Analysing Ambulance Dispatcher Decision Making: Trialing Emergent Themes Analysis

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Abstract

Understanding how people make decisions in actual, real-time operational environments can provide software developers with useful insights into how systems should be designed to support them. However, part of the difficulty is developing that understanding. In this paper we describe a case study of how Critical Decision Method interview data was analysed using the Emergent Themes Analysis Approach we trialed to identify themes and subsequently decision strategies for extracting design insights.

1. Introduction

Understanding complex work settings is demanding: there is a need to gather appropriately rich data on the work and to apply rigorous qualitative analysis techniques. Established techniques such as ethnography (e.g. Martin *et al,* 1997) and Grounded Theory (Strauss & Corbin, 1990) yield important insights, but are time-consuming and therefore expensive to apply. In the work reported here, we applied a qualitative technique, the Critical Decision Method (CDM), as the method for investigating the nature of decision making in the complex socio-technical domain of emergency ambulance dispatch. We then trialed a data analysis technique we have called the Emergent Themes Analysis (ETA) approach with the aim of increasing the data analysis yield, i.e. more insights for the same or less effort. The ETA approach is based on Grounded Theory but tailored to take advantage of the exploratory and efficient data collection features of the CDM. In this paper, we will describe the analytical procedure we adopted when we applied the ETA approach to analyse CDM interview data from a study of emergency ambulance dispatchers.

The kinds of questions being addressed are as follows. How do emergency ambulance dispatchers make resource allocation decisions? What strategies do they use when making such decisions? What information do they attend to and how do they consider and use the information? What knowledge do they bring to bear on the decision problem? What difficulties do they experience? A better understanding of these issues can lead to design of systems that are supportive of decision making in such areas, and will contribute towards the development of alternative future systems.

The CDM (Hoffman et al., 1998; Klein et al., 1989) is a retrospective cognitive task analysis technique that delivers very efficient data collection. CDM interviews are open-ended and exploratory yet focussed by only addressing specific incidents that the interviewee had experienced. This specificity leads to greater efficiencies in data collection than, say, observational ethnographic methods (Martin et al., 1997; Mumaw et al., 2000). It also focuses on data pertaining to times when work is likely to be at its most demanding, which are times for which the effectiveness of technology support can be most critical. CDM interviewees are asked to think back to a memorable incident they have experienced in the course of their duties. They are then systematically probed about the decisions they made during the incident. CDM then uses

the Recognition-Primed Decision model (Klein, 1997) to guide the data analysis. As with most qualitative research methods, the CDM also suffers from having to analyse a large volume of interview data, eg a one-hour CDM interview can result in a transcript of about 15,000 words, so analysing data across many interviews can take substantial time and effort. If the data analysis process can be expedited while still maintaining rigour and validity, the yield – an estimate of the number of useful constructs identified per unit of effort – can be increased. The ETA approach trialed in this study uses a concept distillation process to systematically identify broad themes initially and then specific themes within them. The process of identifying these themes was guided by the Integrated Decision Model (Wong, 2000) that describes the key features of naturalistic decision making (NDM). The distillation process must be careful not to constrain the emergence of insightful themes. This emergence of themes can be suppressed if strict *a priori* classification categories are used. Once the specific themes have emerged, the data is then categorised and summarised. Qualitative analysis software tools such as NUDIST can be used at this stage to index and collate related parts of the transcripts. This however will not be discussed here. Explanatory descriptions of the nature of the decision strategies used by the dispatchers are then prepared and can then be used to inform any subsequent design processes. The next section will provide a context for this research by describing the nature of work in emergency ambulance control and will be followed by a brief review of NDM which provides the theoretical focus of the work. The rest of the paper will discuss how the ETA approach was used to systematically explore the CDM interview data.

2. Emergency Ambulance Control

This study was conducted at the emergency ambulance control centre of a large European city. The ambulance control centre receives about 3200 emergency calls a day and directs a fleet of more than 400 emergency ambulances in response to these calls. The ambulance control centre is based in a large room, divided into two areas. The first area is the call-taking area where all emergency calls are received and logged directly into the computer system by up to 20 specially-trained call-takers. The second area is the dispatch control area which is organised into sector desks that mirror the city's operational divisions. A sector controller is in charge of each sector, and generally also performs the role of allocator, deciding what resources (ambulances and other vehicles and personnel) to deploy to each incident. The allocator is assisted by a radio operator, who communicates with ambulances on the road, and a telephone dispatcher, who communicates with ambulances still at the ambulance stations.

Once the details of each call, e.g. type, severity and location of incident, have been taken, call-takers also ask a series of questions from the Advanced Medical Priority Dispatch System, a set of protocols established by the emergency medicine community. This is used to establish the medical priorities of calls according to the extent to which the symptoms suggest a case is life-threatening. Although all calls are treated with urgency, not all calls are equally life-threatening, e.g. a broken leg is less life threatening than a heart attack. Management of this prioritisation leads to better utilisation of limited ambulance resources.

Based on the addresses of the incidents, information about each incident is directed automatically to the relevant sector desk. All new calls are presented on a computer display. Call details may be viewed by calling up the associated details screen. Each new call is printed onto coloured paper job tickets, and acknowledged. The nearest available ambulance is selected and then dispatched. The paper ticket becomes the basis for managing the call. Updates such as reports from the ambulance crews and their arrival and departure times at the incident location are written on the tickets. The tickets are placed in a slotted box where each slot represents one ambulance. Sometimes several calls are received for a major incidents such as a serious road traffic incident: many different people call and report slightly different information about what is essentially the same incident. The allocator studies the details, decides whether the tickets belong to the same incident, groups the related tickets together and then manages the calls as a single incident.

3. Naturalistic Decision Making in Emergency Ambulance Control

The field setting in which an allocator makes decisions is dynamic, with new events constantly occurring, and decisions to deploy ambulances will have an impact on later ambulance availability. Decisions are often time-constrained and based on uncertain information, and wrong decisions could lead to loss of life (Klein, 1999). Decision processes described within such contexts have

been referred to as naturalistic decision making, NDM (Zsambok & Klein, 1997). NDM has also been described as "… the way people use their experience to make decisions in field settings." (Zsambok, 1997). The study of NDM involves investigating how experienced people working in these natural settings assess the situations they face, determine the problems they need to address, then plan, make choices, and take actions.

A number of studies have improved our understanding of how decisions are made in complex, dynamic and real-time environments. These descriptive studies have been conducted in other process-control type domains: emergency decision making in oil production (Flin et al., 1996), military command and control (Drillings & Serfaty, 1997; Kaempf *et al*., 1996; Kaempf *et al*., 1993; Pascual & Henderson, 1997), neo-natal intensive care (Crandall & Getchell-Reiter, 1993), and aviation (Orasanu & Fischer, 1997; Stokes et al., 1997). These various studies have developed models of NDM that highlight the different aspects of NDM. A number of key features from these models have been integrated into a single framework called the Integrated Decision Model (Wong, 2000). These key features of NDM are summarised:

(i) situation assessment is an important part of decision making,

(ii) feature matching and story building are key to situation assessment because of missing information and uncertainty about available information,

(iii) situational information are not presented in an optimal manner and often arrive over a period of time, making it hard to piece together a picture of the situation, and

(iv) decision makers in dynamic environments do not appear to analytically generate and simultaneously evaluate all possible options, but instead seek to identify the actions that best match the pattern of activities recognised in the situation assessment, one option at a time.

This framework provided guidance for investigating the decision processes and strategies of emergency ambulance dispatchers.

4. CDM Interview Methodology

Thirteen dispatchers were interviewed at the major emergency ambulance control centre studied. Of the 13 dispatchers, six were allocators and three were radio operators who had also worked as allocators e.g. relieving the allocators during their meal breaks. This paper focuses on these nine interviewees and incidents they encountered in their roles as allocators. They represent about 25% of the total number of allocators at the control centre.

Each allocator was interviewed individually using the CDM. Interviewees were asked to think back to a particularly memorable (usually major) incident that they had encountered in the course of their duties. Employing a technique that used pieces of sticky PostIt™ pad papers, and pencils (Wong et al., 1997), interviewees actively participated in describing the incident. Once the decision timeline was constructed, the allocators were carefully questioned as described by the CDM protocol. The interviews were audio tape recorded. Retrospective techniques are useful in situations where concurrent protocol analysis approaches such as the think aloud methods, can interfere with real-time activities. Asking interviewees to articulate their thoughts and considerations while attempting to plan, dispatch and communicate with ambulance crews could distract the dispatcher and cause delays in dispatching ambulances to medical emergencies. Furthermore, there is only a remote possibility that the researcher would be present during these major incidents to observe and record events as the incident proceeds. Thus, the CDM provides rich data on the most demanding kinds of incidents (though it provides little insight into routine operations). The next section describes how the data from these CDM interviews were analysed.

5. CDM Data Analysis

For context purposes, the CDM's structured approach will be briefly described before explaining how the Emergent Themes Approach was used in this analysis. The structured approach involves summarising the incident, creating a timeline of the decision points in each incident and to show how each decision is progressively taken to action. Key decision points are then identified and charted. The decisions are further analysed in a Decision Analysis Table which supports identification of the cues, the mental processing, the outcomes, the reasons and overall goals. The cues, goals, mental processing and other interesting aspects are then consolidated across incidents. This process is illustrated in Figure 1. The emergent themes approach is explained next.

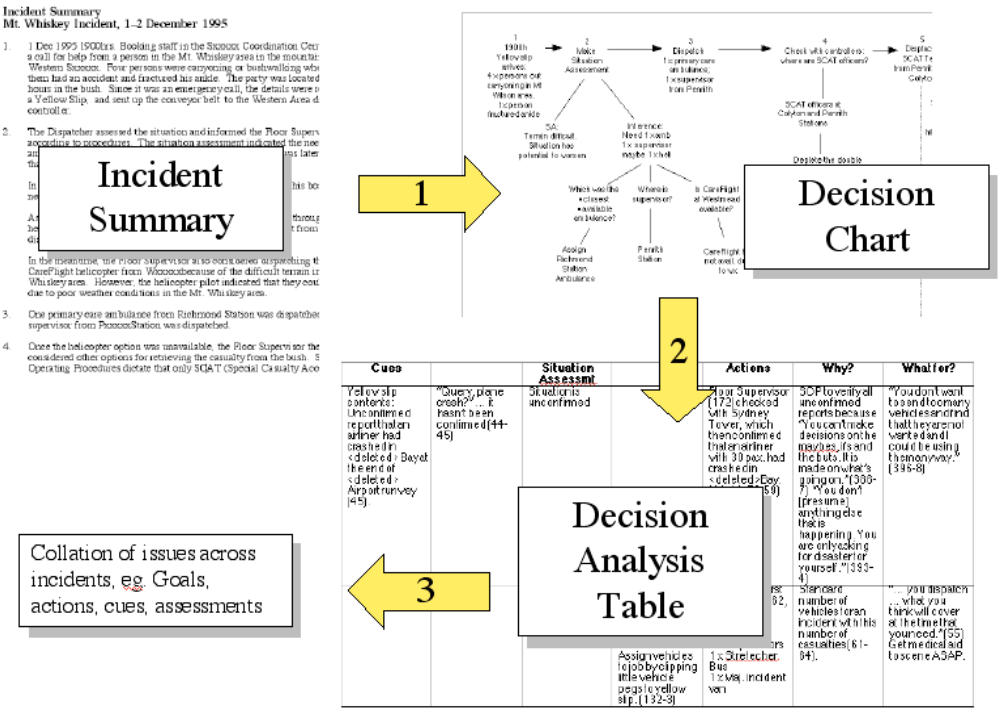

Figure 1. The CDM Decision Analysis Process

6. ETA Data Analysis

The ETA Approach is an iterative distillation process to reduce and to make sense of voluminous interview data. This is outlined in Figure 2. *Broad themes* are similar ideas and concepts reported across interviews or incidents. They are identified, indexed and collated. In this way, themes *emerge* from the interview data. In this study, the themes were initially associated with broad aspects of the decision process, such as the goals that an allocator need to achieve. Using a similar distillation procedure, sub-themes, or *specific themes* within each broad grouping are identified, and the data and the specific themes are further categorised according to a framework for describing each decision process in finer detail. This framework has four categories that describe activities, cues, knowledge and difficulties of the processes, as illustrated in Table 1. The specific themes and supporting data are then summarised into summary tables and narratives, which are descriptive prose that consolidate the data even further. The narratives and the summary tables are then interpreted, and relationships and new ideas about decision strategies are conceptualised. These decision strategies are again in narrative form, and written so as to provide understanding about the needs for representation. This procedure will be elaborated in the next section using actual data from the study. For reasons of brevity, only samples of the data will be used to illustrate how the procedure was performed.

In the study, six broad themes were initially identified (NB: not all of these themes are shown in Figure 2): (i) goals of what the allocator was trying to achieve, (ii) priorities that guided their decisions, (iii) assessment of the situation and resources, (iv) planning and selection of course of action, (v) co-ordination and control of ambulances in real-time, and (vi) situation awareness of developments in the process they are controlling, around them in the control room and through their information systems. These themes were later found to correspond with the key aspects of the Integrated Decision Model which provided further guidance for organisation of the data. Relevant concepts were identified in the transcripts and representative excerpts were indexed for later retrieval. Excerpts relating to a broad theme, e.g. assessment, were collated for further analysis.

Specific themes within these broad themes were next identified and indexed. Excerpts from the transcripts could be categorised according to whether they describe: (i) activities being done by the allocator. These activities are then used to identify (ii) the cues they attended to, their sources and the considerations they made based on those cues, (iii) the knowledge and experience the

allocators brought to bear on the problem or in the activity, and (iv) the difficulties they encountered, and the likely mistakes and consequences a less experienced allocator would make in performing that activity.

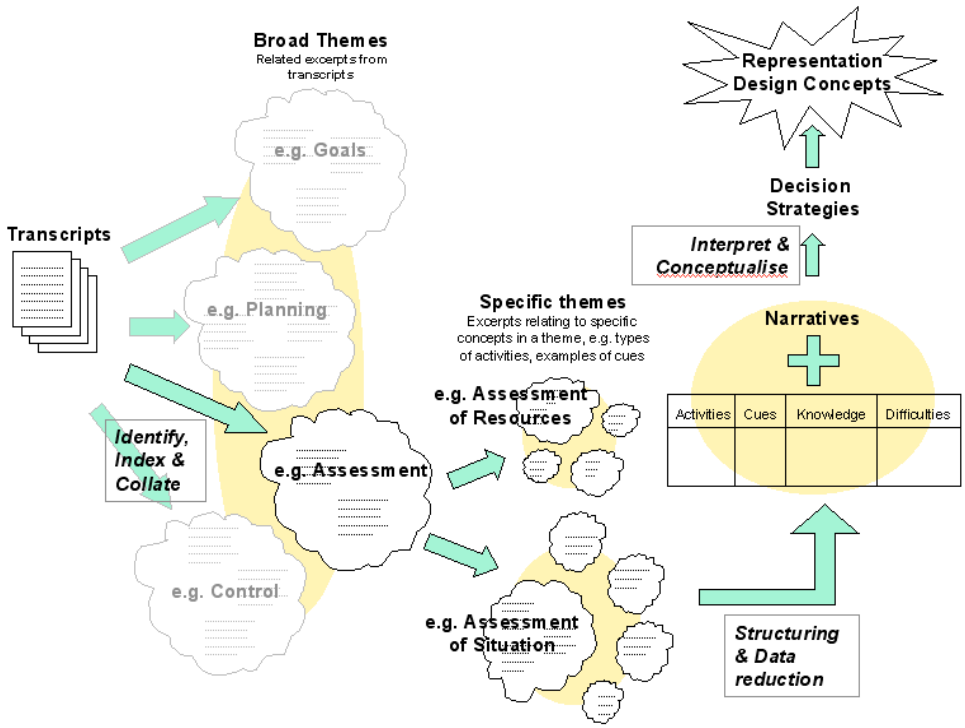

Figure 2. Emergent themes analysis process.

At this stage, the data had been significantly reduced and was represented by excerpts. For example, the following selected excerpts relate to one aspect of the "Difficulties, problems, likely mistakes and consequences" experienced during "Assessment of the situation". They convey the theme of *uncertainty of information* when interpreting information from different callers.

> P1 … you just don't always know from the telephone conversation what's going on. (1/151)
>
> P6 … because the information was confusing at the beginning, it started off as what we thought was gonna be a minor incident and it turned out to be a major incident in the end, … we had about 40 casualties. (6/58-60)

The uncertainty makes it difficult for allocators to assess the situation accurately, which explains why allocators sometimes resort to using their *"6th sense"*, or the feeling they cannot articulate that the information about an incident 'just doesn't look right'. *"6th sense"* is a theme in the "Knowledge and experience" category of assessing the situation. Although reported by other allocators, only the following excerpts from one allocator is reported, being the most descriptive.

> P4 … what we got…a broken window on a train …that just started with the first call. (4/23) …it didn't seem right that they would phone up for a broken window. (4/64) … We were ringing it back just to check when we got the rest of the calls coming in. (4/108) … we start getting further calls … saying, oh there's a train crash. (4/156-158)… when you handle so many calls … you get a feel for the calls, how they're written out, what happens … (4/1269)

The next theme that emerged from the data about difficulties experienced during situation assessment is *the lack of visual differentiation or explanatory information in the calls summary display*. The call summary display in use at the time of the study only showed the computer-generated job number and its priority. The allocator had to then call up the details screen for specific information. It was difficult for the allocators to see at a glance what each call was, its location and even if the calls were related. The following sample describes the difficulties:

> P1 …Just by flicking through really, you have to sort of flick through them to see. … I press F1 to view the calls, … and I'll view it and I go "that's the same". Flick on through it, "that's the same",

'cos they have all got a train crash or the same location, but in all of that I might have had someone in a house that has fallen down the stairs, that's why it is very important to check through and make sure that the tickets are all the same. (1/1392-1406) … you have to keep flicking back to all the sector screens, and when you get a major incident going on, and you've got normal calls coming in, and you don't know on the screen unless you look. (1/1147-1149)

P2 … so what you would do is, depending on how many calls you have on the screen, using the cursor keys, you could flick through and look at the calls and as you look at the calls, see where is it, and then you look at your box, which is next to you, which is with vehicles and depending on the status of the vehicles, where they are, well start making judgements … of things. (2/121-125) …Until the ticket prints out, you can keep flicking through the calls, cos obviously several calls come in at once and you wanna make sure that they all get out within a certain time. (2/130-132)

The data is further reduced by summarising the themes according to categories as presented in Table 1.

Activities	**Cues, sources and considerations**	**Knowledge and experience**	**Difficulties, likely mistakes, consequences**
1. Build a mental picture of the problem by integrating situation and incident information. 2. Collate information from many sources. 3. Corroborate evidence with others. 4. Assess if the incident is real. 5. Assess severity of incident (number of casualties).	1. Information that describes the type of incident – call details screen. 2. Information that describes the scene and the situation (e.g. for crew safety reasons) – could be in original call details screen or could be in another ticket. 3. Information from police and fire – on separate tickets. 4. Call rate. 5. Key cues expected - CHALET	1. "Just doesn't look right" or 6th sense – developed from experience and medical (on road) training. This knowledge is used to assess the situation.	1. Uncertain information. 2. Determining if calls are duplicates – flag calls with similar addresses rather than tie in on locations 3. Flicking between summary and details screens to read, collate, compare and mentally integrate information – effortful process, highly memory intensive and therefore requires full attention. Summary display lacks visual discriminators or explanatory information. 4. Information from police and fire not differentiated on summary display.

Table 1. Summary of Assessment of Resources Process

From the summary in Table 1, narratives are written to summarise and conceptualise the process. A sample narrative that describes what allocators do to assess the situation are presented next.

In assessing the problem, dispatchers build a mental picture of the problem or incident by collating and integrating situation and incident information from many sources. The key information they need is represented by the acronym CHALET, Casualities, Hazards, Access, Location, Egress and Time. They also corroborate available evidence with others in order to assess whether the incident is real, as well as the severity of incident.

The following paragraph from the same narrative shows how the data about 6th sense can be interpreted and conceptualised.

What information is attended to and how the information is considered, is dependent upon the schemata that dispatchers have. These schemata are made up of their ambulance training, medical and road experience. The schemata enable dispatchers to recognise patterns in the presented cues that help them diagnose the situation (Lipshitz & Ben Shaul, 1997). Situational cues that violate these expectations set off alarm bells that relate to what dispatchers refer to as *6th sense*. This is often verbalised by the dispatchers as "it just doesn't look right", and highlights the value of experience in this job.

Then, the narratives together with the data in the summary table (Table 1) are studied, resulting in a conceptualisation of the decision strategies. These descriptions encapsulate key features of what the allocators do in each phase of the decision process. For example, the following describes the decision strategies found during the assessment of situation phase:

Allocators build an understanding of the situation by collating and integrating different pieces of often uncertain information from a variety of sources over a period of time. They often have to compare and evaluate information between different and from within the same incidents to assess the overall situation and the severity of the incident, to gauge the number of casualties they can expect. Incident information on the tickets need to be compared visually. The computer system

does not facilitate the less effortful visual comparison of information, and instead relies heavily on the more effortful memory to make comparisons during the time consuming 'flicking' process.

They verify the information with others in assessing the authenticity or the extent of the incident. Allocators use "6th sense", to help them verifiy the authenticity of information.. This develops a set of expectations for managing incidents and it is the violation of these expectations that constitute the 6th sense. They use this knowledge to assess and verify situational information.

These decision strategies then form the requirements of representation design concepts, ie how information should be portrayed to support the nature of the cognitive work. For example, the above strategies suggest the need for a representation design that consolidates incident information (information about related calls) from different sources, across different modalities and over a period of time, in a manner that facilitates comparison, and communications protocols between all dispatchers that allow free-flow of information.

7. Discussion

So, what are the merits of the ETA Approach? We suggest that it:

- Promotes the exploratory nature of CDM and allows insightful themes to emerge. By not trying to fit the data into a priori compartments or structures initially, this approach allows new and surprising concepts to emerge first and then uses the concepts themselves to guide further exploration and data collation.
- Balances emergence and theory. During the identification of themes, concepts emerge and combine giving rise to new ideas and relationships. The examples of the specific themes identified in this paper illustrate how such new concepts can be identified and yet systematically analysed using a given theoretical framework to create a coherent explanation of the allocators' cognitive work strategies.
- Is fast and practical. Informative themes can be identified during early stages of the analysis. For instance in the study, 'the lack of visual differentiation or explanatory information in the calls summary display' and that of 'uncertain information' were issues that arose in the early stages of the analysis. It provided early indications of the practical problems experienced by allocators and subsequent analysis provided the systematic collation of evidence to show that this was one of the causes of the information handling bottlenecks in the system.

There are of course limitations in the ETA approach.

- Reflexitivity. This is the bias that a researcher brings to the interviews, the data analysis and interpretation (Mays & Pope, 1996). The emergence of themes from the data is somewhat dependent upon what a researcher expects or have been trained to see – their frame of reference. To address this, it becomes important to ensure that the reader is provided with enough data such as appropriate excerpts of transcripts. This allows the reader to trace how the conclusions were made, and therefore to make his or her own judgements about the validity of those conclusions (Patton, 1990).
- Representativeness. Can the conclusions reached be applied beyond the scope of the instances investigated? Though not strictly a problem with the ETA approach per se, the number of people interviewed, how they are selected, the commonalities between the type of incidents studied, can be controlled through deliberate stratified sampling and triangulation techniques.
- Breadth of issues. This represents the situational variety present in naturalistic situations. This is related to representativeness. A wide variety of concepts can emerge in some incidents but not be observed in others. The breadth of issues is important in that it often defines the farther reaches of the boundary of normal performance. But are they valid? The CDM studies incidents where people usually operate under abnormal conditions. This should be expected and evaluated on the merits of the situation and the severity of the consequences that a particular behaviour or action might lead to. A similar approach to addressing reflexivity can be taken – provide enough rich data that allows the reader to make his or her own judgement.

8. Conclusion

In this paper we have described how the ETA Approach can be used in the analysis of CDM interview data. Although the ETA approach is still being trialed and there are limitations, it holds

the promise for preserving the exploratory nature of the CDM so that interesting insights that do not fit a priori categories are not lost, while increasing the yield and ensuring analytical rigour.

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