Guest Editorial

Critical Thinking

Neville Stanton, University of Southampton, William Wong, Middlesex University, Julie Gore, University of Surrey, Nick Sevdalis, Imperial College, Michael Strub.

Accepted for publication in Theoretical Issues In Ergonomics Science April 2011

Critical Thinking

Introduction

This special issue of TIES deals with the complex topic of critical thinking in intelligence analysis and decision-making in medicine, specifically such as in the high-risk environment of the operating theatre. The work reported here was initially presented at the 9th Conference on Naturalistic Decision Making that took place in London, UK (Wong & Stanton 2009). NDM9 brought together researchers in naturalistic decision making and computing, intended to discuss the effect of modern technology on decision making that take place is settings such as medical diagnosis and treatment, command and control, and financial markets. This selection of papers gives us a deeper appreciation of earlier naturalistic decision making models, such Klein's Recognition Primed Decision model. They signal a departure from what were largely descriptive explanations, in a way that helps us understand the relationships between the different modes of analysis, reasoning, decision making and problem solving.

Despite the obvious differences in domain, intelligence analysis and medical or surgical decision-making and diagnosis share many aspects of the critical thinking process, such as uncertainty, time pressure, multiple competing hypotheses, often multiple competing goals, and risk. Within the papers there is some cross reference within and between domains, which reinforces this view with meta-cognitive monitoring emerging as a common skill.

Critical thinking has received significant attention within psychology and most particularly within the field of education (Halpern & Williams, 2008). Experts working within this area question if indeed we will be smart enough to meet the ever increasing demands upon critical cognition within the workplace across a range of expert domains. Sternberg's (1997) seminal work combined with Halpern provides us with evidence that suggests that critical thinking can be taught and acquired, hence the deliberate use of skills and strategies can not only increase a desirable outcome, they can be learned in ways that transfer to novel contexts. Whilst some contradictory

evidence exists about skill transfer across domains of application or expertise, overall the benefits of critical thinking skills appear to support what we know about what we know; i.e. cognitive self-awareness enhances thinking process and decision-making.

Intelligence analysis

Two of the papers in the special issue deal with critical thinking in the domain of intelligence analysis.

Klein (Critical thoughts about critical thinking) argues that critical thinking may be considered as both the thinking skills themselves and the meta-cognitive skill of analysing the reasoning process for the purpose of critiquing and improving those skills. Critical thinking skills are likely to include iterative and cyclic activities, such as problem solving, development of competing hypotheses, calculating probabilities and making decisions. Klein suggests that the introspective aspect of meta-cognitive skills is beset with difficulties, although critical thinking skills require the reflective feedback as part of the learning cycle for improvement. The intelligence community are keen to avoid mistakes in their analysis, but Klein argues these are rarely due to lack of diligence; rather they are inherent in the processes and procedures themselves. He contrasts the twin, and often competing, goals of 'increasing insights' and 'reducing mistakes' which may act as opposing forces in intelligence analysis. The process of reducing mistakes might interfere with gaining insights and vice versa. Klein provides examples of sources of error in the processes, such as: overlooking breaks from tradition, the clutter of too many competing hypotheses, focusing on logic checking rather than pattern matching, using declarative rather than procedural knowledge, and becoming bogged down in the technology and bureaucracy. Looking at evidence from other domains (for example, medicine) Klein suggests that 'adaptive problem solvers' are likely to be the most successful intelligence analysts as they use their initial 'hunch' as a guide for exploration, testing and accepting or rejecting as they go. He argues for a dual pathway model for critical thinking that exploits the combination of intuitive 'insight' and formal 'analysis' to be used concurrently. The insight path resembles recognition primed decision making (Klein, 1993), which allows analysts to intuit coincidences as meaningful discoveries or correspondence with important implications. Experience enables the skilled analyst to spot

meaningful connections in the data. By way of contrast, the analysis path is more explicitly procedural, using the traditional tradecraft of the intelligence community with the tools and techniques for gathering and assessing evidence to evaluate competing hypotheses. The implication of this juxtaposition is that it is the interaction between 'insights' and 'analysis' that leads to breakthroughs. Klein proposes that ideas from both pathways should be subjected to a plausibility filter and, presumably, cross referenced. Similar hypotheses emerging from both pathways may deserve special attention – although Klein does not speculate how the products of these two pathways should be blended, but recognises the importance of both paths working together.

Hoffman, Moon, Moore and Litman (Reasoning difficulty in analytical activity) consider intelligence analysis as cyclic activities that comprise: goal definition, hypotheses formulation, uncertainty identification, information gathering and hypotheses testing. Despite this process driven view of intelligence, the success or otherwise of the analysis seems to be highly dependent upon the knowledge, skills and abilities of the analyst, including their understanding of history, culture, context and language of the subject under investigation together with the interpersonal traits of persistence, creativity, reasoning and organisational skills. Hoffman et al explain that intelligence analysis is difficult for a number of reasons, such as the inherent nature of the subject matter and the reasoning processes as well as the complexity of software tools and organisational bureaucracy. Well-intentioned system and organisational design put in place to reduce mistakes (usually in the aftermath of an error) can led to overly cumbersome and conflicting processes. These may serve their primary goal (i.e., to mitigate against a particular mistake), but can have the unintended (but rather predictable) consequence of introducing or facilitating the occurrence of new mistakes and/or reduced insights. By its very nature the data used in intelligence analysis is often opaque, incomplete, changing, misleading, and transitory. Despite this, the analyst is expected to develop plausible hypotheses under the multiple stressors of time, workload and uncertain payoffs. Added to this, the cognitive demands of causal reasoning are extremely taxing. The adversary will be deliberately attempting to hide their activity and/or deceive the analyst about their intentions. Combining all of these factors helps explain why it is difficult for the analyst to predict plausible hypotheses. There may not be an obvious causal chain

and there is much evidence to suggest that human behaviour is non-linear and non-deterministic in any case, and yet the analyst is expected to forecast likely events and scenarios. Whilst this may seem like an impossible task, Hoffman et al offer the paradigm of sensemaking as a means of resolving some of the difficulties faced by the intelligence community. As a macro-cognitive approach, sensemaking has the advantage of studying collectives, such as teams, groups and organisations. Moving the focus of analysis away from multiple cognitions of individuals to the collective cognition of a group or organisation might help develop new insights and breakthroughs in intelligence analysis.

Decision-making in medicine and surgery

Two of the papers in the special issue deal with critical thinking in the domains of medicine and surgery.

Fioratou, Pauley and Flin (Critical thinking in the operating theatre) consider the critical thinking skills required by surgeons and anaesthetists in operating theatres. Alongside the technical skills associated with their respective disciplines of surgery and anaesthesia, surgeons and anaesthetists also require a range of 'non-technical' skills to deliver safe care to their patients. These are cognitive and behavioural skills – the former comprising skills like situation awareness and decision-making, the latter skills like good communication and teamworking in the operating theatre. Fioratou et al argue that these non-technical skills are underpinned by critical thinking that enables surgeons and anaesthetists to perform optimally as members of a wider clinical team and capitalise on their technical skills. Emergency operations and changes to treatment or care management plans made preoperatively in response to unexpected or adverse events are noted as particularly demanding situations requiring critical thinking skills by surgeons and anaesthetists. Fioratou et al note that although critical thinking is recognised as an important part of the operating teams skill set, very little research has been undertaken. The authors identified three main methods that have been used to date for the empirical investigation of critical thinking within healthcare specialties: observations in situ, verbal protocols and interviews. Whilst each methods has a number of pros and cons, Fioratou et al report some evidence

from their own studies with operating theatre personnel using the Critical Decision Method (although this method does suffer from biases related to recall and introspection). The Critical Decision Method was used to investigate the critical thinking skills of surgeons and anaesthetists in challenging situations. A key finding is that particular nuances and cues of each situation as perceived by an anaesthetist play a significant part in the decision-making whether or not to convert from local to general anaesthetic – including the state of the patient and the nature of the external situation demands on the anaesthetist. In a similar vein, the Critical Decision Method was also used to investigate surgeons' decision to convert a laparoscopic procedure (more novel approach, linked to faster postoperative recovery, faster mobilisation and less pain for the patient) to a traditional open procedure (which can be significantly worse postoperatively for the patient). Again, situational nuances and cues, such as the state of the patient and demands on the surgeon, sway the decision whether to convert or not. Finally, Fioratou et al make the point that critical thinking within the operating theatre should be analysed as an instance and within the wider context of 'distributed cognition' in team – that is, knowledge and skills that are property of the wider operating theatre team – involving not only the surgeons and anaesthetists, but also the nurses and other health professionals, the patient, the monitoring equipment and other artefacts in the clinical environment. Fioratou et al call for further research on critical thinking in surgery and anaesthesia to take place within the framework of distributed cognition.

Schraagen (Dealing with unforeseen complexity in the operating room) first points out that although domain-specific expertise does not generally transfer easily from one domain to another, there are exceptions. Expertise that is adaptive to novel environments, which has been termed 'heedful performance', allows operators to relate specific knowledge and skills to situational demands across a range of task domains by adapting flexibly to novel problem contexts. More specifically, the process of 'heedful interrelating' between individual operators is an apparent simplification of communication and coordination strategies when dealing with urgent demands. Schraagen is somewhat critical of existing studies because they tend to present findings from brief observations and thus cannot contribute to an in-depth understanding of how teams dynamically adapt their strategies over time. In order to study 'heedful interrelating' in a naturalistic environment (paediatric cardiac surgery),

Schraagen and colleagues undertook extended observations within a hospital operating room. Observers coded the activity of the surgical team into four categories: explicit coordination (situation awareness and coordination); heedful interrelating (noticing and communicating, anticipating, maintaining standards, backup behaviours and closed-loop communication); support behaviours (support of others, backup behaviours and relational communication); and decision-making (problem diagnosis, risk assessment, option generation and outcome review). The findings from the study showed that surgeons engaged in more explicit coordination than anaesthetists; anaesthetists, in contrast, engaged in more heedful interrelating than surgeons. Counter to expectations, heedful interrelation did not increase in the more complex operations above what could be accounted for by the longer duration of the surgery. Despite this, qualitative analysis of the data carried out by Schraagen revealed benefits of heedful interrelating. In cases of good surgical outcomes the activities of noticing and communicating, anticipating, maintaining standards, backup behaviours and closed-loop communication were qualitatively (although not quantitatively) better than in the cases of poor surgical outcomes. From this pattern of findings, Schraagen concludes that both explicit coordination and heedful interrelating together can result in better performance in operating theatre teams, particularly when novel situations arise during anaesthesia or surgery. Additional research is also called for, as a number of questions remain unanswered, including how best to teach and train in heedful interrelating, and how this rather implicit communication and coordination process interacts with demands on operating theatre personnel's attention during the management of demanding situations.

Conclusions for critical thinking

Consideration of the four papers in this special issue together shows remarkable similarities in the issues raised, despite the domain differences between intelligence analysis and decision-making in medicine and surgery. From this review, some take-home messages have been derived, as follows:

- critical thinking comprises both thinking skill and meta-cognitive critique;

- adaptive problem solvers are most likely to be the best critical thinkers;
- the combination of intuitive insight and formal analysis used concurrently is likely to provide the most successful predictions;
- good critical thinkers are likely to be able to blend deep domain expertise and situational nuances with the interpersonal traits of persistence, creativity, reasoning and organisational skills;
- simplification of communication and coordination strategies is useful when dealing with urgent situations;
- explicit coordination and heedful interrelating together result in better team performance; and
- the emergent nature of collective group cognition in sensemaking offers a potential new direction for research into critical thinking.

In summary, it appears that there is considerable scope for further research into critical thinking, both with and between domains. The papers presented within this special issue point the way.

Acknowledgment

Sevdalis is affiliated with the Imperial Centre for Patient Safety and Service Quality, which is funded by the UKs' National Institute for Health Research.

References

Halpern, D.F. and Williams, P.B.,(2008) Critical thinking. In: S. Savis and W. Buskit, eds. Psychology in the 21st century. Thousand Oaks, CA: Sage Publishers, 478-484.

Klein, GA. (1993). A recognition primed model of rapid decision making. In G.A. Klein, J Orasanu, R Calderwood, & CE Zsambok (Eds.), Decision making in action: Models and methods (pp. 138-147). Ablex Publishing Corporation; Norwood, NJ.

Stanton, R.J. (1997). *Thinking styles*. Cambridge: Cambridge University Press.

Wong. W. & Stanton (2009) NDM9 *Naturalistic Decision Making & Computers* (Eds). The British Computer Society. ISBN 978-1-906124-15-1.