Elicitation of knowledge from a defence expert

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Abstract. The aim of this work is to understand the way that a defence expert defines the concept of importance in relation to the ideas contained in a scientific document. The expert’s views on the importance of the concepts in this document were elicited in two phases. In the first phase, the expert was asked to summarise an eight-page document on the effects of electromagnetic fields on propellant combustion. Completion of this task generated a series of ‘key points’. Phase two of the methodology was a sit-down interview with the expert. This interview comprised three parts: asking the expert to talk through why each of the key points were important, asking the expert to sort the key points into categories according to how important they are and then asking the expert to generate categories of why the points are important. The techniques used for expert elicitation proved highly successful in relation to this domain of knowledge. Not only were the procedures able to extract the underlying categories through which the expert structured their understanding of the field, but the results indicated reliability in the content of knowledge extracted through different methods. Subsequent papers in this project compare this work to parallel analysis conducted using Natural Language Processing tools.

1. Introduction

1.1. Loss of knowledge
An increasingly pressing problem in the field of defence is the loss of expert knowledge from the retirement of key personnel. Over a prolonged period in an organisation, an employee will develop deeply contextualised knowledge of specific business systems and procedures. When this employee retires this expert knowledge will be lost and is difficult to replace [1]. The significance of this problem is becoming more apparent globally due to an increasingly ageing population. For example, by 2040, approximately one in seven people in the UK will be over the age of 75 [2]. As the UK population ages, retirement rates will rise leading to an increasing number of workers leaving the work force; hence, some roles will hence be left vacant due to a lack of suitable replacements [3]. In extreme cases, this can result in organisations resorting to hiring back retired employees at consultancy rates to resolve complex expert problems.

One potential solution is the development of expert systems that could aid the preservation and transfer of expert knowledge by emulating expert decision making. Expert systems generally consist of a knowledge base and an inference system [4]. The knowledge base, typically designed by a knowledge engineer, consists of facts and information as well as data considered in context
about the domain in question. The inference system uses the knowledge base to obtain a solution to a problem [5].

However, ever since the earliest work on expert systems, both computer scientists and psychologists have struggled with issues around eliciting expert knowledge for the knowledge base [6] [7]. Popular knowledge acquisition methods in the early 90s rely on knowledge acquisition methods from psychology [8]. In recent years these methods have become less popular as a result of the ‘information boom’. Through the development of social media and web-publishing of journal articles, the quantity of information on the web has dramatically increased. Expert systems have consequently evolved to exploit the large quantities of data readily available [9]. As a result, those involved in developing expert systems have turned to computerised methods of processing large quantities of data such as Natural Language Processing (NLP) tools that utilise neural networks [10].

Artificial Neural Networks (ANNs) emulate a human brain. The learning process of a brain is replicated by mimicking the function of its neurons [11]. There has already been some success in developing these systems within the medical field [12] [13]. However, there are some significant disadvantages with using ANNs, e.g. they typically require large quantities of relevant training data for the learning process [14]. This is a hurdle in information-restricted fields, such as the defence industry, which are often the most effected by the loss of knowledge problem. This is because information in these fields is typically complex, interdisciplinary and siloed. Furthermore, the inherently sensitive nature of the information in these fields makes its dissemination even more problematic. As a result, it may be productive to reconsider more traditional forms of knowledge elicitation and compare them to the more contemporary advances in computer science.

1.2. Project overview

This paper forms the first part of a wider project aiming to conduct an in-depth analysis of the ability of traditional NLP tools to acquire expert knowledge. This will be achieved by conducting a direct comparison of the ability of these techniques, against a group of technically-trained readers, to extract what an expert considers to be important in a single document. The exemplary document used in this study is from the field of propellant combustion, meaning that the knowledge to be explored has direct relevance to a defence context.

The document in question is generated as one component of a three-step process. First, policy-makers generate a defence-based driver or requirement. Then, experts in science and technology evaluate the “state of the art” research to define ongoing research projects. This work then leads to the required technological developments. The document used in this study aims to evaluate the latest technological developments within the field of electromagnetic control of combustion in order to eventually lead to the development of defence-based technologies.

This paper presents the first stage of the project: elicitation of knowledge from a defence expert. The purpose of this stage of the research is to elicit the expert’s complex content schema in a confined domain; specifically, this work focuses on eliciting how the expert evaluates the importance of the different points in the technical document. The aim of this phase of the study is to understand the way the expert defines the concept of importance in relation to the ideas contained in a scientific document. Subsequent papers in this project compare this work to parallel analysis conducted using NLP tools.

2. Elicitation of knowledge

One of the challenges in expert knowledge elicitation has been to access an expert’s conceptualisation of their subject area without the knowledge engineer imposing their own view of the field via the elicitation process. In order to achieve this, a variety of open-ended elicitation
techniques have been employed. One of the earliest versions was the Repertory Grid technique, derived from Kelly’s Personal Construct Theory [15].

This tool, while popular with knowledge engineers in the early 90s [16], has subsequently been criticised as a method of knowledge acquisition because it assumes that people organise their knowledge along linear dimensions into bi-polar categories [17].

To address the problems of the repertory grid, Canter et Al [18] developed the multiple sorting method. This well-established method allows a participant to sort elements into categories of their own devising as opposed to using constructs given to them by the interviewer. When categories are presented to the interviewee this can subject the interviewee to bias, since asking to sort elements into categories implies a lot about their expected response. The multiple sorting method allows the interviewer to elicit the meanings and explanations associated with an individual’s categories as well as understanding the organisation of the elements within the categories [19].

No limitations are placed on the sorting process, i.e. the number of categories is undefined. This allows the interviewee to truly conduct the sorting in a way that mirrors their thought process and allows the researcher to obtain insight into the underlying frameworks by which someone organises their own knowledge [20].

Recently the multiple sorting method proposed by Canter et Al has been used in conjunction with in-depth interview methods [21]. The in-depth interview methods allow for participants to talk in detail through the reasoning behind the sorts. In combining the in-depth interview approach with the sorting task, more evidence is gathered to establish the validity of the conclusions and results elicited from the interview [22] [23]. In addition, the reasons behind the sorting may be revealed in more detail when done in conjunction with the interview methodology. By allowing the interviewee to talk through the elements separately they are encouraged to think in detail about each of the elements. This results in a sorting process that has been more considered and hence more likely to be evidenced.

An expert would be expected to have a complex and layered construct system of the domain they are an expert in. Through years of experience in a certain domain, their own construct system would be expected to be refined in a way beyond surface features [24]. As a result, eliciting knowledge from an expert would be expected to be more complex and intensive than eliciting knowledge from a novice [25], and can therefore be time consuming and cost expensive.

3. Capturing expert understanding

3.1. Stimulus materials

An eight-page technical report providing an overview on the effect of electric and magnetic fields on propellant combustion was selected to be the exemplary document of this study. The document contains a review of scientific and technological developments on the effects of magnetic and electric fields on combustion. The emphasis of the paper is on solid propellant combustion but relevant papers describing the effect on liquid or gaseous combustion are also reviewed. The aim of this paper is to establish potential routes of exploration for future defence-based endeavours.

The report was selected as it is on a well-defined neutral subject matter, reducing the amount of additional biases or prejudices in the future participants’ interpretation of the text. Furthermore, the length of the report is a manageable number of pages for human analysis. The report is of a technical nature but focuses in detail on a specific domain.
3.2. The expert author

Given that in this study the domain expertise is limited to a single document, the most obvious expert on the information contained in the document is its author. Therefore, it was decided that the expert to be interviewed in this study would be the author of the document (who was recruited on a voluntary basis).

In this instance, the expert has over 17 years of experience working in commercial research areas and over 23 years experience working in government research fields related to this domain. They therefore have an extensive knowledge base in the selected field of propellant combustion.

3.3. Procedure

The process of eliciting the expert’s views on the importance of the concepts in this document is a two-stage procedure. Phase one consists of a summarisation task. Phase two is a three-part sit down interview. Details of the procedure are detailed below.

3.3.1. The summarisation task

The expert was asked to complete a summarisation task of a report on the effect of magnetic and electric fields on propellant combustion of which they are the author. After reading the report they were asked to list the points they felt were most significant in the text. These points will henceforth be referred to as ‘key points’. The definition of importance was left to the expert to interpret. No constraints regarding the number of points or the word limit of a key point were given. The expert was asked to identify the five most important key points in the text and then rank them in order of importance, with 1 being the most important and 5 being the least important. This information was elicited via a questionnaire.

3.3.2. Interview

On completion of the summarisation task by the expert, an interview with the expert was conducted in order to elicit a more in-depth examination of how the expert views the importance of the key points they generated in the summarisation task. Given the subjective nature of the concept of importance, exploring the topic in this in-depth manner was fundamental to generating an understanding of the expert’s content schema.

The interview was divided into three main tasks: 1) exploring the importance of each of the expert’s key points, 2) ranking the key points and 3) a sorting task.

Before the interview, each of the expert’s key points were printed onto identical cards. The interview was conducted in a formal setting around a table. The cards were also labelled A-Q in order to make the recording process easier. Figure 1 shows an example of a key point card.

Figure 1. Example of a key point card. Points were labelled A-Q in the top right hand corner to aid the recording process.

In the first stage of the interview, the expert was presented with a key point card and asked to explain why they thought that particular point to be important. The card was then removed.
from the table and placed into a pile and the expert was presented with another card and the process was repeated until all of the key points had been talked through. The purpose of this activity was to familiarise the expert with the material and encourage them to consider why each of the points were important individually.

On completion of this task, five cards, labelled one to five, were laid out upon the table. The interviewer informed the expert that each of these cards represented five distinct groups, the card labelled (1) being the least important and the card labelled (5) being the most important. The expert was asked to place each of the shuffled key point cards into one of the five groups. The aim of this activity was to extract how important the expert views each of the key points in the context of the other cards. Using printed cards on a table allowed the expert to visualise the process as they performed it. This task will henceforth be known as the 'rating of key points'. Figure 2 illustrates the set up configuration.

The final part of the interview was the multiple sorting task. The method used in this part was an adaptation of Canter et Al’s multiple sorting procedure. The following adaptation from Canter et Al [18]. was read to the participant.

“You have indicated that the points you identified might be important for different reasons. Therefore we would like you to think about the points that you generated [hand cards over] and to sort them into groups in such a way that all of the points in any group are similar to each other in terms of the reason why they are important, and different from the points in the other groups. You can put the points into as many groups as you like and put as many points into each group as you like - it’s your views that count. Once you have carried out the sorting, I would like you to tell me the reasons why you put the points into each group and what is the points have in common.”

The expert was asked to form their own categories of importance, thereby avoiding imposing any preconceptions from the researcher. The number of categories and the number of points in each category was also left to the expert. Figure 3 illustrates this set up.

Once the expert had sorted the points into categories they were asked to explain the reasons for their classifications. The interview ended with an open-ended question: is there anything
else we haven’t talked about you think I should know? This gives the expert the opportunity to verbalise anything else not said that they feel is relevant.

4. Results

4.1. Summarisation task

The results from the author’s summarisation task are shown in table 1. The first column indicates the key point the expert found to be important. The second column assigns a label to each of the points which will be used later. The third column shows the importance rating the expert assigned to each of the top five most important points, where 1 is the least important and 5 is the most important point. As mentioned in section 3.2.1, no word limit was given to the required length of each point nor to the total number of points.
Table 1. Table displaying the expert’s key points, importance rating assigned and a label assigned to each key point.

| Key Point                                                                 | Label |
|---------------------------------------------------------------------------|-------|
| The application of a magnetic field may affect solid propellant combustion, particularly if ions play a significant role in combustion. | A     |
| Magnetic control of combustion falls into 4 main areas: direct control of the surface burning, influence on the manufacturing process, influence on the combustion flow patterns, and upstream polarisation of the fuel system. | B     |
| Burn rate increases of up to 20% have been observed due to the presence of a magnetic field. However, the results have been variable. | C     |
| Effects may depend on whether combustion occurs in the gas phase or at the surface, resulting in burn rate decreases or increases respectively. | D     |
| Application of a magnetic field during the manufacturing process of a solid rocket propellant containing metal additives has resulted in a 20% increase in burn rate. | E     |
| Theoretical studies conducted by scientists in Tomsk indicate a combustion rate of up to 10 times might be possible. | F     |
| Ionising additives to seed the propellant are necessary to improve the specific conductance to obtain greater effects. | G     |
| The application of an electric field may affect solid propellant combustion. | H     |
| Electric control of combustion falls into 2 main areas: direct control of the burning surface, and ignition and control of the ablation and combustion of electrically conductive solid propellant. | I     |
| Work conducted at Imperial College by Mayo et al in the 1960s resulted in burn rate increases of up to 200 times and burn rate decreases of up to 10 times when applying voltages up to 30kV. | J     |
| A typical rocket propellant containing ammonium perchlorate, aluminium (with and without) and HTPB with iron added showed a decrease in burn rate in the presence of an electric field, regardless of polarity and the decrease was approximately linear with applied voltage. | K     |
| A combined theoretical and experimental study indicated that burn rate increases in the presence of an electric field were due to current heating of the unburnt propellant whereas burn rate decreases were due to flame electrons inhibiting combustion. | L     |
| The PMMA flame is known to contain surplus positive particles. In the presence of an electric field, these can be driven towards the burning surface thereby increasing the combustion rate. Up to 30% increases were observed using voltages up to 35kV and electric fields of up to 266V/m. | M     |
| Electric solid propellants (ESPs) are a relatively new development and have been used in microthrusters. More recently they have been used in electrothermal-chemical (ETC) guns. | N     |
| In an ESP/ETC gun, electrodes are an integral part of the charge. | O     |
| Burn rate enhancements of a solid propellant, similar to JA2 but with metal additives to increase the electrical conductivity, in an ESP/ETC gun have been achieved using as little as 500V. Multiple discharges were possible, achieving a flattened pressure-time profile. | P     |
| Apart from one paper in 2015, no other papers on ESP/ETC have been found. | Q     |
The expert produced a total of 17 points of varying word length.

4.2. Interview

As mentioned in section 3.2.2, the interview consisted of 3 main components. The first of these asked the expert to explain why each of the key points (detailed in table 1) are important. No specific definition of importance was given to the expert, as the purpose of this interview is to elicit how the author evaluates the importance of different concepts in the document.

A transcript of the interview was from this a summary of why the expert found each point to be important was produced. Details of the results are given in the analysis section.

An important note about point N: in the context of the interview, the expert discussed the point as being part of a wider experiment talked about in the document. This is not something that may not necessarily be understood by viewing the point on its own. The expert rated the point in this wider context. The point will henceforth be considered in this context.

The results of the rating task are displayed in table 2.

| A | B | E | J | N |
|---|---|---|---|---|
| F | C | G | L | P |
| D | K | M |
| Q | H | O |
| I |

Once the sorting was completed the expert was asked to explain the reasoning behind their sorting. The author described the most important points (placed in group five) as those that were more application-orientated. These points looked specifically at how enhancing the combustion rate through the use of electromagnetic fields can be applied in a real application as opposed to considering enhancement of combustion in a theoretical or specialised environment. The point P was said to be the most important as this actually demonstrated how enhancing the combustion process through the use electric and magnetic can be effectively applied.

The author also remarked that the points that they considered the least important were those concerning magnetic fields. The reasoning given to this was they felt that studies in this field were not as consistent or reproducible in an application.

The expert further noted that points such as F were placed in lower importance categories as they concerned theoretical studies conducted under specialised circumstances, which would not be directly possible to replicate in an application. The author remarked that studies that were experimental were seen as higher value that non-experimental studies.

The expert was then asked to complete the open-ended sorting task. The expert sorted the key points into four distinct categories of their own devising. These categories are defined as follows:

- Group $\alpha$ is defined as key points that are ESP gun related.
- Group $\beta$ is defined as results which quantify the effect of electric fields on the increase in burn rate.
- Group $\gamma$ is defined as quantifying the effects in terms of the increase and decrease in burn rates seen for magnetic fields.
• Group δ is defined as key points that describe the physics and chemistry of the processes occurring.

Table 3. Table showing the key points sorted into four distinct categories generated by the expert.

| Group α | Group β | Group γ | Group δ |
|---------|---------|---------|---------|
| O       | H       | A       | B       |
| Q       | J       | E       | I       |
| N       | K       | F       | D       |
| P       | M       | C       | L       |

The expert had no comments in response to the open-ended question asked at the end of the interview.

5. Analysis
5.1. Collective observations
As mentioned in section 4.2, once the sorting was completed the expert was asked to explain the reasoning behind their sorting. It was clear the expert viewed the most important category as the most application-orientated and the least important as that viewed to be of less interest in terms of developing an application. It is clear there is a link between how important the expert views the topic to be and its applicability.

In the process of talking through the key points it was revealed the expert used past knowledge to direct their analysis. For example, when discussing why point F was important, the expert explained that from previous work they were aware of good quality theoretical work by scientists in Tomsk within the domain of enhancement of combustion rate using electromagnetic fields [26] [27]. It is for this reason the expert looked at the work completed by these scientist for this report. A similar point was made when discussing point J and the work of Weinberg and Mayo [28]. Similar remarks were made in a study [29] which remarked that when evaluating academic texts the physicists would often use the reputation of the author to guide text selection.

In addition, the expert described the approach to writing the document. It was described how the expert divided the literature on the topic into categories and subcategories based on the physical categories and the applications within the physical categories. The categories were magnetic and electric fields and the subcategories were direct control of the surface burning, influence on the manufacturing process, influence on the combustion flow patterns, and upstream polarisation of the fuel system and direct control of the burning surface, and ignition and control of the ablation and combustion of electrically conductive solid propellant. It is of note that in section 4 the categories devised by the expert in the sorting task were labelled in a similar manner: 'quantification of the effect of electric fields on the increases in burn rate' and 'quantification of the effect of magnetic fields on burn rate'. It is significant that of all the subcategories of literature mentioned in the text only one specific subcategory was used in the authors own categorisation in this interview, 'ETC' gun related. This perhaps further backs up the idea that ETC guns were considered to be the most important application of this work. It is of interest that the sorting task uncovered the way the expert structured the process of writing the document.
5.2. Independent reasoning categories.
The first stage of the analysis draws upon the open-ended descriptions of the key points the expert generated in the interview with the researcher. The transcript of the interview was content analysed in order to generate a series of conceptual categories that represent the range of explanations given by the expert.

These categories will be referred to as, ‘independent reasoning categories’. It is noted that these categories are not necessarily mutually exclusive since it is possible for a point to be in more than one category. The results of this analysis are shown in table 4.

The first category of importance identifies those key points that were said to be important because they were a key piece of theoretical information vital to understanding the scientific processes in the document. ‘Theoretical importance’ applied to points A, G, H and O. In the interview process the expert explained the theoretical value of these points.

The expert explained that when the literature was surveyed they divided the reviewed documents up into two separate categories according to physical concept: papers discussing the effect of magnetic fields and papers discussing the effect of electric field. Within these two categories the literature was further divided up into four and two subcategories respectively. Points B and I detail these subcategories explicitly. The expert explained that these points were important because they describe an overview of the topics covered in the paper. These points were therefore categorised as being a ‘Domain Overview’.

Transcript analysis determined that key points N and P should be grouped together as they demonstrate a direct use of increasing the combustion rate with an electric field in an application: ETC guns. They therefore formed the category: ‘Demonstrated use in an application’.

| Category                        | Definition                                                                 | Key Points |
|---------------------------------|---------------------------------------------------------------------------|------------|
| Theoretical Importance          | A key piece of theoretical information vital to understanding the scientific processes in the document. | A, D, G, H, L, O |
| Domain Overview                 | This is important because it provides an overview of what is talked about in the document. | B, I       |
| Demonstrated use in an Application | This is important as it is a validated example of the work being used in an application. | N, P       |
| Practicality of Methodology     | The methodology described is one that can be applicable to an application. | E, K       |
| Results show clear quantification of effects | The results shown demonstrate a clear quantification of the effects. | F, J, K, M |
| Advancement of the field        | This is important because it is key to understanding how the field has evolved and/or refined itself. | C, Q       |
| Novelty                         | This is important because it is new.                                       | M          |

Point E details how burn rate increases were achieved by treating rocket fuel propellants with magnetic fields in the manufacturing stage. The expert explained that this point is important because it illustrates how burn rate increases can be achieved using a method that is practical
in a commercial environment. A similar point was made when describing why point K was important. The expert specifically highlighted that the methodology described in this point was polarity independent. The fact that the method used to achieve an increase in burn rate was polarity dependent could make it more feasible to be implemented in a practical application. As a result, points E and K were added to the ‘Practicality of Methodology’ category.

When discussing point K, the expert gave another reason why point K was important. Point K states the decrease in the applied voltage was linear with the applied voltage; the expert said that this clear quantification of the effects observed was important as it would be easier to implement in a practical environment. Having a clear quantification of the observed effects would allow for prediction of performance enhancement in an application. For instance, if the work was implemented in a tank gun system one would be able to predict increases in the velocity, range and hence lethality of the gun. Similar reasons were given to explaining the importance of points J and F. These points were hence grouped together into a category, 'Results show clear quantification of effects'.

It is noted the expert made a clear distinction that the results for F were obtained through theoretical analysis only. At various points throughout the interview the author made several references stating that theoretical work was thought to be less important that experimental. Given this, point F could arguebly be in its own subcategory within the larger category of ‘Results show clear quantification of effects’.

Point M was placed into a category labelled ‘novelty’. Point M details a method of achieving the desired control of burn rate in an electric field through the use of positive as opposed to negative species. The expert found this to be significant as it was able to achieve the desired physical effect in a new and distinct way from the other methods described in the paper.

Point C was placed into the category of ‘advancement of the field’. The expert explained that this point was important because it was one of the first studies in the area and although the results were not necessarily well understood, they did show some burn rate increase. It was highlighted that this result formed the basis of future work.

Point Q was also placed in this category. Point Q describes how only one paper on ESP/ETC guns was found. The expert used their expert understanding of the field to explain why this is of significance. From experience the expert knew that if publication was halted it could mean either adverse results may have been obtained leading to a cessation of the work, or that work might have been very successful in which case further work became classified.

In section 4.2, the expert generated four distinct categories of importance. These categories will be explored in more detail by considering the independent reasoning categories assigned to each of the key points in these expert generated categories. Table 5 summarises the categories generated by the expert alongside the reasoning categories assigned to each point in each category.

The starting point of this analysis was to examine group \( \delta \). This group was specified as points that were important because they described the physics or chemistry of the processes occurring. Using the independent reasoning categories, it is clear this group is subsequently divided into two further separate categories: Theoretical Importance and Domain Overview.

Aside from group \( \delta \) there seems to be no relationship between the groups and the reasons of importance between them. This implies the expert has generated the groups \( \alpha, \beta \) and \( \gamma \) purely on the overall physical effect being described by the points as opposed to anything else.

5.3. Rating comparison with summary ratings
A direct comparison of the expert’s key point ratings with the output of the rating task conducted in the interview was performed. Table 6 displays a comparison of the five highest ranking key points in the key points exercise with the corresponding category the expert placed them in the interview.
Table 5. Table showing the categories generated by the expert with the points replaced by their corresponding reasoning categories.

| Group α: Theoretical Importance | Group β: Advancement of the field | Group γ: Domain Overview | Group δ: Domain Overview |
|---------------------------------|----------------------------------|--------------------------|--------------------------|
| Results show clear quantification of effects | Practicality of Methodology and Results show clear quantification of effects | Theoretical Importance | Practicality of Methodology |
| Demonstrated use in an Application | Novelty | Domain Overview | Theoretical Importance |

Table 6. Table showing expert’s top rated points alongside the importance category assigned each point in the interview task.

| Key Point | Rating | Importance Category |
|-----------|--------|---------------------|
| Electric control of combustion falls into 2 main areas: direct control of the burning surface, and ignition and control of the ablation and combustion of electrically conductive solid propellant. | 5 | 3 |
| Magnetic control of combustion falls into 4 main areas: direct control of the surface burning, influence on the manufacturing process, influence on the combustion flow patterns, and upstream polarisation of the fuel system. Work conducted at Imperial College by Mayo et al in the 1960s resulted in burn rate increases of up to 200 times and burn rate decreases of up to 10 times when applying voltages up to 30kV. Burn rate enhancements of a solid propellant, similar to JA2 but with metal additives to increase the electrical conductivity, in an ESP/ETC gun have been achieved using as little as 500V. Multiple discharges were possible, achieving a flattened pressure-time profile. The PMMA flame is known to contain surplus positive particles. In the presence of an electric field, these can be driven towards the burning surface thereby increasing the combustion rate. Up to 30% increases were observed using voltages up to 35kV and electric fields of up to 266V/m. | 2 | 5 (Most Important) |
| | 3 | 2 |
| | 1 | 4 |
The rating task is compared to ranking completed at the time of the summarisation task. It is clear from the table that several of the highly rated points are highly rated in the key points task. This indicates consistency in the expert’s evaluation.

Only two of the five top-rated key points appear in the top two most important categories in the rating task completed in the interview. The top two rated points in the summarisation task (B and I) were said to be important because they were helpful to understanding the document as they surveyed the literature reviewed (see table 4). It is possible the process of talking through the points individually in terms of their importance may have encouraged the author to rethink his evaluation of importance of these two points. This may also explain why only one of the two points in the most important category in table 2 appeared in the top 5 most important points in the summarisation task.

6. Conclusion
The aim of the work completed in this paper was to elicit the author’s complex content schema in a confined domain. The work specifically focused on eliciting how the expert evaluates the importance of the different points in the technical document.

The expert’s views on the importance of the concepts in this document were elicited in two phases. In the first phase the expert was asked to summarise an eight page document on the effects of electromagnetic fields on propellant combustion. Completion of this task generated a series of ‘key points’. The expert was asked to rank the five most important points. Phase two of the methodology was a sit down interview with the expert. This interview was comprised of three parts; asking the expert to talk through why each of the key points were important, asking the expert to sort the key points into categories according to how important they are and then asking the expert to generate categories of why the points are important.

The techniques used for expert elicitation proved highly successful in relation to this domain of knowledge. Not only were the procedures able to extract the underlying categories through which the expert structured their understanding of the field, but the results indicated reliability in the content of knowledge extracted through different methods.

For example, the different extraction techniques employed consistently revealed the prominence of application in the way the expert defined the importance of the material contained in the document. Analysis in sections 5.1 and 5.3 showed that the expert viewed the most important category, \( \alpha \), as the one has the most demonstrated use in an application. The most important points in the rating task were found to be part of the same category.

In addition, in section 5.2 it was shown there were various factors considered by the expert when assigning importance in terms of use in an application; the practicality of the methodology, whether or not use has been demonstrated in a application and if the work in question has been able to quantify the effects in a way that would be useful for applications.

It is clear from this work the expert has an advanced and complex content schema in this domain. Whilst the sorting appeared to be picking up on basic surface features, the more in-depth interview revealed a complex and detailed level of understanding typically associated with experts. There were several points which used clear indications of expert knowledge, the first being the identification of what features in a methodology make it suitable for a practical application. During the interview the author noted that low voltages, for example, were a feature necessary to achieve adaptation to an application. A further example of this is shown in the fact the author kept mentioning that having a clear quantification of the effects observed was important as this would lead to use in an appropriate application. This expert insight is not something that would necessarily be known to a novice.

There has been much work on the comparison between how novices and experts interpret academic text [30][31][32]. The next step in this project will be to ask a group of technically trained readers, that are novices in the domain, to complete the summarisation task detailed
in section 3.1 as well as a rating task. It would be of interest to see how different readers from different backgrounds perform in the completion of this task.

As mentioned in the introduction, this is part of a wider project aiming to examine the ability of Natural Language Processing (NLP) tools to elicit domain specific knowledge. The next phase of this research will focus on generating a parallel analysis using NLP tools.

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