

Managing 'A Little Bit Unsafe': Complexity, Construction Safety and Situational Self-Organising

Abstract

Purpose: To unpack the shared understandings of safety held by workers on large UK construction sites using a complexity lens, and so provide empirical support for the inclusion of situational self-organising within construction site safety management systems.

Methodology: A social constructionist epistemology supports the discourse analysis of talk (semi-structured interview and conversational), text (safety management systems and documentation) and visual (safety related signage) data collection from five large (+£20m) UK construction sites.

Findings: Construction workers readily understand safety to be an emergent phenomenon with the complex system that is the construction site. Contemporary safety management approaches struggle with this complexity, yet there is the potential to mobilise situational self-organising on sites to improve safety in practice.

Research Limitations: Epistemological foundations mean no claim is made to generalisability as perceived by traditional positivistic parameters. The data is limited to large (+£20m) UK construction sites, however underlying construction management systems are common to the industry as a whole and can find fit with practitioner experiences and other empirical academic work from both the UK and other countries.

Practical Implications: Situational self-organising of safety management within the construction workforce is proposed as a key contribution to a relevant, dynamic and effective SMS.

Originality/Value: Data is analysed from a social constructionist perspective and considered through a complexity lens. This approach unpacks this data in an original way to seek synergy with existing adaptive safety approaches, specifically situational self-organising, and make recommendations for practice.

Keywords: complexity, safety, situational self-organising, social constructionism

Introduction

Construction safety has been improving in the developed world over the last few decades. For example, the rate of fatal injury in the UK is currently less than a quarter of what it was in 2000/01 and less than a fifth of what it was in 1990/91 (Health and Safety Executive, 2017). However, there were still 38 fatal injuries to construction workers in UK during 2017/18, and it has been suggested that accident rates have now 'plateaued' (Institution of Occupational Safety and Health, 2018), and reached the level at which established approaches to safety management on sites are unable to support further improvements. Whilst 'simple' accidents have been reduced, for example those now prevented by the inclusion of guards on plant and machinery, those accidents that remain are now more complicated; they can, for example, be a consequence of multiple work interfaces and workspace change, as undertaken within the wider context of production pressure.

Consequently, the construction industry is now looking to alternative ways of managing safety. Here, we argue that, given the complex nature of the both the construction project and the practices and interactions that occur as a normal part of construction work, complexity-theory perspectives are an appropriate set of ideas to be drawn upon to support further improvements and initiatives. The study of failure within complex systems has supported the development of the concepts of High Reliability Organisations (HROs) (Weick and Sutcliffe, 2007) and Adaptive Safety Management (Reiman *et al.*, 2015), both of which, we believe, can bring new perspectives to safety management in practice, as well as the potential for application within the construction industry (Harvey *et al.*, 2016).

Through a consideration of such approaches, and drawing on a substantial body of data gathered from large UK construction sites, we aim to give empirical support to the specific Adaptive Safety Management process of 'situational self-organising' (Reiman *et al.* 2015) and its potential to contribute to improved safety management within the construction site environment. The process of situational self-organising enables workers to adjust and apply safety rules and work procedures according to the immediate work situation, and so self-organise their work in a safe manner (Reiman *et al.*, 2015). By unpacking the ways in which workers already make sense of safety on sites, and then re-contextualising their understandings of safety from complexity-theory perspectives, we are able to empirically reveal a space in which workers should readily be able to find 'fit' with this process of situational self-organising. Our objective is therefore to argue that the construction site is a receptive environment for the successful implementation of this process into existing safety management practices.

Context

Complexity and Construction

Understandings of complex organisational systems have long been associated with safety, or more specifically with safety failures (Perrow, 1999). Complexity influences safety in two distinct ways: through both social and technological complexity. Social complexity is created through conflicting demands on work, for example the balance between production pressures and safety, and also through the necessary interactions of multiple organisations, as found within the construction trade supply chains. Technological complexity can also result in safety implications as problem solving is often needed in practice to maintain production, for example during the translation from work as designed to work as done which in turn creates further, new social complexities that are situational and ever-changing.

It has been suggested that complex systems, involving both social and technological complexity, have identifiable characteristics. These have been used to argue for the existence of inevitable, 'normal accidents' as part of complex technology, organisational or project processes (Perrow, 1999). Such characteristics include the existence of multiple interactions, either sequential, parallel or coupled, which in turn create cycles and feedback loops that are often non-linear and counter-intuitive (Ramasesh and Browning, 2014:194; Bakhshi *et al.*, 2016). Non-linear interactions are those that cannot be predicted by system designers, and as such can remain undetected until they manifest, overlooked because they do not fit expectations about how the system should operate within its specific environment (Ivory and Alderman, 2005). Consequently, when an accident does occur it can be totally unforeseen (Leveson, 2004).

Complex systems are also tightly-coupled (Perrow, 1999), whereby a change in one element can have rapid and multiple effects on others (Ramasesh and Browning, 2014). This can amalgamate, compound and magnify errors to the point of accident. The contingent aspects of complex systems must also be acknowledged (Cilliers, 1998), alongside their often multi-nodal nature, characterised by multiple and distributed sites of control (Wynne, 1988), potentially leading to internal contradictions and tensions when necessary resources (e.g. time, money or equipment) must be allocated or shared (Perrow, 1999; Dekker, 2011). Overall, complex system behaviours are emergent (Ivory and Alderman, 2005; Bakhshi *et al.*, 2016) and are always to some extent unpredictable. As such, they can be highly challenging for the management of safety.

Construction projects are generally accepted to be complex systems (Baccarini, 1996). They contain high levels of social inter-organisational complexity (Milch and Laumann, 2016), due to their reliance on long supply chains. This results in multiple companies involved in myriad work processes and increasing multi-nodality (Wynne, 1988), such as that stemming from the co-ordination, or attempted coordination, of different trades and subcontractors (Pinto *et al.*, 2011). Invariably, construction brings together organisations with greatly varying economic drivers and cultural norms of practice (Miozzo and Ivory, 2000). Construction work tasks frequently involve multiple, technologically complex interactions that are tightly coupled. These are carried out within the spatially-complex construction site environment that is in constant flux, resulting in non-linear interactions and unexpected consequences. Indeed, change and unpredictability can actually be argued to be one of the few constants of the site context, as construction work demands spatial change for progress and ultimate completion (Sherratt, 2016). Such operations also take place within a reality of internal contradictions and tensions, where resources can be scarce due to the reliance on low cost tendering and the resultant need for work to be carried out as quickly and cheaply as possible to return any profit for its participants (Sherratt, 2016).

As such characteristics are themselves consequences of the social interactions and relationships between the components of a system, rather than the complexity of components themselves (Dekker *et al.*, 2011), the behaviour of the construction site system cannot therefore be reduced to the sum of the behaviour of the constituent parts (Reiman *et al.*, 2015). However, the ways in which we seek to manage this complex system arguably does not reflect this: construction organisation and management focuses far more on technological project components than the social complexity of their interactions. There is a continued reliance on Work Breakdown Structures (WBS) and subsequent Critical Path Analysis (CPA) for construction planning which are only able to acknowledge interrelationships in terms of sequence as associated with construction technology. They are unable to acknowledge the processes by which such technologies are made manifest by the workforce, and so how the relationships between these processes (rather than products) emerge in reality. Within such approaches there is also often a lack of detail as well as scope for considerable

variation in the socially complex processes of how work tasks are carried out in terms of method, materials, plant and labour.

When considered from this perspective it is perhaps unsurprising that the construction industry has a disproportionately high rate of accidents worldwide (International Labour Organisation, 2018); they can simply be considered 'normal' given the complex nature of the system, which has significant repercussions for those seeking to improve and enhance safety management within this context.

Complexity and Construction Safety Management

The ways in which safety is managed on site frequently mirror the management processes that seek to plan and control the construction project as a whole. Alongside the WBS and CPA for the project sit Risk Assessments and Method Statements (RAMS). RAMs are often required by law, as they are in the UK (Health and Safety Executive, 2018), but also focus on specific work tasks: the components of the complex system. This is partly by necessity, in order to avoid unmanageability in terms of the size and scope of the documentation, but again neglects the socially complex relationships between these tasks, many of which will be tightly coupled with multiple interactions. Such relationships are difficult to explore or articulate within a bureaucratic management approach. Indeed, despite its name, the ubiquitous Safety Management Systems (SMS) of many construction organisations also struggle to approach and address systemic aspects of construction safety (Sherratt, 2016). Despite bringing together processes for management they are again limited by the simplistic conceptualisations of what they are trying to describe, unable to manage complexity in practice.

Problems with the reconciliation of traditional safety management with complex systems have been duly acknowledged, and have led to the development of a number of approaches seeking solutions in practice. The importance of taking a systems or complexity view of safety (Dekker *et al.*, 2011) has led to a shift away from safety management through bureaucracy, including the 'measurement' of safety through KPIs, AFRs, and other lagging indicators (Dekker, 2014), regulation and root cause analysis of accidents, towards the conceptualisation of HROs (Weick and Sutcliffe, 2007) and resilience engineering. Such thinking also aligns to Hollnagel's (2014) Safety II and the concept of Adaptive Safety (Borys *et al.*, 2009; Reiman *et al.*, 2015). A key foundation of all these approaches rests on the notion that although many accidents can be attributed to human error, it is this very same human capability for adaption, innovation and creativity that enables complex systems to maintain reliable performance in the light of the challenges to they pose (Harvey *et al.*, 2016).

This necessitates a change in perspective for safety management. It suggests organisations should seek to support both organisational and individual capabilities to cope with unforeseen events within such contexts. This develops resilience in the system, allowing production to operate in a robust yet flexible and, most importantly, safe way through a more pro-active approach (Hovden *et al.*, 2010). Contradictions between work as imagined and work as done (Hollnagel, 2014) should therefore be clearly acknowledged. While such locally emergent variation to work as planned can also be considered 'organisational drift' (Reiman *et al.*, 2015) and 'routine violations' (Reason, 1990), these are, nevertheless, essential 'work-arounds' through which the overall functioning of the system is maintained. At the same time, it is when such adapted practices meet and become tightly coupled, that unexpected consequences that can readily lead to accidents can also occur (Reiman *et al.*, 2015). Thus, work practice is the space within which safety is both lost and achieved. Critical to safe working is the bringing together of the often contradictory demands of safety and productivity in the context of a complex system that also presents that space with design and planning shortcomings, and a failure to always appreciate how work is or can be done in practice.

With the acceptance that neither technologically nor socially complex systems work as predicted (Dekker, 2011), centralised control becomes problematic and localised responses become far more important. An example of this can be seen in airline flight safety check-lists. While airlines maintain their own operational checklists for the aircraft they fly, pilots also annotate and develop these from their own experiences. In other words, the checklist as 'handed-down' by the airline and manufacturer is never perfect and in a constant state of repair. This work feeds back into their own learning and practice, but also creates the potential to share better practices with colleagues and with the organisation itself (Gawande, 2010). A process of organisational mindfulness (of which annotating checklists is an example) is one potential route to improving localised responses to experienced contradictions. This allows for a mixture of order and situationally sensitive flexibility in management and work practices, and rejects the notion that there can be one set of rules able to find fit with all situations, by remaining cognisant of varying and complex situational contexts (Ramasesh and Browning, 2014). In management terms, this also leads to a lowered proclivity to simplify interpretations of work systems or incidents therein (Weick and Sutcliffe, 2007).

Yet much of this ideology and the associated practices currently found in HROs and industries operating adaptive safety is very much at odds with contemporary site safety management practices. The construction industry has not yet been brave enough to draw robustly on complexity theories to inform and influence not only safety management but also project organising. For example, although the notion of 'float' is common in CPA, it is very different to the 'organisational slack' required to allow time for reflective decision making and continuous organisational learning as found within HROs (Ivory and Alderman, 2005). Indeed, the accepted necessary provision of generalised uncommitted resources at the organisation's disposal (Reiman *et al.*, 2015) for adaptive safety practices to be effective would certainly make a site quantity surveyor quake. Yet there are some aspects of adaptive safety that can be considered more suitable for adoption within the construction industry than others, one of which is situational self-organising.

Resilience in the System: Situational Self-Organising

On site there is a need to be able to respond quickly to changing circumstances (Harvey *et al.*, 2016), and indeed worker autonomy, responsibility, creativity and initiative are all encouraged to resolve problems of technical complexity and ensure continued productivity. There is therefore also the potential to harness this very same characteristic of the workforce, already found in abundance on sites, and apply it to safety management as considered from complexity and adaptive safety perspectives.

To this end one of Reiman *et al.*'s (2015:85) 'Principles of Adaptive Safety Management' has been selected here for further consideration: that of Situational Self-Organising. This selection is based on the theoretical potential for its application to construction work given the above, as well as the relative ease of its inclusion within contemporary construction SMSs. Rather than argue for a total paradigm shift, it is felt that small, yet significant and appropriate changes have a greater potential for acceptance and implementation, and so success in practice.

Self-organisation is an emergent property of complex systems (Bakhshi *et al.*, 2016), demonstrable through the variation and adaption required to maintain normal work processes. Situational self-organising differs from routine violations in that it involves the deliberate creation of capacity for workers to self-organise in a safe manner, giving permission for them to adjust and interpret rules and procedures according to context (Reiman *et al.*, 2015). Instead of forcing rule-based control onto a complex system, this approach is therefore able to allow for the variance between work as imagined and work as done (Hollnagel, 2014). This also provides a mechanism for adaption and

learning as part of the organisations approach to safety management. By supporting and creating new behaviours that increase beneficial interrelations and mindful comprehension, accidents can be avoided in the places in which they occur (Ramasesh and Browning, 2014). This shifts the control of safety from a centralised command position to one that is localised (Ivory and Alderman, 2005; Dekker, 2011), in which workers can respond locally to information presented to them (Dekker *et al.*, 2011) and make their own evaluations as to when 'suitable' becomes 'unsuitable' for safety (Townsend, 2013).

Methodology

In order to provide empirical illustration of our argument for the inclusion of situational self-organisation within the safety management strategies of construction sites, relevant data collected from a wider study exploring construction site safety overall has been unpacked, revisited and presented here through a lens of complexity theory.

This work mobilises social constructionism (Burr, 2003), an epistemological position which finds excellent fit with complexity-theory perspectives. Grounded in a relativist ontology, social constructionism is able to accept and acknowledge flux in real world contexts, as reality is understood as socially constructed on an ongoing basis by individuals through their interactions, systems and practices (Gergen and Gergen, 2004). There is no one, 'true' reality that can be determined through the research process, and instead different realities and understandings are revealed. Such an approach has been demonstrably able to provide illumination and insight to safety management practices on construction sites, revealing the different 'truths' as found there in the social flux (see for example Sherratt *et al* 2018, Sherratt *et al* 2015 and Sherratt 2013). Such a methodological approach inevitably challenges traditional positivistic conceptions such as validity, which is instead replaced by credibility (Lincoln and Guba 1985) as demonstrated through coherence within the methods used and argument as explicated (Taylor 2001). Reliability must also be judged by different parameters and is demonstrated through standardisation in the data collection, transcription, and constant comparison during the analytical process (Gibbs 2007). Therefore no claim is made to generalisability, and instead the aim is to find 'fit' and resonance with those who experience such places and present the variety and flux in the realities found there.

Analysis of the data is therefore able to reveal the ways in which shared understandings of the world are created within this specific context, and such understandings are identifiable through the use of discourses (Potter and Hepburn, 2008). Discourses represent 'language in use' and can be found in talk and text, shared practices and other interactions (Potter and Wetherell, 1992). Discourse analysis looks to unpack such interactions and reveal how they position, prioritise and make sense of certain phenomena within specific social contexts, able to provide understandings and explanations of the world as manifested through linguistic exchange.

Data referenced in this paper was collected from seven UK construction projects, operated by all located in the north west of England and all of a value of over £20m. Throughout the data collection period, the author was working full-time as a professional construction manager for a large main contractor, and so was able to access data on her own sites, as well as visit other sites for data collection purposes with access gained through her professional network. Data of three distinct types was collected. Talk data was collected through semi-structured interviews as well as informal conversations with workers and supervisors held out on the site, text data was collected in the form of documents from safety management systems, and visual data was collected in the form of safety related signage and posters. A total of 240 separate pieces of data (one piece being one conversation transcript or one document) were collected or generated for the study, and stored

within a NVIVO database. The talk data from both interviews and conversations was digitally recorded and transcribed using the Jefferson system (2004) and the transcripts uploaded into NVivo, in total 21 operatives, 13 site foremen/supervisors and 3 managers participated in the research. Documentary data was scanned and uploaded as image files, and the signage was captured using photographs which were then uploaded. This data set therefore contained both contrived and naturally-occurring data (Potter and Wetherall 1992). The talk data can be defined as contrived, as it would not have been produced and captured without the initiation of the research, whilst the documents and signage are naturally occurring data, not created for the purposes of the research itself, and therefore able to add to the ecological validity of the findings overall.

The process of discourse analysis is interpretive (Wetherell *et al.*, 2001), and the stored data was repeatedly coded within NVIVO, and the software used to seek out patterns (Taylor, 2001) including variability in both consistency and inconsistency within the data, as well a function, construction and representations of the language in use (Potter and Wetherell, 1992). As with traditional approaches to discourse analysis, no pre-determined literature-defined framework was used, instead the findings that emerged were driven by the data itself and the immersion of the researcher in the data. The emic perspective of the researcher as a construction manager was able to provide a level of construct and internal validity within the empirical work, and enabled the initial development of codes that resonated with the experiences of being on the site and working in this environment. For example the simple association of safety with work practices was an early code. A constant comparison process (Silverman, 2001) was used, which practically meant that the data analysis process ran concurrently with the data collection process. As new data was gathered, it was compared to the coded data, and patterns of similarity and difference highlighted, and the new data coded accordingly. This meant that at times codes developed and generated new sub-codes, whilst at other times codes were subsumed by other codes, or developed into new more inclusive codes that were more representative of the data as a whole. For example, the initial code of safety and work developed into two more robust codes: 'safety vs work' and 'work vs safety', better able to describe the relationships between these two elements as they emerged from the data. The data was visited in a number of cycles, as it was compared to itself and the wider analysis in an ongoing process throughout the data collection period. Ultimately, the most prominent codes, and therefore dominant discourses, emerged to the fore. Triangulation both within and between the different data sources also formed an inherent part of the coding and analytical process, able to reinforce or challenge these discourses as they developed, and reveal the different 'voices' of the data sources, as dictated by their creation.

Credibility of the work was reinforced by a process of member checking (Lincoln and Guba, 1985) with industry safety representatives at key stages in the process and on completion. These representatives were asked their opinions on the findings, either through reports or presentations made at company offices. Through this process, the findings of the study were confirmed as representative of the experiences and realities of those who work every day on construction sites.

Discursive work is usually presented in such a way as to allow readers to assess the interpretations made during the analytical process itself (Wetherell and Potter, 1992), however due to the inevitable constraints of space within journal papers, unpacking of the data has here been limited to illustrative examples. These examples are used merely to facilitate understanding of the dominant discourses around safety that emerged from the coding and analysis of the data as found within the site context. The overall aim of the wider project was simply 'to explore the social constructions of safety on large UK construction sites', and here relevant data relating to worker understandings of safety in practice, and so how it is practiced, have been drawn upon. By examining the dominant

discourses of construction site safety from a complexity perspective, and re-examining it through the lens of the complexity literature presented here, these many different discourses are able to reveal the realities of work as done, the associated understandings of safety in practice, and the potential for situational self-organising to find fit within the construction site environment.

Findings

What is Construction Site Safety?

The data revealed that there is no one, coherent, accepted understanding of what safety is on construction sites. A number of discourses were identified within the data that variously considered safety from the perspectives of danger and the moment of unsafety, safety as a practice in and of itself, as well as bound up as an inherent part of construction work, safety as either fluid and flexible or polarised into the categorisations of safe/unsafe, and safety as managed through methods of enforcement or engagement. This discursive variation and the relationships both between the discourses themselves and with wider industry practices arguably demonstrate complexity in practice, and a complexity that surrounds safety within the construction site context.

Indeed, broad understandings of construction site safety, as revealed through the discourse analysis, reveal a place of resignation around safety, and an acceptance of danger within construction work as a whole. Safety was belittled, perhaps necessarily for individual resilience, as one worker said:

'I nearly lost my foot a few weeks back, you know...'

Construction workers know their work can be dangerous, and they know that their understandings of safety do not always find fit with contemporary safety management practice. Indeed, evidence of the bureaucratisation of safety is easily found, as one worker noted:

'it just stops the jobs half the time ... some of the stuff gets too carried away really ... it's just common sense some of the time'

This discourse of 'safety vs work' was common in the data, safety, or rather safety as currently practiced, was frequently positioned as a direct hindrance to the dominant drivers of production. Such understandings are a direct challenge to any worker engagement, and instead disassociate safety from work practice, setting it apart from any personal responsibility, ownership or action by the individual concerned. This discourse was countered by the discourse of 'work vs safety', in which the practices of construction work were themselves positioned as a negative influence on safety, as one supervisor succinctly noted:

'It all comes down to earning money, doesn't it?'

And when workers are on price work or feeling the pressure of time and money created by lowest cost tendering or the squeezing of profits down a supply chain, it is perhaps unsurprising that such a discourse is readily found and accepted within the construction site environment. Indeed, workers rarely considered the negative effects of safety on practice outside of a context of production pressures.

That this reality looms large within the shared understandings of safety on site can be seen by the resignation that accidents will happen. For example, the current positioning of zero by contractors as a construction accident target has been highly problematic, as workers struggle to reconcile their lived experiences with such ambition (Sherratt, 2014). Indeed, workers have developed their own shared understandings in response to this challenge of zero, as one supervisor said:

‘...cause, nobody’s perfect ... and as with anything there are always going to be accidents’

Such resignation finds resonance with the practicalities of a work place in which resources are limited, and time, money and production tend to be prioritised above all else. Such understandings represent a shared acceptance amongst the site workers that the construction site is itself a something of a ‘complex mess’, a place where technical and social complexity create a space in which accidents are indeed normal and will inevitably occur.

A Little Bit Unsafe

A dominant discourse able to find considerable resonance with the principles of HROs and Adaptive Safety is that of ‘the state of safety’, a reference to the different shared understandings of safety found within the site environment that could take on one of two distinct forms; safety as solid and polarised, and safety as far more nebulous and changeable (Sherratt, 2016).

Safety in its metaphorical ‘solid’ state was binary, constructed simply as either safe or unsafe. This black/white assessment was most frequently found within the text-based data sources, drawing on the lexicon as prescribed by legislation and SMS practices in which something can ever only be either safe or unsafe, and there is no in-between. For example, the UK’s Health and Safety at Work Act etc. 1974 simply states in Cl 2(2) d that employers must ensure the place of work, i.e. the site, has:

‘Provision and maintenance of means of access to and egress from it that are safe’

This state of safety supports and perpetuates the bureaucratic approach to safety management found on sites, in which rules, RAMS, checklists and inspections all look to make such safe/unsafe judgements about the construction site space and are readily able to meet quantifiable criteria that allow safety to be benchmarked and measured: work as imagined is always planned to be safe. This approach also supports and enables a continued focus on the components of the construction site system, as demonstrated here by a tangible ‘something’ that is ‘unsafe’, rather than the more complex and arguably unmeasurable relationships between them.

However, a reality of safe/unsafe was not that as experienced by those who worked on the sites. This ‘solid state’ of safety was directly challenged by the opposing aspect of this discourse in which safety was far more fluid and unsettled, and it was this construction of safety that workers drew on when considering their everyday practices. Safety was constructed as variable, highly dependent on the changing circumstances of the context in which it was operating. Safety or un-safety could develop at any time and in any space, and was constructed through shades of grey in contrast to the black/white representations of polarisation. For example, a site worker noted:

‘If you can get away with doing something slightly unsafe, but you get the job done...’

Here, safety is not a case of safe or unsafe, and for this worker their lived experiences instead contains many shades of grey, and things can be just a little bit unsafe. This discourse of safety as fluid was very closely associated with site practice and the accepted realities of site life, suggesting that understandings of safety are reflecting the variability of its context, fully accepting and developing alongside inherent changes in the site environment. The unique construction site context can be a very different place to any other; for example, a barrier around an excavation in the ground may be safe one day and unsafe the next; changes in ground conditions, the weather, the excavation process, all of these contribute to an ever-changing place of work, very different from other industry contexts. Understandings of such change were also clearly acknowledged within a site-produced induction booklet which noted:

'stop working if unsafe or unhealthy conditions develop and inform your supervisor immediately...'

It is perhaps unsurprising that safety is constructed as fluid by those who work, and indeed manage, within such environments. A further example from the documentary data, from a site induction presentation that had been created by the on-site team, sought to make the site the:

'safest site it can possibly be'.

This allowed safety to be fluid and flexible, although not necessarily lacking in rigour, reflective of the specific site conditions at a specific point in time, more reflective of the experiences of those giving the induction as well as those receiving it.

To a large extent, the discourse of the state of safety is dictated to by legislation, legalese and the desire for measurement through binary evaluations (Sherratt, 2016), which in turn perpetuate a reliance on the traditional and bureaucratic approaches to safety management. However, this struggles within the complex system of the construction site, where change and fluidity are inevitable and the relationships between the tightly-coupled components form critical factors in the emergence of a 'continuum of safety' in practice.

Managing Safety on Site

The challenges of safety management within the contemporary site environment were clearly evidenced by the data. Two of the most prominent discourses of safety, identifiable in some way within nearly all the data sources, were found to be 'safety as enforcement' and 'safety as engagement' (please see Sherratt *et al.*, 2013 for a much more detailed unpacking of these specific discourses), both of which were closely associated with a formal, centralised and hierarchical control of safety on the sites, and their mobilisation supported a considerable expenditure of efforts towards ensuring everyone followed the safety rules. From the site inductions, to the SMS, to formal signage, the voice of site management seeking compliance was found throughout the data. The corporate main contractor's voice mobilised a discourse of engagement, as professional posters on the hoardings encouraged workers to:

'choose to work safely' and 'not to jump barriers'

Whilst the voice of the contractor's site supervisors spoke much more abruptly, through handwritten signs and the discourse of enforcement as they threatened:

'disciplinary action' for any 'breach of safety rules, e.g. misuse or lack of PPE' or for those 'found moving barriers or walkways.'

These two sources highlight discourses that reflected different facets of the contemporary approach to construction safety management on large sites in the UK. Although the corporate voice of the posters is seeking engagement in a way that could reflect a sharing of decision-making and localisation of safety control, the site-based voice suggests this is not an approach the realities of the site are, as yet, able to work with. The site rules, and their enforcement, clearly remain. The presence of two such distinct yet closely associated discourses supports understandings of the construction site as a complex place. Neither discourse is able to dominate, and so both endure. Engagement alone within the current site context is unable to have the desired effect and therefore, as suggested by Harvey *et al.* (2016), enforcement is still required to ensure safety is given due attention.

Yet the very presence of the discourse of enforcement and the need for punishment suggests a reality in which following the rules is something of a struggle, a potential consequence of a dissonance between work as imagined and work as it is actually done (Hollnagel, 2014) and a continued reliance on a centralised one-size-fits-all rule-based approach to safety management (Ramasesh and Browning, 2014). Indeed, as the talk data revealed, construction site rules are certainly considered to be 'bendable', as one supervisor noted:

'They've always been good the lads that work with us, they don't really break the rules...'

And so the rules don't quite get broken, just bent a bit. Indeed, violation of safety rules emerged as such a quotidian aspect of construction site life that their consideration did not even merit detailed discussion with regards to any associated danger, accident or incident (Sherratt *et al.*, 2013). The rules are bent and broken on such a regular basis that workers are fully expecting to be punished when caught, as this worker explained:

'you should be allowed, say, a couple of times, if you haven't got your gloves on or something like that ... would you mind putting our gloves on please ... then say the second time ... there'll be consequences ... you can handle that, you know, if it's done politely'

These shared understandings of the safety rules and a ready acceptance of punishment, when done 'correctly', indicate a resignation amongst the site-based workers and supervisors that such ongoing interactions around rule breaking and punishment are simply an unavoidable inevitability. Work cannot be done as prescribed without breaking the safety rules as currently enforced, and so the rules will be broken, and people will be punished.

However, within the workforce there is also an understanding of safety as a holistic, integral part of construction work. It is something that goes beyond engagement and enforcement, reflective of the complexities of practice and instead bringing safety back into localised and immediate contexts. As one worker surmised:

'if he's not looking after me, and I'm not looking out for him, then we're not gonna be getting anywhere, are we?'

Such an understanding clearly supports the potential for workers to self-organise around safety, bringing notions of mindfulness and collaboration to the workspace and positioning safety practice as a dynamic and responsive process that requires the engagement and involvement of all workers to support and maintain the safety of everyone on site.

Discussion: Is Construction Ready to Become Adaptive?

Empirical work in the field of complexity has demonstrated the capabilities of people to detect, adapt, and correct their systems as necessary (Hovden *et al.*, 2010), and construction people should be able to do this, perhaps even more than most. Construction workers are some of the most adaptable and creative in the world, solutions and fixes are part of everyday construction work, and the attitude pervades that there is 'nothing that can't be done' (Sherratt, 2016). The examination of the dominant discourses of safety as found on large UK construction sites presented here has been able to empirically demonstrate a space in which the safety management approach of situational self-organising, as set out in the principles of adaptive safety, has the potential to be adopted.

Considering Workers and Work

Construction workers are fully aware of the complexities of safety management in practice as found on construction sites. Indeed, the nature of safety as found within such a technologically and

socially complex system is perhaps better understood by those on site than those seeking to manage safety from more removed positions. Whilst the corporate voice still speaks of safe/unsafe, site workers and supervisors are only all too aware of the fluidity and flexibility that surround safety in practice. Although formal documentation, and supportive legislation, consider safety as relatively simple and easily defined within the polarised scope of safe/unsafe, practice has necessarily unbent to allow for emergence and change; safety becoming a fluid, flexible and mutable state, also necessarily reflecting the variability of a context in which the relationships between time, cost and production, or work vs safety and safety vs work, are highly influential. These various and interlinked experiential understandings of safety reflect the theoretical positioning of safety as an emergent, diverse and changeable property within a complex system, acknowledged and understood in terms of its relationships with practice.

Workers are also fully aware of the safety, or rather dangers, inherent in construction work, as evidenced by their positioning of safety as danger albeit alongside a belittling and derision of the consequences of its failure. However, the latter could be considered an essential characteristic of construction workers in and of themselves, as they must necessarily be able to face such danger every time they set foot on site (Rawlinson and Farrell, 2009). The dismissal of danger or its reduction to a joke or anecdote is perhaps simply the most straightforward way to create and recreate an acceptable workplace reality, for both themselves and their families. Yet this high risk tolerance among the workers could also negatively affect situational self-organising, reliant as it is on the shared acceptance of what is safe or unsafe within specific contexts. Although, as both argued theoretically and demonstrated empirically here, what is 'safe' or 'unsafe' is never so easily defined within the complex and every-changing system of the construction site, and certainly not from perspectives of centralised control. This 'risk' can therefore be tempered to some extent by both the localisation of such evaluations, experience and context holding influence around the situational, but also by the fact that such self-organising decisions are not made alone but with co-workers. From this perspective, merit can be found on the construction site with workers accepting of the need for their collegiality and shared support of each other in order to ensure the safety of everyone on site.

Indeed, the construction site context is one in which the workers already make sense of safety from perspectives more familiar to HROs and Adaptive Safety practitioners, and they have arguably reached this point before the construction safety management experts. Their understandings of safety are therefore open to a process of situational self-organising as the workers fully accept that construction sites are complex, they are changeable, and safety is never simple. This is something clearly understood by workers as they construct and reconstruct their shared understandings of safety in practice through the dominant discourses of the site.

Considering Management and Control

Yet the adoption of situational self-organising within the construction workforce would require significant organisational change before finding fit within the construction industry. Although small steps have been made in these directions over recent years, for example under the banners of a 'making safety personal' approach to safety culture and various worker engagement mechanisms, these are arguably only additions to the command and enforcement structures that remain firmly in place on sites (Sherratt *et al.*, 2013). Safety management approaches remain reductionist and linear (Dekker, 2011), and the reliance remains on lagging indicators, KPIs, AFRs, bureaucratic measurement (Dekker, 2014) and accident investigation, despite the fact that construction projects are complex and non-linear systems, creating a fundamental dissonance with practice.

Indeed, it could be suggested that the very nature of construction, with its reliance on low-cost tendering and fragmented supply chains that already have negative implications for safety management (Sherratt, 2016), would make the adoption of such adaptive safety measures impossibly challenging. Subcontracting and work package separation fragments expertise, specialisation resulting in a lack of broader experiential knowledge and thereby leaving a project vulnerable to unknown unknowns (Ramasesh and Browning, 2014) and unable to adopt adaptive safety practices. Indeed, as Harvey *et al.* (2016) note, without authority and regulation, worker autonomy within this context currently leads to focus on productivity and so unsafe workarounds and violations, rather than improvements in safety. However, this may itself be a consequence of the need for the organisational slack required to allow time for reflective decision making and continuous organisational learning (Ivory and Alderman, 2005), and physical resources to support such adaptive safety approaches (Reiman *et al.*, 2015; Harvey *et al.*, 2016), both of which are all too often lacking in construction, where time and money dominate production pressures.

In addition to the above, the legal and regulatory requirements in place suggest that a significant amount of organisational bravery is required to develop the management role from one solely focused on command and control to one seeking the creation of positive preconditions for adaptive safety in construction, empowering workers to situationally self-organise, and of course to pay for it. However, the adoption of situational self-organising does not necessitate the removal of all management control or limit wider organisational learning as part of the safety management process. Indeed a key part of the process would be to, where possible, instantiate the local, contextual and project specific lessons learnt through situational self-organising into wider organisational process. Such a clearly realised and practiced bottom-up approach, driven by the site rather than the office, would arguably be better able to avoid the current friction between the discourses of enforcement and engagement that have emerged as a consequence of current practice, and able to authentically prioritise engagement over enforcement in practice. Such site-generated safety knowledge can augment and develop current guidelines, best practice and even construction-specific legislation with due recognisance and acceptance of how safety actually works within this specific context.

Mechanisms for capturing such experiential learning and embedding this in shared practice require effective processes of communication and instantiation between site practice and the organisation, where such knowledge can be captured and then re-distributed. However, this has historically proved challenging within the construction site context (Mohamed and Anumba 2006), although this can be in part linked to organisational motivation. For example, within the airline industry, where a poor safety record is a direct threat to the survival of the airline, the motivation to ensure learning from lived experience is high. Within the construction industry, sanctions are weaker and firms must only stay within the prescription of the law, while accidents have less effect on the bottom-line, and are even seen as normal. The business motivations to find the resource necessary to facilitate detailed learning are therefore much lower. To facilitate such learning in construction would require the organizational capacity to fully involve site-workers in their own safety management processes (including the ability to sanction slack, non-productive time as part of the knowledge transfer process) and have the means to capture this learning in changes to manuals and training. Such an approach would make organisational Safety Management Systems much more dynamic, and constantly under development through self-organising and subsequent organizational learning processes. Furthermore, the investment of time and resources to develop and facilitate such a process would provide the opportunity for the organisation to demonstrate a commercial commitment to safety readily recognisable from client perspectives, thus providing a potential competitive advantage in some circumstances.

Conclusions

The complex nature of the construction industry, both technologically and socially, means it is eminently suitable for both the unpacking of its processes from complexity-theory perspectives. A strong sense of purpose is needed for a system to self-organise effectively (Reiman *et al.*, 2015), but construction has just that: working to drawings and specifications through agreed sequencing as defined by technologies, which lead to a tangible, finished product. It also has a workforce able to invent and innovate with regards to such technologically complex work, therefore why not also apply such innovation to safety?

Here, we have empirically demonstrated the nuanced realities of this site context, as a space in which safety is a fluid, dynamic and emergent aspect of work, something the workers perhaps appreciate far more readily as part of their lived experiences than those who make the 'safety rules' offsite. In this way, we have provided evidence that supports the development of just one aspect of adaptive safety, that of situational self-organising, as an appropriate development for safety management on construction sites. We have argued for its inclusion as a supplemental aspect of existing site SMSs, able to bring a dynamism and ground-up engagement with safety that is currently lacking, supporting organisational development in a positive and demonstrable way. This will need organisational commitment in terms of resources for support, and a measure of organisational bravery to actually 'hand-over' control to the workers, but this is a step that can be justified by those seeking to overcome the plateauing of safety management within the industry, and who genuinely wish to further reduce accidents and incidents on sites.

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