Medical Thinking: What do we know?
Meeting report

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1. Preamble

At a time when governments and many other organisations around the world recognize as never before that medical error is a major cause of mortality and morbidity, and clinical excellence is a powerful driver of public support, it was felt appropriate to hold an up to date review of the theoretical, scientific and practical aspects of medical thinking, drawing on insights from the many fields where it has been studied.

The trigger for the meeting was the 20th anniversary of the publication of Professor Steven Schwartz’s review monograph ‘Medical Thinking’. After 20 years the book is still being cited, because (as the author puts it) “there has been nothing published since with similar coverage”. The main goals of this initial meeting, held at University College London, were to take stock of developments in this highly interdisciplinary field and consider a more comprehensive event in the future.

The event was planned as an initial review meeting to allow participants to hear about the current state of knowledge in contributing fields. Coverage was inevitably not comprehensive, but we were able to invite a number of international as well as UK speakers who are acknowledged experts in their fields, thanks to support provided by Cancer Research UK.

The event was advertised locally through the London Judgement and Decision Making Group (www.psychol.ucl.ac.uk/ljdm/) and on the OpenClinical web site (www.openclinical.org). It was attend by approximately 50 people with very varied backgrounds including clinicians, psychologists and computer scientists/medical informaticians.

The programme (included at end of this report) included two keynote speakers (Vimla Patel of Columbia University and Enrico Coiera of the University of New South Wales) and 11 specialist invited speakers. Nigel Harvey (UCL) and Ted Shortliffe (Columbia) acted as discussants at the end of the first and second day respectively.
The majority of participants completed a brief feedback form: the event was viewed uniformly positively, and a number of comments suggested that a further, larger event would be valuable.

2. Summaries of contributions

(Copies of most sets of slides can be found on OpenClinical.)

Vimla Patel: Emerging paradigms of cognition in medical decision-making (keynote)

Despite major contributions to theory and practice, normative models of decision making cannot accurately describe the complexity of real-life clinical decisions. A more descriptive naturalistic approach is needed to overcome this limitation, one which recognises that decisions are made by negotiations and compromises between competing goals. The theory of distributed cognition takes a new perspective, looking at cognitive aspects of teamwork, especially the teamwork that is interwoven with information technology.

Enrico Coiera: Communication and the organisation of healthcare (keynote)

Health services are inherently complex. The large number of different actors, roles and tasks needed to enact clinical care makes dealing with the required interactions a complex and challenging problem. Observing clinical reasoning ‘in the wild’ reveals that this ‘interaction complexity’ results in a significant requirement for multitasking, and generates a very high rate of interruptions for many clinical staff; these in turn create significant cognitive loads and may result in task inefficiency and error. Consequently, to understand clinical reasoning we cannot just focus on knowledge and inference, but also must understand the practical demands of clinical work, which shape cognition in entirely different ways.


Judgement analysis is an approach to understanding decision-making that dates back to innovative work done by Egon Brunswik in the middle decades of the 20th century. The approach allows investigators to build statistical models that explain at least part of a decision-maker’s behaviour. The technique is sometimes described as capturing the decision-maker’s policy. Interesting applications of the approach in clinical domains include work by
Tape et al. who studied the accuracy of pneumonia diagnosis in different settings and revealed that the poorer performance of physicians in one part of the US was explained by the fact that they were working in a less predictable environment where the validity of diagnostic cues was diminished. A general finding from this kind of work is the diagnosticians are using fewer cues than they think. Interestingly Harries et al. have shown that clinicians are able to recognise their one decision policy when shown graphical representations of different weights that decision-makers give to different cues, suggesting that they have more insight into their own processes than was first realised.

**Philip Dawid: Normative Views of Medical Reasoning and Decision-Making**

Formal theories of decision making are well established and can sometimes be used to solve specific medical problems. In any case they can inform and guide good medical practice. The best known approach is to view a decision as a selection between courses of action each of which may be associated with a number of different possible outcomes. If the probability and the utility of each outcome can be quantified it is possible to identify the course of action which maximises the expected utility. There are variations of this approach, but if they ignore the basic principles, the results can be misleading.

**Nick Sevdalis: Patient Safety and Medical Error**

An emerging consensus of empirical data suggests that about 1 in 10 patients are harmed as a result of their hospitalisation. The performance and the errors of clinicians are determined by many factors, including individual, team, local setting/environment and regulatory factors. This ‘systems approach’ has been used to model surgeons’ performance, with very promising initial results.

**Chris McManus: Ability and Performance in Medical School and Beyond**

Passing medical examinations - and hence knowing more about diagnosis, treatment and management - relates little to intelligence and more to previous educational achievement. (This perhaps reflects motivation, although the hypothesis that it is actually the knowledge or at least the structuring of knowledge acquired in earlier education which is providing the benefit). Medical expertise develops of course but it does not just grow from ignorance to knowledge, it sometimes it seems to go through a phase of being systematically wrong.

**Alastair Gale: Medical Image Perception**
It has been known for 40 to 50 years that radiologists make a significant number of errors when interpreting images. Various initiatives have failed to change the situation: one approach is to use computer aids, although the evidence increasingly suggests that they are not effective. Investigation of radiologists’ eye movements indicates that errors result firstly from deficiencies in visual search and secondly in the detection of features and interpretation. Gale et al. have presented a model of human visual search which is similar to comparable cognitive models for diagnostic problem-solving and gives a strong role to hypotheses. Many experts think, although the evidence is uncertain, that experienced radiologists do almost all the useful processing of an image in the first few seconds during which it is examined and spend the rest of the time trying to report it.

Paul Taylor: Radiological Expertise

Research into aspects of radiological expertise include cognitive and perceptual studies. Cognitive studies have identified the same kinds of effects in radiology as found in other medical decision making tasks. Perceptual studies reveal that the acquisition of radiological expertise is in part a form of perceptual learning in which low-level detectors in the visual system become finely tuned for particular features. Different radiologists will look at different regions of the image. If we use computers to analyse the regions that attract a radiologist’s attention, we can compute features which can be used to train a neural net to predict how he or she will classify a given region.

Sanjay Modgil: Medical Logics

Logic based reasoning has a long history in Medical AI systems, covering reasoning about what is the case (e.g., diagnosis) and what ought to be done (e.g., medical treatment planning). More recently researchers have looked at applying other ideas about how arguments can be constructed and appraised. The state of the art in application of logic based models of argumentation in medical AI includes models to facilitate decision making, support collaborative decision making and enhance communication between medical professionals and patients, as well as informing and educating medical professionals.

David Glasspool: Medical Planning

Much clinical practice can be understood as either creating, modifying or interpreting plans (treatment plans and protocols, diagnosis plans, "integrated care pathways" etc). Despite the central role of plans in medical practice and medical knowledge very little work has been done on how clinicians plan or interpret plans. Planning is known to be very demanding in terms of
cognitive resources. Like other experts, clinicians acquire large numbers of simple, stereotyped plans during their training and practice, which they can adapt to different situations encountered in practice to reduce the need to generate plans from scratch, which can be viewed as hierarchically structured and centred around goals and sub-goals. Full-blown planning from scratch is likely to be too difficult to carry out routinely without assistance as it involves many types of cognitive load, though these can be mitigated by use of appropriate tools (e.g. REACT is a software system developed at CRUK which has proved to be effective in situations where clinicians must develop care plans jointly in collaboration with patients).

John Fox: Medical Thinking: Towards A Unified View

Humans are fallible and the consequences for medical error well known. What do we know that can help? Answer depends on whether you are a scientist, a theoretician or an engineer; all these viewpoints have a contribution. Medical thinking can be viewed as knowledge representation and use (there are now well developed formalisms for understanding knowledge use), or as the application of “rational” logical methods to decision-making and planning, or as cognitive “tasks” that can be rigorously engineered. CRUK’s PROforma representation of clinical process unifies these perspectives in a formal but natural and versatile tool for supporting clinical practice. There is now a significant evidence base that PROforma tools are effective and professionally acceptable.

Jeremy Wyatt: Medical Thinking or Clinical Action

The NHS costs £80Bn per annum; there are severe workforce pressures. For some tests and therapies, we know enough about what helps patients to recommend that their use should be reduced or increased. Despite this evidence, there is much geographical variation in clinical practice and patient outcomes. The issue is how can we narrow the gap between what clinicians know and what they do? The problem is not just about disseminating information but about changing behaviour and can be understood using methods from health psychology. Wyatt and colleagues have developed and studied a ‘clinical practice innovation model’ and investigated a range of approaches to changing clinical practice.

Sue Osborn: From Medical Error To Safety Architectures -Implementing Patient Safety Programmes

The National Patient Safety Agency (NPSA) was created in 2001 and incorporates the world’s first national patient safety reporting system. The
goal of the NPSA is "to improve safety of patients by promoting a culture of reporting and learning from patient safety incidents affecting patients receiving National Health Service funded care" Its tasks include to collection and analysis of information about adverse events from local NHS organisations, NHS staff and patients and carers; Assimilating other safety-related information from a variety of existing reporting systems and other sources in this country and abroad; learning lessons and ensuring that they are fed back into practice, service organisations and delivery; Where risks are identified, produce solutions to prevent harm, specify national goals and establish mechanisms to track progress. Initial evidence suggests that the NPSA approach has a significant contribution to make.

3. Emerging themes

We drew the following general conclusions from the meeting:

1. There is a diverse range of beliefs about and approaches to understanding medical thinking in communities that encounter each other relatively rarely. The participants in the meeting felt that the different approaches had valuable contributions to make and that it is important to create more opportunities to meet and exchange ideas and experience.
2. Empirical research in psychology and cognitive science has generated a number of important insights into medical thinking. The formal techniques developed in medical informatics and computer science have produced some interesting models of medical thinking. These two approaches could be viewed as complementary and it would be interesting to explore the potential synergy.
3. The focus has largely been on the thoughts and actions of individual decision-makers and on individual decisions or errors. This, however, is only part of the story; we also have to understand medical thinking socially and organisationally and seek better empirical methods of study and formal theoretical concepts.
4. Understanding medical thinking, in the broad sense identified here, is of course a key requirement for improving medical effectiveness, reducing error and improving patient safety and other benefits.

4. Next steps

1. Build on the nascent network of people and community of practice by organizing further meetings. The next meeting should aim to be more
international and wide-ranging in its coverage. One possibility we are considering is to make a proposal for a Novartis Foundation Symposium on the topic. This would provide funds for a prestigious meeting whose proceedings would be published in book form.

2. Seek support (from national or international sources) for interdisciplinary research projects that will pull through the potential synergies identified at the meeting into practical concepts and tools.

5. Programme

Many of the presentations listed below, including both keynotes, are available in PDF format.

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| **Keynote 1** | Emerging paradigms of cognition in medical decision-making  
Vimla Patel  
Department of Biomedical Informatics, Columbia University, New York |
| **Keynote 2** | Communication and the organisation of healthcare  
Enrico Coiera  
Centre for Health Informatics, University of New South Wales, Sydney |
| **Day 1 presentations** | Understanding Medical Thinking: the Judgment Analysis Approach  
Clare Harries  
Department of Psychology University College London  
Normative Views of Medical Reasoning and Decision-Making  
Philip Dawid  
Department of Statistical Science, University College London  
Patient Safety and Medical Error  
Nick Sevdalis  
Clinical Safety Research Unit Imperial College London  
Ability and Performance in Medical School and Beyond  
Chris McManus  
Department of Psychology, University College London  
Medical Image Perception |
### Day 1 summary

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<tr>
<td>Nigel Harvey</td>
<td>Department of Psychology, University College London</td>
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### Day 2 presentations

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<td>Paul Taylor</td>
<td>Centre for Health Informatics and Multiprofessional Education, Royal Free and University College Medical School, London</td>
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<td>Health Informatics Centre, University Of Dundee</td>
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### Day 2 summary

| Topic                                      | Presenter                                      |
|--------------------------------------------|------------------------------------------------|------------------------------------------------------------------|
| Medical Thinking: What Should We Do?       | Edward H Shortliffe                            | Department of Biomedical Informatics, Columbia University, New York |