Cognitive Correlates of Improvised Behaviour in Disaster Response: the Cases of the Murrah Building and the World Trade Center

David Mendonça*, Gary Webb, Carter Butts*** and James Brooks******

*Industrial and Systems Engineering Department, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180, USA. E-mail: mendod@rpi.edu
**Department of Public Administration, University of North Texas, 204N Chilton Hall, 410 Avenue C, Denton, TX 76201, USA. E-mail: gary.webb@unt.edu
***Department of Sociology, University of California – Irvine, SSPA 2145, Irvine, CA 92697, USA. E-mail: buttsc@uci.edu
****Industrial and Systems Engineering Department, Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180, USA. E-mail: brookj7@rpi.edu

While emergency response actions are known to range from conventional to improvised, less is known about the thinking processes that underlie these actions. This paper presents a statistical analysis of cognition and behaviour reported by police personnel who responded to two significant US disasters: the 1995 bombing of the Murrah Building in Oklahoma City and the 2001 attack on the World Trade Center in New York City. The results suggest the prominence of conventional behaviour coupled with cognitive processes closely tied to recognition, and of improvised behaviours that are linked to more explicit reasoning processes. The results underscore the value of exploring cognitive foundations of both conventional and improvised behaviours to enrich understanding of human response to disaster.

1. Overview

The literature on organized response to disaster has shown the importance and complementarity of both planning (Drabek, 1985; Perry, 1991) and improvising (Kreps, 1991; Turner, 1995) to effective response activities. The focus of many of these studies has been on phenomena that seem to be at the core of societal resilience: accurate perception, quick thinking, and creative and effective action (Mendonça & Wallace, 2004; Vidaillet, 2001; Wachtendorf, 2004; Webb, 2004). Prior studies of human cognition and behaviour in high stakes situations strongly suggest sharp differences in human thinking and behaviour in environments characterized by dynamism (Brehmer, 1992; Gonzalez, 2004) and higher stakes (Klein, Orasnu, Calderwood, & Zsambok, 1993; Perrow, 1984). Yet with very few exceptions (Bigley & Roberts, 2001; Webb, 2004; Weick, 1993; Weick & Roberts, 1993), studies of improvisation in organizations have largely confined themselves to relatively stable environments. The post-disaster environment offers a radically different set of circumstances, where turbulence is commonplace and where priority is placed on minimization of human and economic costs. By examining improvisation (and its complement, planning) during response operations, we stand to enrich our

 DOI: 10.1111/1468-5973.12057

understanding of how human collectives respond to – and recover from – highly non-routine circumstances.

One approach to attaining this enrichment is to investigate the cognitive processes that underlie the behaviour of response personnel. Prior research has produced numerous individual case studies of how personnel undertaking disaster response operations have thought and acted (e.g., Hutchins, 1991; Weick, 1993) in response to non-routine events [essentially, the conditions in the field that trigger particular behavioural responses (Mendonça et al., 2004)]. The strength of these studies has been the depth of their analysis and interpretation, particularly of cognition among key response personnel. Consequently, they provide a starting point in formulating hypotheses that can be tested on a larger set of individuals responding to a disaster. This latter approach is the strength of studies in more stable domains, such as new product development (for a review, see Pina e Cunha, Vieira da Cunha, & Kamoche, 1999), which has also been undertaken by selected researchers with the intention of generating sociological theory (Quarantelli, 1997). A gap in scholarship on improvisation, then, is in explaining the links between cognition and behaviour by drawing upon data from individuals operating in the post-disaster environment.

This study contributes to addressing this gap by investigating cognition and behaviour among response personnel following the onset of two historically significant US disasters: the 19 April 1995 bombing of the Murrah Building in Oklahoma City (The City of Oklahoma City Document Management Team, 1996) and the 11 September 2001 World Trade Center attack in New York City (National Institute of Standards and Technology, 2005). A set of research questions is used to guide an investigation of differences within and across these two disasters in the fundamental problem-solving processes of goal setting, observing, and hypothesizing, linked to behaviours that range from conventional to improvise. The research questions are investigated via statistical analysis of response-related activities reported by the police personnel. The results offer a closer look at the cognitive underpinnings of human behaviour in response to disaster, leading to a discussion of possible study extensions, as well as implications for the practice of emergency management.

2. Background

2.1. Disaster response

To guide decision-making among response personnel operating in the post-disaster environment, disaster plans specify a sequential patterns of activities (i.e., behaviours) to be accomplished given the occurrence of some contingency. Two different challenges can impede the successful implementation of disaster plans. First, even when a plan is applicable to a particular situation, it might not state exactly how the behaviours are to be executed, leaving room (and responsibility) for personnel to determine how they will be implemented. For example, a plan may call for sending an ambulance to the incident location to transport injured persons. One of many possible implementations of this behaviour is to dispatch a particular ambulance at a particular location to the accident scene via a given route. Second, it may be that no plan is applicable to the current situation. Response personnel must therefore develop and deploy new procedures in real time. Prominent examples of such situations are found in the grounding of the tanker Exxon Valdez (Harrald, Cohn, & Wallace, 1992; Harrald, Marcus, & Wallace, 1990) and many other cases (e.g., Hutchins, 1991, Weick, 1993).

To address either of these challenges, response personnel may draw upon a repertoire of pre-established routines (Feldman & Pentland, 2003; Pentland & Rueter, 1994), shaping them to fit the requirements of the current situation in a process that is here denoted improvisation (Grote, Weichbrodt, Günter, Zala-Mezö, & Künzle, 2009; Mendonça & Wallace, 2007). In contemporary research on improvisation in emergency response, examples of pre-established routines include standard operating procedures and expected patterns of role performance. Improvisations may range from simple substitution of planned-for personnel and equipment to more profound changes, such as the development of new procedures (Mendonça et al., 2004).

Improvisation in emergency response has long been viewed as an activity in which creativity is exercised under time constraint in order to meet response objectives (Klein, 1993; Weick, 1993, 1996). Yet only a few studies (Rosmuller & Ale, 2008) have sought to discover and explore the cognitive and behavioural processes that underlie improvisation, thus leaving the improvisation construct 'unpacked' (Weick, 1998).

2.2. Cognition and problem solving

As suggested by the above discussion, emergencies occur at – and sometimes beyond – the boundaries of human experience, where creativity and an ability to decide effectively under time constraint and in the presence of high stakes can be highly valuable (Kreps, 1984; Mendonça et al., 2007). Prior research on decision-making in the field, for example, has demonstrated the salience of both perceptual and deliberative decision-making processes (e.g., Lipshitz, Klein, Orasanu, & Salas, 2001). From this perspective, response personnel must identify response goals, observe conditions in the field and hypothesize about possible consequences of actions in order to inform subsequent decision-making (Mendonça et al., 2007). Characterizing the distribution of effort across these three activities is one approach to

understanding human problem solving – a process of taking intermediate steps to transform an initial state into a goal state through a set of operators (Klahr & Simon, 1999). These activities may be defined generally as follows. *Goal orienting* is said to occur when an individual expresses a desire to attain a particular situation or state of the world (Okada & Simon, 1997). Goals are used to help decision-makers orient their search through experiment and hypothesis spaces. *Observing* refers to the act of noticing and processing information (Klahr & Dunbar, 1988; Okada et al., 1997). *Hypothesizing* means developing explanations for observed or predicted situations occurring in the field: that is, providing '[a] tentative explanation for an observation, phenomenon, or scientific problem that can be tested by further investigation' (Pickett, 2000). In the context of disaster response, Dynes and Quarantelli have discussed a similar conceptualization of decision-making as 'coordination by feedback', where preliminary hypotheses about conditions in the field are affirmed or denied based on the results of decisions taken (Dynes & Quarantelli, 1977).

Each of these activities may be defined more specifically within the emergency response domain. It may first be noted that various human and material resources are at the disposal of the response personnel to attempt to meet response goals. Human resources may be individuals taking part in the response as professionals (such as police and firefighters) or as civilian volunteers. Material resources are physical entities that are not persons, such as squad cars and firefighting apparatus. *Goal orienting* is said to occur when a personnel refer to target states of the world (e.g., referring to typical response goals, such as mitigation of casualties, control of incident, and minimization of property or other economic losses). *Observing* is said to occur when response personnel scan the environment for information on resources or the broader context of the event (e.g., noticing the spread of a fire). *Hypothesizing* is said to occur in either of two cases: first, when an individual considers how personnel or material resources relate to one another (e.g., are police radios compatible with fire department radios); second, when an individual considers predicted or postulated effects of allocations of personnel or material resources (e.g., can a police personnel effectively support search and rescue operations).

2.3. Disaster role behaviour

Emergency response organizations and the individuals within them are likely to have a set of behaviours that they are expected to be able to execute during the response – that is, a set of social roles. Roles are generally defined as stable patterns of expectations, relationships, and behaviours (Kreps & Bosworth, 1993). Role expectations stem from occupying a particular status in the social structure, such as an occupation. Role relationships arise as a consequence of roles being embedded in social networks, and thus being recognizable through relationships to other roles. Role behaviours in the disaster context include response-related activities initiated by individual responders.

Disaster role behaviour is here conceptualized as having four dimensions: procedure, status, equipment, and location (Webb, 2004; Webb, Beverly, McMichael, Noon, & Patterson, 1998). Each dimension of behaviour may be improvised or performed conventionally. The *procedural* dimension refers to the prescribed way for performing a role, which, when improvised, may be bypassed, short-circuited, or altered in some other way. The *status* dimension refers to the position a person occupies, which, when improvised, would involve behaviour inconsistent with a person's pre-disaster occupational status. The *equipment* dimension refers to the tools used to perform a role, which, when improvised, involves the use of alternative tools or makeshift tools. Finally, the *location* dimension refers simply to the physical place in which a role is enacted, which, when improvised, would involve carrying out a role in an alternate location. For simplicity, a distinction may be made between material and non-material improvisations. A *material* role improvisation involves changes in the tools or equipment used in the performance of disaster roles or changes in the location where a role is performed. A *non-material* improvisation involves alterations to established procedures for carrying out a task or the expansion of an individual's role by engaging in behaviours that are not entirely consistent with the actor's prior occupational status.

3. Research propositions

The research propositions presented in this section are used to guide an examination of cognitive underpinnings of disaster role behaviours. The questions are divided into those concerning cognitive and behavioural processes individually and in tandem, with additional consideration given to the impact of event severity.

3.1. Cognitive processes

For a number of reasons, the emergency response environment is likely to produce considerable ambiguity and uncertainty (Roux-Dufort, 2003; Vidaillet, 2001). First, time pressure, high consequences, and complexity are expected to push response personnel towards decision-making. When this scene is more familiar, a recognition-primed decision-making model is expected to operate (Groenendaal, Helsloot, & Scholtens, 2013; Klein, 1993), a view further reinforced by subsequent

work in the area of naturalistic decision-making (Lipshitz et al., 2001). When the scene is less familiar, recognition becomes less powerful and personnel must rely more on more time-consuming deliberative approaches. Second, uncertainty propels response personnel towards conditioning current actions based on the outcomes of prior actions (Quarantelli, 1978; Scanlon, 1994).

As the disaster response evolves, there is a concomitant need to articulate goals that will help direct attention to either of these activities or towards further data collection. In the emergency response environment, goals are typically tied to conditions in the field, particularly those that relate to possible human or economic loss. Indeed, the Incident Command System – a common US protocol for coordinating response activities (Bigley et al., 2001) – includes tasks associated with identifying, communicating, and tracking progress towards goals. However, time and effort spent on developing goals reduces the resources available for collecting data. When goals are fairly well-specified, then, observation is expected to be emphasized, whether for purposes of informing hypothesis generation or interpreting the outcomes of decisions, leading to the following proposition:

C1: Observation is expected to be emphasized over goal orienting for a given respondent.

3.2. Response behaviour

In order to measure and explain changes in role performance, it is necessary to understand the normal expectations of a role in relation to actual role behaviours. Indeed, when conventional behaviours have been the object of study, they have not been subjected to the same degree of scrutiny as improvised behaviour (Kreps, 1984; Quarantelli & Dynes, 1977). Given the continued acknowledged importance of plans intended to inform response activities, it is perhaps reasonable to expect that conventional behaviours will predominate during disaster response. Consequently, it is expected that the majority of behavioural events will be conventional, leading to the following:

B1: Conventional behavioural events will occur more frequently than improvised behavioural events for a given respondent.

Based on results from archival data from dozens of past disasters in the United States (Webb, 2004; Webb et al., 1998), levels of improvising were much higher in response to civil disturbances than to natural and technological disasters. This difference may be due to the natural and technological disasters under the study having placed relatively low demands on response personnel (Kreps, 1995). However, for a subset of civil disturbances (i.e., those that occurred in the 1960s), demands on police and fire departments were higher as they had not previously dealt with widespread unrest on such a large scale. Overall, levels of improvisation were relatively low in these samples (approximately 25% of behavioural components were improvised). In contrast, for civil disturbances, levels of improvisation were significantly higher (i.e., 50%) (Webb, 1998). About 70% of identified role improvisations were of the non-material type (i.e., involving changes to procedures and status), thus far more common than the material type (i.e., involving changes to equipment and location). These observations lead to the following proposition:

B2: It is expected that there will be more non-material than material improvisations for a given respondent.

As defined in prior research (Webb, 2004; Webb et al., 1998), procedural improvisations involve changes in the pattern of activities prescribed for the task. An example of a minor procedural change is not filling out a form before requisitioning supplies. Status improvisations, on the other hand, involve a greater departure from routine, with individuals doing things they would not ordinarily be expected to do or assuming authority over those whom they do not ordinarily command. In established organizations, such as police departments, it is expected that responding individuals will generally tend to follow prescribed procedures and to adhere to retain their pre-disaster status, leading to proposition B3:

B3: Among the non-material improvisations, procedural changes will be most common for a given respondent.

3.3. Combined effects

As discussed previously, prior perspectives on disaster role performance have generally addressed structural concerns (e.g., how roles relate to one another) and identified the constituent components of role performance. On the other hand, studies of cognition in improvisation in the emergency response context have perhaps not given sufficient attention to cognition's links to behaviour. A number of studies have speculated on the cognitive processes underlying improvised behaviour (for a review, see Pina e Cunha et al., 1999), including within the emergency response context (e.g., Vidaillet, 2001, Weick, 1993). An exploratory approach will be used to investigate these processes by considering goal orienting and hypothesizing activities in relation to role behaviours.

The study design and data to be employed in addressing these research propositions are explained in the following section.

4. Study design and data

The analysis draws upon data from two important US disasters: the 1995 bombing of the Murrah Federal

Building in Oklahoma City and the 2001 attack on the World Trade Center in New York City. Both events were emblematic of the sudden, unexpected crises arising from modern terrorist attacks; each also has features which are shared by other events that provide little prior warning, such as earthquakes, tornadoes, and structural failures. These events are briefly summarized (National Institute of Standards and Technology, 2005; The City of Oklahoma City Document Management Team, 1996) in order to provide context for the subsequent analysis. The procedures by which data on response activities were obtained are then explained. As explained more fully, the focus of this work on police response is motivated both by the versatile roles played by police officers during the two events, as well as the relatively high quality of police officers as trained informants.

4.1. Alfred P. Murrah Federal Building

The bombing of the Alfred P. Murrah Federal Building in downtown Oklahoma City, Oklahoma, United States occurred at 9:02am on 19 April 1995. At the time of the blast, the building housed approximately 850 people, including 600 Federal and contract workers, and 250 visitors. The resulting explosion significantly damaged the Murrah building and caused substantial damage to adjacent structures. As a direct result of the blast, a total of 167 persons were killed and 675 persons were injured (the latter including 20 Oklahoma City police personnel).

All on-duty city, county, and state emergency forces located in or near downtown Oklahoma City (OKC) self-dispatched to the incident location. The first OKC police department (PD) personnel arrived on-scene at 9:04am; shortly thereafter, there were over 150 PD personnel on-site. PD personnel immediately began coordinating their activities with OKC Fire Department personnel. At 9:31am, a police Command Post vehicle was stationed at the scene. Additional PD personnel arrived soon thereafter and were assigned to control the perimeter of the site. Police investigators also arrived to begin investigating the area as a crime scene, which included reconnaissance and evidence collection activities, as well as interviewing of potential witnesses to the explosion. Law enforcement personnel from the Oklahoma County Sheriff's Office were also sent to the scene.

OKC PD's efforts during the immediate response period concentrated on establishing a perimeter, providing security for the scene, and coordinating with the other two lead agencies – the OKC Fire Department and the US Federal Bureau of Investigation. Other OKC PD activities included directing the recovery of bodies from the rubble (in cooperation with personnel from the OKC Medical Examiner's office), as well as traffic control. At the time of the event, the OKC PD had 1340 personnel (995 sworn personnel, 302 civilian personnel, 43 police recruits in training). A total of 454 OKC PD personnel took part in the response on the day of the bombing. During the response and recovery, about 232 OKC PD personnel (i.e., 17% of total personnel) were working on-site. A total of 47,820.70 on-duty and off-duty hours were logged by OKC PD personnel from 23 April 1995 (the day a daily staffing count was implemented) until 5 May 1995.

4.2. World Trade Center

The attack on the World Trade Center (WTC) complex in New York City, New York, United States began at 8:46am on 11 September 2001, when a plane was flown into WTC Tower 1. Approximately 17,600 people were in WTC Tower 1 and its companion building, Tower 2, at this time. Response personnel began work almost immediately, as some were on-site when the initial wave of the attack took place. A second plane struck WTC Tower 2 at 9:03am, producing a huge fireball and spilling fuel and debris, further complicating response operations. WTC 2 collapsed at 9:58:59am; WTC 1 collapsed at 10:28:25am. In total, 2,749 people were killed as a direct result of the attack, 439 of whom were response personnel [37 of these were Port Authority Police Department (PAPD) personnel] (Kean & Hamilton, 2004).

At the time of the attack, PAPD consisted of 1,331 officers. There was a separate command for each of the PA's nine facilities, including one at WTC (Kean et al., 2004). PAPD had primary law enforcement responsibility at the WTC site. Initially, some officers assisted in evacuations from stairwells within WTC 1, others supported evacuations from the other areas outside WTC 1, and others were instructed to climb above the ground floor to assist with rescue on higher floors (Kean et al., 2004).

4.3. Data set

Raw materials for this study are narrative reports produced by PD personnel shortly after the onset of each event. Materials such as these have a long history of use in studies of post-disaster decision-making (Kreps, 1984; Quarantelli et al., 1977). As has been noted elsewhere, appropriate instrumentation is rarely in place to capture respondent behaviour, while data on thinking processes is almost exclusively available solely through retrospective sources such as self-reports and logs of interpersonal communications (see Njå & Rake, 2008 for further discussion). Institutionalization of reporting and debriefing procedures, while not without the limitations shared by other self-reporting procedures, contribute to the internal validity of post-disaster reporting

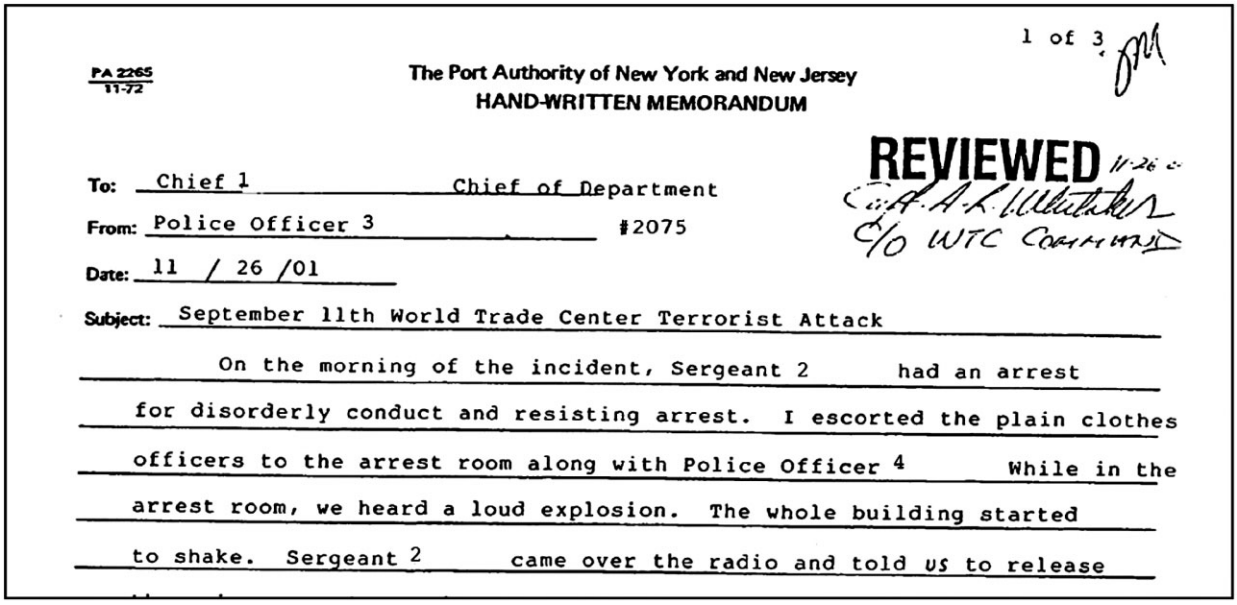
(Stallings, 2002). The validity of conclusions drawn from self-reports – particularly for predictive purposes (Antonsen, 2009) – can be further strengthened through appropriate sampling and encoding techniques, as discussed in the following paragraphs.

In providing these report, which were collected shortly after each event by personnel not involved in the present study, respondents recounted their activities during the immediate response period. Typically, events were presented in a narrative format, with events recorded in order of occurrence. It should be emphasized that this type of reporting is typically institutionalized within police forces. Indeed, many of the narrative materials drawn upon for this study were submitted as official police reports. The fact that police officers are thus 'trained informants' – i.e., persons who are trained in and experienced with providing systematic accounts of their response activities, and for whom the provision of such accounts is a routine expectation when entering the field – makes them appropriate sources of information for a study of this kind. Moreover, police officers typically engage in a much wider range of response activities than fire or emergency medical personnel, thus giving them the potential to provide information on a broader cross-section of the response process than their peers in other service areas.

The WTC materials employed here are publicly available post-event self-reports given by police personnel from the Port Authority of New York and New Jersey. The OKC materials are available through the archives of the Oklahoma City National Memorial. They also consist of post-event self-reports given by personnel from the OKC PD. As discussed previously, the unit of measurement is that of events (whether cognitive or behavioural), aggregated to the level of the individual respondent. In order to reduce issues associated with this quantization (particularly overinflation of standard deviations) (Gray & Neuhoff, 1998), only respondents with more than 30 cognitive and 17 behavioural events are included in the analysis. This produced a set of 26 PD narrative reports from WTC and six from OKC, a figure proportional to the total number of respondents for each disaster (19.4% of OKC, 18.7% of WTC). As discussed, due in part to these smaller sample sizes, conservative (non-parametric tests) are used to test the hypotheses. A sample from one such narrative is shown in Figure 1, with names replaced by numerical identifiers.

All narratives were converted to machine-readable format and the resulting documents verified for accuracy against the originals. As shown in Figure 2, unique identifiers were assigned to each document (*Doc#*), to each sentence within a document (*Dsen#*), and to each disaster (*Dis*).

The machine-readable documents were provided to coders along with instructions for identifying and classifying cognitive and behavioural events that involved the respondent (i.e., the police personnel who had provided the narrative) (Krippendorff, 2012). An event was classified as *cognitive* if it consisted of hypothesizing, observing, or goal orienting, according to the definitions given previously. An event was classified as *behavioural* if it was an action taking place in the performance of a disaster response role. Each behavioural event was further defined along the dimensions of status, material,



1 of 3

PA 2265
11-72

The Port Authority of New York and New Jersey
HAND-WRITTEN MEMORANDUM

REVIEWED 11-26

To: Chief 1 Chief of Department

From: Police Officer 3 #2075

c/o WTC

Date: 11 / 26 /01

Subject: September 11th World Trade Center Terrorist Attack

On the morning of the incident, Sergeant 2 had an arrest for disorderly conduct and resisting arrest. I escorted the plain clothes officers to the arrest room along with Police Officer 4 While in the arrest room, we heard a loud explosion. The whole building started to shake. Sergeant 2 came over the radio and told us to release

Figure 1. Excerpt from original police narrative report.

Doc#	Dsen#	Dis	Sentence
18	1	WTC	On the morning of the incident, Sergeant 2 had an arrest for disorderly conduct and resisting arrest.
18	2	WTC	I escorted the plain clothes officers to the arrest room along with Police Officer 4.
18	3	WTC	While in the arrest room, we heard a loud explosion.
18	4	WTC	The whole building started to shake.
18	5	WTC	Sergeant 2 came over the radio and told us to release the prisoner.

Figure 2. Machine-readable version of Figure 1 excerpt.

Table 1. Examples of Cognitive Events

Event	Sentence	Explanation
Hypothesizing	'We expected to see injured victims and/or responders.'	Hypothesis about personnel expected to be on scene
Observing	'There was an explosion on the upper floors.'	Observation about the broader context of the event
Goal orienting	'As the TV came on and I saw the smoke I knew I had to get downtown.'	Goal orientation towards allocating personnel resources to the scene

Table 2. Examples of Behavioural Dimensions for Selected Behavioural Events

Dimension	Coding	Sentence	Explanation
Location	Impr	'I eventually ran into three Port Authority Police Officers and they brought me over to the college.'	College was not a planned-for location
Equipment	Conv	'I grabbed my flashlight and turned it on.'	Flashlight is one of the standard pieces of police equipment
Status	Conv	'While in Tower 2 I was escorting more people out of the building . . .'	No evidence to suggest that a higher or lower status has been taken on
Procedure	Conv	'I went back inside Tower I and started helping people out of the elevators . . .'	Assisting with evacuation is within the repertoire of police personnel

procedure, and location by stating whether that dimension had been performed conventionally or in an improvised way, according to the definitions given previously. A value of 'missing' was assigned to when there was insufficient information to assess a behavioural dimension.

A number of measures were undertaken to ensure the validity of this coding approach (Carley, 1990, 1997). Coders worked independently to identify and classify each cognitive and behavioural event, with each coder working with one and only one coding scheme. A coder was first individually trained to use the coding scheme on a subset of the documents not included in the present results. Training continued until the coders' results agreed with those of the lead coder (i.e., one of the main authors). Once training was completed, each coder coded a randomly selected subset of all documents (order of presentation was also randomized). An approximate 10% overlap in documents was employed in order to assess intercoder reliability, with the threshold of agreement being 90% (Landis & Koch, 1977). This procedure yielded one set of cognitive events and one set of behavioural events for each respondent. Examples of cognitive events from the narratives are given in Table 1. Examples of behaviour dimensions from the narratives are given in Table 2, along with an indication of whether the dimension was improvised or performed conventionally.

5. Results and discussion

The research propositions described previously are here addressed via statistical analysis of the pattern of cognitive and behavioural events associated with respondents. Table 3 provides a summary of cognitive events. As may be seen in the table, for both OKC and WTC, observation (e.g., 51.79% for OKC) and experimentation occurred with greatest frequency, hypothesis, and goal orienting far less so.

Table 4 provides a summary of behavioural events. The extent to which a single respondent's improvised *overall* may be understood by computing the

Table 3. Mean Rates of Cognitive Events

Disaster	Measure	Hypothesis	Observation	Goal
Oklahoma City	Mean	.087	.845	.068
$n = 6$	SD	.040	.069	.064
World Trade Center	Mean	.069	.860	.070
$n = 26$	SD	.048	.079	.053

Table 4. Mean Rates of Improvisation for Oklahoma City and World Trade Center

Disaster	Measure	Overall	Procedure	Status	Equipment	Location..
Oklahoma City	Mean	.102	.249	.027	.111	.019
$n = 6$	SD	.071	.160	.055	.090	.023
World Trade Center	Mean	.131	.361	.026	.038	.101
$n = 26$	SD	.067	.210	.045	.043	.086

percentage of all the observed dimensions of all of the respondent's behaviours which were improvised. Similarly, and again considering all behaviours reported by a given respondent, it is also possible to examine the extent of improvisation along any one of the four behavioural *dimensions*. As shown in Table 4, *overall* level of improvisation for OKC and WTC respectively are 10.2% and 13.1%. Both figures are due primarily to the preponderance of improvisation along the procedural dimension (i.e., 24.9% for OKC and 36.1% for WTC).

Preliminary analysis of the data indicates that the empirical distributions of the percentage measures in Tables 1 and 2 do not approximate the normal distribution, and neither do reasonable transformations of those measures. Accordingly, the non-parametric Wilcoxon signed rank test (Conover, 1999) is used for statistical hypothesis testing, with significance level set to .05. [It should be noted that the use of non-parametric tests is also appropriate given the smaller sample sizes employed here (Conover, 1999).] Results of the analyses are as follows:

C1. Consistent with C1, the percentage of observation events exceeded that of goal orienting events for both OKC and WTC ($p < .0001$). These rates are not significantly different across the two events.

B1. Consistent with B1, behavioural dimensions in both OKC and WTC were performed in a conventional manner more often than they were improvised ($p < .0001$ for both events). These rates are not significantly different across the two events.

B2. Consistent with B2, non-material improvisations occurred more frequently than material ones ($p = .0351$ for OKC, $p < .0001$ for WTC). It should be emphasized that the difference between non-material and material improvisation is due almost entirely to the rate of procedural improvisation. These rates are not significantly different across the two events.

B3. Consistent with B3, procedural improvisations were more common than status improvisations ($p = .0095$ for OKC; $p < .0001$ for WTC). These rates are not significantly different across the two events.

For both the OKC and WTC disasters, the above analysis suggests the salience of cognitive processes tied to recognition (Klein, 1993) (as opposed to goal setting), and the prevalence of conventional over improvised behaviours. For improvised role dimensions, the rate of non-material improvisation exceeds that of material improvisation, with procedural improvisations occurring more frequently than status improvisations. While these results are consistent in direction with prior work (Webb, 2004), the percentage of conventional behavioural dimensions is higher than those suggested by previous reports. This may in part be due to the fact that these prior studies considered both established and emergent groups, and that the latter group type may reasonably be expected to exhibit higher degrees of improvised behaviour, a point discussed more fully in the following paragraphs.

The analysis presented thus far offers insights into cognitive and behavioural processes considered on their own terms. The second stage of the analysis considers the extent to which patterns of behavioural improvisation vary with differences in cognitive processes. Using a split-analysis approach, response personnel are divided according to the degree to which they improvised (i.e., more vs. less). All possible relationships between cognitive and behavioural events are then examined in order to identify any notable or significant differences in cognitive-level processes between relatively higher vs. lower improvisers. The maximum p-value reported is .10.

Data for each event are split in order to compare the approximate top and bottom quartiles of improvisers. Summary statistics on these two groups are given in Table 5, which shows mean and standard deviation for

Table 5. Summary Statistics for Low and High Improvisers

	OKC-L	OKC-L	OKC-H	OKC-H	WTC-L	WTC-L	WTC-H	WTC-H
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Improvisation	.0253	.0358	.1746	.0423	.0546	.0201	.2194	.0206
Cognition								
Hyp	.0926	.0105	.1061	.0756	.0568	.0258	.1057	.0593
Obs	.8908	.0341	.7589	.0061	.8586	.1047	.8329	.0950
Goal	.0167	.0236	.1351	.0695	.0845	.0830	.0614	.0509
Behaviour								
Proc	.0750	.1061	.3983	.0795	.1429	.0566	.5837	.1574
Stat	.0000	.0000	.0682	.0964	.0148	.0391	.0587	.0650
Equip	.0250	.0354	.2189	.0118	.0190	.0253	.0682	.0489
Loc	.0000	.0000	.0132	.0186	.0419	.0499	.1675	.0596

Equip, equipment; H, high; Hyp, hypothesis; L, low; Loc, location; Obs, observation; OKC, Oklahoma City; Proc, procedure; SD, standard deviation; Stat, status; WTC, World Trade Center.

Table 6. Correlation Results

Event	Low	High
World Trade Center	Observing and procedural (.6786; $p = .0938$)	Hypothesizing and procedural (–.7143; $p = .0713$) Observing and procedural (.0713; $p = .0713$) Observing and equipment (–.7500; $p = .0522$)

(1) proportion of all behavioural dimensions that were improvised, (2) proportion of different cognitive events, (3) proportion of individual behavioural dimensions that were improvised, for low (*-L*) and high (*-H*) improvisers in OKC and WTC.

A correlation analysis may then be used to investigate the degree of association between cognitive and behavioural events (only data from WTC are analysed because of sample size considerations). The results, summarized in Table 6, offer further support for the role of observational processes both in more conventional and in more improvised response behaviour. Moreover, when the level of improvisation is higher, cognition (as reflected in the events of hypothesizing and observing) is more strongly tied to behaviour, particular along the procedural and equipment dimensions. In a conclusion that bears exploration in future work, two negative relationships are present (hypothesizing/procedural and observing/equipment).

These results underscore and extend the reflection by Klahr et al. (1999): 'If we press the boundaries of creativity, the main difference we see from more mundane examples of problem solving is that the problems become less well structured, recognition becomes less powerful in evoking prelearned solutions or powerful domain-specific search heuristics, and more, not less, reliance has to be placed on weak methods'.

6. Conclusions

The theme of improvisation – creative and timely behaviour, organized for a purpose – threads through the literature on organized response to disaster. This study provides a view into the cognitive processes that underlie the behaviour of response personnel in the post-disaster environment, suggesting the prominence of conventional behaviour coupled with cognitive processes closely tied to observation, thus further contributing to ongoing work on the relevance of naturalistic decision-making to studies of emergency response behaviour (Groenendaal et al., 2013). When improvisation does occur, it is predominantly with respect to behaviours tied to processes as opposed to material (i.e., procedural and status vs. location and equipment). But the results also show the salience of explicit cognition – processes of observing and hypothesizing – when behaviour is improvised. The observed significant correlations suggest a possibly fruitful line of research in investigating differences in cognitive strategies across low and high improvisers.

Three other opportunities for future research are suggested by these results. First is the development of frameworks for comparing disasters according to the demands they place on response personnel (Tierney, 2007). This approach would, in theory, inform a more systematic approach to comparing respondent behaviour across disasters – a limitation of the current study. Second, potentially broader area of research would uncover the cognitive processes that underlie how emergency response organizations develop (or fail to develop) the capacity to enact and learn from improvised decisions (Aase & Tjensvoll, 2003; Miner, Bassoff, & Moorman, 2001; Vera & Crossan, 2005). The third recommendation follows from the insights of this

research into the cognitive foundations of routine and improvised behaviours. A natural extension of this work is examining how (and under what conditions) analytic vs. recognition-primed modes of decision-making become operative, and what guidance may be provided to support an appropriate balance between the two.

In the years since both the Oklahoma City and WTC disasters, opportunities for capturing data on respondent behaviour (and, to some extent, cognition) have vastly improved. For example, sensors (ranging from biometric to positional) are far more common, and logs of communication are far more complete. Accordingly, there may be opportunities for adapting methods derived from this research for use with these data, thus reducing some of the threats to internal validity discussed previously. And while these data remain sensitive and difficult to obtain, access may improve in the future.

One implication of this study for the practice of emergency management is the relatively untapped potential of structured analysis of after-action narratives for informing process-level explanations of how organizations deal with disasters. The after-action narratives analysed here suggest the potential of a structured approach to understanding large-scale response to disaster. When methods for compiling and analysing after-action reports are *ad hoc*, it is difficult to compare results within or across organizations over time or across events. Together with other recent studies (e.g., Patrick, James, & Ahmed, 2006), this study offers further contributions to discussions over how systematic observational methods (Weick, 1985) can be employed to inform after-action reporting.

As Kreps (1985, 1989) points out, disasters are strategic sites for answering basic questions about social structure. In particular, they reveal the complementarity of both social action and social order or – stated differently – of both social structure and human agency. For the most part, prior studies of organized response to disaster have devoted more attention to the structural component and less attention to human agency and individual cognition. This study therefore provides a degree of continuity and complementarity with prior research by explicitly linking cognitive processes to the performance of disaster roles. The result is a deeper understanding of the role of human agency in organizational responses to disaster.

References

Aase, K. and Tjensvoll, T. (2003), 'Learning in Emergency Organisations: Trial Without Error', *International Journal of Emergency Management*, Volume 1, pp. 410–422.

Antonsen, S. (2009), 'Safety Culture Assessment: A Mission Impossible?', *Journal of Contingencies and Crisis Management*, Volume 17, pp. 242–254.

Bigley, G.A. and Roberts, K.H. (2001), 'The Incident Command System: High-Reliability Organizing for Complex and Volatile Task Environments', *Academy of Management Journal*, Volume 44, pp. 1281–1299.

Brehmer, B. (1992), 'Dynamic Decision Making: Human Control of Complex Systems', *Acta Psychologica*, Volume 81, pp. 211–241.

Carley, K. (1990), 'Content Analysis', in Asher, R. E. and Simpson, J. M. Y. (eds), *Encyclopedia of Language and Linguistics*, Pergamon Press, Edinburgh, pp. 725–730.

Carley, K. (1997), 'Extracting Team Mental Models through Textual Analysis', *Journal of Organizational Behavior*, Volume 18, pp. 533–558.

Conover, W.J. (1999), *Practical Nonparametric Statistics*, John Wiley & Sons, Inc, New York.

Drabek, T. (1985), 'Managing the Emergency Response', *Public Administration Review*, Volume 45, pp. 85–92.

Dynes, R.R. and Quarantelli, E.L. 1977. Organizational Communications and Decision Making in Crises. Report Series Rep. 17, Disaster Research Center, University of Delaware, Columbus, OH.

Feldman, M. and Pentland, B. (2003), 'Reconceptualizing Organizational Routines as a Source of Flexibility and Change', *Administrative Science Quarterly*, Volume 48, pp. 94–121.

Gonzalez, C. (2004), 'Learning to Make Decisions in Dynamic Environments: Effects of Time Constraints and Cognitive Abilities', *Human Factors*, Volume 46, pp. 449–460.

Gray, R.M. and Neuhoff, D.L. (1998), 'Quantization', *IEEE Transactions on Information Theory*, Volume IT-44, pp. 2325–2383.

Groenendaal, J., Helsloot, I. and Scholtens, A. (2013), 'A Critical Examination of the Assumptions Regarding Centralized Coordination in Large-Scale Emergency Situations', *Journal of Homeland Security and Emergency Management*, Volume 10, pp. 113–135.

Grote, G., Weichbrodt, J.C., Günter, H., Zala-Mezö, E. and Künzle, B. (2009), 'Coordination in High-Risk Organizations: The Need for Flexible Routines', *Cognition, Technology and Work*, Volume 11, pp. 17–27.

Harrald, J., Marcus, H. and Wallace, W.A. (1990), 'The Exxon Valdez: An Assessment of Crisis Prevention and Management Systems', *Interfaces*, Volume 25, pp. 14–30.

Harrald, J., Cohn, R. and Wallace, W.A. (1992), 'We Are Always Reorganizing . . . Some Crisis Management Implications of the *Exxon Valdez* Oil Spill', *Industrial Crisis Quarterly*, Volume 6, pp. 197–217.

Hutchins, E. (1991), 'Organizing Work by Adaptation', *Organization Science*, Volume 2, pp. 14–39.

Kean, T. and Hamilton, L. (2004), *Final Report of the National Commission on Terrorist Attacks Upon the United States*, US Government Printing Office, Washington, DC.

Klahr, D. and Dunbar, K. (1988), 'Dual Space Search During Scientific Reasoning', *Cognitive Science*, Volume 12, pp. 1–48.

Klahr, D. and Simon, H.A. (1999), 'Studies of Scientific Discovery: Complementary Approaches and Convergent Findings', *Psychological Bulletin*, Volume 125, pp. 524–543.

Klein, G.A. (1993), 'A Recognition-Primed Decision (RPD) Model of Rapid Decision Making', in Klein, G. A., Orasanu, J., Calderwood, R. and Zsambok, C. E. (eds), *Decision Making in Action: Models and Methods*, Ablex Publishing Corp, Norwood, NJ, pp. 138–147.

Klein, G.A., Orasnu, J., Calderwood, R. and Zsambok, C.E. (1993), *Decision Making in Action: Models and Methods*, Ablex Publishing Corp, Norwood, NJ.

Kreps, G. (1995), 'Disaster as Systemic Event and Social Catalyst: A Clarification of Subject Matter', *International Journal of Mass Emergencies and Disasters*, Volume 13, pp. 255–284.

Kreps, G.A. (1984), 'Sociological Inquiry and Disaster Research', *Annual Review of Sociology*, Volume 10, pp. 309–330.

Kreps, G.A. (1985), 'Disaster and the Social Order', *Sociological Theory*, Volume 3, pp. 49–64.

Kreps, G.A. (ed.) (1989), *Social Structure and Disaster*, University of Delaware Press, Newark, DE.

Kreps, G.A. (1991), 'Organizing for Emergency Management', in Drabek, T. E. and Hoetmer, G. J. (eds), *Emergency Management: Principles and Practice for Local Governments*, International City Management Association, Washington, DC, pp. 30–54.

Kreps, G.A. and Bosworth, S.L. (1993), 'Disaster, Organizing and Role Enactment: A Structural Approach', *The American Journal of Sociology*, Volume 99, pp. 428–463.

Krippendorff, K. (2012), *Content Analysis: An Introduction to its Methodology*, Sage, Thousand Oaks, CA.

Landis, J.R. and Koch, G.G. (1977), 'The Measurement of Observer Agreement for Categorical Data', *Biometrics*, Volume 33, pp. 159–174.

Lipshitz, R., Klein, G., Orasanu, J. and Salas, E. (2001), 'Taking Stock of Naturalistic Decision Making', *Journal of Behavioral Decision Making*, Volume 14, pp. 331–352.

Mendonça, D. and Wallace, W.A. (2004), 'Studying Organizationally-Situated Improvisation in Response to Extreme Events', *International Journal of Mass Emergencies and Disasters*, Volume 22, pp. 5–29.

Mendonça, D. and Wallace, W.A. (2007), 'A Cognitive Model of Improvisation in Emergency Management', *IEEE Transactions on Systems, Man, and Cybernetics, Part A*, Volume 37, pp. 547–561.

Miner, A., Bassoff, P. and Moorman, C. (2001), 'Organizational Improvisation and Learning: A Field Study', *Administrative Science Quarterly*, Volume 46, pp. 304–337.

National Institute of Standards and Technology. 2005. Federal Building and Fire Safety Investigation of the World Trade Center Disaster, Washington, DC.

Njå, O. and Rake, E.L. (2008), 'An Essay on Research Methodology: An Alternative Approach to Incident Command Research Through Participatory Action Research', *Journal of Contingencies and Crisis Management*, Volume 16, pp. 91–100.

Okada, T. and Simon, H.A. (1997), 'Collaborative Discovery in a Scientific Domain', *Cognitive Science*, Volume 21, pp. 109–146.

Patrick, J., James, N. and Ahmed, A. (2006), 'Human Processes of Control: Tracing the Goals and Strategies of Control Room Teams', *Ergonomics*, Volume 49, pp. 1395–1414.

Pentland, B. and Rueter, H. (1994), 'Organizational Routines as Grammars of Action', *Administrative Science Quarterly*, Volume 39, pp. 484–510.

Perrow, C. (1984), *Normal Accidents: Living with High Risk Technologies*, Basic Books, New York, NY.

Perry, R. (1991), 'Managing Disaster Response Operations', in Drabek, T. and Hoetmer, G. (eds), *Emergency Management: Principles and Practice for Local Government*, International City Management Association, Washington, DC, pp. 201–224.

Pickett, J.P. (2000), *The American Heritage® Dictionary of the English Language*, Houghton Mifflin Co, Boston.

Pina e Cunha, M., Vieira da Cunha, J. and Kamoche, K. (1999), 'Organizational Improvisation: What, When, How and Why', *International Journal of Management Reviews*, Volume 1, pp. 299–341.

Quarantelli, E.L. (1978), *Uses and Problems of Local EOCs in Disasters*, Disaster Research Center, Newark, DE.

Quarantelli, E.L. (1997), 'The Disaster Research Center Field Studies of Organizational Behavior in the Crisis Time Period of Disasters', *International Journal of Mass Emergencies and Disasters*, Volume 15, pp. 47–69.

Quarantelli, E.L. and Dynes, R.R. (1977), 'Response to Social Crisis and Disaster', *Annual Review of Sociology*, Volume 3, pp. 23–49.

Rosmuller, N. and Ale, B.J.M. (2008), 'Classification of Fatal Firefighter Accidents in The Netherlands: Time Pressure and Aim of the Suppression Activity', *Safety Science*, Volume 46, pp. 282–290.

Roux-Dufort, C. (2003), 'The Difficulties of Improvising in a Crisis Situation – A Case Study', *International Studies of Management and Organization*, Volume 33, pp. 86–115.

Scanlon, J. (1994), 'The Role of EOCs in Emergency Management: A Comparison of American and Canadian Experience', *International Journal of Mass Emergencies and Disasters*, Volume 12, pp. 51–75.

Stallings, R.A. (ed.) (2002), *Methods of Disaster Research*, Xlibris Corporation, Philadelphia, PA.

The City of Oklahoma City Document Management Team (1996), *Alfred P. Murrah Federal Building Bombing, April 19, 1995*, Fire Protection Publications, Stillwater, OK.

Tierney, K.J. (2007), 'From the Margins to the Mainstream? Disaster Research at the Crossroads', *Annual Review of Sociology*, Volume 33, pp. 503–525.

Turner, B.A. (1995), 'The Role of Flexibility and Improvisation in Emergency Response', in Horlick-Jones, T., Amendola, A. and Casale, R. (eds), *Natural Risk and Civil Protection*, E.&F. Spon, London, pp. 463–475.

Vera, D. and Crossan, M. (2005), 'Improvisation and Innovative Performance in Teams', *Organization Science*, Volume 16, pp. 203–224.

Vidaillet, B. (2001), 'Cognitive Processes and Decision Making in a Crisis Situation: A Case Study', in Lant, T. K. and Shapira, Z. (eds), *Organizational Cognition: Computation and Interpretation*, Lawrence Erlbaum Associates, Mahwah, NJ, pp. 241–263.

Wachtendorf, T. (2004), *Improvising 9/11: Organizational Improvisation in the World Trade Center Disaster*, University of Delaware, Newark, DE.

Webb, G.R. (1998), *Role Enactment in Disaster: Reconciling Structuralist and Interactionist Conceptions of Role*, Disaster Research Center, Newark, DE.

Webb, G.R. (2004), 'Role Improvising during Crisis Situations', *International Journal of Emergency Management*, Volume 2, pp. 47–61.

Webb, G.R., Beverly, M., McMichael, M., Noon, J. and Patterson, T. 1998. Role Improvising Under Conditions of Uncertainty: A Classification of Types. Preliminary Paper Rep. 289, University of Delaware, Newark, DE.

Weick, K.E. (1985), 'Systematic Observational Methods', in Lindzey, G. and Aronson, E. (eds), *Handbook of Social Psychology*, Random House, New York, pp. 567–634.

Weick, K.E. (1993), 'The Collapse of Sensemaking in Organizations: The Mann Gulch Disaster', *Administrative Science Quarterly*, Volume 38, pp. 628–652.

Weick, K.E. (1996), 'Drop Your Tools: An Allegory for Organizational Studies', *Administrative Science Quarterly*, Volume 41, pp. 301–313.

Weick, K.E. (1998), 'Improvisation as a Mindset for Organizational Analysis', *Organization Science*, Volume 9, pp. 543–555.

Weick, K.E. and Roberts, K.H. (1993), 'Collective Mind in Organizations: Heedful Interrelating on Flight Decks', *Administrative Science Quarterly*, Volume 38, pp. 357–381.