A Ghost in the System: Integrating Conceptual and Methodology Considerations from the Behavioral Sciences into Disaster Technology Research

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ABSTRACT

As the complexity of disasters increases, a transdisciplinary conceptual framework designed to address three key variables – technology, disaster severity, and human characteristics – must be developed and elaborated. Current research at the nexus of disaster management and information science typically addresses one or two of these factors, but rarely accounts for all three adequately – thus rendering formal inquiry open to a variety of threats to validity. Within this tripartite model, several theories of human behavior in disaster are explored using the response of the Federal Government and the general public during Hurricane Katrina as an illustrative background. Lessons learned from practice-based scientific inquiry in the social sciences are discussed to address concerns revolving around measurement and statistical power in disaster studies. Finally, theory building within the transdisciplinary arena of disaster management and information science is encouraged as a way to improve the quality of future research.

Keywords

Transdisciplinary conceptual framework, comparative methods, performance assessment, civil security

INTRODUCTION

The research presented at ISCRAM 2006 called up two countervailing experiences for one of us (ZF) – the first was the joy of being in an interdisciplinary setting that brings together many approaches to both practice and research. The second sensation was scientific skepticism. Although the level of technical expertise at the ISCRAM 2006 event was clear throughout, the overall tenor was nonetheless one of a practitioner conference – with its concomitant strengths in the arts it practices, and weaknesses in the formal research it performs. After attending several of the sessions, a behavioral scientist might be prompted to ask, "What theory or set of theories does this work draw from? How do the results of the study fit into or fault those theories? Where is the discussion of methodology? Why was this group of participants selected? Where are the statistical results?" This is not to say that all presentations were devoid of research, but most appeared to focus more on the development of particular technology solutions rather than formal inquiry. A relatively cursory analysis of the papers presented ($N = 22$) on Day 1 of the ISCRAM 2006 conference reveals the following:

- 68% were single case studies
- 27% reported some form of lessons learned
- 46% had some type of methods section
- 60% did not offer operationalized variables
- Just 27% reported some form of statistics

- There were no randomized trials
- Most participants pools were gathered using convenience sampling
- Typically no information about participant characteristics was provided
- 27% of the studies did not make any generalizability or case-to-case transferability claims
- Just 31% of the studies made comparatively sophisticated generalizability claims
- Where qualitative methods were used, methodological approach and theoretical grounding was not fully explicated [1]

Four things are clear to us about the ISCRAM effort. First, there is a unique opportunity to conduct truly interdisciplinary research in this context, bringing together researchers from the computer sciences, disaster research, disaster management, and social and behavioral sciences. Second, the field of technology supported disaster management research (TSDM) is still in its infancy, and lacks a coherent set of conceptual and measurement approaches. Third, the failure of research in the TSDM field to systematically account for factors (beyond the target technology) that influence performance leaves findings open to a variety of threats to validity. And finally, failing to place studies within a conceptual framework impedes theory building.

A number of disciplines struggle with the difficulties of balancing practice and craft on one hand, and the desire to perform formal research on the other, and the evolution of a more robust approach to inquiry in TSDM can be informed by this history. Our expertise is in clinical psychology – a domain that stands squarely at the intersection of science and practice. One of the lessons that this field has learned is that performing high quality, practice driven research requires the dedication not just of single researchers, but involves hard-won improvements in methodology that are the result of generations of investigators examining the inter-related problems of epistemology, instrument development, and performance metrics formulation (see for example: Standards for Educational and Psychological Testing, AERA, APA & NCME 1999, 1966; APA, 1954).

Interestingly, the nexus between the behavioral sciences and TSDM can benefit both disciplines. While the behavioral sciences may not be able to shed light on the ongoing debate about whether or not computer science is actually a “science,” these disciplines can certainly assist technologists make their work more *scientific* within this transdisciplinary setting by helping to improve the breadth of theories and the quality of measurement tools put to use in TSDM research. Further, technologies designed to improve performance in these settings can offer the social sciences observation platforms with greater temporal and geographic proximity to disasters than can otherwise be achieved, thus opening a window to human behavior in these extreme settings.

In order to illustrate some of the insights and concerns that the social sciences can offer to this discussion we attempt to accomplish the following: First, a transdisciplinary model of TSDM is offered and three key contextual variables for TSDM research are proposed. Second, because of the recency of Hurricane Katrina and its power to illustrate aspects of human behavior that are not well accounted for in current TSDM applications, this disaster is used to illuminate potential interactions of the variables specified in the model. Third, as TSDM research is similar to other practice based inquiry, applicable measurement techniques drawn from the behavioral sciences are reviewed. Finally, the relationship between empirical research, theory building, and the generation of new technology-based applications for disaster management support is explored.

DEVELOPING AN TRANSDISCIPLINARY CONCEPTUAL FRAMEWORK

Kurt Lewin, a renowned social psychologist, once asserted, “there is nothing so practical as a good theory.” Good theories are characterized by their ability to parsimoniously account for a wide range of phenomena, with the ability to make fairly specific predictions about the outcome of a given set of circumstances. One way that prediction is

[1] An informal analysis of ISCRAM submissions was conducted. All accepted papers to be presented on Monday, May 15, 2006 were reviewed for the presence or absence of case studies; lessons learned; identifiable methods section; stated variables; reported statistics (descriptive, inferential, or formulae); new technical system descriptions; discussion of a general problem in the absence of a study or new system description; and relative quality of generalizability claims (ranging from: no claim, claim to similar cases, claim to broader cases with little support, or well supported claim to broader applications). The intent of the review was illustrative rather than as a formal study and scores are based on a single reviewer. Further inquiry along these lines should be seek to establish inter-rater reliability and a commonly agreed upon set of variables.

accomplished is through the identification of key variables of interest that serve as organizing principles for an overarching conceptual framework (Davies, 1965). As the assertions of this framework are articulated, experimental evidence accumulates, allowing the conceptual framework to be supported, modified, or abandoned based on the data (Davies, 1965). One of the things that appears to be missing from research in TSDM is a reflective stance that would allow the field to clearly identify the key variables of interest that reflect the complex, transdisciplinary nature of the field.

Because most developers within this community are deeply invested in novel applications of information science to disaster related problems, the extant research focuses on technology as the primary variable of interest. Unfortunately, two other key variables receive much less attention – the disaster itself, and the people involved. Stated more formally, we assert that to avoid threats to validity and clouded causality claims, research in this context must anticipate interaction effects between *at least* three key independent variables: the technology used, the type and scale of the disaster, and the characteristics of the people using or impacted by the technology. Without systematically measuring changes in all three variables, claims that new technologies improve overall disaster management lack an evidentiary foundation.

The first variable, technology, is more than adequately addressed by specialists in this community. Our focus instead lies with the last two variables of interest. We briefly examine the type and scale of disaster as an interacting influence on the behavior of people, before turning to the under-explored area of individual and group behavior in disaster.

Disaster Type & Scale

Disaster research has catalogued a number of classes of disasters, ranging from natural disasters, to incidents caused by accidental human error, to deliberate events such as terrorist attacks (Stallings, 2002). Further, disasters vary in intensity based on geographical and temporal scope. A number of important initial observations about the relative impact of technology vs. human actors can be made simply by examining the issues of disaster type and intensity. For example, the recent experiences with Hurricane Katrina suggest that once the scale of a disaster reaches catastrophic proportions the physical assets, training of first response teams, and technological tools available to manage the event become less important as compared to a relatively finite set of key decisions made by a small group political actors or the mass behaviors of the general public (Macías and Aguirre, 2006). A given technology may perform well in one disaster, but may have no effect or even degrade outcomes in others. Without addressing the disaster context systematically in research, generalizability across disaster types is impaired.

Human Behavior – A Ghost in the System

Game theorists often assume that humans behave rationally, and perhaps because modeling rational behavior is simple, these assumptions permeate other fields, including information science. In contrast, behavioral scientists have long recognized that irrationality (or apparently irrational behavior) is often the rule rather than the exception (Smith, 1991). As a result, many of the tools offered by information technologist to support disaster management suffer fundamental assumptive flaws. First, many will simply not be adopted by potential users (Grudin, 1988); second, if these technical solutions are adopted, they may be used in ways that are driven by non-rational motives and perceptions (Alberts, 1996); third, many tools designed to assist in disasters are disabled by the disaster itself or are unavailable to those in need (GAO, 1993); and finally, many systems focus on disaster managers, excluding others who may be more important to the outcome of extremely catastrophic events (Quarantrelli, 1992; Adjibolosoo, 1995). These oversights deeply limit the applicability of such tools across situations and degrade the external validity of research performed in an effort to demonstrate their utility.

The phrase "there's a ghost in the system" is one way technologists express and contain confusion over systems that do not perform to expectation. Typically, the phrase is applied to computers that are failing for unknown reasons or programs that contain seemingly unidentifiable bugs. However, human systems are also affected by previously unknown sub-routines and patterns of behavior that are only revealed when the social fabric is stressed. In trying to design information systems to support human processes during crisis, these technologies can not fail to take into account that humans – and more particularly, groups of humans – may not perform as they do in test environment.

This paper reflects our skepticism of purely technical solutions without an exploration not only of Human-Computer Interaction (HCI) and Computer Supported Collaborative Work (CSCW), but also *psyche*-computer interaction, social-computer interaction, and cultural-computer interaction. Clearly, some attempts to address social level phenomena within the HCI/CSCW and the disaster management field have taken place (e.g. Ehrlich, 1987; McGinley, Turk and Bennett, 2006). However, as technology solutions for disasters are increasingly being designed to address the needs of populations (e.g. SMS public alerting systems, distributed wireless meshes, etc.) rather than individuals or teams, the need for well designed research that reflects population level dynamics in times of turbulence becomes more acute.

HURRICANE KATRINA & HUMAN FAILURE

In a recent review article, we identified what we call "The Dirty Dozen" or twelve key failures of the Hurricane Katrina response taken from the perspective of psychology (Gheytanchi, Joseph, Kimpara, Gierlach, Housley, Franco, and Beutler, 2007). This examination reinforces the fact that the same fundamental problems occur repeatedly over the history of disasters in the United States. This well worn path includes the following problems:

1. Lack of efficient communication
2. Poorly articulated coordination plans
3. Ambiguous authority relationships
4. Difficulty transferring power between State and Federal government
5. Over investment in counter-terror efforts at the expense of all-hazards preparedness
6. Ambiguous training standards
7. Poor return on Lessons Learned Systems
8. Performance assessment not addressed (preparedness is a poor proxy)
9. Geography of poverty – the impacts of race and SES on response to disaster
10. Rumor and chaos
11. Personal and community preparedness
12. Difficulties delivering appropriate mental health interventions

While not every area listed here may be easily addressed by TSDM approaches (e.g. mental health), most of them can be. At a cultural level, for example: given the history of minority oppression in the South, will SMS public alert messages be viewed with the same level of trust in African American and Anglo communities? If not, can adjustments in the technology be made that specifically address the concerns of African American communities? Any investigation of technical intervention in disasters must be a performance evaluation of a complete socio-technical system.

In this light, our review noted that overall performance in large-scale disaster management may actually be *declining* over time despite tremendous advances in technology that would seem to push the field toward performance improvement (Winchester, 2006). For example, in the aftermath of the San Francisco earthquake in 1906 it took just 153 minutes for federal troops to be placed at the disposal of the Mayor. By 4:00 a.m. the next day (less than 24 hours after the event) a full scale federal response was ordered and hospital trains from all over the nation were deployed to the disaster affected region (Winchester, 2006). The communication technology used to elicit this federal response was not a teleconference, or a satellite phone call. Terse messages requesting help were issued using a very simple technology: the telegraph.

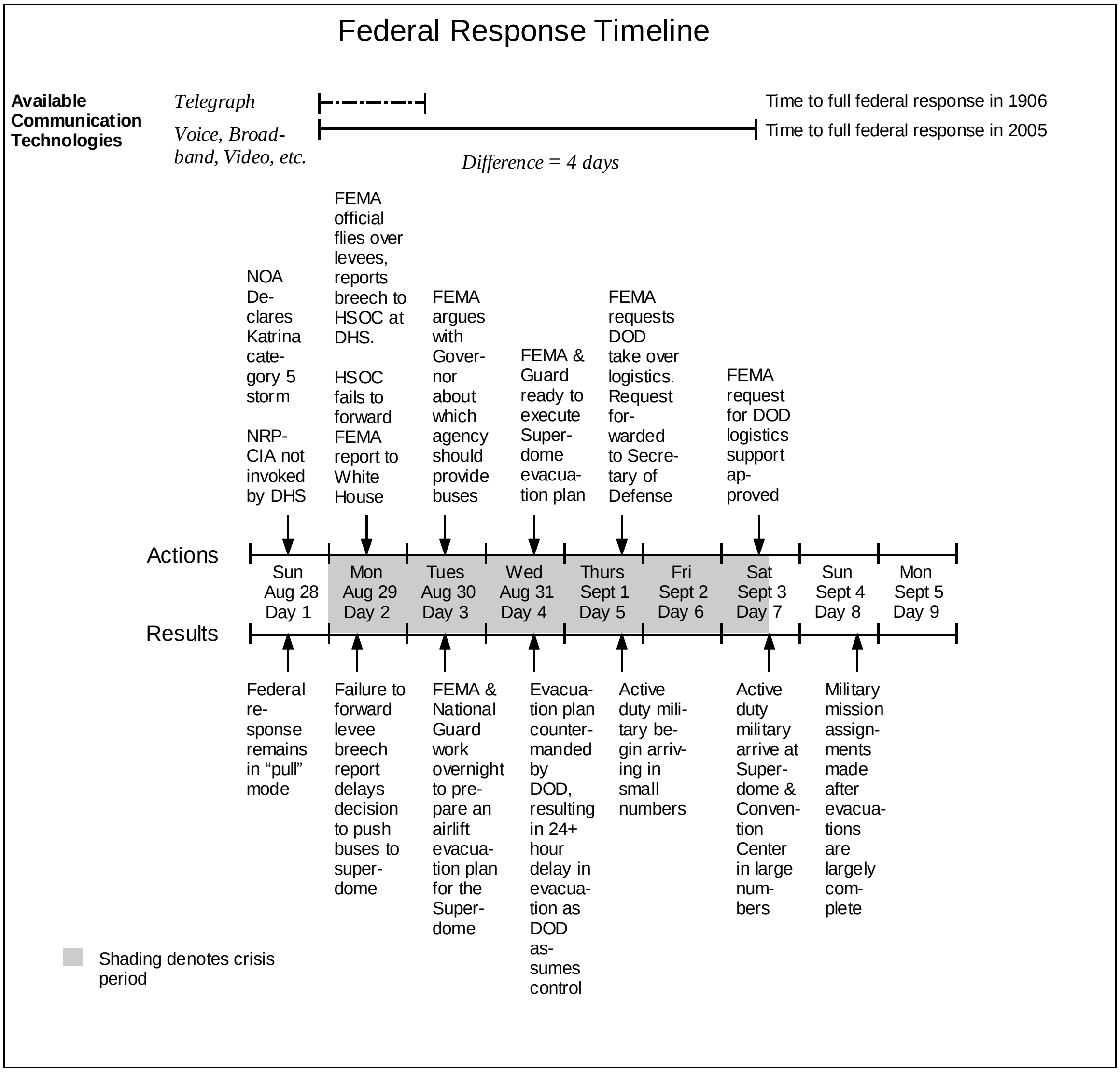

Figure 1. Has Technology Improved Overall Disaster Performance?

Yet a century later, the Hurricane Katrina response was by all accounts an utter failure. Despite the training and expertise of disaster management professionals within the Louisiana State Emergency Operations Center and FEMA's Joint Field Offices, the political whirlwind up the chain of command and the complete loss of social order in the streets of New Orleans deeply impaired overall response and recovery efforts in Hurricane Katrina (Gheytanchi et al., 2007). New communication technologies such as teleconferencing, video conferencing, email, and satellite phones may have improved performance at some levels during Hurricane Katrina, but they certainly were not enough to prevent catastrophic errors from occurring.

The challenge for the ISCRAM community is to begin conceptualizing and building technologies that directly address the problems encountered in the translation of information across the political/operational membrane and to design tools that speak to the needs of the general public during major catastrophes.

SOCIAL THEORIES OF BEHAVIOR – MOVING BEYOND COGNITION AND PERCEPTION

To accomplish this task, TSDM researchers must be aware of the complexity of human behavior, and they must borrow from a wide range of conceptual/theoretical and empirical findings in psychology, sociology, anthropology, and political science. While theories of cognition and perception are well represented in HCI and CSCW applications, it is becoming increasingly important to identify other theories that inform this work as the frame of inquiry moves to address system-wide, national level problems. We attempt here to offer a *few* exemplars of the types of behavioral principles that are applied by psychology and sociology to understand how humans actually respond to large-scale catastrophe.

Psychodynamic Government Dependency Model

Lloyd Etheredge's (1977) psychodynamic government dependency model predicts with striking accuracy what happened in the aftermath of Hurricane Katrina: Mayor Ray Nagin's contradictory demands for more federal involvement combined with bitterness toward potential federal interference and control; Governor Blanco's quixotic insistence that more federal action was needed, which she also blocked by not formalizing her requests; and progressive demoralization and fury from a civilian population toward the federal government – met with equal disbelief and anger from federal officials – ultimately leading to stalemate and unnecessary civilian deaths, trauma, and unrest (for a discussion of psychoanalytic theory application to governance see for example: Gerson, 2004; Thomas, 1979). If further validated, the theory may help us understand some of the failures that occurred during the Katrina rescue effort.

Political Psychology

In examining rapidly formed *ad hoc* disaster management teams at high levels of government, political and social psychology can be particularly instructive. A disaster provides a powerful superordinate goal (Sherif, 1958) for the individuals charged with its mitigation. Yet, it is clear that the political interests of disaster managers' parent agencies and other influences often conflict with optimal disaster response (Pearson and Clair, 1998). The question of why some managers are more concerned about the maintaining the image of their agency, while others "defect" to embrace the extra-agency goals of an ephemeral disaster response coalition can offer important insight for those modeling the performance of these teams. For example, during Hurricane Katrina there were instances in which FEMA Federal Coordinating Officers (FCOs) acted beyond their statutory authority to correct the drifting course of the recovery effort (US House of Representatives, 2006). In such instances, some FCOs committed to the superordinate goal of recovery, despite the potential for personal or agency costs

Narrative Psychology

Problems associated with authority transfer in government response to disaster illuminate an important intersection between political and narrative psychology. It has been suggested some of the apparent ineptitude in evidence at the state level in hurricanes Andrew and Katrina reflect a long standing resentment of the federal government in the South (US House of Representatives, 2006). These feelings of resentment may have impacted governors' willingness to formally request federal assistance, resulting in substantial response delays. Cultural narrative and personal sense of identity may profoundly impact a leader's sense making of a disaster. This internal narrative may serve to widen or restrict the field of options the leader views as viable (Ross, 2003; Shamir and Sagiv-Schifter, 2006).

Sociological Views of Disaster Management – Comparative Strategies

Taking a broader view of human view of human behavior and how disasters are managed, it is clear that not all countries settled on an approach like the Incident Command System (ICS) which serves as the US standard operating procedure for disaster response (Dynes, 2000). For example, Cuba, which experienced six major hurricanes in the seven years between 1996 and 2002 suffered just 16 deaths, but does not use the ICS model (Thompson and Gaviria, 2004). In contrast, Hurricane Katrina, caused about 1,800 US deaths (LDHH, 2006; New Orleans Times-Picayune, 2006). No empirical evidence exists to suggest that ICS the *best* system for managing all types of disasters (Buck, Trainor and Aguirre, 2006) and some theorists have argued that a spectrum of approaches ranging from rigid command structures to improvisational techniques may be necessary to address large catastrophic events (Mendonça and Wallace, 2004).

MEASUREMENT, META-ANALYSIS, AND THEORY BUILDING

If we seek, for example, to test the hypothesis that high level *ad hoc* governance teams and the general public have tremendous impact on disaster management outcomes as disaster scale increases *and* that certain technologies can successfully be applied to assist in these situations, then systematic inquiry is needed. Unfortunately, studies seeking to address external validity and generalizability concerns by using of actual actors rather than larger groups of proxy participants (e.g. students subject pools, etc.) are difficult and expensive to perform, and inevitably suffer because of small sample size and low statistical power – the Achilles heel of disaster research (Mendonça, 2003). These difficulties can be met by creating standard metrics that support a discipline wide effort to conduct meta-analytic research.

Performance Assessment & Measurement Strategies

To date, most of benchmarking efforts have involved the assessment of disaster planning and readiness (EMAP, 2004; Caudle, 2005). However, none of these approaches measures *actual* performance in disasters, which profoundly limits our ability to accurately examine specific disasters and to conduct longitudinal performance research (Franco et al, 2005). In contrast to evaluating planned actions, performance assessment tests the ability to integrate content knowledge, skills, and problem solving approaches into a coherent set of behaviors in response to a complex task in a real or realistic setting – the apex of the Miller pyramid of competence (Wass, Van der Vleuten, Shatzer, and Jones, 2001). As a starting point, a number of performance assessment benchmarking systems drawn from a variety of sources (military, international coalition, physician training, and flight crew performance metrics) can be applied to disaster management (for a detailed discussion, see Franco et al, 2005). We also argue that adaptive civilian performance is necessary in the public sphere for optimal overall response and recovery. It follows that the development of population level performance measures is fundamental to evaluating overall disaster response performance (for a more detailed discussion see for example, Raphael, 2005; Weisath, 1989).

Anticipating the Importance of Meta-analytics

Once a set of standard context and outcome variables is established, the problems of limited power can be addressed. Meta-analytic and longitudinal approaches may be used to compare across numerous small studies involving inter-agency *ad hoc* disaster management groups, and also to compare disaster management performance across time at the national and transnational levels (Franco et al., 2005). By applying some of the hard-won recommendations from medical and epidemiological meta-analysis consensus statements early on in TSDM, the work can proceed more smoothly. At the most fundamental level, performing meta-analytical research requires that a large body of researchers consistently report means, standard deviations, and effect sizes *(*Cohen's *d)* whenever possible [and *(r)* when it is not] for each study that is published – it should be the responsibility of both authors and editors to meet this standard (Beutler and Martin, 1999).

Beyond this, assumptive considerations and biases common to meta-analytic inquiry must be addressed. Publication bias makes it more likely for meta-analyses to demonstrate significant effects where they do not exist (Conn, 1997; Moher, Cook, Eastwood, Olkin, Rennie, and Stroup, 1999). Further, meta-analysis is often stymied by the irretrievability of individual level data (Conn, 1997). The medical field addressed some of these problems through consensus statements; methodology and reporting checklists (see the QUOROM consensus statement, http://www.consort-statement.org/QUOROM.pdf); and trial registers that serve as data archives for both published and unpublished studies (Moher et al. 1999).

THE IMPORTANCE OF THEORY BUILDING

One of the ideas that we have advanced throughout this paper is that theory building is important to the development of well constructed TSDM research. We have argued that the identification of key variables assists in more accurately describing the phenomena encountered in the problem space. An increased effort to explicate the "nomological network" (Cronbach & Meehl, 1955) that defines the problem space of TSDM would serve several purposes, including: encouraging developers to search for explanations that transcend their target technology; refining the nomological network to add to or reduce the number of variables needed to predict outcome; and finally, articulation of the nomological network should encourage the conception of new information systems applications.

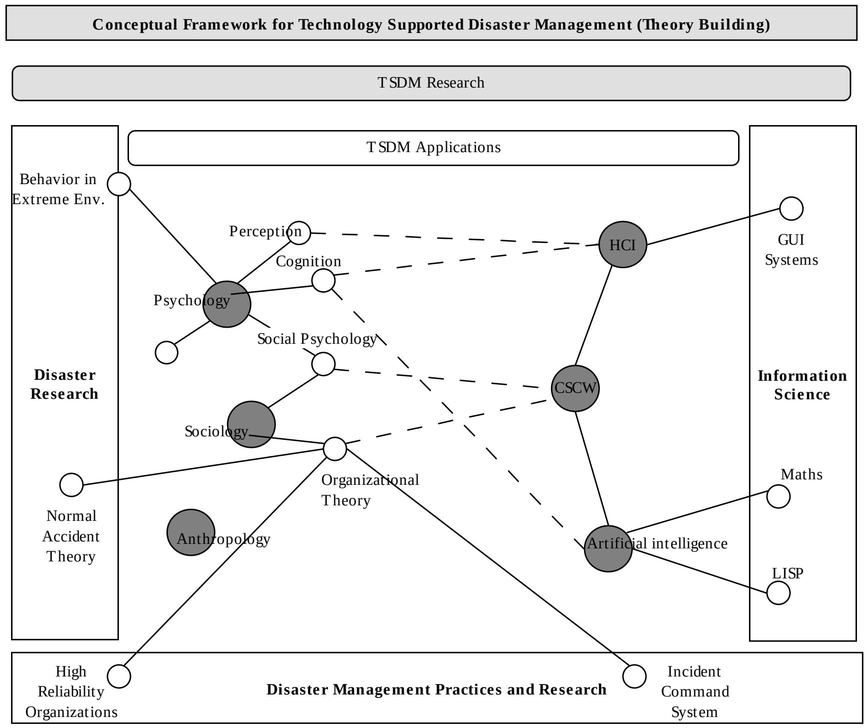

Figure 2. An Elementary TSDM Nomological Structure

We have attempted here to begin the process of strengthening the relevance of constructs from the behavioral sciences within the overall TSDM problem space by presenting some explanations of human behavior that we suspect may govern outcome in ways not fully anticipated by technologists. However, our goal is not simply to critique information science as it is applied to TSDM, but also to open doors for the development of new sociotechnical systems that address these broad concerns.

For example, if the government dependency model is operant in disaster situations, what technologies can be developed that directly strengthen the lines of communication between the federal government and affected communities? Is it possible to develop systems that assist communities fit better into the Incident Command System by helping community leaders to rapidly assess a neighborhood's needs and transmit this information in a format that is interoperable with the terminology used by a response agency? Can information systems be developed that help politicians identify situations in which the general public may loose trust in the government and present alternative courses of action? And if a technology is susceptible to power failure in a disaster, can that technology teach its users what to do if the device becomes unavailable in the midst of a catastrophe?

Ultimately, if research and development at this nexus can not demonstrate a relationship between improved *overall* disaster performance and the adoption of information technology (after controlling for other factors), the current level of investment in technology tools is called into question. While it is a tall order to relate the performance of an individual technology with overall disaster response and recovery, careful identification of the variables of interest, performance assessment benchmarks, the early adoption of appropriate research methodologies, and the development of a coherent conceptual framework for TSDM research will assist in this ongoing process.

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