Surgeons and cognitive processes

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Background: The surgical mind is geared to make important decisions and perform highly skilled tasks. The aim of this review is to explore the cognitive processes that link these actions.

Methods: The core of this review is derived from a literature search of a computer database (Medline).

Results and conclusion: The surgical image is one of action. However, the effective performance of surgery requires more than mere manual dexterity and it is evident that competent surgeons exhibit the cognitive traits that are held by all experts. The changes that are occurring in surgery indicate a need to place greater emphasis on the cognitive processes that underpin the practice of surgery. It is important that surgeons do not become victims of their own cult image.

Paper accepted 22 August 2002
Published online 29 November 2002 in Wiley InterScience (www.bjs.co.uk). DOI: 10.1002/bjs.4020

Introduction

Surgical competence combines the intellectual exercise of decision making with the ability to perform mechanical tasks. It is useful to explore the nature of the processes that link these areas of endeavour. In the past they have been treated as separate entities, and it has been difficult to dissect out the inferences and consequences of phrases such as 'technical skill is a double edged weapon'. Little attention has been paid to the cognitive processes that underpin surgical competence. In this context, the term cognitive processes relates to the ability to acquire knowledge by the use of reasoning, intuition or perception (L. cogno, to get to know).

This review commences with a discussion of the surgical frame of mind and then reflects on how the general traits of experts can be aligned with the characteristics of highly effective surgeons. Finally, there is a discussion of the implications that these issues have for surgical education.

The surgical mentality

This section explores the mindset of surgeons and how they are perceived by others. Much of the 'evidence' is anecdotal, but nevertheless it is an important issue. Behaviour and learning patterns are influenced by perceptions of what it means to be a surgeon.

The image

In 1963, Sir Robert Platt commented that ‘Surgeons, I suspect, see themselves in a setting of glamour, conquering disease by the bold strokes of sheer technical skill. Physicians quietly remember that they were educated gentlemen, centuries ago, when surgeons and apothecaries were tradesmen’. Along the same lines, it has been said that ‘Surgeons are apostrophized as simple souls, men of action who look for straightforward solutions’. However, as Moore has commented ‘Anyone could bleed, give cinchona bark or mercurials, or “puke, purge, and perspire”, but only a few could amputate a painful compound fracture quickly, safely, and with a reasonable occurrence of survival’.

Surgeons sometimes embrace the hypothesis that they are ‘men of action’ and use it as an opportunity to disparage physicians for being too slow to act. According to Harken ‘We surgeons tend to dive into the swamp and look around for alligators while our internist colleagues analyze the swamp water for its osmolality, acidity, and nutrient content to see if the water will support life. We are plungers, they are planners’. However, these words do not define reality in its entirety. It is impossible to be a competent surgeon without using higher-order cognitive skills.

Surgeons are also viewed as being overtly aggressive. The perception of mistreatment is a major source of stress for undergraduate medical students, and surgeons have been identified as being one of the groups most likely to be associated with this kind of abuse. In a similar study,
Richardson et al. found that the students’ perceptions of mistreatment at Wayne State University School of Medicine were lowest for family medicine and highest for obstetrics/gynaecology and surgery. Non-white men reported the worst treatment.

**Selection**

It is natural for surgeons to try to preserve the standing of their profession by selecting trainees who appear to be similar to themselves. This is a group instinct that has both good and bad aspects. The good side relates to the preservation of professional standards and the selection of people who, by their innate characteristics, appear to have a high chance of being successful. On the down side, it is possible that good candidates are being excluded and that intuition is not necessarily reliable. But this external selection process is transparent and open to challenge, whereas the key preceding process of ‘self-selection’ is less visible. It is natural for medical students considering a career in surgery, as well as residents wishing to choose a surgical specialty, to be markedly influenced by role models. Some will be attracted by the ‘men of action’ image presented in the previous section and some will be repelled by it; but there is one entire group of medical graduates that does not meet this ‘men of action’ image and, by definition, never will.

Despite the fact that in most countries women make up approximately half of medical graduates, the number proceeding on to surgical training is relatively small. The American College of Surgeons recently conducted a review of trainees enrolled in surgical programmes. Analysis of the graduating cohort showed that most were Caucasian men, usually aged between 33 and 35 years. When programmes other than in obstetrics and gynaecology were considered, women made up 16 per cent of those entering and 14 per cent of graduates. Furthermore, a study by Aufses and colleagues found that there was a higher attrition rate for women, even when they were in a programme that specifically encouraged women. There are many reasons why women self-select to ‘opt-out’ of surgical training programmes besides issues related to lifestyle; women are more likely to leave to join a spouse in another geographical location and there are perceptions of ‘male bias’ and ‘negative attitudes’.

One of the characteristics required to manage sick patients is the ability to live with ambiguity. Merrill et al. developed psychometric measures specific to the ambiguities encountered in acute-care situations and determined their value in predicting medical students’ attitudes towards patients and their choice of residency. Intolerance of ambiguity was associated with an excessive reliance on high technology, a negative orientation toward psychological problems, and Machiavellianism, which can be expressed as ‘the means justifies the end’ or ‘whatever it takes’. Yet such students were more likely to pursue a career in surgery than in internal medicine, psychiatry or family medicine.

**Survival techniques**

At issue is how surgeons can survive emotionally while working within an extremely traumatic environment. Indeed, ‘thrive’ rather than ‘survive’ may be appropriate because there is strong evidence that surgeons are happy in their work. Firth-Cozens et al. performed a longitudinal questionnaire study of 314 medical students who were followed up more than 7 years after graduation. Surgeons were the least stressed and the most happy with their choice of career, whereas laboratory-based doctors felt stressed and were the least happy with their choice of career. More objective is the very low rate of alcoholism and suicide among surgeons.

There are a number of possible explanations for why surgeons do not suffer from anticipated stress. Besides the selection processes already mentioned, there is a close relationship between the performance of a meaningful occupation and people’s perceived well-being; and having a proactive personality, which certainly characterizes surgeons, plays an important role in moderating stress. But, is there a dark side? The previous section mentioned that doctors who choose a career in surgery may be intolerant of ambiguity, with excessive reliance on technology, a negative attitude towards psychological problems, and Machiavellianism. After going through the processes that must be endured to become a surgeon, what is left? The concepts of insight and denial will now be explored from within this context.

Insight is a complex form of learning. It arose as a concept in 1925 when Wolfgang Köhler described experiments in which chimpanzees stacked boxes and used sticks of different sizes to capture bananas. Such insights are not trial-and-error events, but rather indicate higher-order cognitive activity – a sudden appreciation of a new way of looking at a problem. Insight occurs when a problem is perceived from a new and useful perspective. Junior doctors are confronted with a heavy burden of personal responsibility when they start to practise any form of acute medicine. Their insight into the realities of being a doctor can cause confusion and cynicism, which was the basic theme in Samuel Shem’s classic entitled ‘House of God’ – ‘the first thing to do in a cardiac arrest is feel...
your own pulse’. An alternative is to not think about the problems, to be emotionally blind, to ‘dumb down’. This view is supported by Griffith and Wilson24, who found that as students progress through medical school they become less idealistic toward elderly patients, those with chronic pain and the medical profession in general.

A major problem with a lack of insight is that it leads to inflated self-assessments25. Charles Bosk interviewed neurosurgical trainees who had resigned or been fired and found that they believed they hardly ever made mistakes26. Unfortunately, it is difficult to identify this characteristic when selecting trainees27, and often impossible to provide them with counselling.

Having too much insight can be destructive and denial is one way to deal with problems successfully. For example, surgeons from burns centres found it emotionally difficult to provide psychological support to the bereaved family after the death of a patient28. Particular issues in this environment are the long duration of the patient’s illness and the devastating nature of burn injury. Yet surgeons do not always admit to concerns about emotional stresses, although they are evident to spouses29. Perhaps intolerance of ambiguity is associated with an inability to recognize incongruence.

In all of these things, the fundamental issue is the struggle for self-protection while avoiding insensitivity30. As Baudry and Wiener31 have commented, ‘It must be recognized that a certain degree of isolation from the patient’s emotions may be salutary and essential if the surgeon is to perform his primary function, which is to operate, in an optimal state’.

Surgeons as experts

Little has been written in the scientific or clinical literature about the *modus operandi* of effective surgeons. It is possible to start by looking at some historical accounts. But the problem is that they tend to be projections of the surgical ego, the ‘eye of an eagle, heart of a lion’ stereotype.

In 1935, Professor Frederick Wood-Jones eulogized the concept of ‘master surgeons’32. Borrowing on attributes of great surgeons from the past, master surgeons were idealized as being: dedicated anatomists who were ‘life-long dissectors and operators on the cadavers’; sensitive humanitarians with a ‘feeling of intense pity for the suffering’; individuals with an ‘inordinate capacity for hard work’, the holders of ‘outstanding personalities’; and judiciously dexterous: ‘Skillful though they were and dexterous to a remarkable degree, the master surgeons regarded operations only as a last resort’. It is important to go beyond such stereotypes, and in the absence of hard information, a convenient starting point is to consider the traits that are held by all experts.

There is a general field of knowledge about experts that is derived from comparisons between experts and novices33,34. It is useful to consider these two extremes, although the acquisition of expertise is really a continuum of learning that extends from the novice through various stages of proficiency until the status of expert is reached. This is the ultimate level that extends beyond mere competence.

*Table 1* lists the main traits that characterize experts. They are both quantitative (e.g. speed and accuracy) as well as qualitative (e.g. intuitive decision making). Although all of these characteristics can be applied to surgeons, it can be difficult to identify experts. Experience from other groups suggests that the accolade of one’s peers is not generally considered to be enough because of the confounding effects of self-promotion and professional charisma. In one study, which sought to identify expert teachers35, the investigator did not rely only on the opinions of the teachers’ colleagues, but also considered student growth scores and made direct observations.

**Experience**

Experience does not guarantee expertise, but it is impossible to become an expert without considerable experience. The often-used phrase ‘born to be good, train to be great’ can be supported with good evidence. Helsen et al.36 studied the progress of international, national and provincial soccer players based on accumulated practice, amount of practice per week, and relative importance and demands of various practice and everyday activities. They found a positive linear relationship between accumulated practice and skill.

A report from the American Board of Surgery37, based on a review of the operative logs of 2434 general surgeons, found that practice volumes were very heterogeneous with major index cases being largely restricted to less than 10 per

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<td><strong>Focused on to a specific area</strong></td>
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<td><strong>Can work fast under pressure</strong></td>
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<td><strong>Spend time thinking about problems</strong></td>
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<td><strong>Automation of problem-solving processes</strong></td>
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<td><strong>Early recognition of difficulties</strong></td>
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<td><strong>An intuitive grasp of situations</strong></td>
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<td><strong>A rich professional memory</strong></td>
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<td><strong>Ability to develop broad concepts</strong></td>
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<td><strong>Monitor their own performance and worry</strong></td>
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cent of the total surgical workforce. The implications of this are unclear, but some operations are best performed by surgeons who are trained and experienced in that particular area. This particularly applies to rectal surgery\(^48\), but it may not be so for all operations. In 1998 the National Veterans Affairs Surgical Quality Improvement Program\(^39\) reported the risk-adjusted morbidity and mortality rates after major surgery in 123 Veterans Affairs Medical Centers. A review of the database, which included 417 944 major surgical procedures, indicated that there are many situations in which ‘system competence’ is of foremost importance. However, it is hard to design systems and tactics to reduce the probability of making errors associated with poor cognitive function\(^40\).

**Decision making**

It is generally held that the ability to perform a procedure needs to be accompanied by a thoughtful approach to its application. Spencer\(^41\) thought that 75 per cent of the important events in an operation related to making decisions, and only 25 per cent to manual skill. As Sir Frederick Treves wrote in 1891, ‘The actual manipulative part of surgery requires no very great skill and many an artisan shows infinitely more adeptness in his daily work... It is in the mental processes involved in an operation that not a few fail. There is some lack in... the capacity for forming a ready judgement, which must follow each movement of the surgeon’s scalpel\(^42\).

Seemingly independent factors such as gender, personality, communication skills and age, can coalesce to influence surgical decisions. For example, with regard to breast disease, male surgeons are more likely to perform a mastectomy than female surgeons\(^43\), while surgeons who provide better information are more likely to perform a lumpectomy\(^44\). In addition, the older surgeons are, the less likely they are to take risks\(^45\). Less clear is the effect of new technology on clinical performance\(^46\).

In 1996, the cost for a single 1-year survivor from a surgical intensive care unit was estimated to be US $282 618\(^47\). It is generally appreciated that there is a need to reduce futile care by the selection of appropriate patients for intensive care\(^48\). There is, however, a narrow margin for error, and cultural and social values influence decision making. Japanese healthcare is characterized by the fact that the fee schedule does not reward high-technology medicine, such as surgery and critical care. However, in spite of the low reimbursement, the critical care practice pattern is characterized by the futile treatment of terminally ill patients\(^49\). Of course, the other side to the argument about futile care is the concern that elderly patients might be denied appropriate surgery\(^50\).

**Error avoidance**

It has been suggested that there is a need to adopt ubiquitous error reduction strategies in areas of high risk\(^51\). Incident monitoring borrows its methodology from the well proven airline industry strategy in which ‘near miss events’ are treated as seriously as actual events. This is a very useful strategy because a near miss is often a pointer to the need to correct an inherent underlying problem. For example, Thomas et al.\(^52\) studied aviation accidents in Alaska between 1990 and 1998. Although Alaskan geography and climate do increase aviation risks, many accidents were attributed to pilot error. In another study, National Transportation Safety Board data were analysed for all cases of death, serious injury or major damage involving commuter aeroplanes\(^53\). Three-quarters of cases involved inadequate pilot performance, notably poor handling of emergencies. The areas of human performance psychology and the analysis of complex systems are becoming of greater relevance in the avoidance of error in surgery.

Risk management should be integrated into all levels of surgical training. The Harvard Medical Practice Study\(^54\) reviewed the records of 30 121 randomly chosen patients in acute-care, non-psychiatric hospitals in New York State. They avoided trivial and transitory problems; their criterion was ‘an injury that was caused by medical management (and not the disease process) that either prolonged the hospitalization, produced a disability at the time of discharge, or both’. Adverse events occurred during 4 per cent of hospital admissions in New York State in 1984 and 28 per cent of these were due to negligence, defined as care that fell below the standard expected of physicians in their community. Of all adverse events, 48 per cent related to surgical care and 17 per cent of these were due to negligence.

The Utah Colorado Medical Practice Study provides additional data on perioperative events\(^55\). It found that the incidence of adverse events after surgery was 3 per cent, of which 54 per cent were preventable. Eight operations were classified as ‘high risk’ based on their preventable adverse event rate: lower extremity bypass (11 per cent), abdominal aortic aneurysm repair (8 per cent), colon resection (6 per cent), cardiac surgery (5 per cent), transurethral resection of the prostate or of a bladder tumour (4 per cent), cholecystectomy (3 per cent), hysterectomy (3 per cent) and appendicectomy (2 per cent). Among all surgical adverse events, 6 per cent resulted in death, accounting for 12 per cent of all hospital deaths in Utah and Colorado.

Technique-related complications, wound infections and postoperative bleeding produced nearly half of all surgical adverse events.
Leadership

Schwartz and Pogge\textsuperscript{56} have identified that it is necessary for surgeons to develop ‘the technical skills necessary for major leadership/management roles that will both change and empower the local healthcare service delivery environment’. Such skills include strategic and tactical planning, persuasive communication, negotiation, financial decision making, team building, conflict resolution and interviewing. Probably, few of us will reach such heights, but one of the main characteristics of surgeons is their ability to lead others. Many surgical achievements, such as those of the early transplantation surgeons\textsuperscript{57}, have melded great creativity with determination.

Cognitivism in surgical education

Cognitivism can be represented as an educational philosophy\textsuperscript{58}. The cognitivist approach seeks to provide a framework for attitudes, beliefs and values. It is based on the assumption that learners actively construct their world according to their experiences. Here, the focus is away from reproductive learning and memory towards thinking, reasoning and understanding (Table 2). It embraces the types of topic that have been discussed in the previous sections of this article.

The cognitivist approach contrasts with the more prevalent behaviouralist approach, which emphasizes observed behaviour rather than internal processes. The behaviouralist approach to operative surgery is typified by attitudes such as ‘see one, do one, teach one’, with an emphasis on the number of completed procedures. It represents the way things used to be done, rather than a useful model for the future. Reductions in the hours that surgical trainees can work signals an end to learning by ‘service saturation’. It is becoming necessary to exploit the educational value of every experience in an effort to reduce the length of the learning curve for new procedures\textsuperscript{59–62}.

Promoting higher-order cognitive skills

Higher-order cognitive skills involve the ability to identify central issues and assumptions in an argument, recognize important relationships, evaluate conclusions drawn from data, and appraise evidence. The successful performance of surgery draws upon these higher-order cognitive skills. Mechanisms that have been used to promote deeper learning include problem-solving within structured-knowledge formats\textsuperscript{63}, the development of critical evaluation techniques\textsuperscript{64,65}, and involvement in teaching\textsuperscript{66}. Perhaps surprisingly, there is no firm evidence in support of the conventional wisdom that such traits are developed by involvement in a compulsory period of research.

How can judgement be taught? There is little information available on the relationship between learning styles and surgical decision making. However, it is appreciated that there are many different styles of learning: concrete experience, abstract conceptualization, active experimentation and reflective observation\textsuperscript{67}. Lynch et al.\textsuperscript{68} have stressed that clinical performance ‘requires additional cognitive skills and abilities, and behaviors that are not adequately reflected in objective measures of academic performance’. Formal mechanisms for enhancing problem-solving skills include involvement in the development of clinical algorithms\textsuperscript{69} and the evaluation of decision analyses\textsuperscript{69,70}.

Regrettably, higher-order cognitive functioning can be influenced adversely by external factors. A study of surgical house officers found that cognitive functioning and emotional state were adversely influenced by a weekend on call\textsuperscript{71}. Concern over resident work hours prompted a study of the stress associated with surgical training programmes. A sample of 257 surgical trainees reported loss of sleep and exhaustion associated with nights on call\textsuperscript{72}. Despite this, they had no evidence of more emotional stress than trainees in other specialties. Although the surgeons were more likely to have used alcohol during the previous month, they were less likely than their contemporaries in other disciplines to have used marijuana, cocaine or other drugs. It seems, at least superficially, that those training in surgery cope well with the extreme stresses of the training programme.

Conclusion

Changes in technology and societal values influence the way in which surgery is practised and the types of people who are attracted towards surgery as a career. These forces will gradually change the face of surgery and alter perceptions about what it means to be a surgeon. This evolutionary process will be aided by a greater appreciation of the underlying cognitive processes.
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