The art, science, and simulation of performance

Roger Kneebone

Department of Surgery and Cancer, Imperial College London, UK

This article juxtaposes two contrasting professional domains—surgery and music—as a starting point for discussing the concept of performance in different settings. The paper examines possible parallels between emergency surgery and jazz improvisation as distinct yet related forms of performance, drawing selectively upon relevant literature. It then develops the concept of simulation as a bridge between the closed world of the operating theatre and the wider world of those who cannot access it. Presenting an accurate yet safe “transcription” of this closed world can offer an experimental setting for exploration. The article describes Distributed Simulation, a concept developed by the author’s research group at Imperial College London. The possibilities of low-cost, portable yet highly realistic simulation extend beyond its obvious value for practicing safety-critical skills and procedures. There is clear potential for vicariously experiencing other worlds such as those of music, drama, and dance, allowing each domain to learn from others.

Keywords: performance; surgery; simulation; expertise; music

Operative surgery is often perceived to be a “scientific” activity. At first glance this may seem self-evident. After all, the framework within which patients are diagnosed and operated upon fits comfortably within a scientific paradigm. Diseases are diagnosed by the systematic gathering of information from history taking and physical examination, supported by increasingly sophisticated laboratory tests and imaging technology and (where necessary) surgical intervention. If diagnosis proves difficult, more tests (it is widely believed) will eventually yield the answer.

The same appears to apply to operative surgery. Decisions about treatment are based on the evidence of controlled trials conducted according to the methods of science. Surgeons are trained to lay aside their emotions and
hone their technical skills. The public perception of surgical operations is of structured and controlled events, where high levels of skill combined with an almost superhuman clinical detachment leave no room for the unexpected.

The reality, however, is different. Although rigorous science must underpin clinical practice, medicine is also an art. All experienced clinicians are acutely aware of the complexity and unpredictability of dealing with individual human beings (whether these be patients or colleagues) and the challenges of applying general scientific knowledge to particular instances (Kneebone et al. 2006). The operating theatre is no exception.

**MAIN CONTRIBUTION**

In this article, I argue that operative surgery can be considered as performance and that, although usually framed as a science, the operating theatre has much in common with the performing arts. Even the terminology of surgery has obvious resonances with the drama. Operations are “performed”; surgery takes place within a “theatre”; and everyone has to “play their part” as an operation unfolds.

Of course there are obvious differences as well as similarities. In performance arts such as theatre, dance, and music, performance is designed to take place before an audience. This “public face” of the process is an integral element of its nature. Surgery, however, can be witnessed only by those with privileged access, by legitimate participants in a community of practice (Lave 1991, Wenger 1998). And of course, error or misfortune in surgery can lead to serious damage or even death for the patient. However, although the stakes are different for the receivers of a surgical and an artistic performance—patients as opposed to audience members—the levels of expertise and professionalism of the performers have much in common.

Nevertheless, the successful performance of a challenging operation by an expert surgical team has much in common with a well-rehearsed play. In music, dance, and drama, extensive practice and rehearsal underpin every production or recital. As Malhotra (1981) puts it, a rehearsal is “the delivery table upon which the world-of-music is born” (p. 116). In the case of surgery, however, most of the learning that culminates in expertise is gained through participation in repeated performance, in the form of actual operations on real patients. Rehearsal (as opposed to practice) is seldom used (Kneebone 2009).

In all these domains, however, the finished performance conceals the hard work and artifice that underpins it. In every case, it is only the performance itself that is on show. The antecedent stages of practice and rehearsal are hidden from those outside the profession. Much that appears spontaneous
and fluid is the result of intensive preparation, yet this is seldom acknowledged. And there is surprisingly little consistency about how experts acquire their expertise. It seems that everyone has to learn for themselves how to practice, how to recover from mistakes, and how to ensure that the performance is perceived as successful.

In order to explore the notion of surgery as performance in more detail, I focus on one type of operation—emergency surgery for traumatic injury—and one type of performance art—jazz ensemble improvisation. Some explanation may be helpful for the non-medical reader. Much operative surgery is “elective,” where a patient undergoes a planned procedure for a disease or condition that has already been diagnosed. For example, a patient with gallstones may have their gallbladder removed, or someone with cancer may need part of their intestine cut out. Preoperative tests will usually have shown the extent of the problem, allowing the surgical team to plan in detail what needs to be done. Although each patient is unique and unanticipated complications may always arise, the overall sense is of a procedure whose stages are clearly mapped.

Emergency surgery for trauma, on the other hand, has a different character. When a patient is admitted with a stab or gunshot wound, it may be evident that they need emergency exploration but not at all clear what has been damaged. The surgical team cannot know what they will find until they open the patient’s body.

Such emergency operations are not uncommon and often take place outside normal working hours with hastily constituted groups. Especially in the current climate of the UK National Health Service, members of the surgical team may never have worked together before. So individual clinicians (surgeons, anesthetists, nurses, and others) are required to form an effective team under conditions of great uncertainty and stress, performing to the best of their ability in the interests of a patient for whose safety they are jointly responsible.

Of course it is expected that each clinician will show mastery of the elements of their individual craft. The surgeon must be able to handle tissues, control bleeding, remove or rejoin organs. The anesthetist must keep the patient both alive and asleep. The theatre nurse must ensure that all equipment is ready as needed, providing the surgeons with the right instruments at the right time. And so on. But all these elements, though necessary, are not in themselves sufficient. It is possible to have highly competent individuals who nonetheless do not work as an effective team.

So the social functioning of performing teams is of great interest and importance. If allowed to become destructive, the stress and unpredictability of
emergency surgery can cause fault lines to emerge and the patient’s safety to be jeopardized. But that same stress and unpredictability can also result in inspired performances, where experts respond to the unexpected with fluidity and co-ordination to achieve spectacular success. It is this aspect of surgery—this responding effectively to conditions of uncertainty—that resonates with musical improvisation.

This paper therefore considers the parallels between emergency surgery and jazz improvisation. It links the author’s personal experience as a surgeon and a teacher with recent literature on musical improvisation. Much of this highlights the human, social nature of jazz performance. Ingrid Monson (1996) points out that “interacting musical roles are simultaneously interacting human personalities, whose particular characters have considerable importance in determining the spontaneity and success of the musical event”. She goes on to state that “a prerequisite to successful participation within a jazz group is a repertoire of tunes that may be called by other musicians—and the ability to play them in more than one key” (p. 26). In surgical terms, this equates with team members needing to master a wide range of skills and techniques which can be activated as required in response to a given situation in the operating theatre.

Berliner (1994), in his monumental study of jazz improvisation, also highlights the social aspect of performance. “The operations of improvisation involving more than one person,” he says,

require the instant assimilation of ideas across the band’s membership. Musical materials extemporaneously introduced in any of the parts can influence the others, potentially providing renewed inspiration for all. The unpredictable quality of the band’s musical negotiations is a fundamental ingredient in every performance, imbuing its creations with uniqueness (p. 497).

This resonates with Sawyer’s (2003) point that group performance is more than the sum of its parts and that the complexity of group behavior makes accurate prediction impossible. This property of emergence, of not knowing in advance how a particular group of people will function creatively, is clearly evident in trauma surgery. At its best, inspiring performances can coax more out of every member than they knew they could provide. At its worst, dysfunction and failed communication can jeopardize the whole performance.
Solis and Nettl (2009) emphasize that effective improvisation is based on hard work. Writing about music (but giving a description equally applicable to surgery) they say that:

outsiders or novices to the world of improvised music may perceive improvisation as a phenomenon on the edge of magic [my italics]. As the journey into the art and craft of improvised performance continues, the sense of magic dissipates, revealing an experience steeped in the musical nuts and bolts that are so primary to improvisation within a given genre. Jazz musicians have often maintained that musicians must be prepared in advance to gain the freedom to play with spontaneity in public performance (pp. 127-128).

This mysterious, almost magical aspect of surgery is often commented on by newcomers such as medical students and novice nurses. It is only after long exposure that the ways of the operating theatre become familiar.

Eventually, all these elements of technical skill and team work becoming seamlessly integrated. As long ago as 1921, Dalcroze (cited in Solis and Nettl 2009) said:

Learning to improvise is similar to learning a language. You speak a language fluently when you reach the stage of not having to think about each and every word you enunciate; you can concentrate entirely on the content of the communications. Thus it is with music, that by knowing it one no longer thinks atomistically about individual notes but rather shapes larger phrases, often in improvisatory fashion, according to what it is that one wishes to communicate (p. 135).

So there seems a consensus that the apparent freedom of jazz improvisation is built on a solid foundation of many years of rigorous preparation, both in terms of technique and knowledge. Repeated playing with other musicians trains players to listen, to be aware, and to avoid over-focusing on one’s own task to the exclusion of what is going on around. Similar behavior can be seen in the operating theatre, where inexperienced surgeons often become fixed upon a technical task and lose sight of the bigger picture of the operation at large.

Although the literatures of surgery and music are vast, direct comparisons between the two are few. To make that connection, this paper therefore draws on the author’s experience in directing a Masters in Education (MEd) in Surgical Education at Imperial College London. This programme is aimed at
those wishing to explore the relationship between the biomedical world of surgery and the humanities-based world of education. Exploration of parallels between surgery and other professional domains forms part of the course.

An interactive session in January 2011 with 20 MEd students showcased a professional baroque duo (harpischordist Sophie Yates and violinst Alison Townley) and a professional jazz pianist (Liam Noble). The aim was to explore the differences between scored and improvised musical performance and critically examine parallels with elective and emergency surgery. The students were all qualified doctors, some undergoing specialist surgical training and some already established as consultant (attending) surgeons. The session allowed engagement between surgeons and musicians with the specific aim of exploring commonalities between their two worlds. Through a process of debate and critique, it became apparent that mastery of instruments (whether musical or surgical) and the acquisition of high levels of technique are central to both performers’ professional identities.

The musicians set the frame with examples of baroque and jazz performance. Discussion between the musicians and surgeons identified areas of similarity and difference. For example, the operating theatre is a highly complex social and technological environment. Communication is multimodal—much that is communicated is unspoken, being conveyed by stance, gaze, gesture, or silence. During a musical performance too, much is conveyed without being spoken—again through gesture, gaze, and movement (Bezemer et al. in press-a, -b, and –c).

What emerged particularly clearly was the crucial importance of the interaction between people who are working together. For example, both surgeons and musicians took it as a given that all participants would have acquired high levels of knowledge and technical skill, whether about anatomy and surgical technique, or harmonic structure and the ability to play their instrument. But in addition to this individual mastery was the need to function effectively with others, under conditions that dramatically differed from those of practice or (in the case of the musicians) rehearsal. The pressures of real life performance brought out characteristics that were often unknown in advance.

The ensemble as a social setting is of crucial importance. Here, much that is written about jazz could apply equally to surgery. For example, active listening—the continual awareness of what is happening in the wider context of the whole situation, rather than over-focusing on one specific area of activity—distinguishes experts from novices. It seems that the ability to respond to the unexpected is grounded in years of painstaking practice, of gaining technical mastery that allows the execution of tasks to be taken care of automat-
cally. This mastery frees the surgeon or musician to focus on *what* should be done, rather than being bogged down in the details of *how* it should be done.

If the practices of surgery are hidden from view behind the defenses of the operating theatre, how can these practices be brought out for discussion with experts from other domains? Is it possible to construct a bridge between the closed world of surgery and the wider world of other performances?

It is here that simulation offers an attractive solution. By recreating the conditions of surgery within a realistic yet safe environment where no actual patient can come to harm, the *processes* of surgery can be made visible to a wide constituency. At the same time, the *processes* of music can be discussed through comparison.

For example, from a surgeon’s point of view the opportunity to *rehearse* an emergency operation, experiencing what it is like to deal with the unexpected (both in terms of injury and the behaviors of a transient team) is invaluable. Although rehearsal is an integral part of most performers’ professional lives, I have argued elsewhere that surgeons rarely use it. Instead they move from practice to performance (Kneebone 2010).

Although medical simulation has been used in various forms for centuries, it is only in recent decades that simulation has become widespread in surgical education. Much emphasis is placed on simulation for *practice*, for gaining component technical skills such as tying knots, joining sections of intestine together, or gaining the psychomotor skills of keyhole surgery. More recently, simulation centers have replicated full scale operating theatres, allowing teams to interact with one another and with sophisticated mannequins that mimic a patient’s physiological response to drugs and fluids (Gaba *et al.* 2001). Yet, such centers are scarce and prohibitively expensive, both to establish and maintain. Many people who would benefit from their facilities cannot access them. If simulation is to become widely available it needs to be realistic and affordable.

In response to these challenges, our group at Imperial College London has developed the innovative concept of Distributed Simulation (DS) (Kneebone *et al.* 2010). Its aim is not to replicate every detail of an operating theatre or other clinical space, but rather to present only those cues that are necessary to create a sense of engagement and belief. The simulation consists of a lightweight, rapidly inflatable enclosure which can be set up in any available space and which separates the activities inside from the surroundings (see Figure 1).

DS is underpinned by what we have termed “circles of focus,” based on the principle that attention is selective. By making what is closest to participant’s awareness seem most real, objects in the periphery of vision can be
represented more crudely but still be effective. In the case of the operating surgeon, for example, his or her attention is focused intently on the part of the patient’s body being operated on. The field is brightly illuminated by an overhead lamp, and normal social conventions are suspended to allow the surgeon to request and receive appropriate instruments without making eye contact with other members of the team. Objects at the edge of the visual field are registered dimly if at all (Kneebone 2010).

To achieve an effective simulation, highly realistic physical surgical models (made of silicon and created by prosthetics experts from film and television) create a powerful sense of engagement, allowing more peripheral objects (such as the operating lamp and the anesthetic machine) to be represented by more rudimentary models or even by photographic backdrops. Other cues include the beeping of the patient monitor and the physical sensation of being gowned and gloved and working in close proximity to other members of the surgical team. Initial validation studies have shown very high degrees of perceived realism, and a powerful effect upon participants of rapidly losing any sense of artificiality and of becoming fully immersed in a surgical environment. For example, more than half the surgeons participating in one study were unaware that the anesthetic machine was represented by a photograph rather than a real machine (Kassab et al. in press).
This realistic yet low-cost approach to recreating clinical environments is opening promising lines of interdisciplinary research. By detaching immersive simulation from the need for dedicated, scarce, and prohibitively expensive static simulation centers, new ways of using simulation can be explored and developed. For example, it may be possible to develop rehearsal environments where musicians can experience at least something of what it feels to step onto a concert platform in front of an audience, using audiovisual techniques to reproduce authentic sounds of audience response and the acoustics of a recital space. It is also becoming feasible to invite experts from domains outside medicine (such as musicians) to take part in simulations of emergency surgery without any danger of harming real patients, exploring unexpected links in a way that would be unthinkable in the primary environment.

I conclude by proposing that the skills demanded by any professional domain constitute a range of elements, though in differing proportions. These may include technical, craft, interpersonal, or situational components. This is equally true for surgery as for the performance arts. No one domain will correspond exactly to any other, but systematic study of these elements will provide a blueprint for an analytical, comparative approach that can bring together insights across disparate domains.

IMPLICATIONS

This comparison of surgery with jazz improvisation highlights how common features of performance can be found in unlikely places. Framing operative surgery as performance and viewing it as a performing art has highlighted new perspectives and provided new insights. I hope this process may illuminate both surgery and music, to the benefit of each.

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Address for correspondence

Roger Kneebone, Clinical Skills Centre, Department of Surgery and Cancer, Imperial College London, St Mary’s Hospital, Paterson Wing 2nd Floor, Praed Street, London W2 1NY, UK; Email: r.kneebone@imperial.ac.uk
References


