CUE-driven Retrospection–a data Capturing Technique

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Abstract: A cue-driven retrospection (CDR) method is presented here that is developed for modeling the decision making process of naturalistic decision makers. The method is obtained from analysis of data obtained for nonroutine situations from fireground incident commanders and focuses on the use of cues instead of patterns. The method revolves around the tenet that in no routine situations, the decision makers think in a bottom-up fashion using the important, relevant and diagnostic cues intuitively (Shaikh, 2011); the method intends to capture the arguments that the firefighters give to term or not term a cue important, relevant and diagnostic. The thematic analysis of data gathered for Shaikh (2011) gave rise to this method. For testing the method, a total of 12 firefighters were asked to recall an incident that was of no routine nature and they were asked to fill the CDR template. The firefighters were provided a set of cues to assist in the activity and extract more mentally. The results shows that the firefighters were able to identify the relevance, importance and diagnosticity of cues. The CDR method can be used for naturalistic decision makers as well as for professionals such as design engineers, paramedics, and computer programmers etc. The method can be used for developing decision support systems, evaluating performance of decision makers, as certaining areas where more training is required, and for investigating the decision making process. This research in itself is one of its kind because fire brigade in Pakistan is mostly unexplored and how firefighters make decisions in the absence of even water and other basic resources needs to be investigated. Moreover this researcher found them highly non cooperative in this research endeavor.

Keywords: Data Capturing, Retrospection, Methodology, Decision Support Systems

1. INTRODUCTION

Data collection for analysis from the professionals working in naturalistic settings is atypical. These professionals consume far too much information and process it very quickly. Reporting it in a narrative fashion leaves out important details regarding the available information, the existing situation, selection of course of action (CoA) etc. The judgment of naturalistic decision makers is based on part of the available information (cues) and not the whole. Shaikh (2011) noted that especially in no routine situations, the professionals intuitively focus on cues that are relevant, important and/or diagnostic. This is different from the routine situations in which the professionals look at the situation as a whole instead of picking specific information. Cues collected during the routine situations have the sole purpose of identifying a representative mental schema to match the existing situation.

Capturing data from professionals paying attention to the detail is different from capturing data from those doing pattern recognition. The example situations range from no routine fire incidents to triage cases to emergency management, team selection etc. This paper presents a new data capturing method that is called "Cue-driven Retrospection (CDR)" that focuses on a bottom-up fashion of understanding decision making process. At the outset, it should be specified that the method has emerged from retrospective analysis of data collected for Shaikh (2011).

The method is that a professional from whom data is to be captured should instead of narrating an incident, explain what specific cues he has observed, how were they relevant in the existing situation, what was the importance of those cues among the available information, how were the selected cues diagnostic in the situation, and what was the stimulating object. They were also asked to point out at what stage the cue was used; whether it aided in building the mental schema they came up with, or selecting a course of action or in explaining the feedback as desired outcome. The following section explain what cues are. Later, the cue-driven retrospection method is explained.

Cues

Human decision making is normally categorized as skill, rule or knowledge based behavior (Rasmussen, 1986). The performance in each category is based on the role of the information observed from the environment (Rasmussen, 1986), which is basically different in the different categories. Generally, this 'information

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observed from the environment' is called cues. Cues are a 'specific physical force, energy, or agency (resulted because of the changes in the stimulus object) which brings about stimulation' (Troland, 1930) and can produce a change in behavior (Jennings, 1906). Elsewhere, cues are also termed as signals, symptoms and symbols (Rasmussen, 1986). For Skinner, a cue is simply a part or modification of a part of the environment which refers to a class of events, the members of which possess some property in common (Skinner, 1959).

In a naturalistic environments such as firefighting, triage etc. cues act as indicators of problems or faults that invokes a response from the perceiving body. Cues are the disturbances or symptoms that the faults or problems produce (Klein 2006). The cues are informative about the stimulating object (Haukedal, 1994) and also have meaning when viewed separate from the source as standalone factors.

Cues have identifiable attributes and data exist along with identifiable attributes (Haukedal, 1994) making the cues perceivable. Cues are embedded in situations and both (cues and situations) are embedded in environment (Shaikh, 2011). Haukedal (1994) noted that cues can be classified as central and peripheral. Central cues are the direct result of changes in the stimulus object. Peripheral cues exist because of central cues; they cannot exist in the absence of central cues. Cues vary in strength as strong and weak (Haukedal, 1994; Mintzberg *et al,* 1976) and points to well-structured or ill-structured problem situations (Mintzberg *et al,* 1976). The latter are described as 'problems whose structure lacks definition in some respect' (Simon, 1973).

Cues can be structured or ill-structured (Haukedal, 1994; Minstzberg *et al,* 1976). Haukedal pointed out that illstructuredness of the cuecan be understood on three dimensions that are "novelty, complexity and ambiguity" (Kaufmann, 1987).Novelty could stem from the lack of pertinent familiarities or awareness. Complex cuesare more demanding on short-term memory because of the large quantity of information they contain (Kaufmann, 1987). Ambiguous cues are encountered in the arrangement of conflicting solution substitutes, where the difficulty is to distinguish which solution efficiently achieves goal requirement (Haukedal, 1994).

Cues are selected for their usefulness in making decisions. Schwartz *et al* (1989) noted that the decision environment is characterized by the information available for making decisions(information context) and facets of the surrounding situation in which decisions have to be made (situation context). Information context is the information available and the cues used for decision making. Situation context is about the present and current scenario. Schwartz et al further noted that the available cues are selected for their importance, relevance and/or diagnosticity. Diagnosticity is indicates the degree to which a cue provides information and can invoke thoughts to solve problems. Importance is the "degree to which cue affects judgment". Relevance is about "whether a cue is used or not" (Schwartz *et al,* 1989).

As the information context changes cue importance changes too, similarly variations in situation context have effects on cue relevance. Cues may be still be used even if they are not important in a given situation, however they are relevant or diagnostic enough to enable problem solving (Schwartz *et al,* 1989). Cues are important for several reasons such as cues can be psychologically analyzed; they can illuminate path to crises, problems and opportunities; and cues can also describe events carrying information about the developing trends in the environment, therefore they help in ascertaining the significant developments in the environment (Klein, 2006; Haukedal, 1994).

Cue-driven Retrospection– Development

The cue-driven retrospection (CDR) method basically emerged in analysis of data originally collected for Shaikh (2011); for that research19 fireground incident commanders from different fire brigades of the UK were interviewed using critical decision method (Klein *et al,* 1986). The data was analyzed in theoretic or deductive thematic approach and through process reconstruction method (Nutt, 1983) which gave rise to the proposition of cue-centric model for fireground incident commanders (Shaikh, 2011). This also revealed that the "cues" instead of "patterns" are guiding factor in decision making in nonroutine situations on the fireground. Moreover it was found that fireground incident commanders were referring to the diagnosticity, relevance and importance of the cues as guiding and explanative factors for making decisions in nonroutine situations. Hence a cue-centric (instead of pattern centric) knowledge elicitation method is proposed based on the use of cues and their diagnosticity, relevance and importance for making decisions. CDR is an alternative for those researchers that intends to study a decision making process in bottom-up fashion instead of typical top-down fashion example of which is Klein *et al* (1986).

Safety cues	Cues that indicate the 'nature of Problem'	Environmental cues	Emotive cues	Cues that inform incident command and control decisions
• Cracked wall • Falling wall • Roof condition (possibility of collapse) • Substances present/perceived to be present in a building, for example, combustible materials such as petrol, acetylene cylinders, LPG cylinders • Potential of fire spreading • Smoke behaviour (flashovers, backdrafts) • Location of the seat of fire • Location of unaffected properties • Type of building (terraced, block of flats, single-story, multistoried) • Entry point (accessible, obstructive) • Category of victims trapped (elderly, disabled, mentally challenged)	• Size of fire • Intensity of fire • Pattern of flame movement • Egress of the flames • Smoke colour (yellowish rainbow, blue, thick black) • Smell/odour of smoke and burning substances • Texture of smoke (thick, light, cloudy) • Severity of physical damage • The nature and extent of injury suffered by victims • Room temperature (A room on fire can sometimes be as hot as 1000°C) • Type of materials burning or class of fire (metal fire, gas fire, batteries, acetylene) • Noise of vibration on the ground • The intensity of heat emitted from the blazing fire to the environment • The quantity of water that has been used up in the process (10,000 L shows how serious a fire is)	• Wind direction (is the wind blowing towards or away from the fire?) • Wind speed/intensity • External temperature/climatic condition (hot, warm, harmattan, cold) • Catchment area (residential, factory, industrial, rural, city) • Location of incident (rural or urban area) • Distance to water supply (availability and proximity of hydrants) • Topography of the street, for example, steep slope, high slope	• Verbal threat from victims • Shouts for 'help' from crowd • Level of panic displayed by the crowd • Cry and wailings from trapped victims • The number of passers-by at the scene of incident	• The rank/level of experience of the officer currently in charge • The number of pumps deployed (a more superior officer takes over when the number of on-scene pumps gets to five) • The size of the building (building size determines whether sectorization is needed) • Height of the building (e.g., if building is too high beyond the reach of a ladder, then the use of an aerial appliance becomes necessary)

Fig. 1: Example of cues reproduced from Okoli *et al,* 2016

Cue-driven Retrospection –Core Procedure

An interviewee will approach a decision maker (interviewer) and during one session following steps will be taken for capturing data:

Step 1 -Select Incident: The decisionmakeror interviewer is asked to choose an incident that exhibits instances of nonroutineness and were challenging.

Step 2 - Obtain a List of Cues that the decision maker focused on using the CDR template: The officer was asked to describe the cues that heconcentrated on throughout the incident at various instances (for example whilst understanding the problem, whilst proposing a solution and whilst seeking feedback of implemented solution). For each identified cue, the interviewer is optionally required to describe if it was novel, complex or ambiguous. The interviewer is also asked to describe in the template in detail about the relevance of the cue in the existing situation, importance in the existing situation and/orits diagnosticity. It is not necessary that a cue that is deemed less important is not relevant as pointed out by Schwartz *et al* (1989). **(Fig.2)** shows the CDR template. For an example of cues, see Okoli *et al* (2016) and **(Fig. 1).**

Step 3 - Construct the Links between the Observed Cues in a Timeline and Reconstruct a Mental Schema: After

the incident had been related and CDR templates are filled, the interviewee proceeded to reconstruct the account in a narrative style (that is recorded electronically) the timeline that establishes the relation as well as sequence (if any) of each cue reported. The interviewee is asked to reconstruct mental image of the situation that he came up to at the incident scene. This step is to confirm that the cues he had reported were actually used at the incident scene.

Fig. 2: Cue-driven Retrospection template

Step 4 – Probing Cue-driven Mental Schema and Selection of Course of Action: using the semi-structured interviewing technique, the interviewer is asked to explain the mental schema. He is asked to explain why he came up with this image of the situation using the cues that he selected and reported. The cues reported using the CDR template will work as the probes for the interview. The interviewer is also asked for the course of action that he selected. This step is to confirm that the interviewee was able to judge the importance, relevance and diagnosticity of the cues for making the decisions he made.

Step 5 – Explaining CoA on the Basis of Cues using CDR: the interviewer is asked specifically about the selected CoA and why he selected that CoA through cues – which cues motivated him to select a particular CoA that he applied. This step too will confirm that the cues he selected were used in selecting a CoA.

Step 6 – Explaining feedback through cues using CDR: once again the interviewee is asked to explain feedback using the cues he noticed after applying the CoA to assess if the applied CoA was correct. This too will confirm that the feedback too are based on the cues he selected as important, relevant and diagnostic.

2. METHOD OF EXPERIMENT

Various Fire brigade offices of Karachi were contacted for testing the practicality of this method. A total 12 fire brigade personal working as firefighters were asked to recount those incidents that they deemed nonroutine. They were asked to report these incidents via email or on a paper. The firefighters were also provided with a set of cues as gathered by Okoli (2016) and they were asked to fill the cue-driven retrospection template so that they don't have to work hard in identifying or recalling cues from their past experiences and then explain how they were diagnostic, important and relevant. Since most of the firefighters were not too conversant with English therefore they were assisted in understanding the technical and nontechnical words of the template. All firefighters described the incident in Urdu and filled the CDR template in the same language.

Each of these firefighters were working in the organization on a full time basis for over 10 years. Since Karachi is an industrial city, the incidents of large scale fires is moderate. The firefighters have normally worked from the peculiar role of a firefighter to a breathing apparatus wearer to something even like a sector commander (normally called leading fireman) because of the virtual absence of any strictly used incident command system. The purpose of asking these firefighters to fill the template and recall the incident was to judge if the firefighters can gauge the diagnosticity, importance and relevance of cues in their particular situation.

3. RESULTS

The incidents that the firefighter recalled were about industrial fires to arsons to minor house fires. Typically the firefighters reported all those cues that firefighters all over the world note and report such assize of the fire, cracked wall, cylinders, time lapse since the fire started, the number of people at the incident scene, risks to own life, lack of facilities to fight the fire such as harness belt, snorkel, water and hydrants etc. Although the firefighters from Pakistan

don't get the same level of training as do the first world or BRIC states give to their firefighters however it is important to note that the loss of life in most fire incidents is not very high. The Baldia factory fire however is an exception; it is claimed that the incident was an arson attack that was launched by one of the leading political party's activist in order to punish the owner of the factory for not paying the full protection money. Apart from that fire incident, all others result in loss of material goods however the loss of life is not too high, credit of some of which can be attributed to the actions of the firefighters.

The firefighters were told that importance signifies the general importance of a cue irrespective of a current situation whereas relevance signifies that once the cues is extracted from the environment, would this cue help us find a solution to the current situation or should we ignore this particular cue. Diagnosticity is once the cue is selected how that cue helps in diagnosing the current situation. It seems that when the firefighters were explained what these terms means, they were able to recall how they select the cues as well as what was the stimulating or fire causing object. All firefighters narrated the incident in written in Urdu language. Firefighters were asked to report as many cues as possible that led them to make a decision irrespective of whether the cues was ignored or not ignored. For some, the incidents reported here may look like of routine nature, however in a country where there are not enough firefighting equipment and resources available for fighting even a common fire, providing simulated trainings is far cry. Therefore sometimes even the most common situation for a firefighter from the UK may look like a unique and new situation for Pakistani firefighter.

Fig 3: Wheels on Fire

In one incident a huge pile of disused wheels were on fire **(Fig. 3).** The firefighters were using water indiscriminately. This is because they had already checked that the wheels were stored in a plan ground. This situation awareness played as a cue for them to try and extinguish the fire which this author saw firefighters left burning in an incident in the UK. The Pakistani

firefighters were of the opinion that since the water spent may not harm any field or underground water tanks of the nearby other buildings and the wheels are emitting enormous amount of hazardous smoke therefore they can try and extinguish it earlier than leaving it to die by itself. In another incident a firefighter reported that though the fires can be raging in cloth manufacturing factory however chances of it spreading to the neighboring factories is remote mainly because the buildings are made of brick and mortar instead of wood structure. The construction of the building helped diagnose whether the situation may spread to other buildings.

Fig. 4: Neutral plane

In one incident, a firefighter noticed a less known phenomenon of neutral plane in a room on fire in a lavishly built house. The house was generally ornate by expensive rugs, and several show pieces large and small that were of wood and plastic. The room on fire too had these items. Moreover the room had a giant bed and lavish curtains. The fire started after a drunk occupant of the house left touched his cigarette with the expensive spread on the mattress while dousing off. The man was unable to escape the fire and had already perished firstly due to smoke and secondly due to the fire, before the fire was reported. The room was already on fire for fifteen minutes before a gardener noticed it and alerted the fire brigade. The house was nearly empty and had only two occupants inside the house; one was a grandmother and the other was the man who had perished in the fire. When the firefighters reached the house the neutral plane had already developed. It is probably not a commonly available cue for Pakistani firefighters. The firefighter who was tasked to enter the room through the external window reported the neutral plane asa glow in the room visible from outside. It is a very important cue however since the firefighters here don't find it commonly therefore the firefighters almost ignored it. The firefighters did noticed the smoke coming under the door that was sucking in and out – a typical characteristic of backdraft. Finally the window was broken to a huge backdraft. In this incident the smoke under the door was noticed and its relevance, importance and diagnosticity helped asserting the ensuing backdraft.

One firefighter that was fighting a fire in a garage where old and new cars come to repair, told that he asked the people working in garage if the cars were running on CNG as well besides the petrol and the answer was in affirmative. He then had to take all the precautions related to incidents where compressed cylinders are involved too in the fire and this also led him to extract further cues such as length of fire. Similarly, in one incident the firefighter ignored the large cracks in the walls of an apartment block which was on fire. The building was comparatively new and was only built 10 or 12 years ago. The firefighter was of the opinion that the steel bars used in construction of Pakistani buildings are strong enough to withhold the debris from falling immediately therefore he still had enough time to undertake the rescue operation by entering the building via snorkel or with wearing breathing apparatus. The age of the building helped the firefighter to implement his plan of action. In other situations, the cracks in the wall are diagnostic and relevant and may encourage the firefighters from abandoning the idea of entering the building.

In another incident, a fire in a large cinema was reported (**Fig. 5**). The cinema was one of the oldest in the city. The fire was an act of arson. The material included a large cache of old tapes, highly flammable cushions of the cinema seats, the large curtains and fire catching floor and ceiling work. The fire was started after some hardliners entered the cinema when the cinema was closed observing the religious days of Muharram. The fire was started by the mob and it spread quickly developed into a large fire. By the time the firefighters reached the incident scene the flashover had already caused the fire to consume much of the hall and was quickly spreading.

Fig. 5: Cinema with the attacker and a room full of burnt reels

The old movie reels were stored in one of the store rooms. Since the cinema was an old building constructed long ago and had already passed its usable life and had not been properly maintained therefore the fire officers were reluctant to enter the building. Moreover the verbal and physical threats by the mob and accumulation of passers-by had caused panic in the firefighting staff. The threats and the presence of attackers at the incident scene made it difficult for the firefighters to salvage the building. The threats and attackers together acted as cues that were diagnosed to instigate no action which too in Janis *et al.,* (1977) point of view is an action and option. The building still is in burned condition and presents a haunting tail of how firefighters sometimes have to abandon their operation to save their own lives.

In one other incident, a leading fireman who had obtained thermal imaging camera through own means, assessed the compressors of five to six fridges placed near to a fire in one of the workshops for remaining cooling machines such as freezer, fridge and air conditioners. The use of use of thermal imaging camera helped them isolate and cool one fridge in the nick of time before it would have blasted and caused other nearby fridges to perish as well. Typical roadside workshop in Pakistan have tens of fridges and other equipment with compressors in stock and some of them are in use as well after getting repaired. In such workshops, fire means a lot of combustible material will help it to sustain and spread. Mere presence of firefighters at such incidents scenes or the small size of workshops should not give false hope to the firefighters that they are in control, said the firefighter.

Fig. 6: LPG decanting

Another firefighter related an incident where an LPG cylinder had blasted. It is common illegal practice in Pakistan that vendors transfer LPG from one cylinder to the one that is owned by the buyer normally called LPG decanting (**Fig. 6**). This often cause large accidents; the blasts are sometimes so loud that they may be taken for a terrorist attack. In one such incident, firefighters rushed to the incident scene where a blast has occurred in the wee hours of the night. By the time they reached the incident the fire had engulfed the whole shop where dozens of other cylinders were in store.

The fire heated up other cylinders stored in the shop. The firefighters first judged that the fire was on for about 10 minutes which was enough to heat up other cylinders. Only days before this incident, a cylinder blast in Sunlight colony India had caused massive damage. This information was not completely known to all the firefighters except the senior ones. Those few firefighters focused on evacuating the small three story building through the snorkel. Some firefighters were adamant upon extinguishing the fire whereas the senior ones only focused on evacuating the building while asking others to direct a jet of water on the fire. Within 20 minutes since the fire started, all the occupants were evacuated from the aged building. The ongoing fire caused the other two cylinders to blast. However a constant jet of water was able to control the fire and stopping any further blasts. The firefighters that insisted on evacuation were of the opinion that the overall situation awareness including the information from one past incident enabled them to take a different course of action which is to rescue and evacuate people instead of focusing all energy on fighting the fire. Had they focused only on fighting the fire, the two nearest cylinders from the blast that too exploded would have caused the loss of several lives.

Fig. 7: Sunlight colony blast

A fire in a multistory very large building was reported. The snorkel available to the firefighters was unable to take them all the way to such a height from where they may fight the fire externally, therefore the firefighters were air dropped at the top of the building through a police helicopter. The breathing apparatus wearer was an experienced firefighter. The building was situated in commercial hub where there are offices of many companies and banks. The smoke emitting from the windows was a mix of white and black. The firefighter deduced that since the building is office of an insurance company and there is mixed color smoke although the windows are mostly open therefore the fire could be because of the burning of papers and files.

They got in there in time and were able to salvage a large number of files from burning. The fire that moments ago was looking like it may consume all the office eventually was controlled in a successful manner. The uniqueness of the fire was that it was at the top floor of a building and was inaccessible because of the lack of facilities. If the BAs were not have been air dropped and if the BA wouldn't have been able to judge the characteristic of fire by its smoke and overall situation awareness they might have ended up destroying the salvageable material. The diagnosticity of the color of the smoke saved the day.

Some under training firefighters too were asked to fill the CDR template. They were asked to put some cues on the template and mock up a situation in which they can be important, relevant and diagnostic. They were able to do that which shows that even if the overall situation is unique for a firefighter, the knowledge and understanding of cues can help them bring situation under control using bottom up fashion of decision making which this data collection method dictates.

4. DISCUSSION

This data capturing technique is designed to gather data from nonroutine events. We live in very different times. Today men uses all sort of chemicals, machines and other materials that may cause disasters in unique fashions. This data capturing method will enable the trainers in training the expert and novice emergency professionals in training for those no routine situations. This method is also develop for those timeswhen the performers are not too proficient, lack in training on live incidents yet are aware of the theoretical knowledge; this applies to emergency professionals working in countries such as Pakistan, Bangladesh etc.

Most incidents happening to such performers are considered of nonroutine nature. This data capturing technique helps such performers focus on bottom up fashion of decision making. Though these performers are not exposed to training in simulated environment training them for every possibility yet theoretically they are taught very well and know the cues and how to use them in particular situations. Since the performers are exposed to events in their jobs therefore they may practice their theoretical knowledge using the CDR template to recall and work on knowledge related to the cues that they extracted from the environment whilst at the incident scene. This technique if practiced in a developed country can actually minimize the need of interviews to extract the information as the incident is built using this technique through the cues making up a situation and not through an overall description of the event. Verbal reports or interviews are not undeviating window into people's cognitive processes and the people can distort their own decision making strategies and goals (Klein *et al*, 1989).

The method can be used for developing decision support systems, evaluating performance of decision makers, ascertaining areas where more training is required, and investigating decision making process. The method can be used in countries where naturalistic decision makers don't have the facility of physical training and simulation based training as good as it is available in European countries and America. However the method is equally good for novices working in the field irrespective of whether they are from developing countries or the developed countries.

5. CONCLUSION

The CDR is developed to capture data from naturalistic decision making process. It has emerged from a theory (Shaikh 2011) that stresses on bottom-up strategy of decision making in no routine situations. It is most appropriate for experts experiencing no routine situations, novices in any situation, and for naturalistic decision makers working in those countries where there is dearth of trend of training for naturalistic decision makers. These includes countries such as Pakistan, Sri Lanka, Bangladesh, Nepal etc.

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