

An analytical evaluation of the methodological constraints and affordances of an incident investigation manual

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ABSTRACT

Incident investigations are important for maximising the resilience and safety of socio-technical systems. A manual is one way of disseminating an investigative methodology, and of guiding investigators in applying it. Here we explore the shaping effects of investigative manuals in terms of the methodological constraints and affordances they provide, and propose an analytical approach, the Systematic Reanalysis Method (SRM), to help understand these shaping effects. It is based on earlier work on the systematic analysis of methods. We illustrate the approach by applying it to the investigation of an everyday incident using the Root Cause Analysis methodology, following the guidance of a specific manual. How the investigative understanding of the incident evolved was recorded in detail, and used to provide an explicit account of the relation between the actual investigation done, and the methodological specification expressed by the manual. This kind of decompositional understanding is useful for helping to assure the validity of a particular investigation. It can also systematically highlight parts of a manual that may be further improved and refined. Consistent improvements to system resilience and safety can only be achieved if we have clear analytical understanding of the tools and instruments supporting investigations. The approach proposed in this paper is a contribution towards this broader goal.

KEYWORDS

Analytical evaluation, Incident investigation, Manual, Methodological constraint, Shaping effect, Socio-technical system.

HIGHLIGHTS

- An approach for analytically evaluating the shaping effects of investigative manuals.
- The proposed approach builds on earlier systematic analysis of methods work.
- The approach is applied to validate the investigation of an incident.
- The approach systematically identifies methodological certainty and ambiguity.
- Analytical results may also support refinement of investigative manuals.

1. Introduction

Incident investigations are an important part of the ongoing effort to maximise the resilience and safety of socio-technical systems. As part of the 'safety value chain' [1], such regulatory processes are a means for systematically improving safety over time. Particular investigative methodologies act as instruments for supporting this process, and facilitate specific styles of learning and intervention in response to the system understanding gained through investigation. Recent systems-thinking across a wide range of systems ranging from medicine [2] to cyber security [3] have identified an increasing need to adopt a style of learning and intervention with a stronger focus on the human factors aspect of incidents.

Investigative methodologies are often expressed through investigative manuals. Such artefacts are one way to prescribe and codify methodological guidance for investigators, and are one of many factors that shape the course of an investigation. As a kind of 'complex safety rule', investigative methodologies and manuals express normative methodological guidance, which may or may not be followed precisely in practice [4]. The perspective we adopt of such procedural guidance is similar to that proposed by Hale and Swuste [5] in the context of discussing 'simple' safety rules. We view investigative methodologies as imposing 'soft' limits on the degree of procedural freedom of the investigative response to an incident, with the specific limitations imposed dependent on the particular manual and methodology used. The increasingly specific levels of procedural guidance provided by such safety rules may be goal-based (least well-defined), rule-based (partially defined), and action-based (most well-defined) [5], corresponding to procedural guidance roughly at the knowledge, rule and skill-based levels [6] of human performance respectively.

The analytical approach we propose was developed as part of a larger study comparing the performance of a novel investigative methodology against Root Cause Analysis (RCA). We needed a way to analytically assure the validity of the initial RCA investigation, and there is no standard approach for doing this in the literature. The approach proposed was developed as a means for doing this.

1.1 Root Cause Analysis (RCA)

RCA is used across a wide variety of work-domains and levels of organisation. It is one of the simplest investigative methodologies to understand and use quickly and effectively, involving a backward tracing of the possible causal factors leading up to an incident. Hollnagel and Speziali [7] summarise the general Root Cause Analysis philosophy as:

- Step 1: Determine sequence of events,*
- Step 2: Define causal factors,*
- Step 3: Analyse each causal factor's root causes,*
- Step 4: Analyse each root cause's generic causes,*
- Step 5: Develop and evaluate corrective actions,*
- Step 6: Report and implement corrective actions.*

In the research reported here we used the Canadian Root Cause Analysis Framework manual [8].

1.2 How investigative manuals mediate between theory and practice

An investigative manual provides guidelines, which are used to 'instantiate' actual investigations and their subsequent reports [9]. The implication from this perspective is that such a set of guidelines represents and describes a space of potential actual investigations and reports. Our record of an everyday incident investigation (discussed in Section 3) provides primary data reporting on one of the instances of the space described by the RCA manual used. Due to the devolved and collectively-defined nature of RCA, the manual used here mediates between the general RCA investigative philosophy (described in Section 1.1), and the specific procedural details necessary for an actual investigation. Given this perspective, the record of the investigation done clearly

provides potentially useful real-world data for exploring some of the methodological properties of both the particular manual used, as well as the underlying RCA philosophy of investigation.

1.3 The notion of constraints and affordances

The notion of constraints is a familiar one to the system resilience and safety community. Researchers in the past have proposed specific ways of using the limiting notion of constraints to help deal with the combinatoric complexity of modelling critical interactions within socio-technical systems (e.g. the FRAM [10] and STAMP [11] approaches). Investigation manuals are a means of imposing constraints on the investigative process, where an investigation done according to a particular manual will most likely be different from one done without using that manual. Like Vicente [12], we consider *constraints* here as limiting (investigative) behaviour, removing degrees of behavioural freedom that may otherwise have been possible and/or likely. We refer to these limiting aspects as the **methodological constraints** offered by a particular investigative manual or methodology.

The converse to the limiting aspects of manuals and methodologies is the behaviours that they encourage. We refer to these aspects as the **methodological affordances** offered by a particular manual or methodology. This reflects an extension of the established notion of affordance as used in the Human-Computer Interaction literature, as a set of action possibilities predicated on a particular environ, situation or artefact (see Gibson [13] and Norman [14] for example). We consider here the action possibilities that are either explicitly or implicitly encouraged by a particular investigative manual or methodology.

1.4 Systematic analysis of methods

Our approach builds on previous work on the systematic analysis of usability evaluation methods [15, 16]. In this previous work, the analysts draw an explicit and independently inspectable analytical link between the particular method used and the findings subsequently obtained. In particular, they classify findings resulting from the use of a method by comparison against a reference document, and explicitly account for their reasoning according to the following five categories:

a) The finding should have been found by the method but was not, b) The finding was identified but attributed to the analyst's craft skill, c) The finding was found by the method, d) The finding was not found, but could have been by craft skill, e) The finding was not found due to a level of abstraction issue.

Here we extend their approach to account also for the actions taken through using a particular (investigative) method. A different ternary classification is used here, as discussed in the next section.

2. The Systematic Reanalysis Method (SRM)

2.1 Overview

Our systematic reanalysis approach involves the analyst challenging, and reusing the investigative guidance document to evaluate the validity of the actions done, and findings obtained during an investigation. Parts of an investigation are labelled as one of three mutually exclusive categories of '*constrained*' (should not have done/found with respect to the manual), '*weakly afforded*' (ambiguous whether should, or should not have done/found with respect to the manual) and '*strongly afforded*' (should have done/found with respect to the manual). This analytical assignment is based on close reading of the methodological specification expressed by the entirety of the investigative manual used. Detailed discussions grounded with explicit reference to the manual used are then recorded to provide independently inspectable argumentation for supporting each analytical assignment made.

The 'constrained' investigative actions/findings identified may be used to evaluate the quality and validity of an investigation with respect to the manual used. These highlight where investigations might be improved with closer adherence to the manual used.

Areas of methodological ambiguity are localised through the actions/findings labelled 'weakly afforded'. These represent parts of an investigation where its validity with respect to the methodological guidance provided by the manual used is unclear. Actions or findings with this label also indicate where the procedural control aspect of the guidance given in the manual is potentially weak, and less able to provide or maintain a dominating shaping effect over the wider contextual shaping factors typically present in traditional investigations. In these cases the investigator must use their best judgement in the face of methodological ambiguity.

Finally, the set of investigative actions/findings found to be 'strongly afforded' provide explicit evidence for assuring the validity and quality of the investigation done with respect to the manual used. These actions/findings also help highlight where, and how the investigation does in fact closely adhere to the manual and methodology used.

The actions/findings falling under the 'constrained' and 'strongly afforded' categories correspond to areas of clarity in the expression of a particular investigative methodology through a manual. Those falling under the 'weakly afforded' category correspond to areas of methodological ambiguity. The systematic identification of these areas may also facilitate the systematic iterative refinement of the manual and/or underlying methodology.

The core steps of the approach we propose consist of the following three sequential steps:

Step 1: Generate initial methodological criticisms (described in Section 2.2),

Step 2: Review and rephrase the criticisms initially generated in terms of a normalising set of phrase templates (Section 2.3),

Step 3: Compare the actions and findings from the investigation actually done with the methodological specification expressed by the manual (Section 2.6).

Two pre-analysis steps, the 'preparatory orthogonal markups' (Section 2.4) and 'random sampling' (Section 2.5), are both optional and may be done following Step 2. They may be particularly useful when not all the potential methodological criticisms initially identified will be exhaustively evaluated. It is also important to bear in mind how to deal with vague methodological criticisms (Section 2.7) as part of doing Step 3. Section 2.8 describes the stopping criteria to use in our approach. It is also important to note that aspects of the investigation done due to *a priori* limitations of the specific investigative context represent an *a priori* lack of investigative choice. These should not be used to comparatively analytically evaluate a manual/methodology, as they are clearly not primarily due to the shaping influence of that manual and methodology.

2.2 The initial identification of methodological criticisms

The analyst critically inspects and compares the actions and findings from the actual investigation (which ideally will have been recorded in detail) against the specification expressed by the manual. While inspecting the record of the investigation, the analyst challenges the validity of the investigation done by intuitively identifying potential methodological criticisms, relating either to the validity of the investigative *procedure* followed, and/or the validity of the investigative *findings* obtained with respect to the manual and methodology used. The analyst's naturally preferred means of recording and notation should be used at this initial stage. Note that criticisms may include both ones about 'omissions' (ie. things that were *not* done/found), as well as about 'commissions' (ie. things that were done/found) in an investigation.

2.3 Reviewing and rephrasing the methodological criticisms identified

After identifying the set of methodological criticisms that may be brought to bear on the record of the investigation done, the analyst reviews and rephrases each in terms of statements fitting into one of the three templates below:

- 1 " *The investigative choice(s) <?> was/were invalid* ", or
- 2 " *The investigative finding(s) obtained <?> was/were invalid* ", or
- 3 " *The investigative choice(s)/finding(s)-obtained <?> was/were invalid* " (this is for when a particular part of the investigation done seems to be both a choice and a finding).

Here <?> denotes the rephrased methodological criticism. These phrase templates are prescribed in the interests of creating a normalised set of criticisms for later comparative analysis (described in Section 2.6). The assumption behind these phrase templates reflect the fact that if a methodological criticism is indeed a valid one (ie. where something should *not* have been done/found with respect to the manual used), then alternative investigative actions may have been chosen, perhaps resulting in different investigative findings being obtained also. This 'normalisation' step is intended to facilitate a sharper focus on the specific nature and scope of each criticism that may be levied at the particular investigation done.

2.4 Preparatory orthogonal markups

Two sets of orthogonal markups may be used to further decompose the criticisms identified. The resulting partitions help to give a more decompositional overview of the set of methodological criticisms conjectured. These partitions may also serve as a reasoned way for prioritising the order in which to analyse the criticisms when the number of criticisms initially identified may be unmanageably large.

The first set of markups correspond to the phrase templates prescribed in Section 2.3. These label the methodological criticisms identified according to whether they relate to criticisms specifically about the *investigative procedure*, *investigative findings*, or criticisms potentially relating to both *investigative procedure and findings*.

The second set of markups label the criticisms according to whether they are *general* or *specific*. *General* criticisms are ones that may, if found to be valid with respect to the manual used, undermine the methodological validity of a significant portion of the rest of the investigation done. *Specific* criticisms are ones judged to have only a localised potential effect on the validity of the investigation done. The precise boundary at which a methodological criticism is considered *general* rather than *specific* is left to the discretion of the analyst.

These markups partition the methodological criticisms initially identified into more manageable subsets. The analyst can prioritise which to look at first depending on their particular interests and concerns. For example perhaps by exploring the *general* and *investigative procedure* related criticisms first, as they in principle may affect the validity of the investigation done most significantly with respect to the manual used. Note that there is no single 'correct' way of marking up the methodological criticisms. These markups are intended purely as a means for facilitating the subsequent comparative analysis, not an end in themselves.

2.5 Random sampling of methodological criticisms

If there are insufficient resources for the exhaustive evaluation of every criticism identified, simple pseudo-random processes may also be used to control for potential sampling bias on the part of the analyst. Such random sampling may be used either in conjunction with, or independent of the orthogonal markups described in Section 2.4 to help select and order the actual subset used for the comparative analysis of the constraints and affordances of the manual used. This core part of the approach proposed is described in Section 2.6.

2.6 Comparing the investigation against the manual

The analyst has by this point decided on a specific set of methodological criticisms to evaluate against the methodological specification expressed by the manual, and the order in which they will be analysed against the manual. They now compare the investigation done against the manual, to systematically understand the validity of each particular methodological criticism in terms of the *methodological constraints* and *methodological affordances* offered by the manual (these two notions were discussed abstractly in Section 1.3).

Concretely, the investigation done is understood in terms of whether particular investigative choices and findings were '*constrained*' (should not have done/found), '*strongly afforded*' (should have done/found), or '*weakly afforded*' (ambiguous whether should, or should not have done/found) with respect to the manual used. The detailed semantics of these mutually exclusive categories are described in the following paragraphs. The analyst should evaluate and assign each methodological criticism to one of these three categories of '*constrained*', '*weakly afforded*' or '*strongly afforded*' based on the guidance given below.

The **constrained** criticisms are those where the investigation done is unambiguously contradicted by the manual used, and where the particular criticism identified is in fact valid with respect to the manual used. This is where the manual does not offer methodological support explicitly for, but only explicitly against the investigation done.

The **strongly afforded** criticisms correspond to the converse situation, where the manual used only offers methodological support explicitly for, and not against the investigation done. This is where the criticism identified is invalid with respect to the manual.

Finally, the **weakly afforded** criticisms correspond to the situation where the manual used may offer contradictory, underspecified, or express otherwise unclear methodological prescription in supporting an investigator using the methodology. These criticisms highlight parts of the methodological specification where the users of the manual are less likely to be able to faithfully follow the methodology prescribed. Due to potential ambiguity for understanding what ought to be done, these areas of the manual highlight where the methodological specification expressed is less likely to be the dominant shaping factor in guiding an investigation. In a sense these aspects of the manual partially contradicts the point of developing a particular investigative methodology and manual in the first place. Especially under the perspective of such procedures and communicative artefacts being developed in order to induce a degree of normativity and standardisation with respect to both the actions done and findings obtained in an investigation. In the face of methodological ambiguity more *ad hoc* investigative solutions may *necessarily* dynamically develop. There may be consequently little tendency to pause in a particular line of reasoning to backtrack and develop alternative or parallel paths of reasoning, with strategies which depend on sequences of simple operations being intuitively preferred [17]. Such unpredictable investigative solutions may not always be suitable and effective with respect to the broader goal of improving safety. The minimisation of the shaping effects of the methodological guidance provided by the manual at these points of weak affordance may also indirectly raise the impact of any wider contextual confounders that may also be present to potentially confound the effectiveness and validity of investigation using a chosen methodology. Due to the generally one-to-many mapping between a particular investigative approach and the intended individual contexts of application, intentional methodological underspecification is however often necessary to ensure a usable degree of methodological flexibility. This caveat should be borne in mind when considering this 'weakly afforded' subset of the analytical results.

The analyst should fully search the manual for methodological guidance relevant to each of the criticisms under consideration. This should be done regardless of the particular portions of the manual originally used in guiding the part of the investigation being considered. This minimises the likelihood of missing methodological guidance that may be distributed across multiple, or non-contiguous sections of the manual. Detailed discussions grounded with explicit reference to parts of the manual used, as well as the account of the investigation, should be recorded to support the particular category assigned. This provides independently inspectable argumentation to support each analytical judgement made.

2.7 Resolving generalised methodological criticisms

In following our method ambiguities may arise in how to deal with methodological criticisms that are very general. For example, a broad and rather ambiguous criticism of the form: "*The investigative choices made at all steps were invalid*", is a coarse-grained and 'complex' criticism that is potentially confusing to analyse directly. Whenever such situations are encountered, the analyst may wish to deconstruct and further unpack such coarse-grained statements, until the resulting 'spawned sub-criticisms' are specified at a level of detail on par with, or more detailed than that expressed by the manual used. This should be done prior to proceeding with a comprehensive evaluation of the constraints and affordances relevant to a particular investigative choice or finding, to avoid unnecessary confusion in the comparative analysis part of our method.

2.8 The 'stopping rule' for the analytical comparison

The analytical comparison between the investigation done and the guidance in the manual (described in Section 2.6) is finished once all the criticisms of interest have been systematically evaluated in turn against the entirety of the investigative manual used.

3. Case study analysing the RCA investigation of a car parking incident

3.1 The record of the RCA-based investigation used for SRM analysis

Lundberg *et al.* [18] decomposes the process of investigation in terms of the two phases of 1) data collection and analysis, and 2) design and selection of remedial responses to the investigative findings. These two phases of investigation may in practice overlap depending on the context of investigation, and the particular approach used. In terms of the Root Cause Analysis manual used for illustrating our approach, these two aspects are relatively clearly defined. The manual used prescribes 8 sequential investigative steps in total, of which the first 6 relate primarily to data collection and analysis, and the last 2 to the design and selection of remedial actions based on the investigative understanding gained. In the case study described here we analyse only the data collection and analysis part of a RCA-based investigation.

3.2 Overview of the car parking RCA incident investigation done

The incident investigated occurred on the 10/9/2012, and was where the user of a car park (the first author) successfully managed to park the car and pay for the parking space, but did not display the proof of purchase for the space. As a result the user was provisionally charged with a Parking Contravention Charge Notice, which was eventually revoked after further correspondence with the car park management company. The RCA investigation (also by the first author) followed the first six investigative steps prescribed in the RCA manual used [8]. It involved gathering incident information leading to both the initial and final incident understanding, which was then used to analyse the root causes of this incident. Reflection provided the main means of incident understanding, and was supported by both additional photographic evidence of the site, and the correspondence with the car park management company. The starting point for this investigation was the fact that the user of the car park forgot to display the proof of purchase for parking after paying for the space.

The data collection and analysis part of the investigation provides the RCA-based understanding of the incident. It will be used to design and select remedial responses based on the guidance prescribed by the manual. Just over 45 man-hours were spent for the data collection and analysis part of this investigation, which was completed by the end of the 27th day after the occurrence of this incident, when the investigator judged the RCA-understanding of this incident to be accurate and complete. The time spent investigating, and speed of investigative response with respect to the completion of the RCA understanding are both more or less on par with this part of RCA investigations carried out in the context of safety-critical systems. In this particular case no *a priori* deadline was imposed for the time available for completing it.

A variety of contributing factors were found through the RCA investigation, and the full details are presented in [19]. This particular investigation was bounded by the potential scope of future intervention by the investigator (a heuristic suggested by the manual used). In particular, contributing factors relating to the management of the car park used was clearly outside the likely capability of the investigator to intervene on in the near future. These latent factors may however in principle be referred to the applicable external organisation [8], which in this case is the management company responsible for managing the car park used.

The chronological course of the investigation was recorded in detail in [19]. The structure and content of this document more or less matches the corresponding parts of an independent RCA investigation using the same manual in a safety critical context [20]. In the case of our record and account [19] there is arguably more detail provided on the procedural aspects of how the ongoing investigation evolved, facilitating more detailed insight into how the incident was investigated using the same manual and methodology.

3.3 A summary of the analytical results obtained using SRM

We applied the analytical approach described in Section 2 to our record of the RCA-based investigation of an everyday car parking incident. 52 methodological criticisms were initially identified, of which 42 were fully analysed and determined to be one of *constrained*, *strongly afforded*, or *weakly afforded*. 10 of these 52 criticisms were not suitable for full comparative analysis for a variety of reasons, due to being:

- contextually limited (where there was an *a priori* lack of methodological freedom before the investigation even began),
- too vague and broad for useful/practical comparative analysis, or
- either subsumed by, or duplicating a previously analysed criticism.

Out of the 42 fully analysed criticisms, 2 were found to be *constrained*, 8 to be *strongly afforded*, and 32 to be *weakly afforded* by the manual used. We give some illustrative examples in the next section.

3.4 Illustrative examples from the full analytical results

In this section we draw three illustrative examples from the full set of analytical results, to illustrate the kind of analytical reasoning enabled through the use of SRM. The full set of results are presented in two parts in [21, 22], and a summary table of these results provided in [23]. A number of criticisms raised were either subsumed, or identical to a previously analysed one. These were not reanalysed, since we would be duplicating the same comparative analysis of the manual used.

The first illustrative example relates to the stopping rules prescribed in the manual used. The full details are given under the criticism labelled C42 in [21, 22]. In this case, based on reading the account of the investigation [19], the analyst challenged the validity of the investigation being stopped as soon as one of the stopping rules prescribed in the manual used was satisfied (rather than stopping only when all the stopping rules are satisfied). In general the particular choice of stopping rules to use obviously has a significant impact on the scope of an investigation and the subsequent responses. Through SRM analysis we found that there were in fact three discontinuous places where stopping rules were prescribed. The first place presented a set of three (prose-based) disjunctive stopping-rules, the second place presented a (diagrammatic) intervention-consequence-estimation type of rule, and the third and final place presented a (prose-based) team-consensus based rule. The particular choice made in the investigation analysed was to stop further 'latent exploration' as soon as one of these stopping rules was fulfilled. The systematic analysis found that this investigative choice was ambiguously supported by the manual used. The three stopping rules prescribed were clearly quite different in nature, and the manual used offered no explicit guidance on how these rules ought to be prioritised. An assignment of 'weakly afforded' was given to this particular investigation choice. This assignment represents the argument that given the set of diverse stopping-rule prescriptions presented in this manual, it may be somewhat unpredictable which ones are in fact used in practice. Under the semantics described earlier in Section 2.6, this highlights an area of potentially weak 'methodological control', which may then in principle be discussed with the manual/methodology writers to confirm whether this empirically observed methodological ambiguity is indeed intended. Conversely, the methodologically ambiguous nature of the stopping rules prescribed in this manual means that this aspect of the investigation done is arguably quite reasonable and valid with respect to the investigative manual used.

The two *constrained* analytical results obtained (see C43 and C46 in [21, 22] for full details) both relate to the fact that there were several investigative findings incidentally found (through accidentally exploring beyond the scope of the stopping rules prescribed). From the account of the investigation done, these were not apparently intended to be included as part of the overall formal investigative understanding of the incident. The SRM analysis facilitated the analyst in understanding that such omission should not have been so, given the methodological prescription in the manual used. The extent of the formal understanding of an incident presented clearly may have an impact on the subsequent organisational learning and responses. In this case, the 'constrained' nature of this investigative omission clearly highlighted an aspect of the formal investigation that ought to be further improved (and will be as part of our broader study). Through the analysis we found that any such additional findings ought to at the very least be included as part of the 'incidental findings' part of the formal RCA investigation.

A third illustrative methodological criticism was for the analyst to challenge the fact that in the RCA investigation done, only a single investigator investigated the incident (see C11 in [21] for details). In terms of our analytical evaluation of the manual used, this was an *a priori* limitation imposed on this investigation, where we knew in advance that the reason for this investigative choice was not mainly due to the manual used. Such contextually limited methodological criticisms represent where a particular aspect of the actual investigation done was simply

due to pragmatic and practical contextual limitations similar to ones that may be found in investigations within safety critical settings. This was therefore not comparatively analysed, because it would offer little insight into the methodological properties of the RCA manual and methodology used in this particular case.

4. Discussion and conclusions

A relatively simple investigative context was used to trial, and demonstrate the analytical evaluation approach proposed in this paper. The results show that it can be applied to analytically evaluate the degree to which an actual investigation adheres to the prescriptive guidance provided by the manual used. It was developed originally as a means to ensure that the investigation done was indeed valid with respect to the RCA manual and methodology used. The analytical results obtained largely confirmed this assumption. The two *constrained* issues found through the comparative analysis highlight minor improvements to be made to the RCA investigation done. To improve the heuristic coverage and objectivity of the analytical results reported in this paper, an independent researcher is currently applying the same SRM procedure using the same investigation account and investigative manual.

The analytical approach proposed has helped to highlight areas of methodological certainty, and areas of potential methodological ambiguity in the manual used. In principle, investigative actions and findings that were found to be only *weakly afforded* by the manual could support focussed discussion with the manual writers and method developers. Such discussions may help to understand whether the corresponding parts of the manual do in fact need to be further revised and refined, and if so how this may best be done. Such manuals are necessarily relatively static communicative artefacts. Real socio-technical systems are dynamic and ever-evolving. There will, therefore, likely always be a need to understand and respond to the potential, and ongoing gap between such normative guidance and the needs of investigators in practice. With minor amendments, the approach proposed here may perhaps be also usable for facilitating a better understanding of the relation between methods and their consequent applicative results in other non-investigative domains.

Investigative manuals are generally aimed at a variety of end users. For example a part time investigator looking only at minor incidents may have different needs to a senior national investigator. The manual we used was not intended for investigating everyday incidents but for investigating major medical incidents. Due to the relatively simple, and domain-independent nature of RCA (i.e. using a simple causal-tree based model to investigate incidents), we believe that the investigation done, and analytical results reported here nevertheless do still offer some relevant insight into the performance and methodological properties of RCA. Efforts were made during the investigation to do investigative activities that were equivalent to the medical-specific parts of the manual used (see [19] for details). The analytical approach we propose has in this case provided deeper understanding of the constraints and affordances of the generic, rather than domain specific aspects of the RCA manual used.

Hale and Borys [24] present a detailed review of how safety rules have been perceived in the past. They draw a stylised sketch of previous thinking on safety rules according to two opposing views. One view treats such rules as static 'gold standard' prescriptive guidance to be followed rigorously and indiscriminately irrespective of the needs and nuances of the specific application context. The other regards such rules as being there to be necessarily broken in the face of the dynamic and ever-evolving needs of operators in systems in reality. These two views are likewise slightly caricatured here to make the contrast very obvious, and in this paper the operators are the investigators using investigative manuals and methodologies (which are treated as 'complex safety rules'). We agree with Hale and Borys, and other researchers in the field, in arguing for the need to understand how to better bridge the gap between prescriptive procedure and practice. The ideal situation where such prescriptive rules act as a perfectly well-fitted and complementary methodological instrument supporting the domain expertise of investigators may be theoretically difficult and perhaps impossible to achieve, but is nevertheless a positive goal worth aiming for. The analytical approach offered in this paper is one potential means of facilitating this, to contribute towards the broader ongoing dialogue for better understanding how to achieve a more synergistic relationship between investigation in theory and investigation in practice.

Acknowledgements

This work is supported by the EPSRC grant on 'CHI+MED: Safer Medical Devices' (EP/G059063/1). We are also grateful to the reviewers for informal but constructive feedback on an earlier abstract for this paper.

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Note: The weblink for reference [8] was recently updated with a 2012 version of the RCA manual. The 2006 version of the manual used for our study may be provided on request.