own words and a drop-down menu section to elicit contextual details about the incident, for example, whether it was resolved or ongoing and the departments involved. The risk type drop-down menu provides a focus on key risks defined by the organization and helps to create specific and detailed reporting criteria that can evolve over time to meet the changing risks of the firm. This design utilized observations that the common language provided by taxonomies in addition to free-text narratives can retain the richness of narrative reports and at the same time allow for systematically organizing and analyzing the reported data (Macrae, 2016; Holden & Karsh, 2007). Figure 1 is a graphic representation of the reporting form.

The second part of FINANS is a taxonomical system for interpreting incidents and near misses in terms of contributory factors. This system consists of three parts.

1. Based on incident analysis frameworks in aviation, military, and health care (Mitchell, Williamson, & Molesworth, 2016; O'Connor, O'Dea, & Melton, 2007; Wiener, 1993), a framework for codifying problems in nontechnical skills was developed. Nontechnical skills are the cognitive and social skills that complement a worker's technical skills and underpin safe activity in high-risk environments (Flin et al., 2003). Research has shown their importance for managing risk on the trading floor. For example, the decision-making strategies of successful traders can be understood utilizing theory on situation awareness (e.g., information-gathering strategies, comprehension of complex market data, and course of action) and teamwork (e.g., communication on trading). The taxonomy was primarily based on a systematic review of nontechnical skills in financial trading (situation awareness, decision making, teamwork, leadership) and their association with good and poor trader performance (Leaver & Reader, 2015).
2. Drawing on error theory and other incident reporting systems (Reason, 1990; Saward & Stanton, 2015), we collected data on slips and lapses. Slips and lapses occur as a failure of execution of the intended task, whereby the actions deviate from the current intention (Reason, 1995). Slips are observed actions and are typically associated with attentional failures. Within FINANS, an example of this type of error is classified as "fat fingers," whereby, for example, the trader accidently enters an extra zero to the pricing of a deal. Lapses, on

the other hand, are associated with more internal events (e.g., failures in memory, distraction), and they can also influence performance in trading (e.g., during high-volume trading, the trader can forget to follow procedures, such as recording data on a trade).

3. Utilizing the ergonomics literature (Stanton, Salmon, & Rafferty, 2013), data on problems with human–computer interactions were also coded. *Human–computer* (or *human–machine*) *interaction* refers to the errors associated with the incomplete interpretation of system input and outputs as well as the flaws or inadequacies in system design that limits the user's performance (Lang, Graesser, & Hemphill, 1991; Newell & Card, 1985; Rasmussen & Vicente, 1989). The successful interaction of human and computer is crucial in high-technology domains, such as trading, whereby the incorrect interpretation of data output (such as risk variation) can lead to traders' taking the wrong position and potentially large losses or unwanted risk exposure.

It is notable the taxonomy consists of "category" and "element" levels. Categories function at a relatively generic level (e.g., situation awareness), and elements reflect aspects of activity specific to the trading floor environment that illustrate the categories (Flin, O'Connor, & Crichton, 2008). The list of categories and elements within the first-stage FINANS taxonomy is shown in Table 1.

Subject matter experts (SMEs) were involved in the development of the taxonomy, and a preliminary pilot (prior to Study 1) was used to determine whether SMEs agreed with the overall usefulness and fitness of the taxonomy to the incidents. For example, feedback from the SMEs led to the incorporation of further systems elements. To analyze operational incidents reported through FINANS, the subsequent procedure was followed. On an incident being electronically reported by a trading floor employee, a human factors expert reviewed the details and short description, and a risk type was assigned. Risk types are defined by the risk control team and are used for the categorization of the data in the monthly reporting of incidents and can change over time to address the current concerns of the organization (e.g., systems glitch, data entry error, late confirmation of a trade, physical risk leading to force majeure). The narrative text describing the incident was then analyzed using the FINANS taxonomy in order to identify any human factors–related antecedents to the incident.

To test and apply FINANS, we report on two studies using the system. The purposes of the studies were

1. to test the reliability (e.g., interrater reliability) of using the FINANS coding taxonomy to classify human factors–related problems described within operational incidents reported in financial trading (Study 1) and
2. to describe the nature and prevalence of human factors–related problems underlying operational incidents in financial trading (Study 2)

STUDY 1

In this study we test the reliability and usability of the FINANS coding taxonomy (Table 1) for classifying human factors–related problems described within operational incidents reports. Drawing on incidents collected through FINANS, we compare whether different coders perceive similar issues within an error report or incident when applying FINANS. Because FINANS is designed to be used by trading staff to analyze incidents (i.e., that they need not rely on a psychologist), and to reflect the types of errors and problems they experience, in the current study a group of expert trading staff (N = 19) applied the coding framework to analyze 20 incidents. To assess reliability, we examine the interrater reliability of coding by trading staff for the system as a whole, individual categories, and the elements underpinning each category (Butterfield, Borgen, Amundson, & Maglio, 2005). We also examine whether expert participants analyzed incidents in a similar fashion to human factors experts (through creating a "referent" standard) in order to assess whether domain experts unfamiliar with human factors concepts can use the taxonomy in the manner intended (Gillespie & Reader, in press).

Method

To test the reliability of the taxonomical system for interpreting incidents that occur on the

TABLE 1: FINANS Taxonomy

Category	Associated Elements
Situation awareness	• Attention (distraction, lack of concentration, divided or overly focused attention) • Gathering information (poorly organized information, not enough gathering of information) • Interpretation of information (miscomprehension, assumptions based on previous experience) • Anticipation (i.e., thinking ahead, judging how a situation will develop) • Other
Teamwork	• Role and responsibilities (e.g., unclear segregation of roles) • Communication and exchanging of information between team members • Shared understanding for goals and tasks • Coordination of shared activities • Solving conflicts (e.g., between team members and teams) • Knowledge sharing between teams • Other
Decision making	• Defining the problem • Cue recognition (e.g., finding and recognizing the cues to the decision) • Seeking advice on a decision • Noise and distraction (e.g., that reduce capacity to take a decision) • Bias and heuristics (e.g., overoptimism, overconfidence) • Other
Leadership	• Authority and assertiveness (e.g., taking command of a situation) • Listening • Prioritization of goals (e.g., team/organizational) • Managing workloads and resources • Monitoring activity and performance of team members • Maintain standards and ensuring procedures are followed • Other
Slip/lapse	• "Fat fingers" • Procedural (not following a protocol or following a protocol incorrectly) • Routinized task (e.g., a loss of concentration) • Forgetfulness (forgetting information or how to perform an activity) • Memory • Distraction • Other
Human–computer interface	• Use of the tools (e.g., spreadsheets) • Training on the tool • System did not detect the error • Design of the software and application • Maintenance and testing of the tool • Other

Note. FINANS = Financial Incident Analysis System.

floor, an expert user group was recruited from within the participating organization: a leading energy trading firm active in both physical and financial commodity markets. Hedging products include forward contracts, swaps, vanilla options, over-the-counter and exchange-based transactions, and derivatives and futures contracts. Approximately 37,500 transactions are booked with the exchange or over the counter annually on a spot (prompt), medium (futures/forward), or long-term (contract) basis. The sample consisted of three trading managers, two trading supervisors, and 14 midlevel trading staff. Using the FINANS taxonomy, the user group analyzed 20 incidents selected from the incident log. Incidents were selected on the following criteria:

1. At least one of the FINANS categories was evident in the scenario.
2. Each of the teams was represented.
3. The incidents covered frequent and infrequent error types.

The scenarios were presented sequentially and through the Web-based interface. Participants read each scenario and, using an online coding form, indicated which FINANS categories and subcategories (e.g., elements) were contributory to the scenario. In addition, a referent standard was developed by two human factors experts, who coded the 20 incidents separately and then reviewed the incidents again to resolve any differences in coding (and to outline a final set of codes for each incident).

Prior to coding, participants were given a 1.5-hr background tutorial on human factors research and the concepts underlying the FINANS system. Although this tutorial falls below the recommended training time of 3 hr (O'Connor et al., 2002), time constraints in releasing trading staff from their work during market hours (and also asking them to code 20 incidents) meant training was limited. To compensate for this limitation, the initial training was supplemented with a training document distributed to each participant detailing human factors definitions and examples of incident analysis. Moreover, the principal study investigator, whom questions could be directed to, was present in the workplace.

Analysis

The data analysis consisted of comparisons between respondents within the user group (to test interrater reliability) and between respondents and the referent standard.

We ran the following analyses. First, to examine the interrater reliability of the referent users (e.g., the human factors experts), we applied a Cohen's kappa. Cohen's kappa coefficient is a statistic that measures interrater agreement for two raters for qualitative (categorical) items and takes into account the agreement that may occur by chance (McHugh, 2012). Second, to establish interrater reliability among the expert users, we applied a Fleiss kappa (Fleiss kappa is applied to extract the nominal scale agreement across many raters; Fleiss, 1971). We also used this statistic to examine the interrater reliability between the referent ratings and the expert user group. It is suggested that kappa results can be interpreted as values $k \leq 0$ indicating no agreement; $0.01 \leq k \leq 0.20$, none to slight; $0.21 \leq k \leq 0.40$, fair; $0.41 \leq k \leq 0.60$, moderate; $0.61 \leq k \leq 0.80$, substantial; and $0.81 \leq k \leq 1.00$, almost perfect agreement (Fleiss, Cohen, & Everitt, 1969; McHugh, 2012).

Results

First, we examined the reliability of coding for the two human factors experts, from which the referent standard was generated ($k = 0.894$).

Second, we examined the reliability of coding within the expert user group. Overall, we found good reliability for applying the FINANS taxonomy at the categorical level ($k = 0.840$). However, greater variance was found in the reliability of coding at the element level ($k = 0.453$). This finding is consistent with previous empirical studies in other high-risk domains (Baker & Krokos, 2007; Yule, Flin, Paterson-Brown, Maran, & Rowley, 2006). We summarize the findings next through considering the categories and subcategories of the taxonomy that had low versus high reliability.

Low reliability. Consistently low reliability was noted across the element subcategories: procedural (slip/lapse category), $k = 0.400$; authority (leadership category), $k = 0.400$; roles and responsibilities (teamwork category), $k = 0.400$; and anticipation (situation awareness category), $k = 0.348$. Elements that were not able to be calculated via the kappa method due to an absence of data (e.g., they were never chosen in the coding exercise), were problem definition, cue recognition, selecting a course of action, noise and distraction (all decision making), use of tools (human–machine interface category), solving conflicts (teamwork category), prioritization, monitoring, listening, and managing workload and resources (within the leadership category).

High reliability. All categories were reliably estimated with a range of kappa scores from $k = 1.0$ (decision making) to $k = 0.8$ (slip/lapse). Elements were also found to be statistically significant, with interrater reliability ranging from $k = 0.655$ (human–machine interface elements) to $k = 0.859$ (teamwork elements). The within-group elements did not test as reliably across all elements within the cases. The highly reliable elements are gathering information, $k = 0.8$ (situation awareness); system design, $k = 1.0$; maintenance of the system, $k = 0.696$; training of the tool, $k = 0.696$; detection of the tool, $k = 0.696$ (human–machine interface); knowledge sharing, $k = 1.0$; communication, $k = 1.0$; coordination, $k = 0.769$; shared understanding, $k = 1.0$ (teamwork); maintaining standards and procedures (leadership), $k = 0.65$; fat fingers, $k = 0.783$; forgetfulness, $k = 0.737$; and routine task $k = 1.0$ (slip/lapse category).

Overall, high reliability was observed for the category and elements within the teamwork, slip/lapse, situation awareness, and human–machine interface skill sets. Lower reliability was observed for the leadership and decision-making categories.

Finally, the kappa agreement when analyzing the reliability between the reference ratings ($n = 2$) and the expert ratings ($n = 19$) for each FINANS category was good ($k = 0.871$).

Discussion

This study was designed to test the reliability of the FINANS taxonomy for codifying incident reports in the financial trading domain. Given the limitations in training, the results are encouraging and suggest that the human factors problems underlying error in the financial domain can be reliably identified and extracted by trained experts in financial trading. In establishing statistically significant reliability, we can confirm that experts generally agree on the human factors problems underlying operational incidents in financial trading and that the frame of reference held by these experts can be validated (Leeds & Griffith, 2001). This finding is important for demonstrating the appropriateness of FINANS for analyzing operational incidents within financial trading (i.e., it fits to the needs of the domain and its users) and indicates it can be administered with light-touch support. Most crucially, FINANS provides a reliable tool through which to examine the role and extent of human factors–related problems underlying operational incidents in financial trading. This tool has the potential to provide data crucial for identifying, understanding, and ameliorating risk within financial trading organizations. Yet, as indicated in the results, some of the categories and subcategories within FINANS tend either to not be used reliably (e.g., the procedural element within slip/lapse category) or to be used very minimally. This finding indicates FINANS requires further refinement, and we examine this issue further in study 2.

STUDY 2

In Study 2 we examine the nature and prevalence of human factors–related problems underlying operational incidents in financial trading. We refer to the incidents as "operational" to remain consistent with terminology in the financial domain used to describe error reporting and investigation. At present, relatively little is known about the types of human factors–related incidents that occur in financial trading or, indeed, the number of incidents that occur relative to total transactions. This finding compares poorly to other domains, for example, aviation, where the number of incidents and fatalities in relation to the number of flights per year is systematically documented (Boeing, 2014). We used FINANS to collect and analyze operational incidents in a large financial trading company over a period of 2 years. The analysis was conducted with four principle aims: (a) to provide data on the number of trades that lead to an incident, (b) to identify the distribution of human factors problems within the cases, (c) to provide evidence on the outcomes of these human factors problems, and (d) to explore the co-occurrence of human factors codes in the data set (i.e., clusters of problems that occur together). In addition to these aims, we utilized the larger data set to further refine the FINANS taxonomy.

Method

FINANS was used to collect incident reports in the participating organization over a period of 2 years (from January 2013 until January 2015). Prior to study commencement, and with the support of the organization, trading floor staff were given presentations of the incident collection log as well as practice entries and demonstrations by a human factors expert (separate to the reliability study, although all participants in the reliability study were present during the briefings). Presentations and demonstrations were approximately 1 hr in duration (given four times due to turnover in teams and "maturing" incident reports). Following each reporting month, a trained human factors expert provided feedback reports (e.g., histogram and patterns of events by risk type, deconstructed complex events, incidents, and solutions for four to five logged incidents from the month of reporting) to the participating staff and management. Over this period, approximately 750 unique incident reports (i.e., each incident reporting on a problematic trade was different) were collected and deemed suitable for analysis (e.g., clear text).

Of the 750 incidents, the lead author coded all the cases; a further 375 (50%) cases were coded by the second author to provide a reliability assessment for coding. These cases were randomly selected from the batch. The coding process was made up of 8 steps: (1) identification of the incident type (e.g., slip, mistake, violation), (2) selection of the relevant human factors category (e.g., situation awareness, decision making, teamwork, leadership, human–computer interface, or slip/lapse), (3) the selection of the relevant subcategory (e.g., element) of nontechnical skills (e.g., if situation awareness is chosen as a main category, the element[s] can be selected from distraction, gathering information, interpreting information, and anticipation of future states), (4) identification of single team or multiple team, (5) identification of an ongoing state or isolated nature of the incident, (6) reporting whether the incident was a near miss or a failure, (7) identification of the trigger of the incident (e.g., a text box entry), and (8) filling in the blanks in the following sentence: "The main cause of the issue is [blank], and is caused by [blank]."

Analysis

Descriptive analysis. First, we calculated the number of erroneous trades identified by the system in relation to the total number of trades within the organization. Second, we used Cohen's kappa to calculate the reliability of the second coder against the first coder for 375 cases. Third, we described the distribution of human factors problems using frequency and mean calculations for the categories and elements with FINANS, including category and elements that are not reliably coded or not coded for in the $n = 750$ cases.

Serious incident analysis. Next, we adopted a pathway analysis within SPSS to determine whether the incidents classified as near miss or failure had a common set of human factors antecedents. Pathway analyses describe all the variations of the coded data and then are used to predict whether some codes or sets of codes significantly predict an outcome (e.g., financial loss).

Associative analysis. Third, through bivariate correlation and backward likelihood ratios, we conducted an associative analysis to examine co-occurrence of FINANS category codes within incident reports (e.g., to establish whether there are certain patterns of codes that occur together). The importance of investigating the co-occurrence of codes was revealed when we observed how the data were repeatedly coded for multiple human factors codes, and thus this part of the investigation is exploratory.

Results

Descriptive analysis. Financial trading staff reported 750 incident reports through FINANS. This number equates to 1.08% of transactions within the company. Across the total data set, 70% of incidents were a near miss (an error did occur but was detected and fixed by system controls), and the majority of incidents (90%) involved activity distributed across more than one team.

Of the incidents coded by both the lead author and second author (n = 375), good overall reliability was found using Cohen's kappa (k = 0.78). All incidents had at least one code from the FINANS taxonomy applied to explain the incident (e.g., incidents can be coded as multiple categories and elements). At the category level, the reliability was generally good, with the exception of decision making. Substantial reliability was determined for leadership (k = 0.83), teamwork (k = 0.79), slip/lapse (k = 0.72), situation awareness (k = 0.72), and human–computer interface (k = 0.67). Moderate reliability was determined for decision making (k = 0.49). Elements were also coded for each case. At the element level, the reliability was disparate, ranging from good to poor or not applicable. High-reliability elements included maintenance and testing (k = 0.77; human–computer interface category), roles and responsibilities (k = 0.62; teamwork category), and maintaining standards (k = 0.65; leadership category). Acceptable-reliability elements included attention (k = 0.57; situation awareness) and communication (k = 0.48; teamwork). Similar to Study 1, several elements were never or rarely coded, which led to poor reliability (k < 0.4). These elements included bias and heuristics, listening, goal prioritization, managing workload, monitoring activity, memory, and training; and many elements were coded interchangeably, which led to poor reliability. The implications are explored in the discussion.

In terms of applying FINANS taxonomy to the incidents, Table 2 provides a fine-grained analysis of the frequency and percentage for each human factors category and element used to classify human errors. To illustrate the context of data collection (and the potential for intervention), and the types of problems being codified using the FINANS taxonomy, qualitative examples are included within Table 2.

Table 2 shows that over half of incidents involve a slip/lapse or situation awareness problem. Within these subcategories, the most common elements were fat fingers (40%) and attention (56%). Teamwork problems were identified in 40% of incidents, with coordination being the most commonly coded element (30%). The least coded category was decision making (3.6%). In terms of elements, the most commonly coded was attention (213), followed by fat fingers (185) and coordination (87). Again, some elements were never coded; these included noise, seeking advice on a decision, and the prioritization of goals. Similarly, some elements were rarely coded, such as authority and assertiveness, problem definition, software design, and manage workload. Furthermore, elements within more commonly applied categories (e.g., distraction within the slip/lapse category) were also rarely used.

In terms of refining FINANS for future use, a number of observations might be made. Table 1 indicates a number of rarely occurring elements (e.g., training in human–computer interaction, authority and assertiveness in leadership). This finding is consistent with the data in Study 1, and these elements might be removed or amalgamated with other elements (e.g., use of tools, maintaining standards) in future iterations of FINANS. Furthermore, the larger reliability exercise conducted for Study 2 indicates some subcategories to demonstrate low reliability as they are used interchangeably, in particular, fat fingers and routine task, and forgetfulness and attention (within slip/lapse). In order to strengthen the reliability of the tool, the data indicate that these codes might also be combined. Last, although the literature search that informed the taxonomy used in this study does not include stress management, there is a likely benefit in studying the influence of stress and fatigue upon trading staff performance. For example, research shows that traders are less likely to make use of stress coping strategies despite stress resistance being identified as a characteristic of good traders.

Serious incident analysis. In the next analysis we investigated whether the incidents had a common set of antecedents. In the coding framework, incident outcomes were coded as a near miss or failure, and we focused on the distinction between these incidents. Specifically, we assessed whether there were particular human factors issues leading to near misses (system controls detected and corrected the error) or actual failure (systems controls failed to detect the error). For example, the data collected through FINANS indicate that errors that typically originate in the front office may pass through the "layers of defense" in the middle office and then are either detected at the tertiary cross-check by the back office team (leading to a near miss) or left undetected.

TABLE 2: Financial Trading Human Factors Taxonomy Descriptions and Frequency

Category and Element Skill	Description	Example of an Incident	Element Coding Frequency When the Category Is Coded
Situation awareness			
Anticipation	Comprehending the situation, understanding what might happen next	Downloading deals with incorrect volume units, leading to incorrect current risk projection	57 (15%)
Attention	Maintaining concentration and avoiding distraction	Inverting the price and volume of the trade in the system	213 (56%)
Gathering info	Perception of the elements in the current situation (e.g., visual information, screens, auditory information)	Volumes in the system not matching the physical deal sheet	84 (22%)
Interpreting info	Processing the current information to make sense of the current situation in order to understand what is going on (involves the interpretation of various cues)	Hedging a flat position due to inaccurate interpretation of information in the system	28 (7%)
Total			382 (51%)
Teamwork			
Communication	Exchange of information, feedback or response, ideas and feelings	A change in contractual specs poorly communicated between the teams	53 (18%)
Coordination	Coordination within and between teams, improved by equal distribution of task work, monitoring each other, and effective exchange of information	Two members of the same team duplicating the data entry during work flow	87 (30%)
Roles and responsibilities	Lack of adherence to clearly and appropriately segregated roles	Weak definition of business rules in the system leads to the incorrect assignment of access	75 (26%)
Shared understanding	Knowledge held by members of a team that enable them to form accurate explanations and expectations for the task, to coordinate their actions, and to adapt their behaviors accordingly	Validating an erroneous buy trade when the desk wants to short a product	78 (27%)
Total			293 (40%)

(continued)

TABLE 2: (continued)

Category and Element Skill	Description	Example of an Incident	Element Coding Frequency When the Category Is Coded
Decision making			
Bias and heuristics	Simple rule people use to form judgments and make decisions (e.g., availability, representativeness, anchoring and adjustment, affect)	Undervaluing the information provided in a credit risk report	17 (63%)
Cue recognition	The primary situation assessment (e.g., what is the problem) through the recognition and interpretation of environmental cues	Currency units not equal to geographical trade location	7 (26%)
Problem definition	Decision-making method (e.g., what should I do)	Recognizing the input value is incorrect, using the closest settle price as a placeholder until the true value could be determined	3 (11%)
Total			27 (3.6%)
Leadership			
Authority and assertiveness	Ability to create a proper challenge and response atmosphere by balancing assertiveness and team member participation and being prepared to take decisive action	Failing to generate a timely risk assessment and assignment of trading limits of a new trading instrument	2 (2%)
Maintaining standards	Compliance with essential standards (e.g., operating procedures)	Not entering trades on the transaction date	64 (62%)
Manage workload	Understanding the basic contributors to workload and developing the skills of organizing task sharing to avoid workload peaks and dips	Mismanaging staffing schedules, leading to task overload during end-of-month procedures	9 (8%)
Monitor activity	Maintain team focus and monitor the output of the team	Underutilizing the daily reports to cross-check trading limit breach levels (e.g., 80%) with activity forecasts	29 (28%)
Total			104 (14%)

(continued)

TABLE 2: (continued)

Category and Element Skill	Description	Example of an Incident	Element Coding Frequency When the Category Is Coded
Slip/lapse			
Distraction	Avoiding the prevention of concentration	Entering the wrong affair for a number of trades	39 (9%)
"Fat fingers"	The mistyping or mis-entry of data information	Entering an extra digit on the price (e.g., 0.01 vs. 0.1)	185 (40%)
Forgetfulness	A lapse of memory	Updating contractual quantities without amending price details	51 (11%)
Memory	The faculty by which the mind stores and remembers information	Skipping a step in the procedure	27 (6%)
Procedure	An established or official way of doing things (written or oral)	The fitness of the procedures to the task (e.g., adaptation to new changing product definitions)	83 (18%)
Routine task	Task work that is commonplace or must be completed at regular intervals (e.g., data input)	Adherence to daily procedural tasks (e.g., time stamp on all deals)	74 (16%)
Total			459 (61%)
Human–computer interaction			
Maintenance and testing	The system is tested regularly and adaptations are timely to reflect the task work	Multiple downloads of electronic platform transactions by the broker	52 (31%)
Software design	The design of the software does not inhibit task work (e.g., low complexity, interface-friendly)	Transactions for Product A entered on the market for valuation of Product B	9 (5%)
System detection	The system controls work properly	System fails to send out timely and accurate breach reports	40 (24%)
Training	The team members involved in the task have sufficient experience and training	Team member lacks the ability to cross-check data output from the system with confidence	32 (19%)
Use of tools	The team members can navigate the system with proficiency	Ability to enter a new product transaction in the system independently and model the risk	37 (22%)
Total			170 (23%)

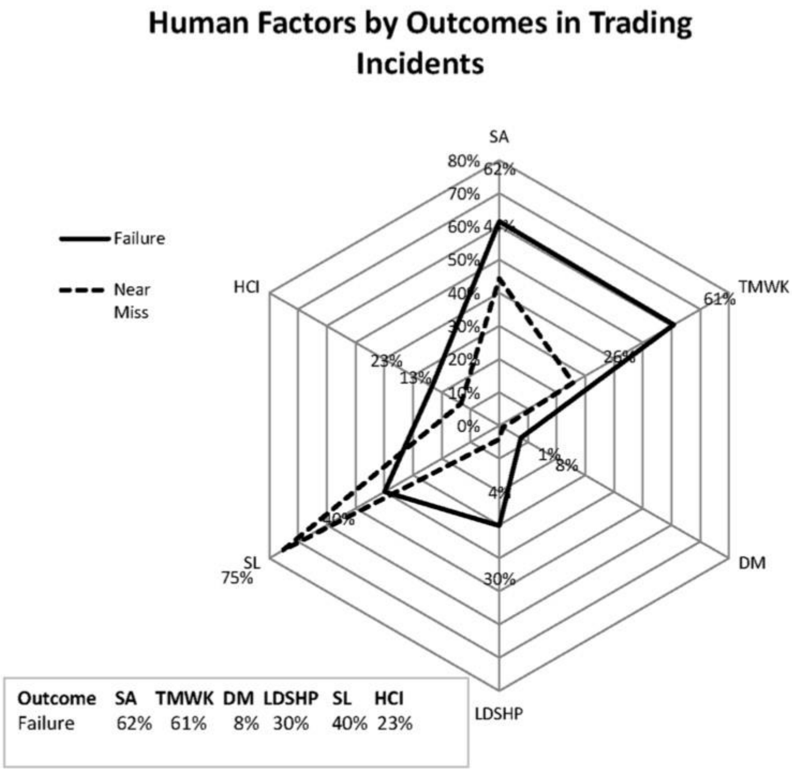

Figure 2. Sets of human factors that lead to near miss or failure in operational trading incidents. SA = situation awareness; TMWK = teamwork; DM = decision making; LDSHP = leadership; SL = slip/lapse; HCI = human–computer interaction.

This finding indicates that particular aspects of team coordination lead to actual losses, and to ascertain whether a distinct pattern of contributory factors was underlying near misses or failures, we applied a pathway analysis to the data set in SPSS. This pathway analysis describes all the variations of the coded data and then is used to predict whether some codes or sets of codes significantly predict an outcome. Figure 2 illustrates the relationship between the human factors categories and how they are related to the outcomes (e.g., near miss or failure).

Figure 2 reveals two significant relationships as a function of outcome (e.g., near miss or failure). First, the interaction between situation awareness and teamwork most often predicts a failure outcome, and second, coding for slip/lapse alone commonly results in a near-miss outcome (indicating it is noticed and prevented by other trading staff). For the most serious incidents, situation awareness and teamwork factors are most commonly attributed to these outcomes. This observation led us to conduct an exploratory analysis into the particular patterns of categories within FINANS that occur together within incidents.

Associative analysis. Spearman correlation coefficient is used to achieve the bivariate correlation between the (noncontinuous) variables (Hauke & Kossowski, 2011), and we used this statistic to examine the associations between FINANS categories applied to the incident data. The results of this analysis are presented in Table 3. This analysis reveals patterns of association

TABLE 3: Bivariate Correlation of Incidents (n = 750)

	SA	TMWK	DM	LDSHP	SL	HCI
SA						
Correlation coefficient	1.000					
Significance (two tailed)	.					
n	750.000					
TMWK						
Correlation coefficient	.370	1.000				
Significance (two tailed)	.000	.				
n	750.000	750.000				
DM						
Correlation coefficient	.061	.080	1.000			
Significance (two tailed)	.096	.029	.			
n	750.000	750.000	750.000			
LDSHP						
Correlation coefficient	.131	.288	.171	1.000		
Significance (two tailed)	.000	.000	.000	.		
n	.000	750.000	750.000	750.000		
SL						
Correlation coefficient	−.179	−.445	−.184	−.322	1.000	
Significance (two tailed)	.000	.000	.000	.000	.	
n	750.000	750.000	750.000	750.000	750.000	
HCI						
Correlation coefficient	−.072	−.071	−.013	−.102	−.344	1.000
Significance (two tailed)	.049	.053	.725	.005	.000	.
n	750.000	750.000	750.000	750.000	750.000	750.000

Note. SA = situation awareness; TMWK = teamwork; DM = decision making; LDSHP = leadership; SL = slip/lapse; HCI = human–computer interaction.

or lack of association between certain categories, and we consider the findings next.

Codes that occur together. The strongest positive correlation was found between teamwork and situation awareness. This correlation means that when an event is coded for teamwork, it is significantly likely that situation awareness will also be coded for (and vice versa). This finding indicates that when breakdowns in teamwork occur, it is likely that a breakdown in situation awareness has also occurred. This coupling occurs significantly within the data set, indicating its presence to increase the likelihood for error in the trading domain. This finding is consistent with previous research in the trading domain showing understanding and sharing insight into risk is underpinned by the distribution of cognition and understanding across teams—often termed "team situation awareness" (Endsley & Jones, 2013; Leaver & Reader, 2015; Michel, 2007). The second most common association was between teamwork and leadership. This close association is unsurprising, given the current evidence that leadership behaviors in the trading domain are determined by situational factors (e.g., incoming team revenue) and that monitoring fluctuates according to team performance (Willman et al., 2002; Willman, O'Creevy, Nicholson, & Soane, 2001).

Codes that do not occur together. There are two striking non-associations that emerge from the data set. First, slip/lapse is significantly likely to occur alone than with any other category of human factors, and the strongest opposition is with teamwork. This finding exemplifies the nature of slip/lapse incidents, which are typically easily detectable by the many layers of defense built into the system and typically low complexity (e.g., characterized by a fat-fingers incident). The second observation from the data set is that human–computer interaction also occurs alone more often than with other categories. This finding indicates that when faults in the operating system or equipment occur, they are detected and reported before elevating in complexity (e.g., interrupting team processes). Inconsistent with the literature on human–computer interaction, an association between situation awareness and human–computer interaction was not observed (Weyers, Burkolter, Kluge, & Luther, 2010).

Discussion

Study 2 revealed approximately 1% of financial trades annually to incur some form of error. This figure is likely a conservative estimate due to potential underreporting and is less than in domains such as health care but greater than in aviation (Boeing, 2014; de Vries, Ramrattan, Smorenburg, Gouma, & Boermeester, 2008). Consistent with the notion of financial trading as a high-risk industry, FINANS provides a practical tool for identifying and understanding the causes of error. In regards to generalizability to other financial organizations, the research was conducted on a large commodity-trading floor, with generally analogous features (personnel, systems, and organizational design) to other trading organizations (e.g., banks). Yet this generalizability requires examination, and FINANS should be used, albeit cautiously, to inform the development of incident analysis in similar trading floor environments.

In terms of the human factors problems underlying critical incidents in financial trading, slip/lapse-related errors (e.g., fat fingers) was the most frequently coded category, occurred often in isolation from other human factors problems (e.g., teamwork), and were more likely to be associated with near-miss outcomes (indicating errors were being caught by trading staff). It is perhaps not surprising that slip/lapse errors are more likely to be reported in the operational incident log than others (e.g., decision-making skills), as they are relatively easy to detect retrospectively, and participants may show a bias for reporting less punitive, easily detected events (e.g., fat fingers, following procedures) than complex, punitive issues (e.g., failing to consider options). In general, slip/lapse problems did not lead to serious incidents, as they were often fixed quickly through organizational procedures (e.g., team cross-checks), and this finding has also been observed in industries such as aviation (Vincent & Amalberti, 2016, Chapter 5).

In addition, we observed that a significant proportion of critical errors originated from failings in situation awareness and teamwork processes. This finding may indicate team-based processes, such as communication and coordination (e.g., cross-checking of information, monitoring of information), to influence team situation awareness on the trading floor and resonates with research in health care and aviation (Jentsch, Barnett, Bowers, & Salas, 1999; Reader, Flin, Mearns, & Cuthbertson, 2011). Thus, future research may focus on how teamwork and situation awareness interact to influence performance on the trading floor, for example, how errors migrate and develop on the trading floor (e.g., typical error migration is from the front office, through the middle office, to the back office) and awareness of interdependencies among team members.

Relatively few incidents were reported as having leadership or decision-making problems, and this finding is contrary to experimental work in the finance domain. The analysis presented in this two-phase study reveals that decision making is a less present indicator of team performance in the trading domain, and this finding may reflect limitations in the abilities of trading staff to self-monitor decision-making activities. Also, the absence of decision making may indicate that incident reporting may not be an optimal way to collect data on decision making in financial trading, and other forms of study (e.g., observations) may be more useful. In terms of leadership, this category might be conceptualized as a more "distal" cause of incidents (e.g., setting and maintaining standards) and perhaps more difficult to isolate as a contributory factor to incidents.

Finally, the findings of this study might lend themselves to develop interventions and inform regulators on the causes of problems in risk management in financial trading, for example, in terms of training programs (e.g., on interdependencies between teams), software design, and changes to systems and procedures.

STUDY LIMITATIONS

The results are constrained by the nature of the incident reporting, which is susceptible to underreporting and incomplete information about incidents (O'Connor et al., 2007). Incident reporting in trading is limited by the need for an individual to be aware that the event has occurred, his or her limited perspective on the incident, and his or her motivation to report. Furthermore, for Study 1, experts undertook a relatively short training exercise, potentially affecting their ability to accurately code incidents—in the future, it is suggested a longer training exercise is utilized. For Study 2, a further limitation was that only one coder analyzed the incidents (with a second coding half of the incidents to assess for interrater reliability), and the data analysis was constrained by the clarity of the text and the potential biases of trading staff in recalling the incident. Finally, the FINANS taxonomy may require further development. Issues such as stress, fatigue, and organizational culture were not examined, and the reliability analysis indicated scope for improving the FINANS taxonomy (which will be the focus of future work).

CONCLUDING REMARKS

This study reports the first system for capturing operational incidents on the trading floor and analyzing the human factors–related issues that led to them. Through two studies, we found that experts in the trading domain can reliably and accurately code human factors underlying in incidents in financial trading and that approximately 1% of all trades incur error. Although slip/lapse is the most common factor underlying incidents, problems in teamwork and situation awareness underpin the most critical incidents. In order to develop a more fine-grained analysis of the nature of these errors, authors of future research should aim to further improve FINANS and to identify the specific skills and conditions that lead to effective risk management on the trading floor.

DISCLAIMER

The study was undertaken by ML and TR in their personal capacities. The opinions expressed in this article are the authors' own and do not reflect the view of the participating organization.

KEY POINTS

- Human factors problems underlying error in the financial domain can be reliably identified and extracted by trained experts in financial trading using the Financial Incident Analysis System (FINANS).
- FINANS is both appropriate for analyzing operational incidents within financial trading (i.e., it fits to the needs of the domain and its users) and can be administered in financial trading organizations without the assistance of psychologists to monitor and analyze data.
- FINANS provides a reliable tool through which to examine the role and extent of human factors–related problems underlying operational incidents in financial trading. This tool has the potential to provide data crucial for identifying, understanding, and ameliorating risk within financial trading organizations.
- Approximately 1% of trades incur some form of error per year, which provides a useful benchmark for financial organizations against other high-risk industries.
- A significant proportion of the underlying causes of the most critical errors originates from failings in situation awareness and teamwork processes. In particular, we find a significant likelihood of teamwork and situation awareness to occur together and lead to critical outcomes (e.g., loss events).

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CHAPTER 5: NEAR MISSES IN FINANCIAL TRADING

5. NEAR-MISSES IN FINANCIAL TRADING: SKILLS FOR CAPTURING AND AVERTING ERROR

5.1 Preface

The fourth aim of the thesis examines what can be learnt in terms of the skills and systems important for avoiding operational incidents in financial trading. This is important, because it demonstrates that the skills of human operators can both create and prevent error within financial trading, and more generally establishes that incident data can be analysed to determine relevant human factors information important to understanding how incidents are captured and detected.

This aim is addressed in chapter 5 (article 3), "Near-Misses in Financial Trading: Skills for Capturing and Averting Error". This chapter examines the utility of near-miss data to identify the core social-psychological skills that are used to capture and ameliorate error. As near-misses regularly occur in financial trading, the study aims to identify opportunities for organizational learning by examining the recovery mechanisms that led to the detection of incidents before failure.

Specifically, the study reports on three sets of analyses. First, the assessment of the reliability of coding for determining the human factors skills that capture and ameliorate error on the trading floor is analysed in order to ensure the coding outcomes are consistent and robust. Second, the study identifies the frequency with which various human factors skills cause and – for the first time in human factors literature – ameliorate near-misses. To achieve this, a frequency analysis of the coded incidents is undertaken. Third is an analysis of the skills and systems used to detect and prevent the error and the causes of error together, the purpose of which is to illustrate how the skills that cause error and the skills that ameliorate error may interrelate.

This work reconceptualizes finance through the application of human factors and challenges the field of human factors to engage with a non-traditional (e.g. high-risk, but not safety-critical) domain. In doing this, aspects of the prevailing worldview in human factors 'safety' thinking and financial risk management practices might also be re-imagined. This work has identified the need for a 'New Era' of error and risk management research in the finance domain that promotes a more human-centred model of safety (e.g. supplementing a focus on what goes wrong with a focus on what goes right). In particular, conceptualising financial trading from a 'Safety II' perspective: this approach conceives of safety as a product of good rather than unsafe practise.

The journal article that follows was authored by Leaver, Griffiths and Reader (2017). Leaver designed the study, collected the data and did the analysis, outlined the article and authored all main drafts, contributing to roughly 90% of the content. Reader provided key supervisory assistance and editorial suggestions. Reader contributed to roughly 5% of the content. Griffiths acted as a second coder for 25% of the cases in the data analysis phase and provided essential statistical input on the analysis and results section. Griffiths contributed to roughly 5% of the content. The article is currently submitted to *Human Factors* and is under review.

Human Factors has an impact factor of 2.219, and is ranked 29/80 in Psychology, Applied and 3/16 in Ergonomics journals.

Title: Near Misses in Financial Trading: Skills for capturing and averting error
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ABSTRACT

Objective: i) to determine whether near miss incidents contain information on the operator skills and systems that detect and prevent near misses, and if so, the patterns and trends revealed by these data and ii) to explore if particular operator skills and systems are found as important for avoiding particular types of error on the trading floor.

Background: In this study, we examine a cohort of near miss incidents collected from a financial trading organisation using the Financial Incident Analysis System (FINANS) and report on the human-factors related skills and systems that are used to detect and prevent error in this domain.

Methods: 1,000 near miss incidents are analysed using distribution, mean, chi-square and associative analysis to describe the data, reliability is provided.

Results: Slip/lapse (52%) and Human Computer Interface (21%) often occur alone and are the main contributors to error causation, whereas the prevention of error is largely a result of teamwork (65%) and situation awareness (46%) skills. No matter the cause of error, Situation Awareness and Teamwork most often detect and prevent the error.

Conclusion: Situation Awareness and Teamwork skills appear universally important as a 'last-line' of defence for capturing error and data from incident monitoring systems can be analysed in a fashion more consistent with a safety II approach.

Application: This research provides data for ameliorating risk within financial trading organisations, with implications for future risk management programmes and regulation.

INTRODUCTION

Financial trading is an environment where staff are under pressure to take risks, and highly reliant on complex technical systems to complete their work. Human or system-related errors lead to ‘operational incidents’: where trading activity results in an avoidable loss (e.g. due to not assessing risk). Operational incidents place the integrity of the financial organisation at risk, and careful analysis of the underlying problems and recovery mechanisms are essential to maintaining organisational performance and long-term integrity. Adopting principles used to manage risk in other high-risk domains (e.g. aviation, healthcare), research in financial trading has identified the factors underlying operational incidents: for example, teamwork skills, poor system interfaces, and slip/lapses. These allow for an analysis of the underlying causes of operational incidents, and where appropriate remedies for stopping their occurrence on the trading floor (e.g. training, system redesign).

Yet, the reality of a complex and dynamic industry such as financial trading is that the nature of risk if likely to evolve, with the potential for human error remaining ever-present (Amalberti, 2013). To detect this evolution, the collection and analysis of near-miss data is essential (Barach, P., & Small, 2000; Gnoni & Lettera, 2012). This is where a failure has occurred, but was detected and resolved before a loss was incurred. Analysing near misses can yield at least two important types of data. First, it can indicate emerging threats to organisational safety (e.g. in terms of systems, tasks, or skills deficiencies), and this is where much of the academic literature on incident reporting has focussed (Hopkins, 2001; NASA, 2001). Second, it can reveal the skills and behaviours that are important for navigating hazards and avoiding error after a failure has occurred, and this latter aspect is less explored within the incident reporting research literature (Van der Schaaf, Lucas & Hale, 2013).

Interestingly, this distinction reflects the debate around “safety-I” and “safety-II” approaches (Hollnagel, 2014b). Safety-I refers to approaches to safety that focuses on error reduction, whereas safety-II refers to approaches that focus on the successful navigation of hazards to ensure organisational objectives are met. In industries, such as financial trading, where risk-taking is integral to success, both approaches appear essential to effective risk management. Yet, in terms of utilising near miss incident monitoring to achieve this, the safety-II approach has been less utilised (Huber et al., 2009; Kleiner et al., 2015).

In the current study, we examine a cohort of near miss incidents collected from a financial trading organisation. Drawing on this set of data, we address the following objectives:

1. To determine whether near miss reports contain information on the operator skills and systems that detect and prevent error from escalating into failure (e.g. a near miss incident), and if so, the patterns and trends revealed by these data.
2. To illustrate how the skills and systems that detect and prevent error and the skills that cause error may interrelate, the purpose of which is to establish whether specific operator skills and systems are important for avoiding particular types of error on the trading floor

This article aims to make three contributions. First, it reveals the operator skills and systems that are important for ensuring near misses do not escalate to failure, and thus contributes to approaches for improving risk management in financial industries.

Second, it demonstrates how data from incident monitoring systems can be utilised to identify operator skills and behaviours important for navigating hazards and avoiding failure. Third, it considers how data from incident monitoring systems can be analysed in a fashion more consistent with a safety II approach.

Learning from near-misses

Collecting and analysing incident data is central to identifying risks to organisational safety, and prioritising and designing changes for avoiding further mishaps (Phimister, Oktem, Kleindorfer & Kunreuther, 2003). Near misses in particular are useful for learning, as they occur more frequently than failure, and point to events that might happen - but can be avoided – in the future (Barach & Small, 2000; Reason, 2008).

In order to identify the general characteristics of successful systems that collect and interpret near miss data, and to identify areas in which the field might develop, we consider a number of key research studies reporting on incident monitoring systems. Although the review is non-exhaustive, Table 1 lists six of the more commonly reported on incident-monitoring systems.

Table 1: Features of Incident Reporting Systems in High-Risk Domains

Author	Name of incident monitoring system	Domain	Type of data collected	Positive skills	Negative skills
Runciman, Webb, Lee and Holland, 1993. (AIMS)	AIMS	Aviation	2000 critical incident reports	N/A	System failure constitutes the bulk of the contributory factors, and human failure identified in approx. 80% of the cases
Staender, Davies, Helmreich, Sexton and Kaufman, 1997 (CIRS)	CIRS	Anaesthesia	60 anonymous critical incident reports via internet	Concluded they are unable to assess the educational importance of the CI reports	Contributory factor of communication in the operating theatre
Beckmann, Baldwin, Hart and Runciman 1996. AIMS-ICU	AIMS-ICU	Intensive care	536 critical incident reports obtained from seven ICU's	N/A	Multiple contributory factors; 33% systems-based, 66% human factor based.
Billings, Lauber, Funkhouser, Lyman, Huff (1976)	ASRS (aviation safety reporting system)	Aviation	Voluntary, non-punitive, anonymous critical incident reports. 1407 reports in the first quarter of operation.	N/A	Phases of flight where the incident occurred were detailed, systems issues, navigation, ground hazards etc.
Davies, Wright, Courtney and Reid, 2000.	CIRAS (Confidential Incident Reporting and Analysis System)	Rail	Gathers data in three ways; initial report form or telephone call, structured follow-up telephone questionnaire, in-depth interview with a researcher.	N/A	Fatigue, lapses of attention, breaches of procedure, problems with equipment
CHIRP Charitable Trust, 1999	CHIRP (Confidential Human factors Incident Reporting Programme)	Aviation	Confidential reports from pilots, flight deck personnel, licensed engineers, maintenance workers in the airline industry.	N/A	Does not formally request information on the contributing / mitigating factors, how the incident was discovered, or suggested

As table 1 indicates, there is no established standard for the design and implementation of incident monitoring systems, yet there are a number of common features (Gnoni et al., 2013; Goldenhar, Williams & Swanson, 2003; Wu et al., 2010).

First, most reporting systems gather data on both realised incidents and near misses, with reports being confidential and anonymous. Second, the systems we reviewed report on the causes of error (e.g. fatigue, lapses in attention or teamwork skills such as problems in team communication) that precipitate incident occurrence. Third, these data are used to provide feedback on the skills and systems that contribute to the error, and feed into developments for improving systems and skills (e.g. teamwork). Fourth, and most pertinent to the current research, none of the studies report on the skills or behaviours used to detect and prevent error. In fact, although most studies considered in our review seek to identify the causes of near miss (e.g. pilot fatigue, drug administration errors) few, if any studies explicitly investigate the skills used to ameliorate error.

The reason for this is unclear, but is likely due to analyses focussing on the causes of error, with the aim being to reduce the rate of error that occurs through altering the conditions that facilitated their occurrence. For example, in the healthcare domain near miss reporting is largely used to consolidate findings on the type of near miss incidents (e.g. slips, trips and falls), their causes (e.g. occurring due to problems with the facilities) and to target prevention measures (e.g. repairing damaged floors and improving janitorial procedures) (Billings & Reynard, 1984; Shaw et al., 2005; Van der Schaff, 1991; Wright & Van der Schaaf, 2004). However, the insights we gain from causation are constrained by the difficulty in eradicating some types of error (e.g. eliminating all environmental issues, administrative mistakes) and the acceleration of technological work (e.g. systems fixes are only a temporary fix to the issues as technology is always moving forward). Furthermore, in fast-paced industries, where dynamic changes to technology and working practices are necessary for success, solutions can focus on the problems of yesterday rather than tomorrow.

Thus, near-miss data may offer a unique insight into the skills and behaviours that ensure hazards are mitigated. Where practices or systems are found to be particularly effective for catching or mitigating errors, they can be preserved (so they are not lost) and trained (e.g. targeting teams or units that have high numbers of errors). This is a somewhat positivistic perspective on incident reporting, and is consistent with Amalberti's (2013) description of 'ultra-resilient' organisations and Hollnagel's (2014) conceptualisation of "safety-II".

Ultra-resilient organisations relate to the observation that in many dynamic and fast-moving industries that manage risk, it is not possible - or in some cases desirable - to entirely engineer risk out of the system. For example, in healthcare where procedures that create alternative risks for patients are necessary to the delivery of treatments (Reader, Reddy, & Brett, 2017), deep-sea fishing where workers operate in dangerous weather conditions (Amalberti, 2013), or financial trading where some risk-taking is necessary to achieve competitive advantage (Leaver & Reader, 2017). Instead, risk is managed through improving employee skills and system design, and ensuring that where risk-taking is not successful, loss is avoided. Reflecting this, the “safety-II” approach argues that safety management involves a mixture of both error reduction (“safety-I”) and also the identification of the skills and behaviours that enable things to go well (and in particular to navigate hazards).

At its core is the observation that, more often than not, safety is effectively managed within high-risk organisations, and that the skills and systems that support this ensure that organisations are flexible in how they respond to evolving risk (Hollnagel, 2014b). Yet, there is a lack of data, literature and methods for doing this (Burford, Fray & Waterson, 2016; Hollnagel, 2014a; Kleiner et al., 2015).

CURRENT STUDY

In the current study, we examine whether near-miss reports yield data that is useful and can be reliably coded on the skills and systems that prevent incidents from being realised (i.e. causing losses). To our knowledge, this is the first study to report these data. We are interested in this because it is an aspect of learning from incident reporting systems that has been hitherto un-examined, yet appears important for contributing to new trends and directions in human factors research.

The study focuses on the high-risk domain of financial trading. Financial trading organizations are where traders buy and sell products (e.g., equities, physical commodities, financial options) to generate profit and optimize their portfolios. It is inherently risky, with systemic failures by traders leading to large fines and economic consequences at a societal level (Leaver & Reader, 2015). Thus, financial trading has been recently conceptualised as a high-risk industry where the management of risk, and management of human factors issues, is essential to success (Leaver & Reader, 2016). Because it is an industry that requires both risk-taking (to make money) and error reduction (to avoid mistakes) it is a particularly suitable setting for evaluating the insights that can be learnt from near misses (as they regularly occur).

Research Questions

Our research addresses the following questions.

First, we determine the extent to which the near miss data collected on the trading floor contain reliably analysable information on human factors skills that contribute to, and prevent, errors. Through analysing these data, we identify the frequency and nature of operator skills and systems that ameliorate near misses. For example, how teamwork skills such as coordination (e.g. cross checking of information on shared tasks) and situation awareness skills such as attention (e.g. during routine task work) are key to capturing error on the trading floor. In terms of financial trading, relatively little is known about how error is averted on the trading floor and FINANS usefully provides a set of collected data and a human factors framework to provide insight into the skills used to detect and ameliorate error on the trading floor.

Second, we establish whether particular operator skills and systems are important for avoiding particular types of error on the trading floor (i.e. combinations of skills). This will reveal whether there are specific skills required for managing particular errors, and yield implications for training and error management strategies in financial trading.

METHOD

FINANS

This study utilises data collected using the Financial Incident Analysis System (FINANS). FINANS is a confidential, voluntary incident reporting system designed with input from other incident reporting systems in similarly high-risk domains such as the Aviation Safety Reporting System (ASRS) in aviation. FINANS provides a standardised method for collecting data on operational incidents that occur on the trading floor, a reliable method for analysing and extracting human factors related contributors to operational incidents, and practical insight into how these contributors might be ameliorated. A fuller explanation of the merits, reliability and theoretical foundations of the FINANS tool can be found in Leaver and Reader (2016).

Fundamentally, the system comprises two parts. The first part is the 'incident log'. To recap, an incident in this context is an event that did lead to (e.g. failure) or could have led to (e.g. near miss) losses or unwanted market or credit risk exposure. Incidents can be wide-ranging, and include technical systems failure (e.g. pricing tool failures), erroneous human input errors, misunderstandings of instructions or procedures between departments (e.g. between a trader and their risk department), and rule violations (e.g. late trade entry). This first part of the system has several functional components: identification of detection teams, identification of the origin of the error (by team), date of incident occurrence and detection, risk type classification and text-based description. Detection encompasses the teams involved and how the incident was discovered. Description involves the recording of a free text narrative that details the event. Data is aggregated and analysed in terms of descriptors for each incident (e.g. consequences, where and when incidents occurred).

The second part of FINANS is a taxonomical system for interpreting incidents and near misses in terms of contributory factors. The taxonomy consists of a ‘category’ and ‘element’ (sub-category) levels. Categories function at a relatively generic level (e.g. situation awareness), and elements reflect aspects of activity specific to the trading floor environment that illustrate the categories (Flin & Patey, 2011). Moreover, each incident can potentially be coded within FINANS as single or multiple category and subcategory levels. For example, an incident may be identified as caused by teamwork (subcategory coordination) or teamwork (subcategory coordination) as well as situation awareness (sub categories attention and gathering of information). The full taxonomy used to codify the incidents is provided in Table 2 below.

Table 2. FINANS Human Factors Taxonomy

Category	Associated Elements
Situation Awareness	• Attention (distraction, lack of concentration, divided or overly focused attention) • Gathering information (poorly organised information, not enough gathering of information) • Interpretation of information (miscomprehension, assumptions based on previous experience) • Anticipation (i.e. thinking ahead, judging how a situation will develop) • Other
Teamwork	• Role and Responsibilities (e.g. unclear segregation of roles) • Communication and exchanging of information between team members • Shared understanding for goals and tasks • Coordination of shared activities • Solving conflicts (e.g. between team members and teams) • Knowledge sharing between teams • Other
Decision Making	• Defining the problem • Cue recognition (e.g. finding and recognising the cues to the decision) • Seeking advice on a decision • Noise and distraction (e.g. that reduce capacity to take a decision) • Bias and heuristics (e.g. over optimism, over confidence) • Other
Leadership	• Authority and assertiveness (e.g. taking command of a situation) • Listening • Prioritisation of goals (e.g. team / organisational) • Managing workloads and resources • Monitoring activity and performance of team members • Maintain standards and ensuring procedures are followed • Other
Slip/Lapse	• Fat Fingers • Procedural (not following a protocol, or following a protocol incorrectly) • Routinized task (e.g. a loss of concentration) • Forgetfulness (forgetting information, or how to perform an activity) • Memory • Distraction • Other
Human Computer Interface	• Use of the Tools (e.g. spread sheets) • Training on the tool • System did not detect the error • Design of the software and application • Maintenance and testing of the tool • Other

The second part of FINANS importantly allows us collect human factors data through the coding framework in order to extract information on the human factors skills that influence error on the trading floor and provides more fine grained insight into the skills (e.g. team communication and coordination) and behaviours (e.g. cross checking with team members) that are important for averting error.

Procedure

FINANS was used to collect incident reports in the participating organization from January 2014 until January 2016. With the support of the organisation, traders and trading support staff were briefed on human factors, non-technical skills and data entry in the system in advance of the deployment of the incident log and then asked to report the incidents in the log.

Following each reporting month, a trained human factors expert provides feedback reports (e.g. historical trends, evolving patterns of risk types) to the participating staff and management. Over this period, 1,042 unique incident reports (i.e. each incident reporting on a problematic trade was different) detailing an operational incident were collected and deemed suitable for analysis (e.g. clear text and a near miss event).

Near miss occurred in 96% of the selected incidents (e.g. 1,000 cases of near miss, 42 cases of failure). Of the 1,000 near miss incidents, the lead author coded all the cases; 250 (25%) were coded by a human factors expert in order to provide a reliability assessment for coding.

For the purpose of this study, the author only considered near miss incidents that were reported as the aim of the analysis is to uncover how the incidents are caught or detected within the organisation.

The coding process was made up of five steps; (1) selection of the relevant human factors skills category (e.g. situation awareness, decision making, teamwork, leadership, human computer interface, or slip/lapse), (2) the selection of the relevant subcategory (i.e. element) of non-technical skills (e.g. if situation awareness is chosen as a main category, the element(s) can be selected from; distraction, gathering information, interpreting information, anticipation of future states), (3) identification of single team or multiple teams, (4) identification of an on-going state or isolated nature of the incident, (5) indication of whether the incident is near miss or a failure. Each of the 1,000 incidents were coded in these five steps twice: once to identify the set of codes dedicated to the causes of error (e.g. identifying what went wrong) and a second time to identify the set of codes dedicated to the skills and systems that led to the detection and prevention of error (e.g. identifying what went right). The human factors codes used in FINANS have been reliably used to extract the skills that underpin error in previous studies across a range of incidents (near miss and failure) (Leaver & Reader, 2016). The concepts that underpin the coding framework were identified through a literature review of relevant concepts in the financial trading domain, a review of existing systems successful in place in other high-risk domains and feedback from subject matter experts (Leaver and Reader, 2016). In this analysis, we follow the assumption that the skills that underpin error are similar to the set of skills used to ameliorate error (Flin, O'Connor, & Crichton, 2008).

ANALYSIS

The results section reports on the following three analyses.

First we assess the reliability of coding for determining the causes of near misses, and the identification of factors that led to their detection and prevention. To do this, we present the reliability between the two expert coders using Cohen's kappa statistic in order to assure the coding outcomes are consistent and robust (Fleiss, Cohen, & Everitt, 1969; LeBreton & Senter, 2007).

Second, to identify the frequency with which various human factors skills cause and - for the first time in human factors literature - ameliorate near misses we undertake a frequency analysis of the coded incidents. This involved analysing the coded dataset to ascertain how often each code or group of codes occurs across the whole dataset in order to infer the most influential (e.g. highest occurrence) and least influential (e.g. lowest occurrence) skill categories. For example, this analysis reveals which skill problems are most likely to generate error (e.g. 'fat fingers') and which skills are most commonly drawn upon to capture error (e.g. attention).

Third we undertook an analysis of the skills and systems used to detect and prevent error and the causes of error together, the purpose of which is to illustrate how the skills that cause error and the skills that ameliorate error may interrelate. Specifically, by examining the frequency of occurrence (or otherwise) of every binary combination of skills we assess the relationships within the human factors codes separately for the causes of error and skills and systems that led to the detection and prevention error. For example, we explore whether, when near misses are remediated by teamwork skills, do situation awareness skills also tend to play a role in the remediation too, or do the two factors not occur together? This analysis helpfully contextualises the human factors findings and promotes a deeper understanding of how error is captured on the floor.

RESULTS

Financial trading staff reported 1,000 near miss incident reports through FINANS from January 2014 to January 2016. Near miss events accounted for 96% of reported errors within this time period (where 4% were classified as failures). This equates to less than 1% of trades within the company, and due to the data being generated through staff self-reporting, is likely to be an underestimation.

Reliability Analysis

We examined the reliability of coding between the author and a human factors expert. Of the 1,000 incidents, the lead author coded all the cases; 250 (25%) of the cases are coded by the third author to provide reliability assessment. Those cases were randomly selected from the batch. All incidents had at least one code from the FINANS taxonomy applied to explain the incident (e.g. incidents can be coded as multiple categories and elements). At the category level, the reliability was generally good or substantial[2] across both positive and negative categories.

For the causes of error at the category level, the reliability was good for situation awareness (k=0.499) and teamwork (k=0.567) and substantial for leadership (k=0.647), slip/lapse (k=0.65) and human-computer interaction (k=0.748).

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[2] Good reliability: 0.41 = k = 0.60 and substantial reliability 0.61 = k = 0.80 (McHugh, 2012)

For the skills and system that led to the detection and prevention of error reliability was good for situation awareness (k=0.549), teamwork (k=0.503), leadership (k=0.453) and substantial for human-computer interface (k=0.655). As decision-making was never chosen in the coding, there are no reliability statistics for this category. This result is similar to previous studies where decision-making was rarely chosen when coding incidents (Leaver & Reader, 2016). Furthermore, for the skills that help to detect error coded in this study, slip/lapse was never chosen. This result is expected due to the nature of the slip/lapse categories (e.g. fat fingers, forgetfulness) that would not detect error, but primarily be the cause.

This shows that near miss incidents collected in the financial trading domain can be reliably coded for human factors and contain relevant information of the skills that cause error and for the first time, indicate that the critical incidents contain information of the skills / behaviours that are used to capture error on the trading floor.

Skills and systems for detecting error

Our first analysis establishes the extent to which near-miss data contains information on the skills and systems for detecting and preventing error. To provide an overview of the data, Table 3 details the occurrences of each human factor category and element used in FINANS to classify the causes of error and the skills that led to the detection of error.

Table 3: Frequency of human factors categories and elements found in the cases (n=1,000)

	Causes of error			Skills and systems that led to the detection and prevention of error		
Category	Category Count (% overall)	Subcategory	Subcategory Count (% within category)	Category Count (% overall)	Subcategory	Subcategory Count (% within category)
Situation Awareness	130 (13%)	Anticipation	12 (9%)	460 (46%)	Anticipation	102 (22%)
		Attention	78 (60%)		Attention	123 (27%)
		Gathering Information	40 (30%)		Gathering Information	161 (35%)
		Interpreting Information	7 (5%)		Interpreting Information	48 (10%)
Teamwork	205 (21%)	Communication	53 (26%)	646 (65%)	Communication	96 (15%)
		Coordination	70 (34%)		Coordination	112 (17%)
		Roles and Responsibilities	79 (39%)		Roles and Responsibilities	340 (53%)
		Shared Understanding	39 (19%)		Shared Understanding	79 (12%)
Decision Making	11 (1%)	Bias and Heuristics	9 (82%)	14 (1%)	Bias and Heuristics	0 (0%)
		Cue Recognition	3 (27%)		Cue Recognition	14 (100%)
Leadership	113 (11%)	Maintaining Standards	27 (24%)	21 (2%)	Maintaining Standards	3 (14%)
		Monitoring Activity	87 (77%)		Monitoring Activity	17 (81%)
Slip/Lapse	523 (52%)	Fat Fingers	343 (66%)	2 (0.2%)	Fat Fingers	1 (50%)
		Memory	56 (11%)		Memory	0 (0.0%)
		Procedural	126 (24%)		Procedural	0 (0.0%)
Human-Computer Interaction	211 (21%)	Maintenance and Testing	123 (58%)	154 (15%)	Maintenance and Testing	1 (0.6%)
		System Detection	29 (14%)		System Detection	84 (55%)
		Use Of Tools	63 (30%)		Use Of Tools	50 (33%)

In terms of using FINANS to better understand the human factors that support the detection of error in the trading domain, Table 3 shows that all near miss were coded with a human factors category, with over half the near miss being caused by slip/lapse (52%) and ameliorated by teamwork (65%). The sections below provide a granular description of the skills that cause error and the skills that help trading staff capture error (e.g. near miss incident).

Causes of error. Table 3 confirms the findings of previous studies of causes of error using FINANS (Leaver & Reader, 2016). The majority of the errors are a product of slip/lapse (52%) problems and issues in human computer interaction (21%). The least coded category was decision making (1%).

In absolute terms, the most commonly coded element was fat fingers (343), followed by procedural (126) and maintenance and testing of systems (123). As seen in previous studies using FINANS, some elements were rarely coded; interpreting information (7), cue recognition (3), and bias and heuristics (9); however, unlike previous studies, each element was coded at least once in the data coding process.

Skills and systems that led to the detection and prevention of error. Table 3 indicates that overwhelmingly the error is detected and prevented by teamwork skills (65%) followed closely by situation awareness (46%). Human computer interface skills were identified in 15% of the near miss. The least coded category was slip/lapse (0.2%), followed by decision-making (1.4%) and leadership (2%).

In terms of elements, the most commonly coded was role and responsibilities (340), gathering information (161) and attention (123). Some elements were rarely coded for such as bias & heuristics (0), fat fingers (1), procedural (1), memory (0) and maintenance and testing (1).

Our analysis of the frequency of human factors in the set of collected near miss incidents shows that slip/lapse and human computer interface are the leading cause of error in the financial trading domain, and for the first time in human factors literature, identifies that teamwork and situation awareness skills are essential to capturing and preventing error.

To illustrate the context of the data collection (and the potential for intervention), and the types of problems and skills being identified using FINANS, Table 4 provides a sample of characteristic codified examples.

Table 4: Example data that could be reported and codified through FINANS

Incident Description	Human Factors problems identified in the cases	Specific behaviours that helped to ameliorate the error
Deals were downloaded with incorrect prices, and the wrong market parameters were sent into pre-publication. The error was picked up when a second team member noticed a discrepancy	Situation awareness (attention) Human computer interface (use of tools)	Teamwork (roles and responsibilities) Situation awareness (attention, gathering information)
A change in a contractual item not communicated between the relevant teams and noticed during a transaction booking	Teamwork (communication)	Situation awareness (gathering information, interpreting information) Teamwork (seeking out information through informal communication)
Entering an extra digit on the price (e.g. 0.01 versus 0.1)	Slip/lapse (fat fingers)	Teamwork (roles and responsibilities) Situation Awareness (attention)
Out-dated procedures not updated in the shared communication platform can lead to problems in task handover	Slip/lapse (procedures), situation awareness (anticipation)	Leadership (maintaining standards), teamwork (roles and responsibilities, coordination) Situation awareness (anticipation)
A hedge transacted by one team member for the group exposure with delayed communication about the details, meaning that hours are lost determining an alternate hedging scenario	Teamwork (coordination & communication) Slip/lapse (procedural)	Situation awareness (gathering of information) Teamwork (roles and responsibilities)
The price and volume of the deal were inverted	Slip/lapse (fat fingers, distraction)	Teamwork (roles and responsibilities) situation awareness (attention)

Table 4 reveals some key features of the reported data: it typically generates from a principal cause and then travels through various social (e.g. teamwork) and/or cognitive (e.g. situation awareness) layers of defence. For example, error on the trading floor is characteristically caused by slip/lapse error (e.g. 'fat fingers'), this might then be compounded by a missed check at the risk control stage (e.g. role and responsibilities) and subsequently detected through a secondary cross-check by another alert team member or the back office team before processing the trade (e.g. roles and responsibilities, gathering of information, attention).

To expand on the observation that error may be captured due to the interaction of multiple skill competencies, we undertook an analysis of the skills and systems used to detect and prevent error and the causes of error together, the purpose of which is to illustrate how the skills that cause error and the skills that ameliorate error may interrelate.

Associations between the causes of error and the skills and systems that detect error

In this analysis we assess whether there are particular relationships within the human factors codes for the causes of error and the skills that led to the detection of error. For example, the data collected through FINANS indicate that near misses are most often remediated by teamwork skills and situation awareness skills, but how often do these categories occur together or in isolation? Are these skills remediating a typical set of causes? This analysis is exploratory in design and aims to examine whether patterns emerge from the coding that shows how error emerges, migrates and is captured on the trading floor.

Associations between the causes of error. Of the 1,000 near miss incidents, 195 had more than one cause of error. Slip/lapse, the most common cause of error, nearly always occurred in isolation. This means that the causes of error are principally one skill or another (e.g. skip/lapse or human computer interface) and less often the result of multiple skill problems.

Associations amongst the skills and systems used to detect and prevent error. Multiple factors were more common for the skills and systems that detect and prevent error than the causes of error. Of the 1,000 near miss incidents, 295 had more than one skill or system that detected and prevented error. Situational awareness was often identified in conjunction with additional factors when it was attributed to ameliorating near misses. Nearly one-third of the 646 near- miss cases where teamwork was a factor, situation awareness was also identified as a factor (208). Based on a chi-squared test, this is a statistically significant relationship ($p<0.01^{32}$).

This means that the human factors responsible for causing (81%) and ameliorating (71%) near miss incidents therefore predominantly occurred in isolation. Exceptionally, teamwork and situation awareness, the two most frequent human factors responsible for ameliorating near misses, were the most likely to occur together doing so in just under half (45%) of all near miss where situation awareness prevented a near-miss. This analysis reveals that regardless of the cause of the error, situation awareness and teamwork are the leading skills used to capture and prevent error.

The association analysis preformed in this study shows that slip/lapse and human computer interface often occur alone and are the main contributors to error causation, whereas the prevention of error is largely a result of teamwork and situation awareness skills. Moreover, regardless of what causes the error, teamwork and situation awareness are the preventative skills that protect the organisation from failure.

Situation awareness and teamwork skills appear universally important as a 'last-line' of defence for preventing trading mishaps, no matter the cause. The specific skills that are important to capturing error (e.g. gathering of information, attention) are supported through processes such as the ability to ask questions, alertness, participatory engagement and collaborative working groups. Teamwork skills such as roles and responsibilities, coordination and communication are also critical. These skills are supported by a strong perception of shared responsibility over team tasks and goals, cross-departmental team working sessions and communication aids such as internal messaging services, break out spaces and global virtual chat rooms.

DISCUSSION

This study identified the role of operator skills and systems for causing and preventing error in the domain of financial trading. It revealed the following.

First, similar to past studies (Leaver & Reader, 2016), slip/lapse related errors (e.g. fat fingers) are the most frequently coded skill category (52%) as a cause of error. These most often occurred in isolation from other human factors problems. Issues around human computer interaction are the second most commonly coded human factors issue (21%), with human computer interfaces compromising the effective gathering and interpretation of information by users.

Secondly, and to our knowledge not reported on previously, near-miss reports contain useful information about the skills and systems that detect and prevent error. They report the attributes and behaviours that prevent errors from becoming realised losses. Whereas errors in financial trading are predominantly caused by slip/lapse and human-computer interface problems, most near miss are averted by good situation awareness (46%) and teamwork (65%) skills. The skills occurred in concert, with trading staff vigilance for arising issues (and understanding what they look like, and when they occur) and abilities to work with others to resolve them (e.g. sharing calculations and task critical information) being essential.

Third, and building on the previous point, no matter the causes of near misses, situation awareness and teamwork were the key skills for detecting and preventing them. This is to say, situation awareness and teamwork skills appear universally important as a 'last-line' of defence for preventing trading mishaps, no matter the cause. The specific skills that are important to capturing error (e.g. gathering of information, attention, roles & responsibilities) are supported through processes such as the ability to ask questions, alertness, participatory engagement and collaborative working groups. Teamwork skills such as communication between team members (e.g. following complex handover of tasks) and clear team roles and responsibilities (e.g. vigilance in verifying the data and conclusions published within the team's daily reports) are also critical.

Theoretical implications

The research findings demonstrate the value of analysing near misses in terms of the operator skills and systems that prevent the realisation of loss. Through the systematic analysis of near miss incidents with robust coding frames, insight can be provided on the 'safety nets' that prevent everyday errors and problems from resulting in error. In the current study, the vigilance and cooperative behaviours of financial trading staff were critical to identifying errors and problems produced by system-related issues (e.g. human computer interfaces) and slip/lapses. Within domains such as financial trading, where risk-taking is inherent to behaviour and systems, such insights are critical for managing risk effectively, and are equally important to identify the skills deficiencies that underlie failure.

Indeed, within financial trading, the skills that are found to cause error are difficult to eradicate and have limited margin for safety improvement (e.g. unrealistic to re-configure the system interface to perfection or eliminate all 'fat fingers' errors). Through the analysis of the skills and systems that led to the detection and prevention of error we shift the risk management perspective to a positivistic assessment of the key skills that prevent error.

Synthesizing the skills that help capture error on the floor helps to build a more comprehensive understanding of the migration of error, leading to better informed and wider reaching safety interventions. It accepts that risk is ever-present within the system, with human operators providing the last-line of defence. This is especially important in industries where change (e.g. technological, expansion of business) can occur at a rapid pace, with frequent new threats and dynamic challenges (Dekker, 2012; Huber, 2009). Within these domains, the true value incident reports are reveal what ‘goes well’ rather than ‘what goes wrong’ (S. Dekker, 2014).

Within the academic literature, incident reports have generally not been analysed in this way, and this line of thinking connects with wider debates. In particular, those around the nature of ‘ultra-resilient’ industries where risk-taking is integral to success (Amalberti et al., 2005), the requirement of safe systems to be able to manage rather than remove uncertainty (Grote, 2015), viewing human operators as a stable resource for risk management in a fast-changing technological industries (S. Dekker, 2014), and safety-II approaches to human factors which extoll identifying and recognising the value of everyday behaviours that support performance and the navigation of hazards (Hollnagel, 2014b). Interestingly, incident reporting data, which is often critiqued within these approaches (as they attempt to identify single, changeable, causes of incidents), can be used to support and develop this focus.

This appears important as human factors research is applied to domains such as financial trading, which are high-risk in nature but can never be entirely reliable or safe. Risk-taking and change are integral to organisational success, yet when serious errors occur they have profound organisational and economic outcomes. Human factors approaches to such domain require a delicate balance in terms of prescribing the conditions and systems requisite for ensuring a level of risk control, but also recognising the flexibility and skills of operators required for ensuring competitive advantage and the avoidance of losses. In the sample of incidents reported on in this study, 4% of the incidents led directly to a loss. Yet it is not clear whether these would have been best avoided through better systems and skills that ensured that the errors could not happen (potentially constraining other behaviours and acts), or vigilant operators who can monitor and respond to emerging hazards.

Practical implications

In terms of organisational learning and risk management within financial trading, near misses provide useful insight.

First, the data indicates the importance of situation awareness and teamwork for capturing and resolving error. This has important implications for identifying the types of skills and behaviours that are valued by trading organisations, and might be shared and trained. Where incidents in financial trading do lead to losses, these can be significant. Well-trained (e.g. in terms of vigilance for types of problems, cooperative activities) operators may be able to reduce the conversion of near misses to 'hits'. Although this is not a novel insight, for an industry such as financial trading, it is somewhat contrary to the socio-technological environment. In financial trading, performance is generally considered to be highly individualised (e.g. bonus allocation schemes rewarding top performers), with market knowledge and analytical skills being especially prized (Willman, Fenton-O'Creevy, Soane, & Nicholson, 2002). Yet, our findings shed light on how the collective system acts as a protective layer for the organisation, with teamwork (e.g. roles & responsibilities) and situation awareness (e.g. gathering of information and attention) skills being essential yet not currently recognised, recruited for, or trained. This perhaps also speaks to the role of organisational culture, and the importance of collaborative acts, responsibilities for risk management, and perceptions of management commitment to safety (Leaver & Reader, 2017).

Second, the data gives insight on organisational changes that might be deleterious for risk management. For example, the change or automation of technical systems that is important for operators to identify and spot errors (e.g. the automation of daily profit and loss calculations). Often in the trading domain, systems and interfaces are changed for business development needs, with insights from users and risk managers not being sought. Furthermore, trading is a highly globalised industry, with risk control functions increasingly being centralised to one geographical location (rather than being co-located with traders). The near-miss data revealed that cooperation between risk control teams and traders are often important for identifying and managing incidents, and changes to working structures may disrupt this. At the minimum, ensuring communication between these professional groups (e.g. using live running web cams or global chat rooms filtered by activity) would appear essential.

Importantly, the skills that have been identified as essential to capturing error (e.g. gathering of information, attention, roles & responsibilities) are supported through processes such as the ability to ask questions, alertness, participatory engagement and collaborative working groups and these are all behaviours that are promoted in a positive organisational (safety) culture. Although the error analysis undertaken in this study usefully guides us with granular insights into the behaviours that generate error and the skills that are used to capture error, these behaviours are positioned within a much larger cultural frame of the organisation. For example, the behaviours that drive the capture of error (e.g. taking the initiative to cross check team members work) are a product of the practises and norms that are encouraged and rewarded within the organisation. Understanding the culture is therefore important for explaining the negative and positive behaviours related to risk-management in financial trading.

LIMITATIONS AND FUTURE RESEARCH

The results are constrained by the nature of incident reporting generally, which is vulnerable to underreporting and incomplete information about incidents (O'Connor et al., 2007). In the trading domain, the need for an individual to be aware that the event has occurred, their limited perspective on the incident, and their motivation to report constrain incident reporting. Furthermore, only one coder analysed all the near miss incidents (with a second coder analysing 25% of the near miss incidents to assess inter-rater reliability) and the data analysis was constrained by the clarity of the text and the potential biases of trading staff in recalling the incident. Moreover, the reliability analysis revealed scope for improving the FINANS taxonomy, and it may require further development to tailor it to near miss data. Issues such as stress, fatigue, and environmental factors (e.g. culture) were not examined and this could be the focus of future work.

CONCLUDING REMARKS

In the current study, we examined a cohort of near miss incidents collected from a financial trading organisation to identify the frequency and nature of operator skills and systems that ameliorate near misses and to establish whether particular operator skills and systems are important for avoiding particular types of error on the trading floor.

Our analysis reveals that the majority of the errors are a product of slip/lapse (52%) problems and issues in human computer interaction (21%). Uniquely, our positivistic analysis of the reported near miss incidents show that overwhelmingly error is detected and prevented by teamwork skills (65%) followed closely by situation awareness (46%). Going further, our research reveals that slip/lapse, the most common cause of error, nearly always occurred in isolation. This means that the causes of error are principally one skill or another (e.g. skip/lapse or human computer interface) and less often the result of multiple skill problems. Exceptionally, teamwork and situation awareness, the two most frequent human factors responsible for ameliorating near misses, were the most likely to occur together doing so in just under half (45%) of all near miss where situation awareness prevented a near-miss. This analysis reveals that regardless of the cause of the error, situation awareness and teamwork are the leading skills used to capture and prevent error.

The outcomes of this research contribute to approaches for improving risk management in financial industries. Furthermore, our research contributes to how current data from incident monitoring systems can be analysed in a fashion more consistent with a safety II approach (i.e. identify good practice for mitigating, rather than reducing, error).

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6. SAFETY CULTURE IN FINANCIAL TRADING: AN ANALYSIS OF TRADING MISCONDUCT INVESTIGATIONS

6.1 Preface

The final aim of the thesis is to examine whether risk management in financial trading can be understood from a safety culture perspective.

At this point, the research in this thesis expands beyond the focus upon non-technical skills and human error, and considers the wider system within which behaviour occurs. This is important, because behaviours in relation to risk do not occur within a vacuum; they are a product of wider norms, values and institutional systems (Chen, Sawyers, & Williams, 1997; Kaptein, 2011; Saini & Martin, 2009). Understanding how the macro-level trading environment might shape micro-level risk-related behaviours of traders is critical for intervention and change. It is also important for conceptualizing financial trading as akin to other high-risk industries.

This aim is addressed in chapter 6 (article 4), entitled “Safety Culture in Financial Trading: An Analysis of Trading Misconduct Investigations”. In this chapter, safety culture theory is applied to conceptualize and explain failures to manage risk within financial trading in a standardized way using FCA Final Notices. A Final Notice (FN) is comprehensive legal documentation available in the public domain that examines systematic investigations into instances of trading misconduct and set out actions taken against companies or individuals for breaches of regulatory requirements. The decision to use case study analysis in this chapter was taken based on the nature of safety culture research. The FCA cases increase access to a wider dataset, and this supports a better understanding of the context of financial trading and generates a robust identification of the commonalities (e.g. shared cultural dimensions) across the industry.

To achieve this, a set of Final Notice (FN, n=10) cases were selected based on a set of criteria (e.g. related to trading, significant monetary fine, range of organizations), and were analysed using content analysis in NVivo to assess whether they could be understood within the dimensions and sub-dimensions of a safety culture framework. Each FN was analysed by a single coder (Leaver) and 50% of the cases were coded by an organizational psychologist (Reader) to ensure reliability.

Analysing the human factors that underpin error in the financial trading domain on their own cannot ensure that failure will be avoided. Importantly, the analysis of the human factors that underpin operational incidents must be layered with an understanding of the culture within the organization; it is meaningless if the culture of the organization is not incentivized to act on the information provided from the analysis. Furthermore, the chapter counters narratives focusing on traders who are unethical 'rule breakers', and emphasizes the value of a systemic approach, whereby safety culture theory is used to explain why risky behaviours in financial trading occur. This work also demonstrates that safety culture shapes how operators behave and think in relation to risk, and this is central to understanding the conditions under which risk in financial trading can be effectively managed.

The journal article that follows was authored by Leaver and Reader (2017) and published in the *Journal of Business Ethics*. Leaver designed the study, collected and analysed the data, outlined the article and authored all main drafts, contributing to roughly 90% of the content. Reader provided key supervisory support and editorial suggestions, and acted a second coder for 50% of the case analysis. Reader contributed to roughly 10% of the content. Three anonymous reviewers (experts in the field of financial services and human error in high-risk domains) provided critical feedback and suggested edits. Additionally, the journal editor provided essential editorial and content suggestions that led to structural improvements in the article, and ultimately approved the article for publication.

The *Journal of Business Ethics* has an impact factor of 2.354 and is ranked 2/51 in Ethics, and 53/121 for Business Journals. It is also on Financial Times top 50 academic journal list.

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ORIGINAL PAPER

Safety Culture in Financial Trading: An Analysis of Trading Misconduct Investigations

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Abstract High-profile failures in financial trading have led to interest in how the culture of the industry produces risky and unethical behaviours among traders. Yet, there is no established theoretical framework for studying this: we apply safety culture theory to examine ten recent high-profile trading mishaps investigated by the UK financial regulator. The results show that the dimensions of safety culture (e.g. Management Commitment to Safety, Systems and procedures) used to understand organisational accidents in domains such as aviation also explain failures in Risk Management within financial trading organisations. This counters narratives focusing on traders who are unethical 'rule breakers', and emphasises the value of a systemic approach, whereby safety culture theory is used to explain why risky behaviours in financial trading occur. Safety culture therefore provides a conceptual basis for further research on risky and unethical behaviours in financial trading, alongside providing insights for possible intervention.

Keywords Safety culture · Failure · Risk-taking · Financial trading · Regulation · Culture measurement

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Introduction

A series of large-scale failures to manage risk in the financial trading sector have led to multi-million dollar losses and fines (e.g. at Societe General, UBS, JPMorgan) and a focus on organisational culture within companies operating in the industry (Ashby et al. 2012; Palermo et al. 2016). This interest has arisen due to the role of unethical and risky behaviours (e.g. rogue trading, mis-selling, systemic rate rigging) in causing such failures (Greener 2006), with these practices being viewed as reflective of the 'values and the situational experience of a multitude of organisational agents' (Power 2009, p. 854).

Thus, culture change has been identified as a way to restore trust in financial institutions, improve Risk Management and avoid future failures (Parliamentary Commission on Banking Standards 2013). Yet, to achieve this, it is necessary to provide a clear conceptualisation of how the cultures of financial trading organisations produce risky and unethical behaviours and what a desirable culture might be. Various 'dimensions' of culture have been suggested (e.g. leadership, governance, competency, controls, rewards, risk appetite), yet descriptions remain atomistic and poorly defined (Power et al. 2013; Ring et al. 2016). This means there is little standardisation for how organisational culture is conceptualised in financial trading and, as a consequence, an incomplete and disjointed understanding of the factors that underlie risky and unethical behaviours.

To address this issue, the current article applies 'safety culture' theory to conceptualise and explain failures to manage risk within financial trading. Safety culture refers to beliefs (e.g. management priorities) and practices (e.g. risk-taking, protocols) for managing safety in high-risk organisations (e.g. aviation, health care, nuclear power, military) (Cooper 2000; Guldenmund 2000; Mearns et al. 2001; Pidgeon 1998; Reiman and Oedewald 2004). Although different approaches exist to theorise and measure organisational culture (Cameron and Quinn 2005; Erez and Gati 2004; Hofstede et al. 1990), safety culture has become the dominant theory used to understand how cultural factors determine risk practices in industries that must balance competing demands of productivity and safety (Glendon and Stanton 2000; Nordlöf et al. 2015). This is because safety culture explains how social environments directly influence risk practices and because problems in safety culture often underlie mishaps within other high-risk domains (e.g. aviation, health care, energy). Although financial trading is not a safety critical industry, mishaps are highly damaging for organisations and economies, and their causes are similar to those in other high-risk industries (e.g. managerial pressure to increase profit, ineffective procedures).

Thus, in this article, we examine whether safety culture theory also provides a useful conceptual framework for explaining and theorising failures to manage risk in financial trading. We do this through analysing ten high-profile investigations (conducted by the UK Financial Conduct Authority) of Risk Management within financial trading organisations. The purpose is to establish whether safety culture theory can provide a coherent account of why large-scale failures in financial trading organisations occur, and through drawing on this literature, to outline potential future steps for research and intervention.

Financial Trading and Safety Culture

Financial trading organisations buy and sell products (e.g. equities, physical commodities) in order to hedge existing risk, capitalise on arbitrage opportunities, speculate on market volatility and enhance their portfolios (e.g. risk position and profit). Financial trading is increasingly conceptualised as similar to a high-risk industry (Sutcliffe 2011; Young 2011), with risk constantly being monitored and when possible hedged. However, an important distinction is that, unlike many high-risk industries, the success of financial trading hinges on overt risk-taking by traders (as it leads to competitive advantage and potential profit). This feature is consistent with Amalberti's (2013) description of an 'ultra-resilient' organisation, where, rather than engineer risk out of the system, risk is managed through improving employee skills and system design (Amalberti 2013).

Yet, whilst some risk-taking is essential for success in financial trading organisations, unimpeded risk-taking can be highly destructive. Investigations into large-scale failures within financial trading organisations have highlighted problems with 'rogue traders' who manipulate rules and Systems in order to gain short-term advantage (but with long-term costs). Although popular narratives have focused on the characteristics and unethical activities of 'rogue traders' as underlying financial scandals (Gapper 2011), academic research increasingly focuses on the organisational cultures that cultivate and allow risky and unethical trader activities (Gilligan 2011; Jennings 2008).

This is because such behaviours are a product of the practices that are encouraged, rewarded and penalised by trading firms (Chen et al. 1997; Kaptein 2011; Saini and Martin 2009). For example, research in finance has focused on the importance of 'fit' between the values of employees and their organisations for shaping ethical practices (Van Hoorn 2015), on tendencies for dishonesty with banking (Cohn et al. 2014), stigmatisation of industry practices (Roulet 2014) and the need for professionals and regulators to monitor and improve the culture of financial organisations (IIF 2009; Sants 2010; Wheatley 2012).

Yet, further description and theoretical analyses are required of what an 'appropriate' culture in financial trading is comprised of (Mcconnell and Blacker 2013; Ring et al. 2016). In particular, it is necessary to develop a cultural framework that is 'reduced and simplified to some observable properties that can be acted upon and audited by others' (Ashby et al. 2012, p. 18), for example in terms of rigorously determined conceptual underpinnings, distinct cultural dimensions and associations between these and risky behaviours by traders. To achieve this, scholars have drawn parallels between financial trading and other industries where risk-taking is sometimes necessary, but hugely damaging if not managed effectively: for example, aviation, nuclear power or health care (Young 2011). Within such industries, the concept of 'safety culture' is widely used to describe, explain and assess risk-related activities (Noort et al. 2015; Singer et al. 2009), and there may be value in applying this theoretical framework to financial trading. We explore this below.

Safety Culture

Safety culture is a safety-related facet of organisational culture and refers to the beliefs (e.g. on the priorities of management) and practices (e.g. risk-taking, protocols) within organisations that influence how risk and safety are managed (Cooper 2000; Guldenmund 2000; Mearns et al. 2001; Pidgeon 1998; Reiman and Oedewald 2004). The concept of safety culture became prominent due to it being identified as a casual factor in various catastrophic accidents (e.g. Chernobyl, NASA Challenger, Piper Alpha). In these cases, poor risk practices at an operational level (e.g. ignoring protocols, disregarding risk) were shown to be influenced by cultural norms that were determined by organisational and industry characteristics (e.g. rewards

Systems, management priorities, regulation) (Paté-Cornell 1993; Pidgeon 1991; Zohar 1980). This was a significant observation, because it moved academic and practical theorisations on why organisational accidents occur away from a focus on individual employees (e.g. 'error', 'incompetence' or 'disregard for safety') and instead to the Systems and environments in which they operate (Reason 1998).

Over a period of 30 years, safety culture has become the dominant theoretical lens through which to understand how organisational culture shapes risk practices (Antonsen 2012; Strauch 2015; Zohar 2010). Although many theories and measurements exist for studying organisational culture and behaviour (Ashkanasy et al. 2000), safety culture focuses upon explaining why organisational employees engage in risky and unethical behaviours, and how these can lead to mishaps. Thus, for industries in which Risk Management is central to delivery, and where failures to effectively manage risk can lead to catastrophic failure, safety culture is valuable both theoretically and practically. Theoretically, it is useful in terms of helping organisations to understand how their social environments determine and shape the ethical and risk-related behaviours of employees. Practically, through safety culture measurement, it allows organisations to monitor their culture and to identify whether the organisational conditions that influence mishaps are positive or changing.

The validity of this approach is demonstrated by research showing safety culture to be associated with safety outcomes and risky activities (Clarke 2006; Hajmohammad and Vachon 2014). Indeed, safety culture measurement and improvement has become an integral part of Risk Management within domains such as health care, aviation, offshore oil and gas production, and nuclear power (Carroll 1998; Mearns et al. 2001; Reader et al. 2015; Weaver et al. 2013). Yet, no comparable approach exists for financial trading, and in the context of financial organisations being required to monitor and improve Risk Management and organisational culture (IIF 2009; Parliamentary Commission on Banking Standards 2013), safety culture theory appears useful for the following three reasons.

First, the approach of safety culture theory—to conceptualise risk-related behaviours by organisational employees as a product of the norms and values within a given system—may be insightful for understanding poor practices within financial trading. Rather than focusing on the behaviour of individual 'bad apples', safety culture theory focuses on how failures to manage risk reflect the normative tendencies and perceived priorities of an organisation (e.g. on pressures related to production versus safety) (Guldenmund 2000), and are representative of the robustness of Systems and procedures for managing risk (e.g. just culture) (Dekker 2012). In particular, safety culture appears relevant to financial trading because similar factors as those found to underlie mishaps in safety critical domains (e.g. reward structures, poorly designed Systems, skill deficits, unclear boundaries of acceptable behaviour) have been identified as important in cases of financial mismanagement and rogue trading (Land et al. 2014; Sims and Brinkmann 2003). Yet, in financial trading, no coherent framework exists for describing how organisational culture influences risky and unethical behaviours (Power et al. 2013; Ring et al. 2016). Safety culture provides an initial and well-established foundation for doing this.

Second, scholars have outlined a number of core 'latent' dimensions that capture the key characteristics of safety culture (e.g. Management Commitment to Safety). This is useful, because it allows for a more nuanced understanding of how different aspects of safety culture impact upon workplace activity, why risky and unethical behaviours are occurring, and what steps could be taken to reduce this. For example, where organisations have a culture of penalising those who make mistakes or slow down productivity for safety reasons, employees are less likely to report safety problems and near misses (Dekker 2012). It is beyond the scope of this article to list and review all safety culture studies; however, to illustrate, Table 1 lists the dimensions of safety culture used in ten prominent empirical studies and three literature reviews since 1999.

Although the micro-dimensions used to measure safety culture vary according to each paper, at a macro-level, conceptualisations of safety culture have a high degree of overlap. As summarised in Box 1, over-arching dimensions used to measure safety culture are Management Commitment to Safety (e.g. perceptions of staff for the managerial expectations on risk-related behaviours), risk handling (e.g. responding to error, risk-taking behaviours), Rules and Regulation (e.g. safety protocols), Systems (e.g. policies, incident reporting) and collaboration (e.g. communication, teamwork on safety). These constructs appear especially relevant to describing the cultural dimensions that account for risky and unethical behaviours in financial trading. For example, in the case of the Barclays Plc. rate-rigging misconduct, the Financial Conduct Authority (FCA) indicated that Systems and control failings, a conflict between organisational goals and organisational stability (e.g. to make profit), and weakly perceived management commitment to effectively manage risk catalysed the trading misconduct. Thus, the specific psychometric dimensions of safety culture used to understand problems in Risk Management within other industries may provide explanatory insight into the different forms of risky behaviour observed in financial trading.

Third, within the financial trading industry professionals and regulators have called for the need to establish guidelines to monitor and improve the 'risk culture' of

Table 1 Literature review of safety culture dimensions

References	Domain	Methodology	Dimensions	Interesting finding
Håvold (2010)	Fishing vessels	Safety culture questionnaire, 50 questions—distributed to experts in EU	Attitudes towards Rules and Regulations Safety training and drills Job satisfaction Fisherman's safety attitude Conflict between work and safety Pressure Management safety attitude	Safety attitude of management had a strong influence on a company's safety policy—fisherman not involved in accident showed more positive attitudes towards safety culture
Jeffcott et al. (2006)	Railway	Two-year qualitative study, 40 interviews and 50 focus groups with 500 employees in 4 organisations	Stakeholder relationships Management commitment Performance regime Blame and culpability Knowledge management Organisational learning Resources Morale Homogeneity of culture	How safety culture influences trust within the organisation—trust is key to safety performance TOCs do not approach the classical 'safe' organisation model (e.g. they exhibit a rigid rather than flexible hierarchy and procedures, deficiencies relating to perceptions of management commitment)
Goncalves Filho et al. (2010)	Petrochemicals	Questionnaire measuring 5 aspects of OSC in 23 petrochemical companies, adopting the model of Hudson (2001)	Information (incident reporting) Organisational learning Involvement (participation of employees) Commitment (planning, priorities) Communication	No theoretical or empirical research on safety culture in this industry—this study shows that the model of Hudson (2001) and the revised framework can identify levels of safety culture maturity in this domain
Olsen (2010)	Healthcare and petroleum sectors	Questionnaires, 1919 (55% return) in health care and 1806 (52% return) in Oil and Gas	Organisational management support for safety Transitions and teamwork across units Supervisor/manager expectations and actions promoting safety Learning, feedback and improvement Teamwork within units	Testing the feasibility of cross-industrial structural model of identifying general safety climate concepts

Table 1 continued

References	Domain	Methodology	Dimensions	Interesting finding
Lu and Yang (2011)	Passenger Ferry	Survey data from 155 experts in Taiwan	Safety policy Safety motivation Emergency preparedness Safety training Safety communication	Study provides empirical evidence of the importance of safety climate in explaining worker's safety behaviours in passenger ferry operations
Reader and O'Connor (2014)	Air traffic control	Psychometric properties of SC model (ATM) were examined in 17 countries, from 4 distinct regions (North, East, South, West)—expert staff ($n = 5176$) and management staff ($n = 1230$)	Management Commitment to Safety Collaborating for safety Incident reporting Communication Colleague commitment Safety support	Demonstrated for the first time that when safety culture is tailored to specific industry, they can operate consistently across national borders
Lee and Harrison (2000)	Nuclear power stations	120-item questionnaire in three nuclear power stations. Seven focus groups, each composed of 10–12 staff and addresses attitudes and behaviour	Confidence in safety (e.g. control measures, safety standards) Job satisfaction (e.g. trust in colleagues) Participation (e.g. perceived empowerment) Risk (e.g. organisational risk-taking, risk versus productivity) Safety rules (e.g. complexity of instructions) Stress (e.g. personal stress, job security) Timing/selection (e.g. quality of training)	Personnel safety surveys can usefully be applied to deliver a multi-perspective, comprehensive and economical assessment of the current state of a safety culture and explored the dynamic of inter-relationships of its 'working parts'
Ek et al. (2003)	Air traffic control	Observations of daily work, COPSOQ questionnaire with 95 questions representing 9 dimensions, standardised interview with 9 employees at each control centre	Working situation Communication Reporting Justness Flexibility Learning Safety-related behaviour Attitude to safety Risk perception	Safety culture varies across locations and personnel levels. All groups felt that they had not received enough training in how the communication should function in emergencies. Managers tend to be very positive in their reports of safety culture

Table 1 continued

References	Domain	Methodology	Dimensions	Interesting finding
Wiegmann et al. (2004)	Theoretical literature analysis (all domains)	Systematic literature review	Organisational commitment Management commitment Employee empowerment Rewards system Reporting systems	This study posits that there is considerable disagreement among professionals on how to define safety culture and to differentiate it from safety climate
Farrington-Darby et al. (2005)	Railway	Group and individual semi-structured interviews were employed. 34 respondents were interviewed in 6 groups (front-line operational staff who volunteered)	Communication Rule dissemination Pre-job information Supervisor visibility Equipment Planners competency Perceived purpose of paper work Training methods	Front-line actors have a strong underlying sense that safety is not only their responsibility—but that they will look for an 'easy and comfortable' way of achieving task even if this involves increased risk. Senior management were seen as having considerable influence on how easy or difficult it was to be 'safe'
Cox and Cheyne (2000)	Offshore environments	Focus group discussions ($n = 40$) using both offshore and onshore personnel in 3 organisations at 6 locations. $N = 375$ employees in groups ranging from between 3 and 12 made up the focus groups. 83 managers, 181 worked on onshore, 194 offshore	Management commitment (e.g. supervisor support) Priority of safety Communication (e.g. safety information) Safety rules (e.g. complexity of procedures) Supportive environment Personal priorities and need for safety Personal appreciation of risk (e.g. risk-taking behaviour) Involvement (e.g. participation) Work environment (e.g. equipment and design)	Most common dimensions were management commitment, management actions and the physical work environment and safety issues and the priority given to safety issues. This helped construct a common taxonomy for the industry—set of safety climate assessment tools
Flin et al. (2000)	Energy sector	Review of methods and results from industrial surveys, thematic basis of 18 scales used to assess safety climate. Thematic analysis following a literature search, 18 published reports of safety climate surveys	Management Safety system Risk Work pressure Competence Procedures/rules	Suggests that the most typically assessed dimensions relate to management (72%), the safety system (67%), risk (67%), in addition themes relating to work pressure and competence appear relevant

Table 1 continued

References	Domain	Methodology	Dimensions	Interesting finding
Halligan and Zecevic (2011)	Health care	Literature review to identify the concepts of safety culture prevalent in the healthcare domain—studies published between 1980 and 2009. 1324 titles were reviewed, 1124 unique abstracts, 200 full text papers, 139 papers fully reviewed	Leadership commitment to safety Open communication founded on trust Organisational learning A non-punitive approach to adverse event reporting and analysis Teamwork Shared belief in the importance of safety	Attempts to determine a common set of definitions and dimensions that can enable researchers to better share information and strategies to improve methods
Clarke (1999)		Questionnaire to elicit the perceptions of 312 rail staff using 25 'dimensions' of railway safety	Management Commitment to Safety Conflict between work and safety Rules and processes Skills and attitudes of employees equipment	The study shows that whilst there is a shared perception of the importance of safety across the group, inter-group perceptions are not representative. Furthermore, inter-group perceptions are essential to mutual trust and the foundation of positive safety culture

trading organisations (IIF 2009; Sants 2010; Wheatley 2012). This is seen as essential to restoring trust in financial institutions, improving Risk Management and avoiding catastrophic failures (House of Commons Treasury Committee 2009; Parliamentary Commission on Banking Standards 2013). Yet, there is little consensus within the literature on what an appropriate culture is or how it should be monitored and measured (Mcconnell and Blacker 2013; Ring et al. 2016). Within other high-risk industries, safety culture measurement is often used to benchmark risk-related practices within organisations in a given industry (Mearns et al. 2001). These data (e.g. surveys, incident reports, qualitative interviews) are used to develop a normative understanding of the industry, to recognise 'outlier' organisations (e.g. 'high' or 'low' performers) and to identify opportunities for learning and change within and between organisations. Thus, the methodology and concepts used in safety culture research provide a potential way forward for enhancing how risk culture is monitored and improved in the financial trading industry.

The Current Study

In summary, whilst large-scale failures to manage risk in financial trading do not necessarily lead to loss of life, they can seriously undermine economic and social structures. Safety culture theory may provide a useful framework for understanding the employee risk practices in financial trading that underlie these failures, outlining the specific dimensions of culture that influence behaviour in trading firms and measuring and benchmarking industry practices on risk. We examine the potential for this through analysing ten high-profile organisational failures in the UK financial trading industry. Specifically, through taking a safety culture perspective to systematically analyse Final Notices (FNs)[1] issued by the Financial Conduct Authority (FCA) we:

1. Examine whether safety culture theory can account for employee risk practices in financial trading mishaps
2. Provide an initial framework of cultural dimensions for measuring and evaluating safety culture in financial trading

[1] FNs are comprehensive legal documentation available in the public domain that examine systematic investigations into instances of trading misconduct and set out action taken against companies or individuals for breaches of regulatory requirements. They provide an unbiased forensic analysis of the working context, nature of the violations and reasons for the breach.

Box 1 Recognised components of safety culture

Management Commitment to Safety: Policies with regard to supervision and motivation of the workforce and the adherence to the rules (e.g. perceptions of staff for the managerial expectations on risk-related behaviours)
Blame and culpability
Employee participation (e.g. perceived empowerment)
Management safety attitude
Supervisor/management expectations
Morale
Safety motivation
Shared belief in the importance of safety

Risk: Policies with regard to which, when and how risks are evaluated (e.g. responding to error, risk-taking behaviours)
Appreciations or risk (e.g. risk-taking behaviour)
Confidence in safety (e.g. control measures, safety standards)

Rules and Regulations: Policies with regard to formal procedures and instructions (balanced by what is trained and how workers are recruited and selected). Basically, policies determining the structure of work (e.g. safety protocols)
Checklists
Planning
Rule dissemination
Safety rules (e.g. the complexity of instructions)
Safety training and drills

Systems: Policies with regard to how identified risks are avoided, reduced or controlled by design or layout (e.g. policies determining the choice of barriers that control present dangers and risks) and policies with regard to maintenance and inspection (e.g. policies, incident reporting) and how often, etc.)
Incident reporting (non-punitive)
Internal audits
Organisation of system access rights (e.g. access to information based on roles)
Resources
Systems alerts and controls
Systems maintenance (e.g. breach reports sent consistently)

Collaboration: Policies with regard to effective collaboration and interaction of (groups) of people (e.g. communication, teamwork on safety)
Ability to speak up within the organisation
Transitions and teamwork across units
Trust in colleagues
Conflict between work and safety (e.g. risk appetite and performance goals)

3. Test the utility of these cultural dimensions through examining whether and how they influenced risk practices reported within the Final Notices

Method

The current study adopts safety culture theory to analyse ten Final Notices. Below we outline a Final Notice, the procedure for case selection and the analytical procedure used to analyse the cases.

A Final Notice is issued by the FCA when it has taken enforcement action against an individual or an organisation due to their conduct falling below the expected standards (Financial Services Authority 2012). An FN sets out action taken against firms or individuals for regulatory breaches and explains the nature of and reason for the breach. The penalties and their publication in an FN are specifically intended to encourage change in the behaviour of the offender and deter future non-compliance by others. In this capacity, FNs provide a rich source of data for understanding how culture shapes employee risk practices in financial trading, and are a valuable learning tool for financial organisations. Although FNs focus on aspects of an incident such as managerial decision-making, technical Systems and controls and internal compliance checks, they have not previously been considered systemically within a culture framework (Bryce et al. 2013).

Case Selection

The selection criteria were that:

1. The Final Notice related to a trading department (e.g. excluding retail banking, insurance funds, wealth management).
2. The events took place after the 2008 financial crisis (as this is when interest in culture and risk practices first emerged within the industry).
3. The magnitude of the financial penalty (>5 M GBP) were large enough that the event can be considered a significant organisational failure.
4. Repeated failures (e.g. LIBOR) were excluded after the first case in order to avoid skewing the results of the analysis.

Our final sample represents 0.47% of the total cases available in the FCA Final Notices database and 21% of the total cases where the penalty is equal to or greater than 5 M GBP. In the final sample, six large banking institutions were represented (Barclays Plc., Credit Suisse, UBS AG, JPMorgan Chase Bank N.A., RBS, Toronto Dominion and RBS). Three of the institutions were repeatedly selected: Barclays Plc. (2), JPMorgan Chase Bank N.A. (2) and UBS AG (3). The problems ranged from individual rogue trading to market collusion and regulatory reporting infractions. To ensure the generalisability of safety culture as a theory for understanding trading mishaps, the case selection ensured that a wide range of offenders and problem types were analysed. To do this, we only included one instance of any particular type of event. For example, in the case of LIBOR rate rigging, five banks were penalised, only one bank was chosen in the cases, and we chose the first case detailed by the FCA. This ensured both variety and randomness in the sample of cases selected.

The selected FNs varied in terms of financial penalty; the average penalty amount is £74.5M, the lowest financial fine is £5.6M, and the highest fine is £196.5M. The summary of reasons for the various infractions also vary from manipulation of foreign currencies (UBS AG), inappropriate submission of regulatory data (Barclays Plc.) and failure to adequately assess and monitor the risks associated with trading activities (JPMorgan Chase Bank N.A.). The ten cases are summarised in Table 2.

Procedure

The method used to analyse the ten Final Notices was qualitative content analysis. This is consistent with accounting studies that used content analysis to examine risk disclosures (Linsley et al. 2006; Miihkinen 2012). The content analysis carried out in this paper follows the method presented by Kowal and O'Connell (2014) and is a more exploratory process than previous studies (Ring et al. 2016; Turner 1994).

Each FN case was loaded into NVivo11 and then analysed by two organisational psychologists: one with expertise in Risk Management in financial trading and the

Table 2 Selected Final Notice cases

Case number	Organisation	Year	Fine	Description of misconduct
1	JPMorgan Chase Bank N.A.	2014	£222M	Failed to control its London voice trading operations in the G10 spot and FX market
2	JPMorgan Chase Bank N.A.	2013	£196.5M	Losses caused by high-risk trading strategy, weak management of that trading and an inadequate appreciation of risk
3	UBS AG	2012	£160M	Misconduct relating to the calculation of EURIBOR, manipulation of certain currencies and inter-dealer collusion
4	Barclays Plc.	2012	£85M	Inappropriate submissions following requests by derivative traders (LIBOR)
5	UBS AG	2012	£29.7M	Rogue trading activity on exchange traded index future positions. Underlying positions were disguised by the use of offsetting strategies, which had no economic reality and no associated external risk position
6	Barclays Plc.	2014	£26M	Failing to take reasonable care to organise and control its affairs responsibly and effectively, with adequate Risk Management Systems (gold price fixing)
7	UBS AG	2009	£8M	Unauthorised foreign exchange and precious metals trading
8	Toronto Dominion Bank (London Branch)	2009	£7M	Failing to conduct business with due care, skill and diligence—numerous and serious failings in the Systems and controls concerning trading book pricing
9	Credit Suisse	2008	£5.6M	Failing to conduct business with due skill, care and diligence. Failings relate to the pricing of certain asset-backed securities
10	The Royal Bank of Scotland Plc./N.V. ('RBS')	2013	£5.6M	Failing to accurately report trading transaction as a result of significant Systems challenges post-takeover

other with expertise in safety research across a range of high-risk industries. The framework used to analyse the cases was derived from the five dimensions (and 25 sub-dimensions) of safety culture extracted from the literature review (see Table 1, Box 1). All ten FNs follow the FCA standard template. Cases were assessed in terms of whether they were consistent with the dimensions and sub-dimensions of safety culture listed in Box 1. The parts of the report that appeared to be associated with a dimension of safety culture were coded within NVivo. Each FN was analysed by a single coder (lead author), and five FNs were additionally coded by an organisational psychologist (second author) to ensure reliability.

Analysis

Prior to investigating the research questions, the reliability of the qualitative content analysis was established. To do this, the inter-rater reliability of the two raters (first and second author) was examined using a Cohen's kappa calculation in NVivo11. Cohen's kappa coefficient measures inter-rater agreement for two raters for qualitative (categorical) items such as safety culture dimensions.[2] Overall, the reliability across the ten cases for the five safety culture dimensions was good and across the dimensions ranged from substantial agreement: Management Commitment to Safety ($k = 0.80$), Rules and Regulations ($k = 0.67$), Organisational Communication ($k = 0.62$) to moderate agreement: Systems ($k = 0.53$) and fair agreement: Risk Management ($k = 0.26$). Consistently low reliability was shown across all sub-dimensions.

In order to investigate the role of safety culture in financial trading, the following analyses were performed:

1. Establishing the role of safety culture in the Final Notices

To examine whether safety culture theory can account for employee risk practices in financial trading mishaps, we investigated the extent to which the safety culture dimensions listed in Box 1 were described in the FNs as underlying the problems leading to failures in Risk Management. Each case was read and any textual references to the pre-determined set of safety culture dimensions were identified and classified in NVivo11.

2. Developing an initial framework of cultural dimensions for measuring and evaluating safety culture in financial trading

We further refined the safety culture framework in Box 1 in order to provide an initial framework of cultural dimensions for measuring and evaluating safety culture in finance trading (Box 2). We did this through an examination of the most commonly occurring dimensions within the cases (established in the first phase of analysis and reporting), as well as exploring rarely used dimensions across all the cases and creating a refined list of the relevant dimensions in this domain. Simply, where safety culture dimensions were identified within the FNs, these were included within the framework. Where they were absent, the dimensions were removed.

3. Examining how the dimensions of safety culture for financial trading relate to risk practices reported in the Final Notices

Finally, we examined the utility of the specific safety culture dimensions for explaining risk practices in financial trading. We did this through identifying parts of text in the report previously coded as being associated with a dimension of safety culture. We then analysed those segments of text in order to establish whether and how the specific activities identified as problematic within the FNs were influenced by the cultural dimension.

This required a more inductive approach (Braun and Clarke 2006), whereby associations between the safety culture dimensions and trading activities were identified. Specifically, for the segments of text coded in NVivo as referring to a safety culture dimension (in the first stage of analysis), a single coder (lead author) identified the patterns of trader activity that were reported and described. This was an iterative process, whereby themes of associations between the safety culture dimensions and trader activities emerged (and were logged in NVivo). A second coder (the second author) independently evaluated the generation of themes, and these were then refined and interpreted through further conceptualisation of how the safety culture dimensions might be argued to influence activity. This was done through reference to the broader literatures on safety culture and financial trading. The inductive phase of analysis helps to reveal themes or patterns specific to financial trading that emerge from the cases, and this in turn informs the creation of bespoke dimensions.

Results

The role of safety culture in financial trading mishaps

The content analyses of the Final Notices were found to yield rich data on how the organisational environment shaped behaviours in the featured organisations. For

[2] It is suggested that kappa results can be interpreted as value $k \leq 0.01$–0.2 as none to slight, $k \leq 0.21$–0.40 as fair, $k \leq 0.41$–0.60 as moderate, $k \leq 0.61$–0.80 as substantial and $k \leq 0.81$–1.00 as almost perfect (Fleiss and Cohen 1973; McHugh 2012).

example, in eight of the cases, the perceived ability to speak up (Organisational Communication) was critical to embedding error and undermining mitigation opportunities within the offending organisations. In the case of Barclays Plc. (2012), the lack of ability to speak up was driven by factors such as: unwanted negative press (p. 3); 'internal political pressure' (p. 25); and a culture of secrecy 'if you breathe a word of this I'm not telling you anything else' (p. 21). It appears that these unsafe practices influenced traders' behaviour, leading to the continued submission of inaccurate data and manipulation of internal performance evaluation tools (e.g. profit and loss reports). To illustrate the context of the data collected and the types of problems codified across the safety culture dimensions and sub-dimensions, qualitative examples from the text are included in Table 3.

Table 3 illustrates that 25% of the assessed cases relate to the dimension of Organisational Communication and, within this dimension, the most common coded sub-dimension is the ability to speak up (23%). The dimension 'Systems Implementation' was identified in 21% of the assessed cases, with Systems alerts and detection (11%) and incident reporting (10%) being the most common sub-dimensions. The least frequently identified dimension was Rules and Regulations (17%). In terms of sub-dimensions of safety culture, the most common was rule dissemination (16%) and safety training and drills (15%). The sub-dimension checklists (Rules and Regulations) was not identified in any of the cases. Similarly, certain sub-dimensions were rarely coded such as: morale, blame and culpability (Management Commitment to Safety), confidence in safety (Risk Management), planning (Rules and Regulations) and internal audit (Systems). Table 3 indicates that there are rarely occurring sub-dimensions including confidence in safety, planning and internal audit.

In order to refine the safety culture framework for future use (e.g. to guide the development of a survey, root-cause analysis of trading incidents), a number of further interpretations were made, and we explore these in the following section.

A framework of cultural dimensions for measuring and evaluating safety culture in financial trading

Below we describe and present a refined safety culture framework, tailored to the financial trading domain. This framework is based on the preceding analysis, and in particular, the results are reported in Table 3.

First, it is noticeable that the absence of sub-dimensions (e.g. confidence in safety, planning and internal audit) may indicate that these are less relevant in the assessment of safety culture in the finance domain, and could be either removed in future iterations of the framework or tested through alternative methods (e.g. interviews).

Second, the content analysis of the sub-dimensions reveals that some sub-dimensions exhibit low inter-rater reliability. However, rather than removing the sub-dimensions, it may be that those which touch on similar issues could be combined in order to benefit the overall reliability. For example, resources and system maintenance may be combined, and safety training and rule dissemination might also be combined.

Lastly, the FCA notices highlight the influence of organisational incentives (e.g. bonuses) and opportunities for advancement as drivers of safety behaviour (e.g. in the LIBOR notices, the FCA indicates that it was commonplace for senior management to determine bonuses and career advancement based on the size of an individual trader's book). Although the literature search that informed the development of Box 1 does not explore power and monetary rewards (e.g. bonuses), there is likely benefit in studying the influence of rewards upon trading staff's safety behaviour. For example, research shows that, given the nature of leaders in an organisational setting, and their ability to dismiss or punish employees, it could be beneficial to explore the value placed on money relative to that of safety (Flin and Yule 2004; Zohar 2002). Therefore, we believe that this sub-dimension warrants inclusion in the safety culture framework and is most relevant to Management Commitment to Safety (Antonsen 2009).

Informed by the aforementioned findings and interpretations, a synthesis is presented in Box 2, where we offer a refined list of safety culture dimensions, tailored to the context of financial trading.

Associations between safety culture dimensions and risk practices in financial trading

We expand on Table 3 and Box 2, and consider (from a safety culture perspective) the various manifestations and poor employee risk activities that were captured in the analysis of the FNs. The purpose is to test and operationalise how the constructs that comprise safety culture theory impact behaviour within financial trading. Below we report on associations between safety culture dimensions and risk activities observed in the FNs, and also interpret these within the wider safety culture and financial trading literature. Crucially, the interpretative section allows us to effectively map the safety culture dimensions onto the observed behaviours in the FCA cases, and this promotes a more nuanced understanding of the relationship between safety culture and trading mishaps.

Box 2 Components of safety culture in finance

Organisational Communication: Policies with regard to effective collaboration and interaction of (groups) of people (e.g. policies determining who should talk with whom about what)

Ability to speak up within the organisation

Transitions and teamwork across units

Trust in colleagues

Management Commitment to Safety: Policies with regard to supervision and motivation of the workforce and the adherence to the rules (e.g. what is acceptable behaviour and how deviations should be corrected)

Blame and culpability

Employee participation (e.g. perceived empowerment)

Management safety attitude

Supervisor/management expectations

Safety motivation

Shared belief in the importance of safety

Risk Management: Policies with regard to which, when and how risks are evaluated (e.g. what the present dangers and risks are and how they should be perceived and controlled)

Appreciations or risk (e.g. risk-taking behaviour)

Confidence in safety (e.g. control measures, safety standards)

Conflict between work and safety (e.g. risk appetite and performance goals)

Rules and Regulations: Policies with regard to formal procedures and instructions (balanced by what is trained and how workers are recruited and selected). Basically, policies determining the structure of work

Rule dissemination

Safety training and drills

System Implementation: Policies with regard to how identified risks are avoided, reduced or controlled by design or layout (e.g. policies determining the choice of barriers that control present dangers and risks) and policies with regard to maintenance and inspection (e.g. when (preventative vs corrective) and how often, etc.)

Incident reporting (non-punitive)

Organisation of system access rights (e.g. access to information based on roles)

Resources

Systems alerts and controls

Systems maintenance (e.g. breach reports sent consistently)

Organisational Communication

Communication on risk (e.g. discussing threats to safety, communicating procedures and changes and raising concerns) was found to underpin an effective safety culture. Across the FNs, organisations lacked a coherent communication plan for disseminating safety rules, procedures and training. A lack of clear training and guidance regarding internal policies of conduct was cited in nine of the ten cases reviewed. For example, at Barclays Plc., the FCA noted that 'the firms lack of specific training and guidance, given the absence of clear and sufficiently-tailored policies and procedures…meant that personnel may have been unaware of which conflicts of interest they should pay particular attention to…' and precipitated this particular failure (Barclays Plc., p. 3).

The absence of training and communication on best practices fostered confusion between the departments and a lack of clarity regarding the utility of new policies or collective regulatory responsibility. This meant that oftentimes, the operational staff overlooked their regulatory responsibilities (e.g. price testing) or continued to participate in the established risky practices (e.g. modifying the submissions data when asked by Front Office).

In terms of the wider literature, previous research shows good communication on organisational risks (e.g. as established through training) is critical to developing a strong safety culture (Olive et al. 2006), and it also appears important for conceptualising and assessing safety culture in financial trading (e.g. developing incident reporting Systems, change, clear communication protocols).

Management Commitment to Safety

The FNs provide numerous examples of the importance of Management Commitment to Safety in financial trading organisations. Key drivers of employee risk practices identified in the FNs were the behaviours and attitudes of

Table 3 Safety culture dimensions and sub-dimensions identified in the FCA cases

Dimensions	Sub-dimensions	Description	Example	Coding frequency
Organisational Communication				124 (55%)
	Ability to speak up	Refers to extent to which employees are comfortable or perceived to be able (e.g. organisational constraints) to voice concerns inter-/intra-team	'Lack of product knowledge within the collateral team which meant that no effective challenge was made'	52 (23%)
	Transitions across teams	Refers to the coordination of processes and tasks within and between interdisciplinary teams	'Work streams operated in silos; those preforming the work lacked awareness of the overall context'	26 (11%)
	Trust in colleagues	The measure of confidence and competence in team members	'These traders formed close, tightknit groups or one-to-one relationships based upon mutual benefit'	25 (11%)
Total				227 (25%)
Management Commitment to Safety				105 (62%)
	Blame and culpability	A measure of the culture of blame shifting or lack of acceptance of organisational responsibilities	'Are we guilty of being part of the pack? You could say we are'	6 (4%)
	Employee participation	The extent to which employees perceive they are able to contribute to decisions and organisational process	'Front office was able to input, change and approve FX trades with no effective challenge from the Back Office'	15 (9%)
	Management safety attitude	Management perceived prioritisation of safety and productivity	'Senior management at high levels within Barclays expressed concerns over this negative publicity'	12 (7%)
	Manager expectations	The perceived expectations of management to perform safely	'Senior management concerns in turn resulted in instructions being given by less senior managers at Barclays to reduce LIBOR submissions in order to avoid negative media comment'	10 (6%)
	Morale	The confidence, enthusiasm and discipline of the team at a specific time	'The external trader thanks Trader G for Barclay's LIBOR submissions later that day; "Dude. I owe you big time! Come over one day after work and I'm opening a bottle of Bollinger"'	1 (0.5%)
	Safety motivation	The reasons for demonstrating good or poor safety behaviour	'The authority was deliberately misled on one occasion'	12 (7%)
	Shared belief in the importance of safety	The beliefs and values in regard to safety that originate from manager-directed joint learning	'Although action plans were in place to improve processes for future months, no additional scrutiny of the March month-end valuation process was undertaken by CIO Finance or CIO VCG management'	9 (5%)
Total				170 (19%)
Risk Management				96 (56%)
	Appreciations of risk	The perceived likelihood and action or inaction taken as a result of gaining or losing asset value	'Barclays did not believe the submission of LIBOR was an area of significant risk'	31 (18%)
	Confidence in safety	The state of being certain with the management's course of action in regard to safety process and procedure	'Business model placed significant reliance on the honesty of employees and the supervisory obligations of Desk Heads without taking steps to mitigate against the risk that employees would act incompetently or dishonestly'	5 (3%)

Table 3 continued

Dimensions	Sub-dimensions	Description	Example	Coding frequency
	Conflict between work and safety	Impacts the decision to meet performance requirements (productivity) or to adhere to the standard operating procedure (safety)	'At the direction of the SCP management, they deliberately mismarked the SCP in order to conceal what one trader believed to be genuine losses'	38 (22%)
Total				170 (19%)
Rules and Regulations				91 (60%)
	Planning	The existence of procedures to evaluate risks and establish the necessary safety measures for avoiding accidents	'Reassignments and reorganisations within certain control functions, together with remote supervision and demanding workloads, exacerbated the situation'	1 (0.7%)
	Rule dissemination	The availability (e.g. access) and distribution of information in regard to safety rules within and across the organisation	'Compliance replied with appropriate advice by email, there is no record of wider dissemination of the guidance or of steps to ensure this was reflected in (JPMorgan's) policies or controls'	25 (16%)
	Safety rules	Refers to the existence of protocols and procedures for operating safely during routine and non-routine tasks	'Compliance reviews lacked depth and a robust risk assessment process. The monitoring (of international wealth business) had limited impact on identifying and improving the control framework'	13 (9%)
	Safety training and drills	The existence of training programs or opportunities to simulate situations where employees face routine and non-routine tasks	'The firm's lack of specific training and guidance, given the absence of clear and sufficiently-tailored policies and procedures … meant that personnel may have been unaware'	22 (15%)
Total				152 (17%)
Systems implementation				100 (53%)
	Incident reporting	A method of recording details of non-routine events that occur within the organisation that can undermine organisational safety and performance (e.g. human error, Systems error)	'It failed appropriately to escalate issues that may have led to earlier detection of the pricing issues'	19 (10%)
	Internal audit	The provisions of independent assurance that Risk Management, governance and internal control processes are operating effectively	'Internal audit failed appropriately to follow up, finalise and report the finding that GMO were accepting market quotes from the front office as independent'	7 (4%)
	Organisation of system rights	Segregation of access to system information and modifications based on job responsibilities	'There was confusion within GMO as to the segregation of duties and responsibilities in conducting the IPV process'	14 (8%)
	Resources	The efficient apportioning of time, capital and personnel	'CIO VCG needed to manually copy this data into its own price testing spreadsheet row by row. This resulted in data entry errors'	10 (5%)
	System alerts and detections	The capability of the system to accurately monitor and detect system abuse	'There was no automatic filter in the trade input Systems which identified off market or large notional transactions and the amendment of a price'	21 (11%)
	System maintenance	The timely maintenance and modification of system controls and capabilities	'(Barclays) made no changes to its Systems and controls to take account of the BBA'	16 (9%)
Total				187 (21%)

senior management for prioritising safe operations. For example, at the direction of the management at JPMorgan Chase Bank N.A., traders falsely priced their positions in order to minimise published losses and benefit the bid-ask spread in the organisation's favour. Going further, when management at JPMorgan Chase Bank N.A. discovered the large, relatively illiquid positions, they did not immediately request a reduction in the positions and instead allowed the traders to take increasingly larger positions.

In all ten cases we analysed, the FCA cites insufficient scrutiny by the management tasked with overseeing trading strategy as a key factor in the occurrence of trading mishaps. A consistent pattern emerges of a lack of actual or perceived management prioritisation for safety in the cases (as enacted through behaviour, statements, Systems and procedures) shaping normative expectations on trader performance, and influencing trader risk-taking activities through this mechanism. This perhaps emphasises the importance of Management Commitment to Safety for creating the atmosphere and tone (e.g. attitudes towards issues around risk, error, blame) for the acceptability and unacceptability of risky and unethical practices.

In terms of the literature on safety culture, the influence of management prioritising production goals over safety upon risk-related activities is observed in many domains and is associated with safety activities (Zohar 2010). It has also been identified as crucial in incident investigations. For example, mishaps such as the Deep-water Horizon (DH) oil spill are somewhat analogous to the FNs (Reader and O'Connor 2014). In the case of the DH blowout, the National Commission (2011) reported that many of the riskier operational decisions were made due to a desire to save time, costs and ensure long-term viability of the well 'without full appreciation of the associated risks' (National Oil Spill Commission 2011, p. 223).

Risk Management

Key to an effective safety culture is a description, perception and acceptance of what the present dangers and risks to the organisation are (e.g. conflicts between performance and safety). A recurrent problem identified within the FNs was the failure of organisations to recognise and address incidents. For example, in the Toronto Dominion case, the FCA finds that the organisation 'failed to appropriately escalate issues that may have led to earlier detection of the pricing issues' (Toronto Dominion, p. 2). Similar key findings are listed in eight of the ten cases reviewed. Through not sharing, collecting or emphasising information on previous incidents and near misses, the likelihood of a future failure is increased. Furthermore, in the cases studied, the lack of a clear policy on reporting incidents or a dedicated feedback system discouraged front-line staff from reporting incident information, which negatively shaped risk escalation behaviours.

In relation to the safety culture and financial trading literature, this is consistent with research showing that poor internal management processes, general Systems, or a lack of willingness or ability of staff to escalate incidents can seriously hinder the collection of relevant risk data and undermine the development of robust Risk Management models (Bryce et al. 2013). In other industries, the implementation of a confidential incident and near-miss reporting system provides a means for the organisation to collect, identify and ameliorate risks within the system, and to provide a proactive measure of Risk Management that encourages employee participation, raises awareness, promotes adaptation and engenders social responsibility for safety (Jeffcott et al. 2006). Similar Systems are being developed in financial trading and would appear useful for developing the safety culture of trading organisations (Leaver and Reader 2016).

Rules and Regulations

The FNs illustrate numerous issues relating to Rules and Regulations, with issues around training and skills being particularly prominent. For example, an over-reliance on the technical knowledge of the traders exacerbated the failures described in the FNs. In the Credit Suisse case, the FCA points out that 'Undue reliance was placed in the technical ability and revenue contribution of certain Front Office staff, who were highly influential in down-playing price testing and variances' (Credit Suisse, p4). Front Office staff (e.g. traders) regularly circumvented the controls in place by exploiting their technical ability and expertise relative to the control teams, which centralised the decision-making on the floor. Lack of training or knowledge in the support teams shaped the practices of the risk control team (e.g. inability to challenge the Front Office strategies and the acceptance of inaccurate pricing data) and led to a situation where the trading support team tasked with challenging the Front office operated at a diminished capacity.

In the most obvious case of exploitation, the FCA notes that 'Within UBS the Operations Division (trading support) acted as a facilitation division rather than having a specific risk control mandate…There was a culture of helping the traders to clear breaks on the basis of the explanations they provided as opposed to challenging the traders and questioning whether their explanations were correct' (UBS AG, p4). In this case, problems arose as a result of the organisations approach to the first line of defence in Risk Management, which assumed skills those involved did not have (e.g. the ability to challenge the Front Office).

The safety culture literature has indicated the importance of Rules and Regulations for influencing behaviour (Hopkins 2011; Lawton 1998; Reason et al. 1998), for example in terms of ensuring procedures reflect the work that is done within an organisation and ensuring safety procedures are followed. Rules and Regulations provide frameworks and protocols for controlling risk and are useful because they specify the expected minimum behavioural standards of employees. This appears also to have been the case in the FNs, indicating the importance of Rules and Regulations as a dimension of safety culture in financial trading.

Systems Implementation

Across the ten FCA cases, the Systems used to oversee and monitor the trading activity were identified as complex and fragmented. Within safety culture theory, Systems Implementation (e.g. policies, monitoring Systems) is crucial for ensuring organisations are able to identify risks and provide appropriate resources for effectively managing and ameliorating risk. The FNs revealed systematic problems in System Implementation, with 'overly complex and fragmented' reporting Systems undermining the ability of employees to detect and manage warning signals. For example, in the UBS AG case, the FCA noted that 'The Systems and controls in place, such as a complex matrix structure for the supervision of traders in the SCG, were too complicated and fragmented. Some individuals within the control functions lacked a clear understanding of the responsibilities that had been assigned to them' (UBS AG, p. 4).

Similarly, in the RBS case, the FCA found that 'overly complex and fragmented recording and reporting Systems required significant work to ensure they were effective … (the Company) failed to appreciate the full scale of the reporting problems across the business' (RBS, p. 3).

This is consistent with the financial trading literature, where it is argued that without an effective and transparent risk escalation process (e.g. ensuring front-line personnel are willing to report problems), risk managers will struggle to measure, assess, control or manage the risks within the organisation (Bryce et al. 2013; Wahlstrom 2006). In relation to the FNs, it appeared that the lines of supervision were blurred by complex and fragmented supervision and the coordination and communication of information was disrupted within and across the teams. This reduced the ability of the operational staff to gather and interpret relevant safety information and make appropriate safety decisions. Future research is required to examine the impacts of this fragmentation, with System Implementation being important for ensuring clear lines of reporting and access to relevant information for decision-making.

Emergent Theme of Organisational Incentives

In addition to the synergies between the safety culture literature and the Final Notices, it is notable that, across all of the cases, organisational incentives were identified as a cause of employee risky and unethical behaviours.

For example, investigation of the Final Notices reveals several instances where conflicts of interest between work (e.g. profit generation) and safety (e.g. regulatory adherence) exacerbated the trading mishaps. This is a classic indicator of safety culture (Flin et al. 2000) and illustrates how the failure of active trading strategies can lead to fiscally disastrous consequences. Many of the riskier trading strategies (e.g. JPMorgan Chase Bank N.A.) were allowed to continue in a desire to post stronger gains and avoid financial penalties, and decisions were made without a full appreciation of the risks involved. The profit-making interests of the management conflicted with the realities of the market and led to situations where traders were forced to decide between one outcome (follow management directive) and another (publish in line with the market). In the case of UBS AG, these 'mixed messages' had disastrous consequences, as increased media scrutiny regarding its submissions process and speculations about its credit worthiness led to the dissemination of informal directives by group management to 'protect our franchise in these sensitive markets' (UBS AG, p. 4). In turn, traders and submission staff continued to collude with other market players in order to stem the publishing of daily losses. The conflict of interest between organisational interests (e.g. making profit) and client or wider market interests (e.g. in the fair valuation of the underlying assets) are cited by the FCA as key findings in all ten of the cases reviewed.

In terms of the safety culture literature, incentives are generally not included as a dimension of safety culture. This is perhaps because, in many high-risk domains, financial incentives are not used to the same extent as a reward (or otherwise) for performance. Yet, they appear crucial for the trading domain (and in particular, for shaping trader activity), and merit being considered as a distinct dimension.

Discussion

In this study, we examined the role of safety culture in ten high-profile organisational failures in the UK financial trading industry.

First, we found that dimensions of safety culture were routinely identified as underlying failures in financial trading organisations, for example in terms of how management attitudes regarding negative performance influenced traders to submit false prices in order to achieve productivity goals.

Second, based on the absence and presence of safety culture dimensions identified within the FNs, an initial framework of cultural dimensions for measuring and evaluating safety culture in financial trading was developed.

Third, through examining how the specific dimensions of safety culture related to risk practices reported in the Final Notices, their utility for explaining risky and unethical behaviour in financial trading was examined, for example in terms of how Management Commitment to Safety influenced trader pricing positions, Risk Management influenced risk escalation and System Implementation compromised the ability of management to detect warning signals.

Theoretical Implications

In financial trading, risky and unethical employee practices do not necessarily lead to loss of life, but can have a huge impact upon economic and social structures. The current analysis indicates the relevance of safety culture for understanding mishaps within the financial industry. Financial trading was conceptualised in terms of high-reliability industries, whereby risky and unethical behaviours are understood as a product of organisational environments, with poor practices reflecting management priorities, inadequate safety Systems and a lack of training and communication.

Yet, it is notable that financial trading also differs substantially from most high-risk domains where safety culture is applied. Commonly, in such domains, risk is something to be mitigated or removed from a system. However, in financial trading, risk-taking is key to profit and competitive advantage and this changes how safety culture is conceptualised within financial trading (e.g. in comparison with aviation). Consistent with 'risk culture' research (Ashby et al. 2012), safety culture in financial trading refers more to the extent to which employees are implicitly or explicitly encouraged to take risks where long-term costs are significant, but are outweighed by short-term gains for the organisation and employees. For example, the FNs illustrate how various organisational issues (fragmented Systems and controls) and behavioural practices (ability to escalate an incident), regulation (inconsistent distribution of information regarding safety rules) and incentives (the prioritisation of profit over market compliancy) lead to poor employee risk practices.

It is noticeable that there are also broad similarities between the dimensions of safety culture identified in Box 2 and the Institute of Risk Management's (IRM) 'Risk Culture Aspects Model'. For example, selected themes identified in IRM's model such as 'tone at the top' and 'governance' map well onto the behaviours indicated in Box 2 under 'Management Commitment to Safety' and 'Rules and Regulations' (Institute of Risk Management 2012). These similarities provide further evidence of the applicability of a safety culture framework in this domain, indicating that the application of a safety culture framework is not only fitting, but that it can enrich the existing models though a deeper understanding of the specific behaviours that underlie the incidents. Drawing on previous safety culture research (Antonsen 2012) it is also indicative of the interventional steps that might be taken to improve safety culture in these settings (such as team training, incident reporting and monitoring and organisational learning exercises).

Future investigations might focus on refining the dimensions identified as underpinning safety culture in financial trading. For example, our analysis of Management Commitment to Safety and incentive structures reveals that employee's perception of management prioritisation (and how they are rewarded) influences risky and unethical behaviours. This might be useful to explore further. For example, by focusing on the priority workers place (and lengths they will go to) on securing financial rewards and avoiding penalties, we can better understand how pressure from a superior can lead to unsafe behaviour. Crucially, the predictive validity of safety culture theory for predicting or reducing mishaps in financial trading is required to demonstrate its ultimate utility. This can be achieved through the development of rigorous and psychometrically robust tools for measuring safety culture in financial trading.

Practical Implications

Although this industry is not a tabula rasa in terms of tools to analyse risk culture (e.g. surveys, structured questionnaires and scorecards), we aimed to empirically inform current approaches through adopting a safety culture perspective (Institute of Risk Management 2012).

The framework presented in Box 2 is a first step in achieving this and can inform the development of culture measurement tools in financial trading. The form of these tools may be diverse (see Guldenmund 2000, for a review); however, the most common procedure for collecting safety culture data is the use of employee cross-sectional surveys. Through a series of questions, surveys typically measure staff at all levels of an organisation on their beliefs, values, attitudes and perceptions towards risk. Data are associated with organisational outcome data and triangulated against other culture indicators data (e.g. incident reports, customer evaluations).

Box 2 outlines the potential dimensions of a safety culture survey, and a safety culture assessment would examine the strengths, weaknesses and conflicts (e.g. between management and employees) on each cultural dimension. This typically leads to remedial action: for example training, modification of key processes, communication from management (Mearns et al. 2013). Such data also allow for benchmarking and inter-organisational learning, which is routine practice within aviation, energy and nuclear power (Carroll 1998; Mearns et al. 2001; Noort et al. 2015). As our current research is limited by the use of only one data source, we propose the development and testing of a survey tool with the participation of employees in different financial institutions internationally. This would be of considerable use for financial trading organisations (e.g. for learning about their culture, addressing problems) and regulators (e.g. to identify best practice, and problematic organisations). In addition, research might examine whether the safety culture model needs further adaptation to reflect the different nature of organisations working in the financial sector (e.g. asset-driven organisations versus speculative trading houses).

Alternative approaches to examining safety culture may not focus on perceptions of risk practices, but instead gather behavioural data, for example, through systematically collecting and analysing data on trading incidents. Such incidents can contain valuable data for avoiding future mishaps (on poor working practices, IT Systems) and for monitoring risk. Where incidents are reported voluntarily by staff, this can be highly symbolic *of* the culture (as it indicates a 'just' and 'mature' culture), whilst also revealing issues *within* the culture (e.g. on the pressures being experienced by staff). These approaches (surveys, incident reporting Systems) are mainstay approaches to monitoring risky and unethical practices in other high-risk domains and would appear equally useful for financial trading.

Limitations

This study has the following limitations. First, the literature review for identifying safety culture studies was not comprehensive, and it may have failed to capture other dimensions of safety culture important for financial trading. Second, the use of FCA FNs is only one method of collecting data on safety culture in the finance domain and the data have not been triangulated with other forms of data. This may lead to methodological bias, such as common method bias, with assumptions being based on one form of data and analysis (Podsakoff et al. 2003). Furthermore, the use of FNs as the data source also produces a limitation as they are considered secondary sources and their accuracy is difficult to confirm. Third, there are limitations in inter-rater coding. As the level of discrimination is quite high in the analysis of textual data with several dimensions, reliability is more difficult to assess and careful training of the coders is crucial. Also, judgements about the level of kappa that is deemed acceptable in the literature vary and should be considered in the interpretation of the results. Lastly, there are other existing culture-based theoretical lenses beyond safety culture that could be adopted to analyse these cases such as a competing values framework. For example, the competing values framework is a widely used cultural framework for profiling the culture of organisations (for a full review, see Cameron and Quinn 2005).

Conclusions

Culture measurement and change has previously been identified as crucial for restoring trust, improving Risk Management and avoiding future failures in financial institutions (House of Commons Treasury Committee 2009; Parliamentary Commission on Banking Standards 2013). Yet, a clear conceptualisation of what the desired culture for the industry is, and how it might be measured, is currently lacking (Power et al. 2013; Ring et al. 2016). To address these challenges, we examined whether, akin to other high-risk industries, safety culture theory provides a useful conceptual framework for understanding failures to manage risk in financial trading.

Through applying safety culture theory to analyse ten trading mishaps published in the FCA Final Notices, the study found that dimensions of safety culture were routinely identified as underlying failures in financial trading organisations. This counters narratives focusing on traders as unethical 'rule breakers' and instead emphasises the influence of social environments upon behaviour in financial institutions. To investigate this, the study developed an initial framework of cultural dimensions for measuring and evaluating safety culture in financial trading and examined how these dimensions were associated with the specific risk-related activities reported in the Final Notices. The results indicate that safety culture is a useful conceptual framework through which to understand and predict risky and unethical behaviour in financial trading, and can also inform the development of tools for assessing and invoking culture change.

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Compliance with Ethical Standards

Ethical Approval This article does not contain any studies with human participants or animals performed by any of the authors.

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7. Critical Discussion

The work undertaken in this thesis re-conceptualizes how we understand financial trading (and financial services more generally) in terms of human factors theory and contributes to the expansion of human factors theory through its application to the financial trading domain. The financial incident analysis system (FINANS) developed and tested within this thesis not only allows us to test and provide evidence to this premise, but also delivers a contextualized description of the behavioural nature of the problems in financial trading and illuminates how these are often a product of environmental factors such as culture.

In the sections of the thesis that follow, each of the thesis aims will be addressed. Discussions on the implications of the research as well as the limitations are provided for each aim.

7.1 Discussion of the aims

Aim 1. Establishing whether non-technical skills are critical to risk management in financial trading

The first aim of this thesis was to establish whether non-technical skills are critical to risk management in financial trading. This is important, because it reveals that the behaviours and skills of human operators can both create and prevent risk within financial trading. This is an integral part of human factors approaches to managing risk in other industries, and through the establishment of its importance in financial trading; it provides the first step to re-conceptualising the financial domain using human factors concepts.

This aim was addressed in chapter 2 (article 1) through a systematic review of studies reporting on non-technical skills and behaviours in the financial domain. The study i) identified ‘real-world’ (e.g. non-laboratory) research reporting behavioural data in financial trading, ii) examined and synthesized data on non-technical skills (and other human factors issues) found to underpin good or poor performance and risk management in financial trading and iii) considered the quality and coverage of research investigating non-technical skills in financial trading and provided a scope for future research.

The results of the systematic literature review show that a range of human factors can be usefully used to understand performance in the financial trading domain. For example, the review (presented in chapter 2, article 1) revealed a range of decision-making (e.g. heuristics and biases, intuitive decision-making, emotional regulation) and leadership skills (e.g. setting standards, monitoring behaviour, encouraging speaking-up) as important for managing risk and performance in financial trading environments. Furthermore, the review identified how situation awareness (e.g. information search and assessment strategies, vigilance, identifying 'noise' data) and teamwork (e.g. avoiding 'role' conflict, communication between traders) are important factors in determining trader performance. For example, the literature revealed that problems in non-technical skills, such as managers failing to lead and monitor behaviour on the trading floor, traders incorrectly interpreting risk-related data, poor communication between traders on critical information pertaining to transactions and traders not taking action on identifying irregular trading activities by colleagues, undermined risk management and organizational performance.

Implications. The insertion of financial trading into the non-technical skills literature is novel, and integrates an industry that previously had not been considered in this work. Furthermore, it tested the wider principle that human factors concepts, and in particular non-technical skills, are important for understanding risk-management in financial trading, and thus should be more formally applied. Besides the clear theoretical implication that the results of this work imply: that human factors theory can be usefully applied in the trading domain to understand essential aspects of performance, the results also have important practical insights. For example, in the development of interventions, NTS theory and human factors theory more generally, provides an alternative psychological-based method for improving trader performance. In fact, rather than focusing on strategies for minimizing cognitive heuristics and biases that influence decision-making (Croskerry, 2003), intervention strategies can focus on improving trader' situation awareness and decision-making through focusing upon team processes.

Additionally, as public interest in the behaviour and actions of traders is growing, the formal assessment of human factors and non-technical skills could inform future regulation in this domain. This is currently the case within aviation, and is increasingly discussed within other high-risk domains that have recognized the importance of non-technical skills for risk management (e.g. healthcare).

Limitations. This work is not without limitations. First, the literature review search strategy may have failed to capture relevant papers with important NTS-related information. Often, the studies identified in the literature review did not focus on non-technical skills explicitly (e.g. situation awareness), rather they contained data that appeared relevant to NTS concepts and this information was extracted and synthesised. Other publications with data relevant to non-technical skills, but not reported using the terminology of the strategy, may have been missed. Second, the focus on non-technical skills meant that other factors underlying critical incidents in financial trading were not explored. These include political, regulatory and technical features (such as the human computer interaction failures) of the trading environment that might shape activity. For example, in the process of publication, a peer reviewer and human factors expert noted the influence of stress and the importance coping strategies in high-risk domains – a topic that was not covered in our analysis – and there may be benefit in its inclusion.

Research has shown that traders experience higher levels of stress and anxiety than the wider population, with the need to take risks, pressure to perform, and lack of control over decision outcomes being associated with poor mental health (Kahn & Cooper, 1996; Oberlechner & Nimgade, 2005). Furthermore, traders are less likely to make use of coping strategies, despite stress resistance being identified as a characteristic of successful traders (Kahn & Cooper, 1996; Oberlechner & Nimgade, 2005). Therefore, future iterations of the human factors framework in the finance domain could be expanded to include stress management and performance.

The work carried out to achieve the first aim of the thesis effectively demonstrates that financial trading can be considered a high-risk domain, where performance is shaped by the non-technical skills of the staff and where a combination of social and cognitive skills underpin trader performance. Yet, the literature review also reveals that human factors research remains at an embryonic stage within financial trading, and there is a need to better understand the specific behaviours and cognitive strategies that underpin effective trader performance.

Therefore, the results of this systematic literature review provide an empirical basis for the development of a system to codify incident reports, to reveal the specific cognitive and social skills that underpin error on the trading floor. To achieve this, the development of a methodology for collecting reported incidents and interpreting the human factors skills that underpin performance in the trading domain is undertaken in chapter 3 of this thesis and is described in the following aim.

Aim 2. Developing a methodology for capturing operational incidents within financial trading

The second aim of this thesis was to develop a methodology for capturing, and then analysing, operational incidents in financial trading. The generation of a robust methodology was essential to the work within this PhD so that data on error and non-technical skills could be retrieved.

This aim was addressed in chapter 3 through the formal investigation, and synthesis of the common features, of existing incident monitoring systems in other high-risk domains.

Within financial trading, there was no precedent for incident reporting in terms of either methodology for collecting incident data, or defining and understanding what constitutes an incident. Therefore, the development of a system for capturing, monitoring and analysing operational incidents in the financial trading domain was an original application in the trading domain. The data collected through FINANS described 'Operational incidents', which occur when trading activity results in an avoidable financial loss (e.g. making a trade without assessing market related risk) or compliance failures (e.g. breach of trading limits), which place the integrity of the financial organisation at risk even if no loss has occurred (e.g. overexposure to volatile markets: Zhao & Olivera, 2006).

Specifically, chapter 3 described the development of the first part of the Financial Incident Analysis System (FINANS), which is the first system to i) collect voluntary operational trading incident reports (where trading activity results in an avoidable financial loss, for example due to poor decision-making or a compliance breach) from employees working on financial trading floors, and ii) analyze incidents in order to identify the human factors issues reported within them.

Chapter 3 reviewed the literature and identified the common features of existing incident collection systems used in the aviation, healthcare and rail domains and used them to guide the development of the incident reporting system that was then tested in Chapter 3 and 4 of this thesis. The identified and adopted features include; voluntary and anonymous reporting, details of the type of event, personnel involved, activities leading to the incident and how the event was detected.

The extension of human factors methodology to the financial trading domain is novel, and accessed a set of methodology that had previously not been considered in this domain. Moreover, the work evidenced the premise that human factors theory and concepts are relevant in the trading domain and provided the structure for the formal empirical application of human factors concepts in the trading domain.

Implications. The generation of robust methodology presented in this chapter is essential to the retrieval of error and non-technical skills in the financial trading domain. From a methodological perspective, this research extends the current application of human factors tools for extracting the skills and systems that underpin error in the financial trading domain and provides empirical evidence for the utility of human factors frameworks for understanding error in contemporary high-risk domains such as financial trading.

Practically, the development of the methodology described in this PhD provides the basis of a new approach to monitoring risk in financial trading (e.g. based on human factors concepts). This generates a range of implications for the financial trading industry, such as the scalability of FINANS. For example, FINANS provides the opportunity to share lessons learned on the behaviours and practises that lead to error in the domain and this could be used by other organisations that share similar characteristics to trading floor where this work was undertaken. Furthermore, FINANS could be used to inform regulation in the financial domain. For example, regulators could synthesise the findings from FINANS to generate feedback across the domain, to inform new policy initiatives (e.g. training mandates) and guide organisational audits (e.g. determining safety or 'risk' culture within organisations and across the industry more generally). In addition, FINANS provides the opportunity to reflect on current analytic techniques that are applied to understand 'operational risk' and 'Enterprise Risk Management' schemes and usefully provide a template for a qualitative understanding of error in the financial trading domain. Lastly, FINANS could be used to test the impacts of organisational change, such as identifying a change in error profiles following a change in senior management or helping to identify the success of organisational programs (e.g. compliance initiatives).

Limitations. The limitations of the tool are similar to those found in other high-risk domains, principally that we cannot capture every aspect of performance and the opportunities to observe some behaviour and human observer bias (e.g. the trader staff's ability to self-report, report on incidents where they were involved). Some aspects of the incident reporting system were not ideal (e.g. database constraints such as inability to delete repeatedly reported events) and the use of symbols (e.g. to explain formulas) within the narrative section undermined the efficiency of a qualitative analysis. Moreover, as the 'safety maturity' of the organisation progressed, the quality of the reports reflected this, and some elements of the original methodology were inflexible to this change (e.g. drop down profiles of risks were not nuanced enough to capture the range of issues in one report). Similarly, as the organisation globalised (e.g. subsidiary trading locations), the original organisational 'tree' was difficult to adapt using the Microsoft access software (e.g. the addition of new reporting lines disrupted the previous reports reporting lines). These issues could be considered in future iterations of the incident reporting system. Yet still, critical to the effective utilisation of the incident collection tool is the development of an incident analysis system to analyse the events through a human factors lens.

Aim 3. Examining human factors underlying operational incidents within financial trading

The third study of the thesis presented in chapter 4 examined i) the frequency and consequences of operational incidents in financial trading, and ii) the role of non-technical skills and other human factors issues as contributors to them. Through the process of analysing incidents, the reliability and validity of the FINANS methodology was tested.

This aim is addressed in a two-part study presented in chapter 4 (article 2). Results of the study (e.g. kappa scores) indicate that categories within FINANS can be reliably used to identify and extract data on human factors-related problems underlying trading incidents. In terms of the human-factors problems underlying critical incidents in financial trading, slip/lapse related errors (e.g. fat fingers) was the most frequently coded category, and occurred often in isolation from other human factors problems (e.g. teamwork), and was more likely to be associated with near miss outcomes (indicating errors were being caught by trading staff). It is perhaps not surprising that slip/lapse errors are more likely to be reported in the operational incident log than others (e.g. decision making skills), as they are relatively easy to detect retrospectively, and participants may show a bias for reporting less punitive, easily detected events (e.g. fat fingers, following procedures) than complex, punitive issues (e.g. failing to consider options). In general, slip/lapse problems did not lead to serious incidents, as they were often fixed quickly through organizational procedures (e.g. team cross checks), and this has also been observed in other industries such as healthcare (Vincent & Amalberti, 2016).

In addition, the study reveals that a significant proportion of critical errors originated from failings in situation awareness and teamwork processes. This may indicate team-based processes such as communication and coordination (e.g. cross checking of information, monitoring of information) to influence team situation awareness on the trading floor, and resonates with research in healthcare and aviation (Jentsch, Barnett, Bowers, & Salas, 1999; Reader & Cuthbertson, 2011).

Notably, relatively few incidents were reported as having leadership or decision-making problems, and this is contrary to experimental work in the finance domain. In fact, the analysis reveals that decision-making is a less present indicator of team performance in the trading domain, and this may reflect limitations in the abilities of trading staff to self-monitor decision-making activities. Also, the absence of decision-making may indicate that incident reporting may not be an optimal way to collect data on decision-making in financial trading and other forms of study (e.g. observations) may be more useful. In terms of leadership, this might be conceptualized as a more 'distal' cause of incidents (e.g. setting and maintaining standards), and perhaps more difficult to isolate as a contributory factor to incidents.

Implications. The research undertaken in this chapter marks the expansion of current empirical and theoretical applications of human factors theory in financial trading. The implications of these results are both practical and theoretical. First, the descriptive data isolated in the studies can be used to benchmark the financial trading industry against other high-risk industries. This is particularly relevant when considering the current regulatory environment. For example, financial regulators such as the FCA (Financial Conduct Authority) could use this data to inform future conduct policy (such as targets and risk management initiatives). Additionally, our data helps us to contextualize the problems in financial trading and describe them, which carries implications for ameliorating risk within financial trading organizations through adaptive training strategies and targeted human resource development programs to train the identified skills.

From a theoretical perspective, this research extends the current application of human factors methodology for extracting human factors to the financial trading domain and also provides empirical evidence for the utility of human factors frameworks for understanding error in emerging high-risk domains such as financial trading. In fact, this is the first study to ever determine the error rate in financial trading and to detail the human factors causes of incidents. This work not only achieves the goal of determining the relevance of human factors to financial trading, but it also maps of the terrain for future risk management in financial trading. For example, in terms of the provision of robust methodology for collecting and identifying incident data, the establishment of a reliable framework to codify the incidents, analytics to score, the description of the human factors skills that underpin error occurrence and a discussion of the implications for the wider industry.

Limitations. A first limitation of the empirical studies described in this chapter is that incident reporting systems generally suffer from under reporting. Underreporting results in a bias in the type of errors reported and reduces the organizations ability to quantify and accurately measure how risk management processes are leading to improvements in safety and performance. The reasons why underreporting is prevalent vary and are well summarized by van der Shaaf & Kanse (2004) in a systematic four tier framework; i) *fear* (e.g. 'blame culture', litigation, disciplinary action), ii) *risk acceptance* (e.g. incidents as just 'part of the job', or a 'macho' culture that suppresses reporting), iii) *useless* (e.g. the perceived attitudes of management, lack of follow up actions, handling the incident alone), and iv) *practical reason* (e.g. time constraints, insufficient information, lack of incentives) (van der Schaaf & Kanse, 2004). In the scope of the current study, these four principles are relevant and underpin the future efficacy of the tool. Yet, measures were taken to stem the impact of each limitation. For example, reports were anonymised to prevent undue blame and litigation, monthly reports with solutions and feedback measures were distributed to all stakeholders to help spread awareness for the usefulness of incident reporting and the incident reporting form was made available on each work station with as few input variables as possible in order to decrease time spent logging events.

Yet still, it is critical to acknowledge the existence of these limitations in the data (e.g. interpretations of broad causality) so that we do not overstate the findings when drawing conclusions from the dataset as well as develop a tool with these principle limitations in mind (e.g. ensure targeted and active feedback and clear procedures for data entry).

A second limitation that is common to both the empirical chapters (chapter 3, chapter 4 – article 2 and chapter 5 – article 3) is the participant – observer effect. As the introduction to this thesis makes clear, the author cannot claim to be a free value observer. In terms of social reality, the author was particularly conscious of the insider / outsider debate in research. As a result of the author's role as both colleague (e.g. insider) and researcher (outsider), she had privileged access to insider knowledge and this enabled her to gather intimate knowledge (and a shared experience) of the organization and its members, which offers unique insight (Merton, 1972). For example, this relationship contributes to an initial level of trust and can lead to open exchanges with participants that allows the author access information she might otherwise not have access to (e.g. punitive errors, behaviours) and as an unobtrusive observer, this also means that she can take advantage of 'privileged eavesdropping' (Burke, 1989). Admittedly, the author used her 'insider' knowledge to understand the context of the trading domain and the task work and to modify the theoretical frameworks in terms of the participant's experiences and working environment. For example, the author exploited her position as a senior risk analyst to engage with the participants, observe and take part in the daily tasks and discuss organisational constraints. Throughout the authors time within the organization she engaged with trading floor staff in a professional capacity and built social relationships (e.g. trustworthiness). During this time, the theory, incident reporting form and models of analysis were discussed (formally and informally) and conversations invariably centered on limitations, feedback and the generation of incidents.

A fundamental challenge of the insider / outsider relationship is to maintain objectivity as a researcher and to resist epistomological tunnel vision (e.g. confining the author's understanding of the working environment to the perspective ascribed by the 'inside'), which can undermine the coding and inferential process. This means that the coding can also be shaped by the experience and impartiality of the researcher and this must be considered in the analytical outcomes. For example, the researchers experiences in financial trading shaped their preconceptions, attitudes and beliefs and their view of the human factors and the incidents reported in the domain are bound to be different from those of an 'outsider'.

Looking back at the broad descriptions of the data, notably, over 90% of the errors reported through FINANS described incidences of near miss – where an error occurred in the system, but was detected before escalating to failure. Therefore it is seemingly relevant to ask: what skills help the organization capture error on the trading floor? This question was explored in chapter 5 (article 3), which extended the use of FINANS to analyse near miss incidents to identify the skills that are used to capture error on the trading floor.

Aim 4. Investigating whether operational incident reports contain data important for understanding how operational incidents are averted

The fourth aim of the thesis examined what could be learned in terms of the skills and systems important for avoiding operational incidents. This is important, because it demonstrated that the skills of human operators can both create and prevent error within financial trading and empirically established that incident data contains relevant human factors information important to understanding how incidents are captured and detected. Moreover, this research has shown that data from incident monitoring systems can be analysed in a fashion more consistent with a safety II approach (e.g.. identify good practice for mitigating, rather than reducing, error). This aim is addressed in chapter 5 (article 3) "Near Misses in Financial Trading: Skills for capturing and averting error".

This is a unique contribution to both the human factors literature and the financial trading domain. Before the work in chapter 5 (article 3) was undertaken, relatively little was known about the types of human-factors skills that are used to capture error on the trading floor and safety management was largely concerned with safety critical industries (e.g. aviation, healthcare, nuclear power).

The analysis revealed that the majority of the errors are a product of slip/lapse (52%) problems and issues in human computer interaction (21%). Uniquely, the positivistic analysis of the reported near miss incidents has shown that error is overwhelmingly detected and prevented by teamwork skills (65%) followed closely by situation awareness (46%). Going further, the research reveals that slip/lapse, the most common cause of error, nearly always occurred in isolation. This means that the causes of error are principally one skill or another (e.g. skip/lapse or human computer interface) and less often the result of multiple skill problems. Exceptionally, teamwork and situation awareness, the two most frequent human factors responsible for ameliorating near misses, were the most likely to occur together doing so in just under half (45%) of all near miss where situation awareness prevented a near-miss. Moreover, the research has shown that regardless of the cause of the error, situation awareness and teamwork are the leading skills used to capture and prevent error. This research indicates that trading staff is the last line of defence in capturing error and keeping the system safe.

This work has reconceptualised finance through the application of human factors and effectively challenged the field of human factors to engage with a non-traditional (e.g. high-risk, but not safety critical) domain. In doing this, aspects of the prevailing worldview in human factors 'safety' thinking and financial risk management practises are re-considered. This work has identified the need for a 'New Era' of error and risk management research in the finance domain promotes more human-centred model of safety (e.g. supplementing a focus on what goes wrong with a focus on what goes right).

Implications. The research shows that the variables that shape local situation awareness (e.g. system interface, experience, workload) can be maintained and improved through targeted staff training, workload management and user-informed system design. For example, the way in which information is presented via the system interface (e.g. trading screens) will largely influence situation awareness by determining how much information can be acquired, how accurately it can be acquired, and to what degree it is compatible with the trader's situation awareness needs.

A further implication of the finding that good situation awareness skills help trading staff overcome error refers to the increasingly common automation of work in the financial trading domain. In an age of increasing automaticity in the financial services sector (e.g. high-frequency trading, VaR simulation, automation of daily

P&L reporting), the findings indicate that trading organizations should heed caution. Whilst automation may be useful in overcoming situation awareness attention limits (e.g. the idea that individuals have limits to their attention span that are determined by individual ability to process information, complexity and workload), automation may also lead to front line actors missing out on novel stimuli. This can negatively affect situation awareness by undermining the availability of meta-cognitive strategies that support the assessment of information in new and challenging work scenarios (Endsley, 1995).

The finding that teamwork and situation awareness are the leading cause of error prevention in the trading domain offers two key practical insights.

The first is in regards to the current trend towards the globalization of risk control functions in the trading domain (centralizing the support role functions in one location). Our research indicates that this changing nature of work could have deleterious consequences in terms of safety if the skills that are used to detect error (e.g. teamwork and situation awareness) are not carefully maintained and trained by the organization so that disparate teams can continue to develop a shared understanding of their roles & responsibilities and positive perceptions of risk.

The second, drawing on the leading skills that are used to prevent error, is that our research has the potential to achieve greater impact on the safety improvement outcomes of tailored interventions. For example, when we only focus on the causes of errors, we observe that 20% of the errors are caused by problems in teamwork. Therefore, interventions that are informed by this finding have an upper boundary for safety improvement of approximately 20%. However, our analysis reveals that teamwork is a critical factor in 65% of the cases for preventing error on the floor. Through targeting the teamwork skills found to be essential in the prevention of error (e.g. shared understanding of roles and responsibilities), we have a potential upper boundary for improvement of 65% - significantly more than if we focus only on the skill deficiencies that cause error. In terms of risk management, this has important implications for structuring teams and training programs. This effect is further enhanced when we consider that regardless of the cause of the error, teamwork and situation awareness are the leading skills that prevent error.

Further analysis reveals two distinct findings regarding the non-technical nature of error prevention on the trading floor: that a significant proportion of near miss incidents are captured using situation awareness and teamwork skills and that regardless of the cause of error, teamwork and situation awareness skills are the leading skills used to capture the error.

These findings have important implications on how financial trading is conceptualized and future interventions. For example, this research establishes that the detection of error privileges the team working as a unit, rather than purely technical capacities and illustrates the importance of the socio-technical space in the trading domain – in an industry where performance is generally considered to be highly individualized (e.g. bonus allocation schemes rewarding top performers).

Although the error analysis undertaken in this study usefully guides us with granular insights into the behaviors that generate error and the skills that are used to capture error, these behaviors are positioned within a much larger cultural frame of the organization. For example, the behaviors that drive the capture of error (e.g. taking the initiative to cross check team members work) are a product of the practices and norms that are encouraged and rewarded within the organization and therefore any conclusions we draw from them should be also be considered through a perspective of organizational culture to fully appreciate how the skills that lead to and prevent error are developed and supported within the organization. One method for doing this would be to use a form of culture analysis (e.g. case study, safety climate survey) to identify how the collective values, beliefs and principles of organizational members (e.g. the trading staff) support the behaviours that capture error on the floor in order to have a comprehensive understanding of error and performance in the financial trading domain. The influence of culture was explored in chapter 6 (article 4), which identified how the components of safety culture underpin the generation of error in ten high profile cases of trading misconduct in the financial trading industry.

Limitations. The limitations of the study presented in chapter 5 are methodologically shared with those in chapter 4 as they share the same framework and analytic techniques (e.g. participant / observer effect). In regards to the nature of incident data, the results in chapter 5 are constrained by the nature of incident reporting generally, which is vulnerable to underreporting and incomplete information about incidents (O'Connor et al., 2007). In the trading domain, the need for an individual to be aware that the event has occurred, their limited perspective on the incident, and their motivation to report also constrain incident reporting. The reasons why underreporting is prevalent vary and are well summarized by van der Shaaf & Kanse (2004) in a systematic four tier framework; i) *fear* (e.g. 'blame culture', litigation, disciplinary action), ii) *risk acceptance* (e.g. incidents as just 'part of the job', or a 'macho' culture that suppresses reporting), iii) *useless* (e.g. the perceived attitudes of management, lack of follow up actions, handling the incident alone), and iv) *practical reason* (e.g. time constraints, insufficient information, lack of incentives)(van der Schaaf & Kanse, 2004). Similar to chapter 4, steps were taken to ameliorate these effects such as anonymised reporting to prevent undue blame and litigation, monthly reports with solutions and feedback measures were distributed to all stakeholders to help spread awareness for the usefulness of incident reporting and the incident reporting form was made available on each work station with as few input variables as possible in order to decrease time spent logging events.

Furthermore, only one coder analysed all the near miss incidents (with a second coder analysing 25% of the near miss incidents to assess inter-rater reliability) and the data analysis was constrained by the clarity of the text and the potential biases of trading staff in recalling the incident. Moreover, the reliability analysis revealed scope for improving the FINANS taxonomy, and it may require further development to tailor it to near miss data. Issues such as stress, fatigue, and environmental factors (e.g. culture) were not examined and this could be the focus of future work.

The work that was undertaken to achieve the three sub-aims describes the granular features and behaviors that guide the occurrence and detection of error within the participating organization. Through a series of three studies, this research maps the typical migration of error on a trading floor and empirically test and describe the essential recovery mechanisms (e.g. teamwork situation awareness). However, the skills, behaviours and practices observed are importantly shaped by the working environment and in particular the values, beliefs, expectations and norms within the organization (e.g. the culture). Therefore, the final aim of this thesis focused on culture as an explanatory variable in organizational failure within the trading domain.

Aim 5. Establishing the utility of safety culture for understand risk-related activities in financial trading

The final aim of the thesis examined whether risk management in financial trading could be understood from a safety culture perspective.

At this point, the research in this thesis expanded beyond a focus on non-technical skills and human error, and began to reflect on the wider system within which behaviour occurs. This was an important conceptual leap, because behaviours in relation to risk do not occur within a vacuum: they are a product of wider norms, values, and institutional systems (Chen, Sawyers, & Williams, 1997; Kaptein, 2011;

Saini & Martin, 2009). Therefore, understanding how the macro-level trading environment might shape micro-level risk-related behaviours of traders is critical for intervention and change. It is also important for conceptualising financial trading as akin to other high-risk industries.

This issue was addressed in Chapter 6 (article 4) entitled "Safety Culture in Financial Trading: An Analysis of Trading Misconduct Investigations". In this chapter, a safety culture framework was applied in order to conceptualize and explain failures to manage risk within financial trading in a standardized way drawing on data from ten FCA Final Notices. The work in this chapter complements the previous chapter's analysis of human factors that underpin operational incidents with a macro-conceptual layer of understanding the culture within the organization. This is essential because it is meaningless if the culture of the organization is not incentivized to act on the information provided from the analysis. Going further, chapter 6 (study 3) countered the prevailing discourse in the financial industry, and in particular in current regulation discourse, that tends to focus on traders who are unethical 'rule breakers', and instead emphasized the value of a systemic approach, whereby safety culture theory is used to explain why risky behaviours in financial trading occur.

The content analysis undertaken in chapter 6 (article 4) indicated the relevance of safety culture for understanding mishaps within the financial industry and yielded rich data on how the organizational environment shaped behaviours in the featured organizations. In fact, the study found that dimensions of safety culture were routinely identified as underlying failures in financial trading organizations. For example, in terms of management attitudes regarding negative performance that influenced how traders submit false prices in order to achieve productivity goals. In addition, based on the absence and presence of safety culture dimensions identified within the FNs, an initial framework of cultural dimensions (e.g. the components and sub-components) for measuring and evaluating safety culture in financial trading was described.

The recognized components (and sub components) are: *Organizational Communication* (ability to speak up, transitions and teamwork across units, trust in colleagues), *Management Commitment to Safety* (blame and culpability, employee participation, management safety attitudes, supervisor / management expectations, safety motivation, shared belief in the importance of safety), *Risk Management* (appreciations of risk, confidence in safety, conflict between work and safety), *Rule and Regulations* (planning, rule dissemination, safety rules, safety training and drills) *System Implementation* (incident reporting, organization of system access rights, resources, systems alerts and controls, systems maintenance).

Lastly, through an examination of how the specific dimensions of safety culture related to risk practices reported in the FNs, their utility for explaining risky behaviour and practices in financial trading was established. For example, in terms of how Management Commitment to Safety influenced trader-pricing positions, Risk Management influenced risk escalation and Systems Implementation compromised the ability of management to detect warning signals.

Implications. This study has shown that risk management in the financial trading industry can be conceptualised using a safety culture framework, and that in doing so, the industry gains access to a set of (tested) tools for measuring organisational culture.

Although this industry is not a tabula rasa in terms of tools to analyses risk culture (e.g. surveys, structured questionnaires and scorecards), there are some novel practical implications of this research. For example, the work undertaken in this thesis can empirically inform the development of culture measurement tools in financial trading. The form of these tools may be diverse (see Guldenmund, 2000, for a review), however the most common procedure for collecting safety culture data is the use of employee cross-sectional surveys.

Through a series of questions, surveys typically measure staff at all levels of an organization on their beliefs, values, attitudes and perceptions towards risk. Data is associated with organizational outcome data, and triangulated against other culture indicators data (e.g. incident reports, customer evaluations). In addition to the synergies between the safety culture literature and the FNs, the analysis reveals that across all the cases of misconduct, organizational incentives were identified as a cause of risky employee behaviour and practices.

The work undertaken in this thesis also outlines potential dimensions of a safety culture survey (Chapter 4, article 2, box 2), and a safety culture assessment would examine the strengths, weaknesses, and conflicts (e.g. between management and employees) on each cultural dimension. This typically leads to remedial action such as; training, modification of key processes and communication from management (Mearns et al., 2013). Such data also allows for benchmarking and inter-organizational learning, which is routine practice within aviation, energy, and nuclear power (Carroll, 1998; Mearns, Whitaker, & Flin, 2001; Noort, Reader, Shorrock, & Kirwan, 2015).

The safety culture study has drawn from one data source; and there is merit in expanding the development and testing of a survey tool with the participation of employees in different financial institutions within the UK and globally. This would be of considerable use for financial trading organizations (e.g. for learning about their culture, addressing problems), and regulators (e.g. to identify best practice, and problematic organizations). In addition, research might examine whether the safety culture model needs further adaptation to reflect the different nature of organizations working in the financial sector (e.g. asset driven organizations versus speculative trading houses). In terms of safety culture theory this research would expand current empirical work and serve to broaden aspects of the theory through its application to a previously un-accessed domain. For the industry, this would be particularly useful in terms of providing a tailored assessment of local cultures and could be used to inform risk management and training initiatives. In relation to regulation, the results of such analyses would be useful in providing a map of the different (and changing) organisational cultures and identifying safety trends, sharing lessons learned across the industry and providing a guide to advising organisations on how to assess and benchmark their organisational culture.

Alternative approaches to examining safety culture may not focus on perceptions of risk practices, but instead gather behavioural data. For example, through systematically collecting and analysing data on trading incidents. Such incidents can contain valuable data for avoiding future mishaps (on poor working practices, IT systems) and for monitoring risk. Where staff reports incidents voluntarily, this can be highly symbolic *of* the culture (as it indicates a 'just' and 'mature' culture), whilst also revealing issues *within* the culture (e.g. on the pressures being experienced by staff). These approaches (surveys, incident reporting systems) are mainstay approaches to monitoring risky and unethical practices in other high-risk domains, and would appear equally useful for financial trading.

Limitations. This study has the following limitations. First, the literature review for identifying safety culture studies was not comprehensive, and it may have failed to capture other dimensions of safety culture important for financial trading. Second, the use of FCA FNs is only one method of collecting data on safety culture in the finance domain and the data has not been triangulated with other forms of data. This may lead to methodological bias, such as common method bias, with assumptions being based on one form of data and analysis (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003).

Furthermore, the use of FNs as the data source also produces a limitation as they are considered secondary sources and their accuracy is difficult to confirm. Third, there are limitations in inter-rater coding. As the level of discrimination is quite high in the analysis of textual data with several dimensions, reliability is more difficult to assess and careful training of the coders is crucial. Also, judgments about the level of kappa that is deemed acceptable in the literature vary and should be considered in the interpretation of the results. Lastly, there are other existing culture-based theoretical lenses beyond safety culture that could be adopted to analyse these cases such as a competing values framework. For example, the competing values framework is a widely used cultural framework for profiling the culture of organizations (for a full review see Cameron & Quinn, 2005).

Through applying safety culture theory to analyse cases of trading misconduct, the dimensions of safety culture have been reliably and routinely identified as underlying failures across a variety of financial trading organizations. This counters current narratives focusing on traders as unethical 'rule breakers' and instead emphasizes the influence of social environments upon behaviour in financial institutions. The results indicate that safety culture is a useful conceptual framework through which to understand and predict risky and unethical behaviour in financial trading, and also informs the development of tools for assessing and invoking culture change.

7.1.1 Summary

The work undertaken in this thesis re-conceptualized how we can understand financial trading (and financial services more generally) in terms of human factors and contributed to the expansion of human factors theory through its application to the financial trading domain. This work in this PhD has shown the importance of non-technical skills for risk management in the financial trading domain and developed a new methodology in financial trading for the collection of incident data. Moreover, the work revealed that incidents are frequent and caused by human factors skill deficiencies and are averted using key non-technical skills such as teamwork and situation awareness. Lastly, safety culture provided an essential macro-theoretical framework to understand safety and 'risk' in financial trading.

The application of human factors theory in the finance domain challenges the field to engage with a non-traditional (e.g. high-risk, but not safety critical) domain. The socio-technical complexity and intractability of financial trading is reflective of the changing economic landscape – where rapid technological change redefines the relationship between people and systems, transforms work processes and practise and increase operational requirements of operators. Thus, this work contributes to a 'new era' of human factors research that engages with these domains and promotes a more humanist interpretation of safety (e.g. safety as a focus on what goes right) (Dekker, 2014).

8. CONCLUSION AND IMPLICATIONS

The application of human factors theory in the finance domain challenges the field to engage with a non-traditional (e.g. high-risk, but not safety critical) domain. This serves to expand the types of domains of interest to human factors researchers, with financial trading being a particularly complex domain due to the importance of both risk-taking and risk management for organisational success. The application of human factors concepts in financial trading has generated meaningful insight into how risk is managed in this domain, and extends human factors research into a previously unexplored complex socio-technological environment.

8.1 Conclusions of the research

The work within this PhD has served to reconceptualise financial trading as a high-risk, 'ultra-resilient' industry. The research described the development of a methodology for collecting and studying incidents and produced concrete findings on the nature and consequence of human factors problems in financial trading. Furthermore, this work has shown that the last line of defence within the organisation is reinforced by teamwork (e.g. crosschecking of tasks) and situation awareness (e.g. attention). Lastly, the work has shown that risk management in the financial trading industry can be conceptualised using a safety culture framework, and has generated insight into how aspects of organisational culture (e.g. management commitment to safety, ability to speak up) can support or undermine ethical behaviour in the financial trading domain.

On a theoretical level, the insertion of financial trading in the non-technical skills literature is quite original, and accesses a set of literature that previously had not been considered in this domain. Additionally, the research undertaken in these chapters marks the expansion of current theoretical applications of human factors theory in financial trading. This expansion challenges the field of human factors to engage with a new domain – a high-risk, but not safety critical domain – and therefore provokes prevailing aspects of the current human factors 'safety' worldview to be re-imagined.

For example, current approaches to managing safety and risk in the human factors literature assumes that adverse outcomes can be explained by linear cause-effect chains (e.g. Swiss cheese models) and assumes that all adverse outcomes have causes which can be found and fixed and that these causes differ from the causes of ordinary and successful work. This approach largely limits human factors to niche areas of work (e.g. tractable systems) and no longer matches the reality of today's systems (e.g. intractable). the work carried out in this thesis has dealt with a unique challenge – to design a methodology to study and improve risk management, utilising safety concepts, and apply them to a non-traditional safety domain (e.g. where risk-taking is core to the business). This is quite new in the human factors domain and highly challenging. However, the challenge to the human factors domain to adapt to today's system is already underway in domains such as healthcare. In fact, most healthcare activities can be considered intractable because the setting is complex and unpredictable and current research in this domain aims to change the way care is currently done, embracing working with complexity rather than against performance variability (Braithwaite, Wears, Hollnagel, 2015). Yet, a key difference is that in healthcare people don't take risks as deliberately as in financial trading and the research in this PhD, which reveals that human operators are both the sources of error as well as the protective layer, may hold essential insight for risk-taking and risk management in the financial domain. At a conceptual level, this may mean that human factors research could inform effective risk-taking within the financial trading domain, mapping out the non-technical skills 'hazards' and guiding the training of the 'soft' skills that are necessary to navigating effective risk taking on the floor. This would mean drawing on the skills of operators to inform safety decisions – using their experience and knowledge to inform risk management. This research resonates with the safety II and associated literature (e.g. safety differently) and the work undertaken in this thesis provides some of the first research investigating how safety thinking can be used differently in a high-risk domain.

The work in this thesis is one of the first empirical attempts to employ human factors concepts in a new domain where 'safety' is no longer about accidents (e.g. safety critical domains). In the case presented in this PhD, this is about financial failure and misconduct, yet other high-risk domain that share organisational safety features (e.g. socio-technological dependence) might also be relevant (e.g. cyber security). This work has shown how underlying problems in financial trading are very common human factors issues (that are frequently observed in other domains such as healthcare – for example, teamwork), with consequences that are far-reaching. Perhaps this is also the case for other domains, particularly domains that similarly navigate deliberate risk taking within their daily business. These domains face similar challenges to financial trading (e.g. navigating risk trade-offs, globalisation of operations) and could benefit in similar ways such as gaining insight into the skills that capture error (e.g. good teamwork skills such as communication) and adapt organisational processes to support the maintenance of these essential skills (e.g. deploying screen based web cameras to communicate with disparate team members). Moreover, the work within this PhD has shown that culture plays a crucial role on the ethical navigation of risk trade-offs (e.g. influencing the micro-level behaviours that shape the macro-level organisational environment) in the trading domain, and this lesson could be shared with other emerging high-risk domains in order to help them prioritise the development of culture measurement tools.

Finally, the work in this PhD delivers new methodology for collecting, identifying and analysing error and informs not only risk management in financial trading, but may also be used to inform future safety management in high-risk, but not safety critical domains. In particular, this PhD demonstrates the utility of capturing and analysing near miss data and this insight should be used to guide future safety research in high-risk domains.

8.2 Going forward: ideas for future research

In the following sections, various areas for future research that are rooted in organizational intervention and contribute to impactful and actionable outcomes for the financial trading domain and broader human factors field of research are discussed.

8.2.1 Improving non-technical skills

The research in this thesis has revealed that non-technical skills of trading staff are integral to ensuring safe performance in the trading domain and therefore future research could focus on improving these skills. In other high-risk domains that face similar problems (e.g. time pressure, rapidly evolving situations) to financial trading, training programs such as crew resource management (CRM) have been adopted to target training the specific non-technical skills that underpin error.

Crew Resource Management (CRM) is an instructional strategy that trains crews to effectively use all of their available resources (e.g. people, information, equipment and systems) (Helmreich et al., 1999). CRM can take many forms, and has evolved through several phases over the past two decades, but it can be conceptualized as a team training strategy focused on improving crew coordination and performance. CRM is now used as a way to manage human error by focusing on teamwork skills that will promote error avoidance, early detection of errors and minimization of consequences resulting from CRM errors.

The success of CRM programs is variable and due to a lack of longitudinal data to assess its organizational impact, its success is mostly anecdotal (Salas, Burke, & Cannon-Bowers, 2000). However it has generally been found to produce positive reactions (e.g. affective and utility based) enhanced learning (primarily measured through attitude change) and desired behaviour change in the cockpit (Salas, Wilson, Burke, & Wightman, 2006). For example, empirical data from the surgical field reveals that CRM training can improve the participant's perception of safety climate within the organization (Kuy, & Romero, 2017).

These findings warrant investigation in the financial services domain. For example, adapted CRM training could be generated from the core taxonomy identified in study 1 (chapter 2) and refined in study 2 (chapter 4). The outcomes of the training could be triangulated with other safety data – such as incident reporting rates and safety culture measurement techniques to enable performance progressions, promote collaborative learning initiatives and identify areas for improvement.

In order to successfully contribute to 'the bigger picture' of human error and to foster organizational learning across the industry, it is recommended that the behaviours' and skills that are identified and synthesized through FINANS be expanded to other financial service organizations.

8.2.2 Using FINANS to benchmark financial services firms

A next step in research is the expansion of the application of FINANS more broadly to facilitate the benchmarking and assessment of other financial services firms industry wide, similarly to how incident collection is done across other high-risk industries such as aviation and healthcare. As it stands, we currently do not have a good understanding of how the cultures within these firms differ, and cannot confidently conclude what good or bad performance looks like relative to performance and activity. Broadening the use of FINANS would help to ascertain what is 'normal' across the industry and to describe the profiles of what goes wrong within and across firms.

For example, in healthcare the National Reporting and Learning System is a central database of patient safety incident reports established in 2003 with over four million reports across more than 170 acute hospitals (NHS Improvement, 2017). Analysis of these reports reveals several trends such as reporting rates over time, relationship with type/severity of incidents reported, relationship with hospital size and organizational features and relationships with safety culture data. Findings reveal a significant relationship between higher reporting rates and a higher proportion of positive responses to safety culture survey questions. Reporting rates also appear to improve over time across all participating hospitals with regular feedback reports that allow the hospitals to benchmark data in comparison to other, similar hospitals. This ultimately aims to improve the quantity and quality of data reported. Moreover, nationally established procedures for analysis allow hospitals to see, comment on and spread the relevant safety lessons learned from reported incidents at the organization and specialty level (Hutchinson et al., 2009).

A limitation of FINANS is that it has only been used in one organization and therefore the conclusions we draw from the data (e.g. on the number of trades that are erroneous) is limited to the profile of this one firm. Rolling out the system to assess other firms of generalizable size and structure would help to determine a typology of error within the financial services more broadly. Additionally, the use of FINANS over time within participating organizations could lead to the establishment of longitudinal trends, which could then be triangulated with other data (such as market volatility and other market data) to ascertain whether the risk profile of the organization fluctuates in sync with the market. Moreover, we could analyse if there is a relationship between, and impact of, risk profile changes (e.g. an increase or decrease in risky behaviours and perceptions of risk) as a result of specific organizational changes, such as management turnover.

The limitations of expanding the use of FINANS across the financial services would be broadly similar to those experienced in the financial trading domain and articulated in this PhD. Meaning, the underreporting of error (blame, usefulness, disruption to daily procedures) and the importance of establishing reliability of interpreting the data (e.g. having human factors experts evaluate the data). Furthermore, across the financial services domain, the organizational environments (e.g. cultures) and conditions (e.g. task-work) vary, and the system (e.g. FINANS) should consider and reflect on these contextual differences.

Therefore, an essential next step is to get a better understanding of the local and industry cultures that influence the generation of error.

8.2.3 Managing culture

The logical next step in terms of future research in this domain is to extend the final study on safety culture through the development and deployment of a culture assessment tool. In safety culture research a standard safety climate questionnaire has been the principal measurement instrument (Gadd & Collins, 2002; Guldenmund, 2000).

Safety climate questionnaires are popular given it is a quick methodological instrument (e.g. ease of distribution among a large group of participants in a relatively short period of time) that yields immediate quantifiable results, enabling researchers to produce trend data, identify patterns and compare groups and sub-groups (e.g. comparing the perceptions of risk between the traders and risk control teams).

Pre-existing research suggests that a typical survey is composed of a series of thematic questions that tap into people's evaluations of various aspects considered to be relevant for safety (e.g. management commitment to safety, rules and regulations). This has been detailed across several key papers (Cooper, 2000; Cox, Flin, 1998; Flin, Mearns, O'Connor, & Bryden, 2000; Mearns, Whitaker & Flin, 2003; Williamson, Feyer, Cairns, & Biancotti, 1997). A proposed survey in the trading domain could look to surveying trading staff in a cohort of trading organisations to generate data on the generalizability of safety culture concepts within the industry and unpack the existence of sub-cultures (e.g. trading versus trading support departments) that exist within the domain.

Notably, there are several key limitations in administering a safety climate survey, both methodological and theoretical, that must be considered. One such challenge is the development of a questionnaire that yields enough relevant and valid information that facilitates the prioritization of corrective measures and actionable change. To overcome this, the results of previous research could be combined to guide the development of a new questionnaire. This pragmatic approach would be a good fit for the financial trading domain, using the results of the safety culture analysis presented in chapter 6 (article 4) to guide its development.

A second key limitation is that with regard to culture, the organization cannot be considered a closed system. This means that not only local conditions within the organization determine the culture of its members. Schein (2004) contends that when an organization has not experienced any serious problems during its existence, that there will probably not be a typical culture and its culture will be largely a product of external conditions (e.g. national, regional) and the (educational, social-economic) background of its workforce (Guldenmund, 2007; Schein, 2004). Therefore, arguably a questionnaire would not necessarily draw out culture, but it would draw out participant's espoused values (e.g. attitudes) towards culture, which provide a source of raw data to extract an organizational culture from (Schein, 2004). These limitations would need to be considered in any future applications of safety culture measurement in the financial trading industry.

8.2.4 Investigating emergent phenomena within the human factors data

Shared team situation awareness. Findings from the application of FINANS indicate that team situation awareness is critical to performance in the financial trading domain. In fact, in the most critical cases of error (e.g. failures) the studies found that teamwork and situation awareness play a significant role (Leaver & Reader, 2016). This observation is shared across other high-risk domains such as aviation, where the significant role of shared situation awareness in undermining safety has been well documented (Hartel, Smith, Prince, 1991). Although research indicates that shared situation awareness across teams underpins performance; there is currently not a good understanding of how team situation awareness it is supported within and between the teams.

Future research could focus on understanding how situation awareness is distributed across the teams on the floor. This could be investigated in a number of ways. Endsley (1993) and Matthews et al (2004) suggest doing this by conducting unstructured interviews with subject matter experts, with goal directed task analysis and questionnaires in order to determine the relevant situation awareness requirements. Also, the Coordination Assessment of Situation Awareness of Teams (CAST) uses situational roadblocks and judgments on how the team responds to these roadblocks in terms of coordinated perception and action processes in order to derive a measurement of team situation awareness.

Identifying how teams share situation awareness is geared towards the development of a holistic representation of knowledge - one that emphasizes the importance of the integration of knowledge across team members at the group level (e.g. identifying knowledge similarity and distribution) and not just at the individual level (Cooke, Stout, & Salas, 2001). This would be beneficial to training intervention in the financial trading domain because problems in knowledge symmetry (e.g. team members sharing the same mental model of the shared task) and knowledge distribution (e.g. the communication and sharing of critical information between front office and middle office on shared tasks) underpin performance in this domain.

The relatedness of safety culture and incident reporting. Reflecting on the findings of the safety culture research in chapter 6, future research might assess how the offending organisations would perform using FINANS. Following the previous point about extending the use of FINANS across the industry in order to generate meaningful benchmarking abilities and the sharing of lessons learned, FINANS outcomes in these organisations could be triangulated with data from safety culture measurement. This research would aim to answer questions such as: do organisations with a more positive safety culture report less critical incidents (e.g. failures)? Do they report more near misses? What do the features of the incidents look like within these organisations (e.g. broad descriptions of human factors)? Are these features shared across the industry? At a practical level, this research would provide a holistic description of the state of safety across the industry, detailing granular details of the skills needed to ensure safety as well as the environmental factors that support ethical behaviours. At the theoretical level, this research would be informative for future iterations of error research and regulatory frameworks (e.g. industry wide frameworks, benchmarking).

Protective Acts. The analysis of trading incidents within this body of research has pointed to the phenomena of trading staff committing protective acts (e.g. staff vigilantly checking on the task work of other team members to correct error) in order to keep the organisation safe. These informal acts of 'citizenship' are desirable to the organisation as they support resiliency and safety yet they are not (currently) tied to the formal reward system (e.g. salary, bonus allocation). This research acknowledges the importance of these pro-social behaviours and future research could look to monetising this phenomenon in order to further incentivise trading staff to engage in them. To achieve this, close attention must be paid to how front line staff successfully navigate and capture error (e.g. through the cross checks in order to develop an understanding of how staff manage their work flexibly and safely). This is consistent with a Safety II approach, which supports a proactive management of safety that focuses on how everyday performance typically succeeds rather than why it may occasionally fail (Braithwaite, Wears, & Hollnagel, 2015.).

8.3 Final remarks

Based on this research, we now can conclude that human factors concepts used to understand error and improve risk management in other high-risk domains are relevant and can be reliably used to interpret incident data in financial trading. Additionally, this research identifies the rate of error in trading (approximately 1%) and the broad description of the skills that underpin error (e.g. slip/lapse, human computer interaction) and the skills that help the organisation overcome error are rooted in the social system (e.g. teamwork and situation awareness). Moreover, having successfully mapped out the safety culture concepts that are relevant to understanding the behaviours and practises that are featured in cases of financial misconduct, we can conclude that culture provides an essential preventative layer of defence to ensure organisational safety.

Each aim of this thesis has established the relevance of human factors concepts in the financial trading domain. In doing this, the work contributes to the re-conceptualisation of the financial trading domain as a high-risk, ‘ultra-resilient’ industry where the last line of defence is reinforced by social (e.g. teamwork) and cognitive (e.g. situation awareness) skills. The behaviours and practises that have been identified and analysed are a product of more widely held beliefs and attitudes and this thesis provides evidence that they can be understood using a safety culture framework. Safety culture shapes how operators behave and think in relation to risk and this is central to understanding the conditions under which risk in financial trading can be effectively managed.

Furthermore, the application of human factors theory in the finance trading domain challenges the field to engage with a non-traditional (e.g. high-risk, but not safety critical) domain. This expands the types of domains of interest to human factors researchers, with financial trading being a particularly complex domain due to the importance of both risk-taking and risk management for organisational success. The application of human factors concepts in this domain has generated meaningful insight into how safety is managed in a complex socio-technological domain and guides a 'new era' of human factors research oriented to the demands of today's high-risk domains.

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Non Technical Skills in Trading

Gas & Power

Pilot Survey Information Manual

Leaver, 2013

Participant Information Sheet

You are being invited to take part in a research study. Before deciding to participate it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information. Feel free to discuss issues with anyone, and if there is anything which is not clear or any questions you have, feel free to ask. Take your time reading, and don't feel rushed.

What is this research about?

The aim of this survey is to identify and extract the relevant non-technical skills that influence team performance in the financial trading domain.

Who is doing this research?

Meghan Leaver and Dr. Tom Reader, Department of Social Psychology, London School of Economics, Houghton Street, London, UK, WC2A 2AE

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Why have you asked me to participate?

Participants have been selected based on their relevant expertise and experience in financial / commodity trading.

What will participation involve?

Participants are asked to complete a survey regarding (20) trading scenarios where errors occurred in a trading setting and to select the relevant non-technical skills associated with each scenario.

How long will participation take?

The survey should last approximately 35 minutes.

What about confidentiality?

All data is strictly confidential and anonymous.

If you are willing to participate, then please sign a Consent Form.

You can keep this Information Sheet for your records.

Informed Consent

Project: Extracting Non-technical Skills the Trading Domain

Researcher: Meghan Leaver (PhD Candidate), Department of Social Psychology, London School of Economics, Houghton Street, London, UK, WC2A 2AE, m.p.leaver@lse.ac.uk

Supervisor: Dr. Tom Reader, Department of Social Psychology, London School of Economics, Houghton Street, London, UK, WC2A 2AE, t.w.reader@lse.ac.uk

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To be completed by the Research Participant

Please answer each of the following questions:

Do you feel you have been given sufficient information about the research to enable you to decide whether or not to participate in the research?	**Yes**	**No**
Have you had an opportunity to ask questions about the research?	**Yes**	**No**
Do you understand that your participation is voluntary, and that you are free to withdraw at any time, without giving a reason, and without penalty?	**Yes**	**No**
Are you are willing to take part in the research?	**Yes**	**No**
Are you aware that the interview/focus group will be audio/video recorded?	**Yes**	**No**
Will you allow the research team to use anonymized quotes in presentations and publications?	**Yes**	**No**
Will you allow the anonymized data to be archived, to enable secondary analysis and training future researchers?	**Yes**	**No**

Participants Name:______________________________

Participant's Signature: ___________________________ **Date:**__________

Please read the following set of 20 questions carefully. Each of the 20 scenarios was recorded by a risk control participant between January 2013 and November 2013. Each scenario includes elements of non technical skills that were relevant in the causation of the event.

In your professional experience, please indicate which factors and associated elements you think were causal in the described events. This data will be used to develop a framework to conceptualise the human factors that are involved in the events that occur within the trading domain, and to promote training at the operational level.

If you have any further questions, please do not hesitate to contact me; Meghan Leaver (PhD Candidate, London School of Economics St Clements, Houghton Street, London, WC2A 2AE), or m.p.leaver@lse.ac.uk

Factors and their relevant elements in the logic analysis

Human Machine Interface

- Use of tools (e.g. spreadsheets)
- Training on the tool
- System did not detect the error
- Design of the software and applications
- Maintenance and testing of the tool

Slip / Lapse

- Fat fingers
- Procedural (e.g. not following a procedure, or not following it correctly)
- Routine task (e.g. loss of concentration)
- Forgetfulness / Memory (forgetting information, how to perform and activity)
- Distraction

Situation Awareness

- Attention (e.g. distraction, lack of concentration divided or overly focused attention)
- Gathering Information (e.g. poorly organised information, not gathering enough information)
- Interpretation of Information (e.g. miscomprehension, assumptions based on previous experience)
- Anticipate (e.g. thinking ahead, judging how the situation will develop)

Leadership

- Authority and assertiveness (e.g. taking command of a situation)
- Listening
- Prioritisation of goals (e.g. team / organisational)
- Managing workload and resources
- Monitoring activity and performance of team members
- Maintain standards and ensure procedures are followed

Teamwork

- Roles and responsibilities (unclear segregation of roles)
- Communication and exchange of information between team members
- Shared understanding of goals / tasks
- Coordination of shared activities
- Solving conflicts (between team members and teams)
- Knowledge sharing between teams

Decision Making

- Defining the problem
- Cue recognition (finding and recognising cues to the decision)
- Seeking advice on a decision
- Noise and distraction (reduce capacity to take a decision)
- Bias and heuristics

Q1:

On a spot cargo sold to EDFT (Montoir) and purchased from SNOHVIT, the purchase formula was a SNOHVIT MONTOIR USD formula, converting the EUR into USD. Yet, the current contract does not reference any EUR conversion (or any conversion specifications or optionality within the contract). When this formula came to pricing, a bug in the book occurred and a new currency maturity was created automatically. This discrepancy in the maturity led to middle office investigating the currency conversion of the deal (given that the contract had always been quoted in EUR and there was no stipulation for USD rates, perhaps that was the initial trigger of the incorrect maturity creation).

After consulting the team member who entered the formula, it seems that the trader had instructed middle office to create the formula with USD conversion, outside of the contact agreement. MO did not question the information, or check against the contract specifications. Moreover, MO should have noticed this discrepancy when they pulled the formula to check it in the book (additionally however, the contract information had not been correctly added in the formula check and creation process and no information was available to check against). All the forward FOS cargos purchased to SNOHVIT which were previously booked in USD were promptly changed to EUR (8 cargoes). If this error had not been detected, FO could have potential material losses.

Teamwork: Coordination and cooperation amongst team members on a shared task

Decision-Making: The process of reaching a judgment or choosing an option, sometimes called a course of action, to meet the needs of a given situation.

Leadership: Management, coordination, and motivation of team members

Situation Awareness: Monitoring and perceiving information, comprehending it within the task context, and thinking ahead

Slip / Lapse: Failures in the execution of an intended action due to a slip (i.e. a manual error) or a lapse (i.e. a memory failure)

Human Computer Interface: Problems in the operation of the control systems (e.g. computer software and hardware, 'the book'), and management of the data

Q2:

The coal desk executed a deal with the counterparty TransAsia (purchasing 75Kt of SAF coal for Dec-13 delivery, and selling to the coal to a second counterparty - Vitol). TGP entered into this trade even though the counterpart had recently defaulted on another similar trade with TGP. Due to the uncertainty of the counterpart to deliver on the purchase, the P&L of the deal was provisioned (+£288K). A few days following the most recent deal, TransAsia confirmed that they were in breach (and unable to deliver) and the coal desk accepted the breach for a second time. The transaction with TransAsia had to be cancelled, however TGP still have the obligation to supply Vitol with the SAF coal. By this time, the cost of replacing the cargo is higher ($61/t versus the new deal on the market with Glencore at $69.50/t) and TGP must pay a higher price and wait for the default counterpart to repay the costs (if they ever do).

Teamwork: Coordination and cooperation amongst team members on a shared task

Decision-Making: The process of reaching a judgment or choosing an option, sometimes called a course of action, to meet the needs of a given situation.

Leadership: Management, coordination, and motivation of team members

Situation Awareness: Monitoring and perceiving information, comprehending it within the task context, and thinking ahead

Slip / Lapse: Failures in the execution of an intended action due to a slip (i.e. a manual error) or a lapse (i.e. a memory failure)

Human Computer Interface: Problems in the operation of the control systems (e.g. computer software and hardware, 'the book'), and management of the data

Q3:

The gasdesk entered into two deals with TNOR on the IPEP formula. The deals were confirmed with the counterparty via email with one pricing period, and entered into the book with another. There are several different formulas set up for IPEP that will reflect different pricing periods (e.g. IPEP m-1, m-2 etc) or the dates of pricing can be manually entered to force the pricing period. In this case they were discrepancies in the pricing month. Moreover, the confirmation was not received from the third party until the agreed upon pricing period had passed. This resulted in an overall P&L loss of £750K. Several errors led to this large loss; the initial confirmation from FO was not communicated to MO, MO never sought out the detailed confirmation of the deal and pricing, and BO was behind in confirming the deal. Furthermore, once it seemed that upon reflection, FO were also not clear about how each IPEP formula priced (e.g. which month was priced from which formula).

Teamwork: Coordination and cooperation amongst team members on a shared task

Decision-Making: The process of reaching a judgment or choosing an option, sometimes called a course of action, to meet the needs of a given situation.

Leadership: Management, coordination, and motivation of team members

Situation Awareness: Monitoring and perceiving information, comprehending it within the task context, and thinking ahead

Slip / Lapse: Failures in the execution of an intended action due to a slip (i.e. a manual error) or a lapse (i.e. a memory failure)

Human Computer Interface: Problems in the operation of the control systems (e.g. computer software and hardware, 'the book'), and management of the data

Q4:

The difference between the provisional actuals from GRT and the final actuals are credited into a "compte d'ecart" called CEA. The in-storage deal should always be booked with a dummy counterpart called MGRT. In this case, the deal was mistakenly entered into the book with GRT as the counterpart. Therefore, this deal was then invoiced to the client. The errors that occurred here seem to be two fold; firstly when MO paste the deals into the book from their spreadsheet the thirdparty is erased (this is a bug in the book), which means MO need to manually enter it (leads to an increased chance to make an error as there is large amount of data to be pasted). Secondly, the inattention of the MO when assessing the logic of the deals, this deal type should never be invoiced and therefore a dummy counterpart should always be applied when booking the deal.

Teamwork: Coordination and cooperation amongst team members on a shared task

Decision-Making: The process of reaching a judgment or choosing an option, sometimes called a course of action, to meet the needs of a given situation.

Leadership: Management, coordination, and motivation of team members

Situation Awareness: Monitoring and perceiving information, comprehending it within the task context, and thinking ahead

Slip / Lapse: Failures in the execution of an intended action due to a slip (i.e. a manual error) or a lapse (i.e. a memory failure)

Human Computer Interface: Problems in the operation of the control systems (e.g. computer software and hardware, 'the book'), and management of the data

Q5:

One of the front office traders on the power desk mistakenly bid on an auction for capacity in Switzerland – Austria on the CASC platform. Currently, we do not trade in this zone and are not set up to trade or have capacity / transportation between these zones. Luckily, the trader bid far out of the money and we were not allocated the capacity. Notably, the trader was also unfamiliar with the platform and (seemingly) had not been adequately trained in the capacity purchase procedures. Furthermore, no purchased auction capacities are regularly confirmed via back office, due to an archaic system whereby the information is only communicated with the single trader involved in the auction. The only way that BO could pick up on discrepancies between what was bought and what was allocated is via the invoicing stage (additionally, as these capacities are entered into T-contracts, unless the cost invoice or physical invoice option is chosen, the deals do not pull through in the invoicing module and will be missed by the BO). Currently, there is no robust measure / control in place to check the allocated volumes and bids.

Teamwork: Coordination and cooperation amongst team members on a shared task

Decision-Making: The process of reaching a judgment or choosing an option, sometimes called a course of action, to meet the needs of a given situation.

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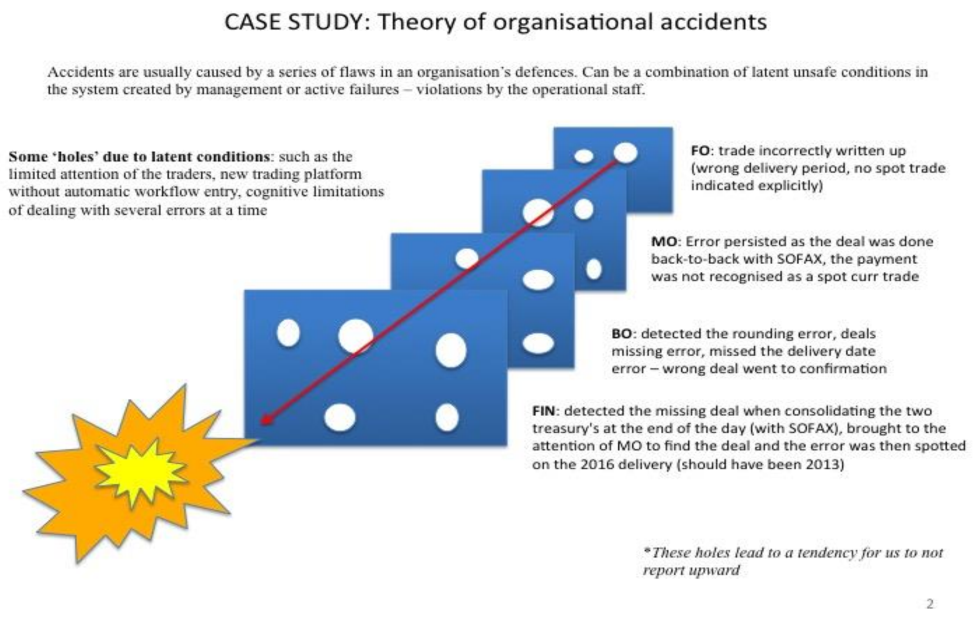
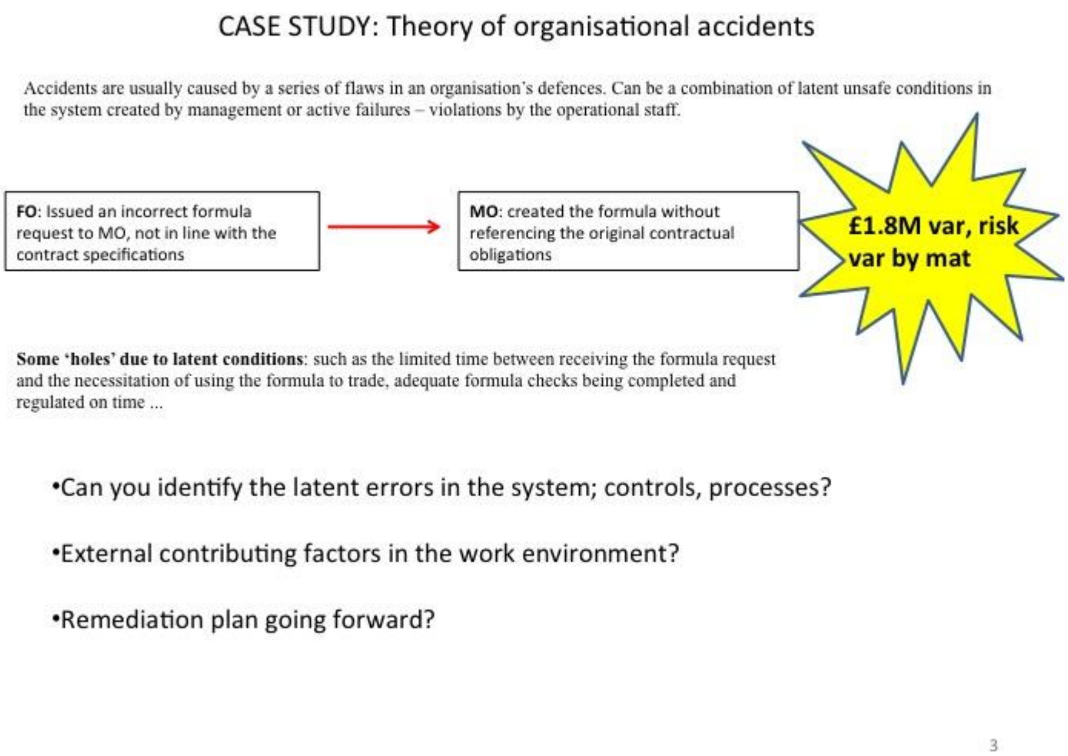
Training Presentation Sample 1





Event Logging

What to record in the event entry:

- •Brief Description: Title of the event (e.g. Wrong Prices, Booking Error, Contract Breach)
- •Describe what happened in the long form description
- •What was the outcome
- •Reflect on the reasons for the incident occurring (e.g. control failure, lack of vigilance, lack of training, fat fingers)
- •How could this event have been prevented? (e.g. limit a control? Add a control? Increase training?)
- •Identify the latent / contributing factors
- •Indicate the frequency of the error (e.g. how often does this error occur)

✓Team interaction failures (e.g. between operations and middle office, front office and middle office, back and middle office etc.)

✓Training issues

✓Deal entry and booking issues

✓Deals not entered in the book

✓Wrong prices

✓Market parameters incorrect (e.g. wrong risk of P&L)

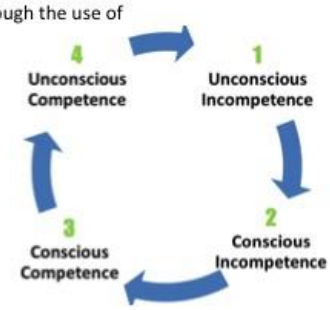
Training presentation sample 2

Team Training

Risk Control Training: Setting Common Ground Rules

Aims of a 'risk control' training policy

- Develop *common understanding* of the team environment and apply appropriate task strategies to accurately monitor performance
- *Anticipate other team members needs* through accurate knowledge about their responsibilities and redistribute workload around members to achieve a balance during high-pressure situations
- *Adjust strategies* based on information gathered from the environment through the use of compensatory behavior and reallocation of intra-team resources
- Exchange information in *a clear and precise* manner
- Follow up and *ensure that the message* was received was the one intended



Limitations in achieving the aims

Complexity of routine role requires mastery of procedural skills & effective communication / coordination with other teams

Communication is imperfect / silo within or between the teams, junior members may feel enable to speak up or escalate problems & questions

Learning strategies differ and training tools need to be adapted to fit the context and employee

Knowledge transfer during volatile times (e.g. staff turnover)

Drafting Common Training Ground Rules

Standardize routine processes with procedures & checklists – to be edited by all members (google-doc style) and available on a shared drive

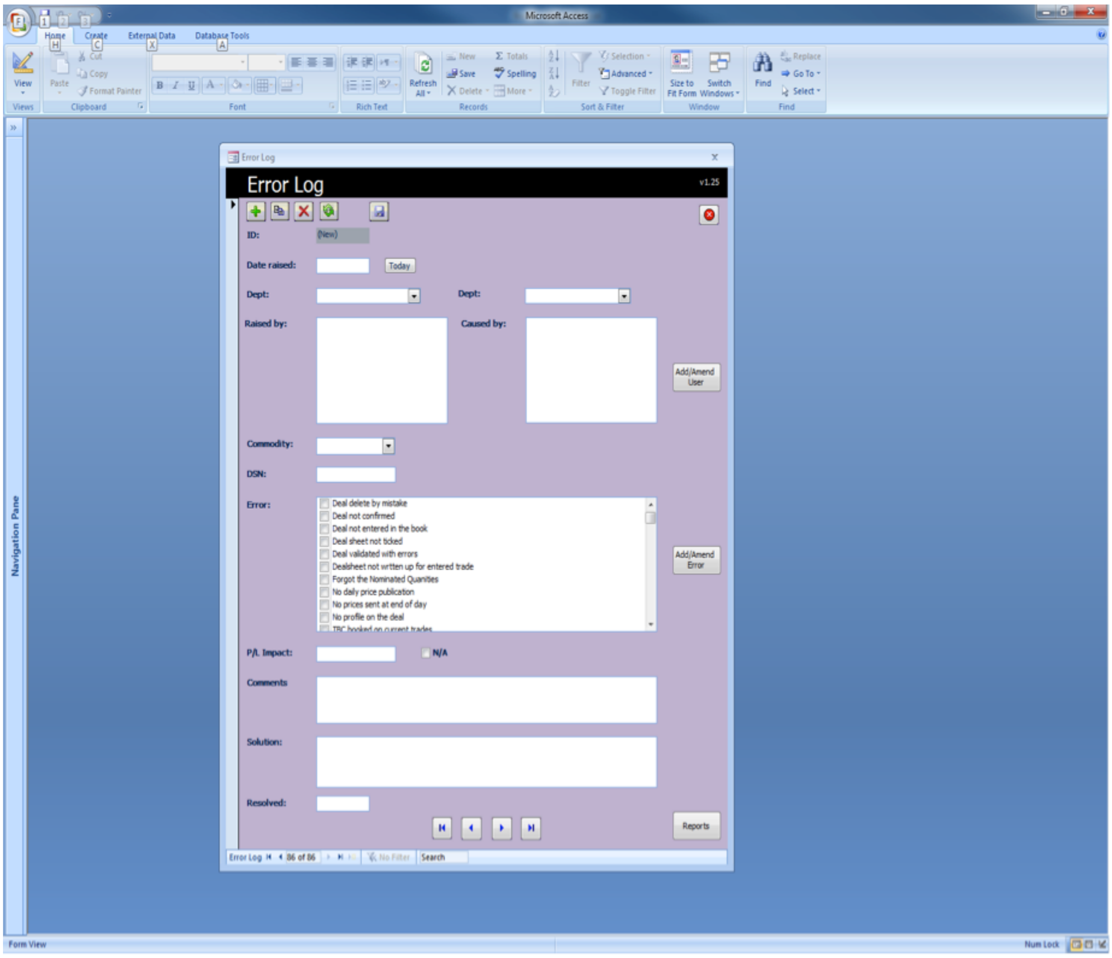
Rotate team training responsibilities across the team – entry level skills can be trained by mid-level members, deeper knowledge can be shared by the expert level member

Pairing up entry & mid-level team members to develop and share the work – heterogeneity of learning approaches

Improve situational knowledge with de-briefings or scripting of complex / non-normative situations

Formalizing Team Training Policy

- Focus on a subset of teamwork processes and document them (procedures)
- Define specific learning objectives, rooted in teamwork competencies (coordination on certain tasks)
- develop a targeted checklist to capture the predefined objectives and competencies (e.g. issue resolution)
- Measure the learning objectives in working contexts (one routine, one non-routine)
- Hold meetings to run a scenario analysis of events that can occur or did occur to ensure team members have the opportunity to display targeted checklist elements
- Debrief non-routine events (verbal, written), field questions


Microsoft Access
Error Log
v1.25
ID:
(New)
Date raised:
Today
Dept:
Dept:
Raised by:
Caused by:
Add/Amend User
Commodity:
DSN:
Error:
Deal delete by mistake
Deal not confirmed
Deal not entered in the book
Deal sheet not ticked
Deal validated with errors
Dealsheet not written up for entered trade
Forgot the Nominated Quantities
No daily price publication
No prices sent at end of day
No profile on the deal
Add/Amend Error
P/L Impact:
N/A
Comments
Solution:
Resolved:
Reports
Form View
Num Lock