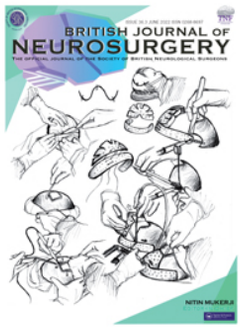

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REVIEW ARTICLE

Five psychological mechanisms that might bias learning from neurosurgical complications: case discussions and a narrative review

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ABSTRACT

Purpose: The ability of neurosurgeons to analyze and reflect on their complications in a constructive way is important both for professional development and for patient safety. The purpose of the present paper is to highlight some psychological factors that might impair or bias the ability of the neurosurgeon to do this successfully.

Methods: Five fictitious cases, loosely inspired by real events and situations, are used as a basis for a discussion of some of the most important potential sources of psychological bias in the context of understanding neurosurgical complications.

Results: The issues of a) self-serving bias and the actor-observer effect; b) heuristics and biases in interpreting probabilistic events; c) emotional avoidance and denial; d) limitations of attention (dual systems theory) and e) errors of memory, are discussed.

Conclusion: There are a number of psychological factors, that are well known to science that may be ubiquitous sources of influence on the ability of neurosurgeons to grow by reflection on their own complications. Exactly how these factors can and should be efficiently adressed by the individual neurosurgeon and/or the organisation and team in which the neurosurgeon works may vary according to type of bias, context and circumstances. However, being aware of these issues and addressing them on an individual and organizational level remains important to the quality of our craft.

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Complications; heuristics; biases; denial; memory

An important part of our responsibilities as neurosurgeons is to inform our patients about the risk that an operation will not go "as well as could reasonably be hoped" as well as the possibility that the procedure may at worst even have "undesirable, unintended results, affecting the patient".1 In the unfortunate and hopefully rare situation when such complications of neurosurgical procedures actually do occur there are strong expectations that the neurosurgeon should pause, reflect and learn from the event. Such reflection, analysis and learning may occur in solitude but may also transpire in the context of collegial mentoring, during morbidity and mortality conferences, or even during formal inquiries or litigations. The underlying assumption is that a successful analysis of neurosurgical complications may contribute to the safety of future patients through the professional development of the individual neurosurgeon. In addition such reflections may also at times trigger changes in local departmental routines or even inspire changes at national or international levels.

Obstacles to the successful analysis of neurosurgical complications

However, living up to the demand to learn from ones complications is often psychologically challenging and at times difficult. The perhaps most important reason for this is the simple fact that dwelling on ones own shortcomings just isn't very enjoyable. Another reason is that owning up to and acknowledging ones complications might appear as strategically detrimental for a neurosurgeon working in a highly competitive and unforgiving, local or national environment.

But there are also a large number of more covert psychological factors that might impair the ability of the neurosurgeon to learn from complications in ways that may be hard to immediately recognize. An important part of becoming able to analyze ones own complications is thus to learn a little bit about these phenomena in order to be able to compensate for them and address them. Below a selection of five such factors will be presented and discussed from the point of view of five case reports that are all fictitious albeit to different extents inspired by real events and situations. The presentation is followed by a brief discussion of the relative utility of debiasing strategies in handling some of these sources of bias.

Case 1

At a Monday morning meeting at a neurosurgical clinic a last year resident reports having evacuated an intracerebral hematoma on Friday night. He describes the procedure as successful but also explains that he sensed that 'there might have been something seriously wrong with the the coagulation status of the patient.' as he closed the wound.

He then goes on to demonstrate the postoperative CT scan which shows a rebleed that looks even worse than the preoperative pictures.

> So what did the lab workup say about the coagulation?, the head of department asks.
>
> Strangely, the parameters were all normal. Still the blood was just oozing as I sutured the skin.

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At this moment the head of department thinks to himself 'This is just so typical of this guy. First he decides that he feels like operating on an intracerebral hematoma that should probably never have been evacuated in the first place. Then he blames his inability to control hemostasis on the patient.'

At the same time the resident wraps up his report:

> - I really had no choice but to operate, otherwise the patient would have died. Still, this was obviously a really challenging case.

The actor observer effect and self-serving biases

For some conditions, such as intracerebral hematomas, the evidence base for surgical treatment vs conservative treatment is inconclusive. This makes clinical decisions regarding these patients potentially heterogenous between neurosurgical departments as well as between individual neurosurgeons.[2] Ambiguity, also makes decision-making, including life and death decisions vulnerable to influence by different forms of unconscious cognitive and social biases[3,4,5] A similar ambiguity can of course also be present regarding the question whether perceived problems with hemostasis during the end of a procedure should be attributed to characteristics of the patient or characteristics of the neurosurgeon. This leaves the field open to two inter-related forms of largely unconscious cognitive biases that are often referred to as 'self-serving bias' and the 'actor-observer effect' respectively.

In the case outlined above the resident may have been right in asserting that his actions and management as well as the unfortunate outcome in the form of a rebleed was all caused by circumstances beyond his control, patient characteristics being one of those. However, attributing responsibility for ones actions to circumstances when outcomes are negative and taking personal responsibility when outcomes are positive is also a typical definition of self-serving bias. This phenomenon has been subject of many experimental psychological studies and is considered stable and well documented[6,7] The tendency to blame patient characteristics for failed outcomes of neurosurgical procedures is for instance used as one example of such bias in a study by Tait et al.[8] These authors had 17 neurosurgeons and 23 orthopedic surgeons imagining being responsible for the management of four different cases of lower back pain. Results showed a significant tendency of the participants to attribute blame for failed surgical treatment to psychological characteristics of the patients when all other differences between cases were controlled for. This effect was however attenuated in surgeons who scored high on 'empathy' on a personality assessment instrument.

The ambiguity of a situation such as the one in the above case vignette also makes it impossible to know for sure whether the critical appraisals the head of department made of his younger colleague were warranted or not. Still, such an appraisal could fit well with the effect known to social psychologists as the actor-observer effect. This concept refers to the principle that people observing someone performing an action tend to explain that action as a manifestation of personal characteristics of the observed agent (e.g.[9]). In this case the effect would bias the head of department in the direction of understanding the failed surgery as something that the resident performed because he 'felt like' doing it rather than as a response to external situational demands. Interestingly, whereas the strength of this effect has been subject to debate within the field of psychology it apparently holds true for events with negative outcomes[10] (such as failed surgery for an intracerebral hematomas.)

Case 2

During one summer week a total of 6 patients with suspected or verified deep infections have their bone flaps removed at one neurosurgical department. More than 60% of these (4 cases) had been operated by the same specialist.

The department is relatively small with 3 consultants, 3 specialists and 5 residents, that all in all perform approximately 300 craniotomies a year, so 6 cases in a week, far exceeds what the organisation can expect and is prepared for. Resources were stretched and two elective operations had to be rescheduled. At the end of the week the specialist who had operated most of the cases went on a two month vacation. During these months the rate of deep infections dwindled to approximately 1/month. As word reaches the hospital management the possibility of protecting future patients as well as the reputation of the clinic by keeping her from the OR was discussed.

Heuristics and biases in interpreting probabilistic events

One of the challenges when neurosurgeons or local organisations try to understand and draw conclusions from individual cases lies in the interpretation and understanding of statistical probabilities. These difficulties are further augmented by the fact that, as demonstrated most prominently in classical works by Tversky and Kahneman'[11] people are not very good at *intuitively* understanding probability and statistics. Instead sophisticated reasoning about statistics is often substituted for heuristics that may serve most of our everyday needs reasonably well but may also at circumstances lead to irrational and erroneous conclusions. One illustration of how statistical irrationalities may influence neurosurgical decisions was made by Redelmeier and Shafir[12] who had 352 neurosurgeons and neurologists prioritize one of several patients for carotid endarterectomy surgery in a situation with only one slot available. In one condition the choice was between a female journalist in her 50:s and a retired male policeman in his early 70:ies. In the second condition a female bartender in her 50:ies was added to the group of patients. Adding the third patient actually made more neurosurgeons and neurologists schedule the retired policeman for surgery. Whereas this appears irrational from a statistical point of view it can be explained by the fact that choosing to operate on the policeman makes it possible to avoid a difficult choice between two relatively similar women.

In the case description above more than 60% of the total number of deep infections at one neurosurgical department occurred amongst patients operated by one of 6 specialists when one salient week with an extreme caseload of infections was considered. Here two variants of what Tversky and Kahneman called the 'representativity heuristic' may inspire premature conclusions about the role of the specialist in the situation. First people tend to assume that a brief section of a series in a random process should be representative of the process as a whole, even when the section is short. In this case this heuristic would leave you believe that if patient 1, 2, 3 and 5 in a sequence of 6 infected patients had been operated by specialist X, this would be representative of the frequency with which patients operated by specialist X would occur in a longer sequence of patients with postoperative infections at the clinic. Another version of this heuristic will have people disregarding the risk that a limited sample size will be biased relative to a larger one. Finally another heuristic, that of 'availability,' may also be at play here. Since the hospital administration is likely to hear and talk about the week with 6 infections this limited sample of neurosurgical infections

will be much more available in the mind of a lot of individuals when local issues of neurosurgical infections are discussed. This is likely to subjectively inflate the importance of these particular complications relative to other similar ones in the minds of the hospital administration.

In order to control for these biases measured and controlled systematic statistical sampling and reasoning is needed. In this case, chances are that it will turn out that the specialist with 4 infections in one week is still not over represented in the infection statistics in a meaningful way over a period of one or two years, as compared to her other colleagues. If this would indeed be the case, other venues of prevention of infection than keeping this surgeon from the OR may in fact be more useful.

Case 3

A treatment plan is made at a multidisciplinary vascular round, for a neurologically intact 11 year old girl with a 4×7 cm arteriovenous malformation (AVM) with feeders from the left Medial Cerebral Artery (MCA), Anterior Cerebral Artery (ACA) and Middle Meningeal Artery (MMA). The plan is to try to shrink the size of the AVM by selective embolisation of feeders from the MMA and MCA in order to make it more amenable to stereotactic radiotherapy. However, during the procedure the endovascular neurosurgeon decides to change the plan and performs a complete Onyx embolisation of the whole AVM. After having finished the procedure, while the patient is still under anesthesia, the parents are informed that the whole AVM is obliterated. However, the patient wakes up with a complete Broca's aphasia and a plegia of the right arm. A postoperative CT scan with perfusion series demonstrates a manifest ischemia encompassing most of the middle and inferior left frontal gyrus and part of the internal capsule. It takes the responsible interventionist three days to approach the parents and the child. As he finally talks to them he informs them that he has thoroughly reviewed the case and that he is convinced that the neurological deficits are just a temporary phase while the brain vasculature and brain tissue adjusts to the effects of treatment. He finishes of by congratulating the child to having been subject of a successful treatment.

The emotional impact - avoidance and denial

The experience of physiological and psychological stress is an integral part of performing open and endovascular surgery.[13] Dealing with and controlling stress without compromising sound clinical judgement and the ability to engage in a meaningful and empathetic way with the patients is thus a necessary skill for the surgeon that can be seen as 'part of the drill'.[14] The experience of having been instrumental in causing a severe complications in a neurologically intact patient may however overwhelm the ability of the surgeon to successfully deal with the emotional impact of the event (e.g.[15]).

Avoidance and denial in response to non target embolisation of AVM during endovascular procedures was probably first discussed by Hetts et al..[16] Unlike some other coping mechanisms described amongst surgeons handling complications such as seeking peer support or counselling or mentally deconstructing the event,[17] avoidance and denial have obvious disadvantages for the impacted patient[18] as well as for the ability of the surgeon to constructively reflect on the incident.

Denial that an event has occurred or of its impact that is apparently driven by a desire to escape negative feelings of anxiety, fear, guilt and shame has been repeatedly observed in a wide variety of settings from individuals being confronted with a cancer diagnosis to victims of documented child sexual abuse (e.g.[19,20]). Historically and following the theoretical discussion of the phenomenon by Anna Freud[21] (p. 89) based on a psychoanalytic perspective, the phenomenon has been understood as a deeply problematic mechanism by which the psyche defends itself from 'frustration' inflicted by 'the external world.' Later Lazarus[22](p. 232) integrated the concept in coping theory and presented a more optimistic conceptualization of the phenomenon as something that may to some extent be necessary or at least a necessary part of a psychological coping process in the face of adversity:

> … strip us of beliefs in which we are heavily invested and we are deeply threatened, alienated and perhaps even seriously disrupted in our life course and perhaps even in our capacity for involvement and satisfaction. In effect we pilot our lives by virtue of illusions that give meaning and substance to living.

According to this view and the process descriptions of coping with for instance a cancer diagnosis or ones own impending death, denial may be one early stage in a process of accepting and integrating reality in a mature way (e.g.[23,20]).

However, as noted by Hetts et al.[15] neurosurgeons mourning their own surgical complications may be at risk of getting stalled in the early parts of such a coping process. Obviously, regardless of what theoretical framework is applied for the understanding of mechanisms behind denial of ones own complications, a surgeon who becomes permanently stuck in a state of denial will have minimized his or her ability to learn from the event.

Case 4

At two o clock in the morning a 62 year-old female pedestrian is admitted to a neurosurgery department after having been hit by a young man driving an electric scooter. A CT scan shows a complicated system of comminuted fractures extending from the temporal bone, over the midline to the occiput bilaterally in addition to extensive epidural and subdural hematomas. A CT ai shows evidence of active bleeding from the middle meningeal artery and from a lacerated superior sagital sinus that has been penetrated by a bone fragment. The neurosurgeon on call immediately makes a hurried, improvised plan for the surgery. The plan involves using neuro navigation to identify and coagulate the middle meningeal artery through a burr hole at the skull base, proximal to the bleed; to remove the bone fragment that has penetrated the superior sagittal sinus after having prepared for tack up sutures and to reposition another fragment over the posterior superior sagittal sinus by drilling away the overlying bone. As he is about to execute his plan in the OR, some 45 minutes after the patient was admitted the neurosurgeon realizes that the fact that the system of fractures extends bilaterally means that the midline and occipital bone needs to be exposed. He also realizes that he has no plan for how to do this. In a snap decision he settles on a traditional question mark, trauma flap that extends well beyond the occipital midline. The postoperative results are good, except for the fact that there is occipital necrosis of the flap that requires multiple surgical revisions.

When discussing the case during a morbidity and mortality round a couple of months later, the neurosurgeon maintains that his decision on how to place his incision was necessary considering circumstances. When asked:

> Why didn't you just make a T-shaped incision instead?, he answers.

> I guess I'm just not comfortable with those incisions. I'm comfortable with the trauma flap. I've used it a lot and it always seems to do the job.

Attention, cognitive load, dual systems theory and the illusion of validity

A wide variety of our interactions with the world around us is based on cognitive processes that are intuitive, automatic and unconscious but that are complemented by more energy demanding alternative routes of processing that require conscious attention (e.g.[24,25,26,27]). An emerging trend in psychological research on decision making[28,29]) strives to integrate our understanding of such dual processes, describing them as the workings of a largely unconscious and automatic 'System 1' and a conscious and more energy demanding 'System 2.'

The speciality of system 1 can be described as finding efficient shortcuts to good and useful decisions. Of course, the appeal of a system that is able to find quick routes to high quality decisions on issues that may be important but still not the most critical issues at hand is obvious in any situation but especially so in a neurosurgical emergency occurring at 2 o clock in the morning. Consequently, in the case description above, the surgeon decided to accept the answer 'I'm comfortable with the trauma flap,' presented by his system 1 as a valid answer to the question 'What would be the most appropriate and safe incision in a case like this?.' Not further engaging system 2 in conscious scrutiny of this answer allowed the surgeon to spend his limited cognitive resources and limited time for preoperative planning on preventing two potentially catastrophic bleedings. However, had he chosen to engage the conscious careful deliberation of system 2, chances are that he would have realized that 'I'm comfortable with the trauma flap' was actually not an answer to the question at hand.

To some extent further experience and expertise may counteract negative effects caused by system 1. First, the intuition of system 1 may be described as based on the ability of this system to 'recognize' and immediately react to patterns that are familiar. Chances are that this surgeon will recognize a similar situation in the future as potentially problematic and chose the T-shaped incision instead. Second, experience may also have attenuated some of the cognitive load caused in this situation by having to pay attention to and solving other more pressing surgical problems. This could have made it easier to engage system 2 in the issue of how the incision should optimally have been placed.

Finally it can be noted that in this case, even when the skin incision was retrospectively discussed at a morbidity and mortality conference, the neurosurgeon choose to stick with the notion that his choice was the right one (Again because he was 'comfortable with the trauma flap'). This phenomenon can be understood as an example of the 'illusion of validity,' originally described by Kahneman and Tversky[30] according to which the surgeon would be expected to be content with an explanation that an incision representing what would be the typical incision in a trauma case was also the right one for a case like this.

Case 5

We return to the final year resident who evacuated an intracerebral hematoma during a weekend on call. While presenting the postoperative CT scan that showed a catastrophic rebleed the resident described the patient as severely coagulopathic as evidenced by oozing blood from the skin sutures during the finish of the first surgery. In preparing for discussing the case with the resident the head of department found that a camera mounted in one of the operating lamps had routinely recorded the whole procedure. The head of department starts the conversation by showing the part of the recording that depicts the suturing of the skin. He then confronts the resident:

> I remember you describing oozing of blod from the sutures as you stitched the patient up. Please, tell me. Where did that even come from?

The resident pauses. Then mumbles:

> I must have misremembered.

Memory reconstruction and false memories

What we know about human memory at least seems to suggests the possibility that the resident may have been right in attributing his description of the oozing from the sutures to an error of memory. In scientific psychology memory is often described as a process defined by the steps of encoding, storage and retrieval of information.[31] Today memory researchers agree that the last of these stages (retrieval) occurs in the form of a reconstruction of the memory. This mean that memory is not, as once hypothesized by Penfield,[3233] an intact engram of the stream of consciousness which would appear to imply that its core aims are objectivity and accuracy. Instead a more central function of memory appears to be to make sense of the past in the form of meaningful and useful mental representations of it (e.g.[34,35]). The quest for meaning and usefulness makes memory prone to major and minor errors of reconstruction. During some circumstances and in vulnerable groups, the effects of such memory errors can be dramatic. So for instance even though most psychiatric patients in a study answered the question whether they had been mechanically restrained during a period of hospitalization accurately, the positive predictive value of such reports was only approximately 58%.[36] One of the hottest topic of discussion in forensic psychology during the latest 3 decades is the accumulating research evidence demonstrating the capacity of suggestion for instance of childhood abuse to produce false memories of events that never occurred (e.g.[37,38]). There is even evidence to suggest that such memory errors may have been an important factor behind false allegations made by children of Satanist abductions during the early modern European witch persecutions.[39,40]

Misattribution of the sources of memories[41,42] may be a key mechanism behind such false memories.

When memories of clinical cases or of performing manual procedures are reconstructed, source attributions may also be triggered by cognitive schemas. A schema is a network of associations describing what is perceived as typical for members of a certain category[43,44] When activated a schema will influence subsequent processing of an event, and will later influence retention and retrieval of the event details. One illustration of this phenomenon is given in a study by Lindholm et al.[45] who first gave a detailed description of a boy visiting a surgical emergency department with injuries suggestive of child abuse. A group of participants who decided that the case should be reported to the authorities by the surgeon in charge were tested for their memory, 2 weeks after being confronted with it. At that time they tended to remember a number of features of the case that are stereotypically associated with suspected child abuse but that were actually never presented to them. In a follow up study on another group of participants these findings were replicated.

Furthermore, being exposed to the information that the boy had died from skull fractures 2 days after his first visit to the emergency department had a similar effect on the group that had decided not to report the case as suspected child abuse. That is, after having been exposed to information suggesting that child abuse had actually occurred, this group also added features typical of child abuse to their memories for the case.

Of course there is no way of knowing whether the resident in our hypothetic case description did misremember the closure of the surgery or if other explanations would be more reasonable in a case like this. However, there should be no doubt that over reliance on a malleable memory may both cause neurosurgical complications and make the retrospective evaluation of them more difficult than necessary. Retrospective analyzes of mistakes that eventually led to complications will undoubtedly benefit from detailed reviews of case records and scans even when the surgeon subjectively feels that he or she remembers them clearly since even some erroneous memories may be held with great confidence.[46]

Debiasing strategies

For thousands of years there have been notable efforts by ambitious individuals to become better persons by overcoming the limitations of their own psychology, first by understanding it and then trying to find ways of rising above it. This challenge is complex and effortful. However, neurosurgeons trying to reflect on their own complications at least have the benefit of being able to rely to some extent on decades of systematic psychological research on mechanisms that might bias their clinical reasoning. A modern term commonly used for strategies to counteract biases and psychological limitations in decision making this is 'debiasing'.[47] In an excellent review on the issue Croskerry et al.[48] explain the fundamental principles of debiasing like this:

> Those who are successful learn the consequences of their actions and take steps to avoid falling into the same thinking traps. Often this can be done using forcing strategies or deliberately suppressing impulsivity in certain situations. We can't find our car keys at a time when we are in a hurry, so many of us learn the forcing strategy of always putting them in a specific place as soon as we arrive home. In some situations, we can adopt simple, protective forcing rules whenever we are going to do something irreversible for example, by following the maxim 'measure twice, cut once' (Croskerry et al.[48] ii62).

Put in other words, what the motivated neurosurgeon can do to avoid being biased by psychological mechanisms such as those described above, when reflecting on his or her own complications, is first to make a conscious decision to try to consciously engage in identifying and counteracting possible sources of bias. Checking ones own reasoning, memory and reflecting on emotional dimensions of the case may be useful at this point. In addition outside help, through perspectives provided by colleagues and/or corrective habits, flowcharts or checklists may help in providing points of reference outside of ones own thinking.[49] However, the exact methods that might be effective for debiasing in a particular situation are of course dependent on the individual, the circumstances but most important the type of bias at hand.[50] In order to counteract a bias caused by misremembering details of a case, use of objective documentation is obviously efficient. In counteracting biases in reasoning on statistical probabilities the application of appropriate statistical methods and reasoning rather than intuitive snap decisions may be efficient and so on. However, in a general sense spending time and effort to reflect on and identifying possible sources of bias is the most important first step.

Conclusion

In addition to learning the manual skills and theoretical principles of our craft, one of the most central and important parts of the professional development as a neurosurgeon is to achieve a realistic and nuanced self-understanding including a sense of ones abilities and limitations as a professional. In neurosurgery 'knowing ourselves' may not only have the benefit of helping us turn into more mature and hopefully amiable persons. In particular our understanding of our limitations may have a very direct impact on the health and welfare of our patients. Being able to understand and recognize psychological principles and phenomena that may at times stand in the way of the development of such a professional self-understanding is thus important.

In the present review an attempt has been made to illustrate and discuss how five different common psychological mechanisms that may hinder or bias our ability to reflect on our neurosurgical complications and by extension ourselves as professionals, may appear in the clinical context. These five mechanisms were subjectively chosen because of their relative importance and since they largely represent different broad aspects of psychological functioning. However, it is important to note that there is a large number of detailed additional concepts and more specific psychological mechanisms with the potential to impact clinical decision making in general and ones ability to reflect on neurosurgical complications in particular that have not been covered in this review.

The practice of neurosurgery is often a big stakes endeavor. This means that factors that might significantly influence the quality of this practice are important and need to be taken seriously. The main point of the present review and case discussion was to illustrate that there are a number of psychological factors, that are well known to science that may be ubiquitous sources of influence on the ability of neurosurgeons to grow by reflection on their own complications. Exactly how these factors can and should be efficiently adressed by the individual neurosurgeon and/or the organisation and team in which the neurosurgeon works may vary widely. However, being aware of these issues and when the need becomes apparent, addressing them on an individual and organizational level remains important to the quality of our craft.

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