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Conceptualising forensic science and forensic reconstruction. Part II: The critical interaction between research, policy/law and practice

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ABSTRACT

This paper builds on the FoRTE conceptual model presented in part I to address the forms of knowledge that are integral to the four components of the model. Articulating the different forms of knowledge within effective forensic reconstructions is valuable. It enables a nuanced approach to the development and use of evidence bases to underpin decision-making at every stage of a forensic reconstruction by enabling transparency in the reporting of inferences. It also enables appropriate methods to be developed to ensure quality and validity.

It is recognised that the domains of practice, research, and policy/law intersect to form the nexus where forensic science is situated. Each domain has a distinctive infrastructure that influences the production and application of different forms of knowledge in forensic science. The channels that can enable the interaction between these domains, enhance the impact of research in theory and practice, increase access to research findings, and support quality are presented. The particular strengths within the different domains to deliver problem solving forensic reconstructions are thereby identified and articulated. It is argued that a conceptual understanding of forensic reconstruction that draws on the full range of both explicit and tacit forms of knowledge, and incorporates the strengths of the different domains pertinent to forensic science, offers a pathway to harness the full value of trace evidence for context sensitive, problem-solving forensic applications.

1. Introduction

The need for research in forensic science that addresses theory and principles to underpin the discipline is not new [1]. More recently the published literature has articulated clearly the need for a research culture that undergirds the whole forensic enterprise and offers high quality empirical research to address theory, policy and practice of forensic science [2–4]. Indeed, the importance of the development of empirical evidence bases to inform the interpretation of forensic evidence has been highlighted as one of the highest priorities for forensic science [5] given that 'our ability to analyse may outstrip our ability to interpret [trace evidence]' [6]. Whilst the role of trace evidence has been challenged (as outlined by Robertson and Roux [7]), it is acknowledged that trace evidence can offer answers to pertinent questions asked during forensic investigations. There is, therefore, value in incorporating trace evidence into forensic reconstruction approaches [8]. The FoRTE model that outlines the role of trace evidence within the forensic science process, and the critical components for effective forensic reconstruction inferences, has been presented in part I of this paper [9]. Such a conceptualisation of the forensic science 'endeavour' [10] offers the means for effectively harnessing the insights from trace evidence, ensuring that robust evidence bases undergird each stage of the forensic process, and offer a foundation upon which to test the strength and/or significance of the trace evidence that is identified in a specific case. Understanding the holistic system that encompasses forensic reconstruction offers a very significant step to addressing the call to enable trace evidence to be utilised effectively [8], and forensic science to deliver robust, transparent, reproducible intelligence and evidence.

This paper builds from the FoRTE conceptual model [9] to address:

- The forms of knowledge that are integral to the model, which exist in every forensic science reconstruction.
- The domains of practice, research, and policy/law that intersect to form the nexus where forensic science is situated [11].
- The role of the institutional infrastructures of those intersecting domains and the individuals within those institutions, in the production of new knowledge in forensic science.

Understanding the different forms of knowledge (what we can know) that are embedded in the forensic science process and in the forensic reconstruction approach offers insights into how best to use

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those different forms of knowledge to ensure that forensic reconstruction is a truly holistic enterprise. Incorporating the roles of the intersecting domains of practice, research, and policy/law into the model situates a conceptual approach in reality, and thereby enables the different requirements of each domain to be incorporated into the forensic reconstruction process. Addressing the production of knowledge within those different domains at both the individual and institutional level offers the opportunity to identify the different strengths within this forensic science 'matrix'. By drawing upon the diverse forms of knowledge integral to forensic reconstruction, and the approaches to knowledge production, and individual and institutional characteristics, it is then possible to begin to articulate paths for going forward. These paths need to be those that harness the strengths of the intersecting domains to ultimately present an effective approach for forensic reconstruction that is able to assist both the theory and practice of forensic science.

2. Knowledge and how it intersects with forensic reconstruction problem solving

Knowledge within forensic science will take a variety of forms [12–14].

Within the FoRTE model [9] the forms of knowledge present within each component is a critical factor because the model incorporates both high quality, empirical evidence bases to underpin each stage of the forensic process, and also the expertise required for case sensitive inferences that contribute to the forensic reconstruction. The concept of explicit and tacit knowledge [15] offers a way of conceptualising the continuum of knowledge. The continuum encompasses knowledge that is articulated explicitly (codified, abstracted and easily communicated knowledge) or manifested implicitly or tacitly (less easy to codify, often learnt by doing, and more difficult to articulate). Developing an understanding of where and how different forms of knowledge contribute to forensic science is significant if we are to develop a nuanced approach that can deliver effective and robust forensic reconstructions.

2.1. The explicit and tacit knowledge continuum

Therefore, within forensic reconstruction, we are seeking to bring together different forms of knowledge and expertise in order to develop reliable, transparent, robust interpretations of evidence. To achieve this we need to generate new knowledge that is context sensitive (to a specific case), yet generalizable (conforming to the rule of science). This requires the creation of evidence base(s) upon which to draw inferences, but also an interaction of those evidence bases (that have a series of knowns or explicit unknowns) and expertise (which comprises explicit (often taught) and tacit (developed over time) components including technical knowledge, skills, experience and routines).

The theory of explicit and tacit knowledge offers a way of conceptualising the continuum of knowledge, to encompass knowledge that is articulated explicitly or established implicitly (tacit). A critical issue is that explicit and tacit forms of knowledge cannot be considered to be separate and discrete in practice. For the generation of new knowledge, as is required within forensic reconstruction, an interaction between both explicit and tacit knowledge is needed [16,17]. These forms of knowledge have been discussed and outlined within the philosophy of science [15,18] and can be understood to have different attributes with respect to the generation, acquisition, aggregation, communication and transfer of that knowledge as presented in Table 1.

In its simplest terms, explicit knowledge can be considered to be knowledge that can be generated through logical deduction and codified in an objective way that can be shared without a 'knowing subject' [17]. It is therefore knowledge that can be easily communicated and transferred, such as standard operating procedures for an analytical test of a substance by a particular technique, or the chain of custody procedures for exhibits collected and secured at a crime scene. This form of knowledge can therefore be acquired through formal study. In contrast tacit knowledge is more intuitive, and often unarticulated. It is often the type of knowledge that is gained through practical experience and is shaped by the context and different experiences of the individual. It is this personal quality that can make it less straightforward to communicate and formalise in an objective codified manner. For example, the approach taken to collect a sediment sample from an item of footwear, or examine a microscope slide or a fingermark, may well vary from examiner to examiner based on their experiences and their mentors [19,20].

Table 1
Attributes of explicit and tacit forms of knowledge (compiled from Polanyi [15] and Lam [17]).

Characteristic of knowledge	Explicit	Tacit
Generation	Logical deduction, rational understanding of universal principles	'Learning by doing', operational skills/know-how
Acquisition	Formal study	Practical experience in relevant context
Aggregation	A single/discrete location and stored in objective forms	Personal and contextual, dispersed (not easily aggregated)
	Codified into standard operating procedures	Organic and dynamic capable of supporting complex patterns of interaction in the absence of written rules
Communication	Can be easily communicated often in written form	Intuitive and often unarticulated
Transfer	Can be shared without a 'knowing subject'	Requires close interaction and build up of understanding

Due to the nature of explicit knowledge it is generally possible to aggregate that form of knowledge in a single location and it can be stored in objective forms, such as manuals, books, and wikis. The more personal and contextual nature of tacit knowledge makes it more difficult to aggregate and the role of the 'knowing subject' is important for appropriating and transferring this form of knowledge.

It is important to be clear that differentiating between explicit and tacit knowledge is not to make a simplistic and didactic distinction between empirical 'scientific' evidence, and experience and expertise. Both explicit and tacit knowledge are crucial parts of scientific knowledge [15] and the scientific endeavour of producing new knowledge. Tacit knowledge is generated through both learning and innovation of the individual as they interact with their peers and communities and develop practical experience [17]. In contrast, explicit knowledge is generally generated through logical deduction and formal learning.

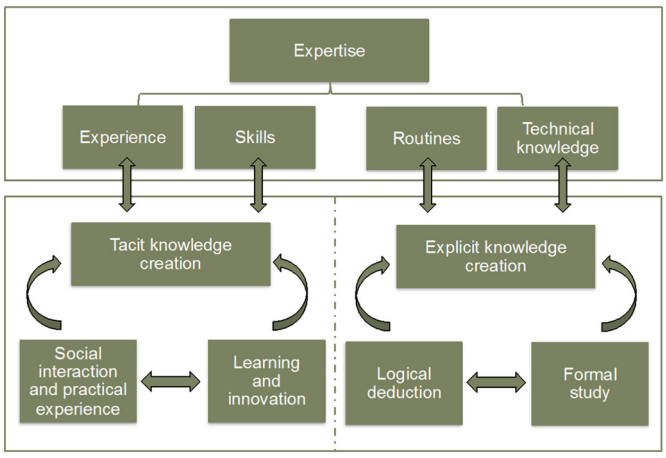

Fig. 1. Explicit and tacit knowledge generation and the forms of knowledge predominantly contributing to different aspects of expertise.

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Expertise requires the generation and contribution of both forms of knowledge as outlined in Fig. 1.

The different attributes of expertise (experience, skills, routines and technical knowledge) are all found on the continuum of explicit and tacit knowledge, albeit with a dominance of one form of knowledge. For example, routines (or heuristics) are generally developed over time through experience (tacit knowledge learnt 'by doing'), however once those routines have been developed they can often be codified (explicit knowledge). Furthermore, skills are predominantly acquired through practical experience but will also be informed to an extent by procedures and approaches that are codified.

Therefore, it can be argued that it is a false dichotomy to distinguish between 'science' and 'expertise' in the context of forensic science. Both are required for robust and effective problem solving and knowledge generation, both draw on explicit and tacit knowledge and thus, both are integral to the scientific endeavour of forensic reconstruction that is accurate, transparent and reproducible. However, it is critical to be aware of when empirical or expertise evidence bases are being utilised, and a conceptual model may assist in identifying the base upon which a specific decision or inference is predominantly founded. Having clarity on the balance between empirical evidence and expertise in a given situation enables a careful and transparent approach to be taken with regard to the way inferences can be made and presented to both investigators (as intelligence) or the courts (as evidence). This form of clarity is clearly highly valuable when assigning significance and/or weight to specific findings.

2.2. Knowledge and expertise

The role of expertise within forensic reconstruction is embedded in the decision-making required in each component of the FoRTE model [9]. It is therefore important to identify the different strands of expertise and the different forms of knowledge that those strands draw upon. There can be considered to be four main components of expertise; experience, skills, routine and technical knowledge (see Fig. 1).

Experience is a key and underpinning strand of expertise. The role of practice over time in a variety of contexts (tacit knowledge) enables the development of expertise. Over time, experts develop the skills to be able to recognise when past experiences may be relevant to a current situation, and use that experience to focus on the important features in the present context more quickly. Expertise is also founded on skills. Many skills can be acquired through training and over time (through explicit knowledge), but there are elements that cannot be acquired only through training. This is seen in the way the transfer of skills can be enhanced through observation, demonstration, coaching, mentoring and practice, where interaction between individuals is an integral part of the process. The routines or heuristics that are developed through experience and increasing skills enable an expert to recognise helpful indicators at a crime scene or attributes of a sample, and react quickly and effectively to challenging situations. These routines are generally leveraged from the tacit knowledge that has been generated and built up through experience, but it is important to note (as mentioned above) that once identified, routines can be documented, codified and shared (explicit knowledge). Technical knowledge is clearly vital for expertise and this can be considered to be primarily the product of formal learning of codified and articulated knowledge. An example would be expertise in carrying out a particular form of analytical technique.

The importance of incorporating both empirical scientific approaches and expertise in the generation of knowledge is critical to robust scientific endeavours. Both explicit and tacit forms of knowledge have important contributions to make to the development of empirical science and expertise. Furthermore, incorporating an understanding of these different forms of knowledge so that the new knowledge required in problem solving can be generated, is critical to being able to deliver a holistic approach to forensic reconstruction. Forensic science as a multidisciplinary domain, lies at the intersection of investigators and forensic scientists (the domain of practice), research scientists (the domain of research) and the criminal justice system (the domain of law/policy). It is therefore imperative that an awareness of the different types of knowledge within each of those domains is articulated and incorporated into an understanding of effective forensic reconstruction approaches. Each domain is made up of different types of institution each with different infrastructures, different dominant knowledge bases, different types of expertise and different approaches to generating and harnessing knowledge. An understanding of these different approaches to knowledge generation and their contribution to forensic reconstruction therefore allows for meaningful insights into how best to equip and deliver the robust forensic reconstructions required for forensic science.

3. Institutional frameworks: the institutional role in shaping organisational learning and generating knowledge

New knowledge is generated through the interaction and combination of both explicit and tacit knowledge [16], and the learning and innovative capabilities of an organisation are dependent upon its ability and capacity to mobilise tacit knowledge and foster interaction with explicit forms of knowledge [17]. Therefore, it is important to identify the different forms institutional infrastructures can take, and how those infrastructures influence individual and organisational learning and the generation of new knowledge. It has been identified that there is a continuum along which different institutions are situated with regard to the dominance of explicit or tacit knowledge, the archetypal characteristics of each organisation, and what forms of knowledge are most dominant within that organisational framework (the balance of explicit and tacit forms of knowledge) [17].

3.1. Knowledge and institutions - the dynamic interaction of knowledge and its generation

Organisations have a significant role in forming, shaping and enabling organisational learning and the role of explicit and tacit knowledge within it.

When considering the infrastructures and frameworks of knowledge production, aggregation and appropriation within institutions, there are two levels to consider; the individuals that make up the organisation, and the organisation as a whole at a collective level. Lam [17] presented a model that draws on the work of Collins [21] and Blackler [22]. Building upon this approach is helpful for addressing the pertinent characteristics of knowledge and its embodiment in the organisations within the different intersecting domains of forensic science along the explicit/tacit knowledge continuum (Fig. 2).

Fig. 2 presents a typology of four forms of knowledge that brings together the form of knowledge generation (along the explicit/tacit continuum) to its manifestation (individual or collective) within organisations; 'embrained' (individual explicit), 'embodied' (individual tacit), 'encoded' (collective explicit) and 'embedded' (collective tacit). Organisations that are dominant in explicit forms of knowledge often have clearly defined knowledge bases. There is often a centralised approach taken within the organisation, and by the individuals within it, which is codified into procedures with consistent approaches to tasks. Organisations more dominant in tacit forms of knowledge are often effective at dealing with issues in specific contexts. The individuals within such organisations are action orientated and strong at developing solutions as an issue emerges. Organisations at this end of the continuum often have fewer formal structures, relying on more contextual and interactive approaches of the individuals within the organisation to generate knowledge and complete projects. This typology accounts for both organisation structures where the individuals within it are more dominant in the generation of knowledge (the 'embrained' and 'embodied') in comparison to organisations where the generation of knowledge takes a more collective approach ('encoded' and 'embedded') [17].

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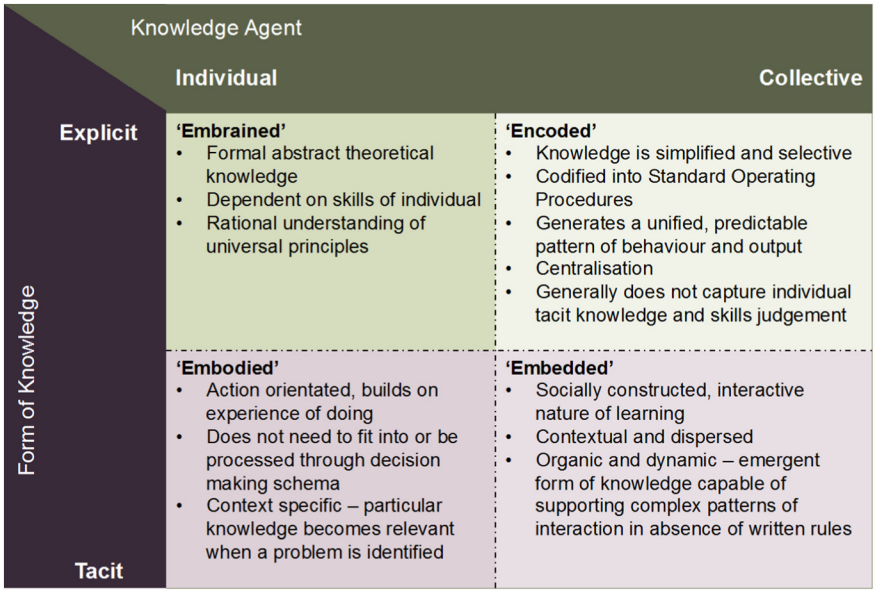

Fig. 2. The epistemological and ontological dimensions of different forms of knowledge within organisations (compiled from Nonaka and Takeuchi [16] and Lam [17]).

3.2. Knowledge and institutions - the standardisation of knowledge and work

Further refinement of this typology can be made by incorporating the degree to which knowledge and work is standardised within an organisation, and the genre of labour market within which the organisation is situated [17]. An occupational labour market (OLM) is one where the knowledge and skills of the organisation are primarily manifested and owned by the individuals within it. This gives rise to career mobility as the networks and interactions between individuals encourage the development and accumulation of tacit skills. The mobility of the individuals often affords an organisation an ability to be responsive to requirements within the market place as changes occur. In contrast, an internal labour market (ILM) is an organisation that is able to offer long term and stable employment to its individuals, with knowledge and skills of individuals being embedded in careers within the organisation. This approach affords the organisation significant stability and the potential to accumulate and retain the knowledge that is generated. Such organisations rely upon the corporate memory of an institution as a valuable means of learning. When the degree of standardisation of knowledge and work within an organisation and the dominant form of labour market are incorporated with the dominant form of knowledge and role of the knowledge agent, it is possible to identify an organisational framework typology (see Fig. 3 compiled and modified for forensic science from the work of Lam [17]).

Lam [17] provides a comprehensive generalised overview of the different types of organisation within this typology, so here only the most pertinent attributes for forensic science are highlighted. Institutions with dominant explicit knowledge and standardisation of work practices can be characterised either as 'professional' (which have an important role for individuals within the organisation and are often operating within an occupational labour market) or 'bureaucratic' organisations (that operate at a more collective level and within an internal labour market model). Within 'professional' organisations individual professionals are key knowledge agents and the capabilities of the organisation are often predominantly derived from the 'embrained' knowledge of highly trained, relatively independent, individuals. These individuals have high levels of formal education and training, which leads to a relatively high standardisation of knowledge and skills within the organisation. In this way standardisation often originates from outside the organisation with external education institutions and professional bodies playing a significant role in articulating the standards and quality of

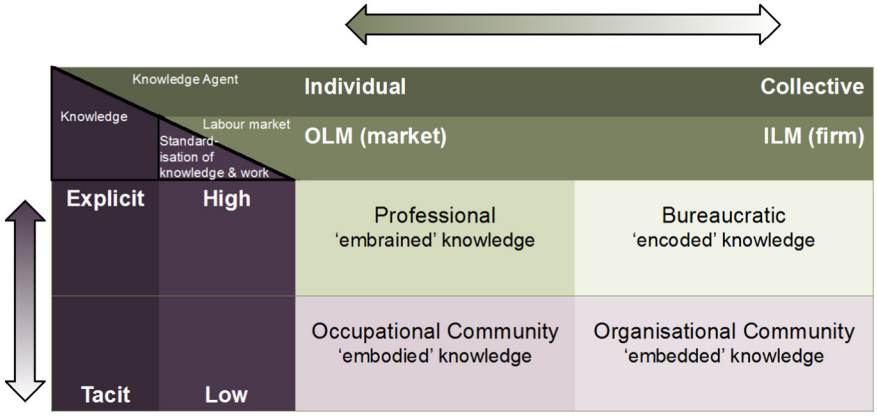

Fig. 3. A typology of organisational infrastructures incorporating forms of knowledge, the degree of standardisation of knowledge, the role of the 'knowledge agent' and the type of market the organisation operates within (OLM (Occupational Labour Market) ILM (Internal Labour Market)). Compiled and modified for application to forensic science from the original work of Lam [17].

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the knowledge within the organisation. It is interesting that this type of organisation often exhibits traits of individual and functional specialisation. Many of these characteristics can be traced within the 'practice domain' within forensic science. The role of highly trained and expert professionals is very important within forensic investigations both from a crime scene (investigators) and a laboratory (forensic scientists) perspective. Lawyers may also operate within structures that have characteristics of this typology.

The 'bureaucratic' organisations are often highly effective at providing efficient and stable approaches to projects. These are the infrastructures that formalise operating skills with codified procedures thereby reducing uncertainty in operational tasks. This form of organisation is well equipped to deal effectively with well known problems as it generally has an accumulated knowledge base that has been derived from the formalisation of the knowledge within the organisation. There is less focus on the individual and more emphasis is placed on the management hierarchy. These traits are often observed within the law/policy domains where stability, formalised knowledge and the codification of knowledge are important attributes. The development of rules and procedures for the production and utilisation of knowledge are a valuable part of the criminal justice system offering transparency and ensuring parity across different cases. These approaches can also be seen where the law/policy domain intersects with investigations, where standard operating procedures exist for given situations and tasks that ensure quality assurance and validation of analytical classification procedures (as outlined in the UK Home Office Forensic Science Strategy [23]).

Institutions with more dominant tacit knowledge and less standardisation of work practices can be characterised either as 'occupational communities' (which have an important role for individuals within the organisation and often operate within an occupational labour market) or 'organisational communities' organisations (that operate at a more collective level and within an internal labour market model). The 'occupational community' organisation is often characterised by an organic structure that has a less standardised approach to work practices and the generation and utilisation of knowledge in comparison to the 'professional' or 'bureaucratic' models. Similarly to the 'professional' organisation, the individual has an important role and yet arguably within the 'occupational community' model the individual has greater independence to make decisions and develop solutions to new situations or issues that arise. There is often a focus on experimentation and practical problem-solving within these organisations which affords the ability to adapt to new situations. However, operating within the occupational labour market can make it a struggle to retain individuals and their knowledge, given the mobility that the more occupational style of labour market affords. Many of these traits can be observed within the research domain where individuals have significant expertise and the scope within their institutions to experiment and derive new knowledge in response to current issues or problems. The level of autonomy afforded to the individuals within these structures can be considered to foster significant creativity and be a fertile environment for the development of new knowledge, but comes with the potential for the creation of knowledge silos between institutions and between different contributory fields (as outlined by Kelty et al. [24]).

The 'organisational community' brings together the more flexible and organic structure with lesser degrees of standardisation in knowledge or work practices of the 'occupational community' genre, and combines these attributes with the efficiency and stability of the 'bureaucracy'. The expertise of individuals is brought together in the form of semi-autonomous teams who are able to work on projects with a degree of autonomy yet in a collaborative manner that shares knowledge and leads to joint problem solving. The stable nature of this form of organisation enables sustained innovation, albeit more incremental than in other organisations. This is generally considered to be a rare form of organisation. It is perhaps possible to see some of these traits in the groups that are formed when national or international level organisations set out a call that requires semi autonomous groups to come together to address a common problem. For example, when research councils award funding for interdisciplinary and inter-organisational teams to address specific issues within the forensic science domain, or international working groups that bring together policy, research and practice.

4. Forensic science 'actors'/institutions

It is therefore possible to identify different traits that are distinctive of the institutions within the different domains (research, practice, policy/law) that have significant roles in the delivery of forensic science. Each institution has distinctive infrastructures that influence how individuals learn and interact with each other within that institution. Additionally, these infrastructures influence how different organisations interact with each other, and how knowledge is generated, accumulated and transferred within and between those organisations.

The difficulties encountered within forensic science in the creation of knowledge and delivery of nuanced and holistic forensic reconstruction are clearly not solely due to the infrastructures of the intersecting domains and institutions. However, it is important to incorporate the influence that such infrastructures have as a critical aspect for looking forward and developing approaches that enable forensic science to harness the value of trace evidence and deliver accurate and context sensitive reconstructions. Raymond and Julian [25] present the pressures that are faced by many forensic-related organisations in terms of the extent to which quality management bureaucracy and compliance policies constrain and put pressure on operational activities. They call for a closer integration between policing and the criminal justice system and a change to the way science interacts with policing in a way that reduces the silos of knowledge. Understanding the typology of the different institutions offers a path to enabling closer integration and reducing silo effects. An appreciation of the different forms of knowledge and how different institutions generate knowledge and interact will enable each domain to work together more successfully and for the strengths of each domain to be exploited even more effectively in forensic reconstruction approaches.

Therefore, the importance of setting out a means of understanding the different actors and institutions that interact with, and are integral to, the delivery of valuable forensic science cannot be overstated. Developing a conceptual understanding of the endeavour of forensic reconstruction [9] and the nature of the institutions of the intersecting domains (practice, research, policy/law), with a focus on how knowledge is generated and utilised in both explicit and tacit forms, is a significant step toward articulating ways forward to achieve the goal of returning to the 'forensic science' paradigm [10]. In taking an overarching view, it is possible to articulate the importance of defining what forensic science needs to achieve, the importance of both empirical and expert evidence bases, and harnessing the strengths of the institutional structures within which knowledge can be generated and applied to forensic reconstructions.

5. Where to from here? Developing an effective culture

Part I of this paper [9] presented a conceptual model (FoRTE) for developing a holistic and integrated approach to forensic reconstruction. The model presented the importance of evidence bases (that incorporate empirical data and expertise) to underpin each stage of the forensic science process (crime scene, evidence analysis, interpretation of evidence, and presentation of intelligence to investigators or evidence in court). It also highlighted the importance of frameworks that integrate the significance of different forms of evidence in a way that offers a sufficiently generalisable approach that has the capacity to be context sensitive to individual cases. The role of expertise was acknowledged in the decision making integral to each component within the model. Part II of this paper has outlined the degree to which it is important to acknowledge the different forms of knowledge, both explicit and tacit, which are

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interwoven into the endeavour of forensic reconstruction. The importance of understanding the role institutional infrastructures play in the generation and application of knowledge has also been set out as a critical component in identifying how to achieve a holistic and integrated approach to forensic reconstruction that incorporates the actors within the forensic science domain.

It is acknowledged that the structure of organisations within the intersecting domains of forensic science significantly impacts the way knowledge is generated and transferred, and how individuals learn and interact with others within and outside the institution. This brings significant opportunity to harness the diversity that exists within forensic science and to articulate what the remit of forensic science can and should be [26] in a way that incorporates different roles for individuals and institutions in the practice, research and law/policy domains [27]. Taking a conceptual approach enables an agreement to be reached as to what forms of knowledge forensic science is creating at different stages and in different situations. Both explicit and tacit knowledge forms are needed. There is clearly a requirement for validated standard operating procedures within many aspects of forensic science such as laboratory analysis, exhibit and sample custody practices and investigation procedures. There is also a necessity for high quality problem solving in a context sensitive manner that ensures that each case is addressed appropriately and that new knowledge is developed that can assist in the inferences being made regarding the meaning of evidence, which will require the utilisation of expertise.

To achieve a holistic approach to forensic science reconstruction as outlined by the FoRTE model [9], the different approaches to the generation of knowledge in the diverse domains and institutions needs to be incorporated. Therefore, channels that enable a complementary approach from each domain and institution to contribute effectively to the endeavour of transparent, reproducible and accurate forensic reconstructions are required. There have been significant developments in the research culture within forensic science since the seminal calls of Mnookin et al. [4] and Margot [26], yet channels are still needed that enable a collaborative approach to establishing the explicit knowledge that already exists and identifying the areas where more is needed, in addition to identifying the areas where more tacit forms of knowledge should be fostered. If this can be achieved there is the potential to have a truly problem solving approach at every stage of the forensic science process that is undergirded by the full spectrum of knowledge and incorporates the strengths of each actor within forensic science. Four areas are outlined here that have the scope to act as the starting point for these discussions; the aspects of interaction, impact, access and quality.

5.1. Interaction

For a holistic approach to forensic reconstruction, effective interaction between the different actors is clearly important. Developing a landscape or culture that enables interaction will require an appreciation of the different infrastructures in order to identify the most effective channels and language of communication [28]. An appreciation of the different strengths and methods of different actors will enable an increasingly collaborative approach to bring knowledge from across the entire explicit/tacit continuum to the endeavour. Building these channels that enable interaction with a common goal (robust forensic reconstruction) has the potential to enable discussion, debate, disagreement, but ultimately approaches that address the most compelling questions of trace evidence interpretation. Whilst this may appear idealistic, there is potential to develop the existing channels and create new ones in a way that enhances what currently exists. A shared vision is a powerful force. Add to this motivated individuals and organisations, acknowledged and complementary contributions, effective language and an appreciation of the strengths different forms of knowledge generation offer and how they fit in to the end goal of forensic reconstruction, and there is potential for a highly effective collaboration. Establishing channels of communication and collaboration between different domains is highly important for innovation and developments in forensic reconstruction. One path forward is increased acknowledgement from research councils that interdisciplinary research in applied fields can enable effective interactions between the different domains. Valuing and funding such endeavours has significant potential.

5.2. Impact

In order to deliver reconstructions that have the required impact, the most pertinent questions need to be asked, and truly implementable solutions need to be created. In order to achieve this, a consideration of impact at the institutional and individual level is critical. At the institutional level the most effective infrastructures need to be developed across the domains of research, practice and policy/law that foster innovation and learning in order to identify where impact is needed and facilitate both explicit standards and tacit expertise to those areas. At the individual level, those with a research remit need to be in dialogue with those in practice and policy/law domains to ensure that the questions addressed in research are pertinent to practice and policy, and the methods utilised appropriate for the generation of the results that are needed. This is also a dynamic interaction, those with a policy remit need to be in dialogue with the research and practice domains to ensure that policies and the justice system incorporate an understanding of the capabilities and scope of forensic science and are underpinned by evidence. Those in the practice domains need to be interacting with researchers not only to inform the questions posed in research but also to set out the challenges that are arising in practice and being open to incorporating research findings into existing and new practices. It is critical that this is not a one-off action, but an activity that is embedded into the entire research practice (including the formulation of the research question, experimental design and iteration, and consideration of the research outputs and the context in which they need to be implemented).

The drivers for institutions and individuals need to be considered, and then creative approaches taken to ensure that each domain can achieve the types of 'win' required in a manner that enables a contribution to be made to the collective endeavour of delivering excellent and holistic approaches to forensic reconstruction. There are examples of this approach, which illustrate the power of interaction to result in effective impact with the research units that exist within operational forensic services that foster a synergy between casework practice and research. Other examples include the work of Earwaker et al. [20] where the domains of practice and research worked together to generate new knowledge that was ultimately utilised to inform bureau practices. There is an argument to be made that these forms of integration offer opportunities to generate valuable knowledge and enhance the capacity for holistic reconstruction approaches.

5.3. Access

A critical component of enabling dialogue that leads to collaboration and innovation is ensuring access to pertinent materials, policies and research. Within the research domain findings are often disseminated by publication in academic journals, which is an excellent medium for sharing knowledge across the research domain. However, given the norms and expectations of the research domain, new findings presented in those research articles are rarely in an easily accessible format for different groups from across domains. At its most basic this manifests itself in only being able to access an article for a financial fee. Access is also an issue in terms of the language and format required of peer reviewed journals which are appropriate for the academic domain, but which do not always make it easy to see how the finding is relevant in practice or policy. Additional platforms are needed where findings can be made available in a variety of easily accessible formats. Such platforms need to take into account issues of intellectual property, copyright and

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commercial sensitivity, but sharing new knowledge has the power to transform the way different domains interact and dramatically increase the generation of pertinent knowledge for forensic reconstruction. Whilst effective structures and channels for the communication of findings from one domain to another will undoubtedly assist the transfer of knowledge, skills in communication across fields and domains is also important at the individual level. Interdisciplinary communication is arguably a skill that should be increasingly built into the curricula of undergraduate and postgraduate courses to ensure that the next generation are equipped with the skills to interact and engage across domains. Many universities offer opportunities for industry engagement within their teaching and placement programmes that offer real world experience and an opportunity to experience first hand the interaction of theory and practice. It is perhaps the areas of oral and written forms of communication that have scope for development within our curricula to reflect more deeply the importance of engagement across domains and to ensure that the investigators, researchers, policy makers and lawyers of tomorrow communicate and interact effectively to generate and apply the new knowledge required and produced.

5.4. Quality

High quality is universally agreed to be critical within forensic science, and the measurement of quality is therefore a significant issue. Incorporating a conceptual view of the scientific endeavour and forms of knowledge intrinsic to delivering robust reconstructions, as in this paper, reveals that explicit knowledge is not completely independent of the tacit knowledge of the individual [15]. Doak and Assimakopoulos [29] demonstrated that in order to carry out standard procedures fully in a forensic laboratory setting, the interaction of individuals and the sharing of expertise and advice (which comprises tacit knowledge dimensions) was also required. It is reasonable for quality assessments to focus upon the evaluation of procedures and standard practices. It is however, more difficult to apply the same approaches designed for evaluating objective codifiable and explicit knowledge to procedures that require a sensitivity to the specific context of a case or expertise of a group of individuals in the problem-solving approaches taken, which are necessarily bespoke to a specific scenario or case. In order to ensure the high quality that is required within forensic science, an approach to assessing and evaluating quality is needed that recognises the importance and role within forensic reconstruction of both explicit and tacit forms of knowledge. This is a significant question, particularly in the current climate of seeking accreditation approaches. However, an appreciation of the different forms of knowledge that are integral to effective forensic reconstruction needs to be incorporated into any accreditation approaches that seek to measure tacit forms of knowledge.

6. Conclusion

This paper built on the FoRTE model presented in part I [9] that set out a conceptual approach for understanding the role of trace evidence in forensic reconstruction. The different forms of knowledge on the explicit and tacit continuum were identified that are integrated within the FoRTE model in both individual and collective forms. The different infrastructures of the organisations that make up the research, practice and law/policy domains were presented, and the influence those structures have on the generation and application of knowledge were set out within the context of forensic science. These attributes of the intersecting domains of research, practice, policy/law were considered in relation to the FoRTE model and four areas outlined where building effective channels has the potential to harness the capacity and strengths of the different forms of knowledge and innovation within the institutions and individuals within the institutions, to achieve effective holistic forensic reconstruction approaches.

Taking a conceptual approach to forensic reconstruction offers a means of incorporating the practice, research, policy/law domains that intersect to frame forensic science, and also the different forms of knowledge integral to the 'scientific endeavour', in order to set out a holistic framework for harnessing the value of trace evidence. The articulation of a conceptual model that is situated within an understanding of organisational and individual knowledge production offers a means for developing an effective culture in forensic science. A culture where quality is paramount, yet where we do not have a 'one size fits all' approach; a culture where evidence based research, practice and policy work synergistically to provide true impact; and a culture where ultimately trace evidence is utilised effectively, at times innovatively, yet always transparently, to offer robust forensic reconstruction that assists investigations and the courts.

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