Expertise & Heuristics in Surgery

Worshop presentation at the Annual Conference
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You are looking at a “pdf” file of this talk, which shows the “notes” page under each slide.

This means you can still follow what the talk is about even though the speaker is not physically present.

Your presenter

Hi!

I'm Michael Patkin, and in the absence of a chair-person as well as me, I'll introduce myself to you.

I'm a retired general surgeon and I worked in the isolated steel-making city of Whyalla for 29 years.

Because I started off clumsy for a surgeon and wanted to do better, I became obsessed with applying ergonomics to surgery.

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I wrote the first paper on the subject in 1967. It was a lonely field to be in for over 20 years, until the early 1990s. When surgeons started in lap surgery they found serious problems with badly designed instruments and mastering the new skills needed. They took up ergonomics to try and cope with these new challenges.

Twenty years earlier, in July 1969, one of the pioneers of microsurgery, Earl Owen, had come to a lecture of mine on ergonomics in general surgery. He saw that this approach would make it possible for microsurgeons to cope with new problems of skill acquisition, control of hand tremor and rational design principles for instruments and other equipment. He and I had a necessary and fruitful association for ten years. (See www.mpatkin.org)

Lap surgery was a replay of this earlier scenario on a much larger scale.

Expertise & Heuristics in Surgery

Time needed

- expertise - what is it ? – many years
- heuristics – what are they? – minutes
  - rules of thumb
  - used by experts

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By 1990 I had given many hundreds of presentations and publications on applying ergonomics to surgery. Then, at an Ergonomics conference, I heard a lecture on expertise by Professor Bruce Abernethy of the University of Queensland on expertise. I realised this was a huge field, well-researched, which I had neglected.

At about the same time I also came across “heuristics”, or rules of thumb, made popular by a German psychologist, Gigerenzer.

These two fields, in some ways a mirror of each other, became the catalyst to expand the acquisition of skill, a basic area of Ergonomics.

a heuristic – my definition

- rule of thumb
- derived from experience
- used by experts
- of which they are usually not aware
- and therefore can't teach

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The usual dictionary definition of a heuristic is "something learned from experience". The word is related to "eureka" ("I have discovered").

Early examples of heuristics include:

Don't put your hand in the fire or it will hurt and get burnt

How to make a fire by rubbing sicks together

North is the side of the tree with moss on it (in the northern hemisphere)

why heuristics

Not yet validated, BUT
heuristics likely to improve :

1. quality of work [= $$$ etc]
2. productivity [= $$$ etc]
3. safety [= $$$ etc]
4. training
5. learning curve [= $$$ etc]
6. satisfaction at work [= $$$ etc]

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The value of ergonomics to work and more specifically to surgery has been shown in many studies and from many aspects, for example design of instrument handles for laparoscopic surgery.

The value of heuristics in surgery has not yet been proven, but seems highly likely on the face of it.

Why heuristics

Not proven, but likely improvements in:

1. quality of work
2. productivity
3. Safety
4. training & learning curve
5. satisfaction at work

6. future surgery by machine

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In the future some surgery will be mediated by computer. But for this to be possible it will be necessary to understand much more of the intimate mechanisms of dissection.

Some of this knowledge is currently hidden, or hidden in heuristics, for example the mechanism of cutting (see http://mpatkin.org/heuristics/heuristics1.htm > A mechanical basis for heuristics of movements).

This is yet another benefit of heuristics, another reason for studying them.

An early model of skill
[Glencross 1960s]

three stages

1. coding
1. ordering
1. timing

Stage 1 is learning a heuristic

Stages 2 and 3 are those of acquiring expertise.

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The late Australian hockey international, Denis Glencross, was also a psychologist at Flinders University who went on to the chair at the University of Western Australia before his tragic early death.

This model of skill learning that he developed proved useful for both further research and for teaching what should happen to others. I simplified the names for the stages.

1. Coding is learning to relate a particular action to a specific end result. This is a heuristic.
2. Ordering means getting the coded movements in the right order without leaving any of them out.
3. Rhythm is about getting the right pulse or synchronisation, with other events that occur or with other people.

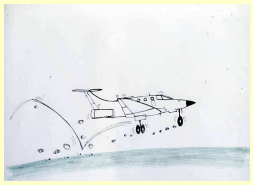
These latter two stages are the way to expertise.

Another example

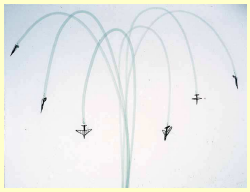
same three stages

1. coding

1. ordering



1. timing



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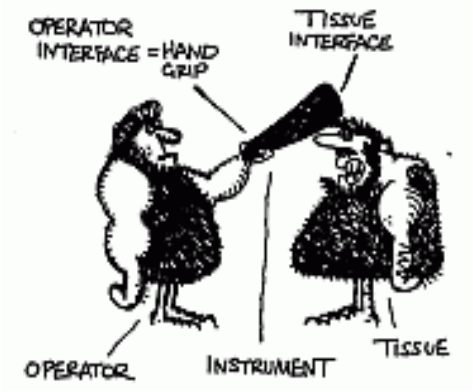
The cartoons I have used in discussing ergonomics and surgery were nearly all created by Stephen Stanley of Whyalla. He is the originator of Lafferty, a newspaper cartoon character known both nationally and internationally. He is now an author and designer of children's books.

One of his earliest cartoons for me followed my request to illustrate the model of a surgeon at work.



problems peculiar to operative surgery

identifying veiled tissue

handling tissue

(visco-elastic

- gluggy
- time characteristics)

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When engineers enter hospital as patients they suggest ways of improving the technology around them.

Often they have forgotten that the consistency of tissues may be quite different to those of metal or wood.

Further, these tissues change with age and disease. The problems of gripping and manipulating structures are quite different to most mechanical tasks.

definitions of expertise

- OED expert opinion,

  knowledge

  = *thinking*

- op. surgery expert perception

  + manipulation

  = *doing*

Defining expertise is like a cat chasing its tail – expertise is what an expert has, and so on.

Dictionaries, like the big Oxford, emphasize knowledge and do not include manual expertise. Both are important in surgery.

Expertise in perception should have more emphasis than it does – the ability to recognise an anatomical structure, especially in a diseased context. There are also tricks that can be used to improve perception, such as better lighting or a magnifier, or a contrasting background.

Requirements for expertise

nature / nurture

- 10 years
- 10 000 hours
- 100 000 repetitions

practice !!!

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Expertise becomes built-in like the hard-wired grammar of Chomsky. It needs lots of practice. A 10 year old child in Paris is an expert speaker of French.

Don Bradman, the cricketer, spent many hours hitting a golf ball with a wicket against a corrugated iron water-tank. The unpredictable rebound made him quick and accurate getting bat to ball in later life.

Victor Chang, the noted Sydney heart surgeon, had a childhood hobby of making model airplanes out of balsa wood and tissue. Others in later life, noting his surgical dexterity, put it down to this.

Yet we expect people aged almost 30 when they start their surgical training to acquire dexterity then. They need to start very much earlier in life. A young member of the Barraquer dynasty of eye surgeons did his first cataract surgery at the age of 11, according to what his grandfather told me at a microsurgery workshop in 1978.

researching surgical skill
(*based on ergonomics, expertise, tissue properties)*

1. differences between expert & non-expert
2. how to analyse the components of expertise
3. how to teach expertise

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In an early research study, Eu Ling Neo, David Watson and I scrutinised videotapes of mobilisation of the oesophagus as a preliminary to a Nissen fundoplasty. It became clear that experts carried out a task in less time because they did not carry out ineffective movements.*

(A movement is defined as effective if it advances the progress of a procedure such as a dissection.).

*Neo EL, Patkin M, Watson DI. Suturing efficiency during hiatal repair for laparoscopic fundoplication.ANZ J Surg. 2004 Jan-Feb;74(1-2):13-7.

expert cf. novice in 6 key areas

sensory ability	=	same
perception	>	much richer
cognition	>	fast, detailed pattern recognition
action production	>	more efficient
attention	>	greater
feedback usage	>	errors detected, corrected

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Experts don't necessarily have better eyesight or hearing, though they may.

Sensation + knowledge → perception

What they have much better of is "pattern recognition", based on a rich memory – chess games for a chess-master, tissue structures (both normal and diseased) for a master surgeon, crime scenes for a detective.

Polynesian navigation was mentioned earlier. You can see more of this topic in Wikipedia.

Intuition blurs expertise ⟷ heuristics

"A judgment in which visual and verbal cues are so rapidly and subliminally observed that their contributions to the final decision are virtually forgotten.""

(Clofti 1997 J Adv Nurs)

Complex sequences of actions become routine – and automatic – allowing more attention to other possibly unusual aspects of the situation

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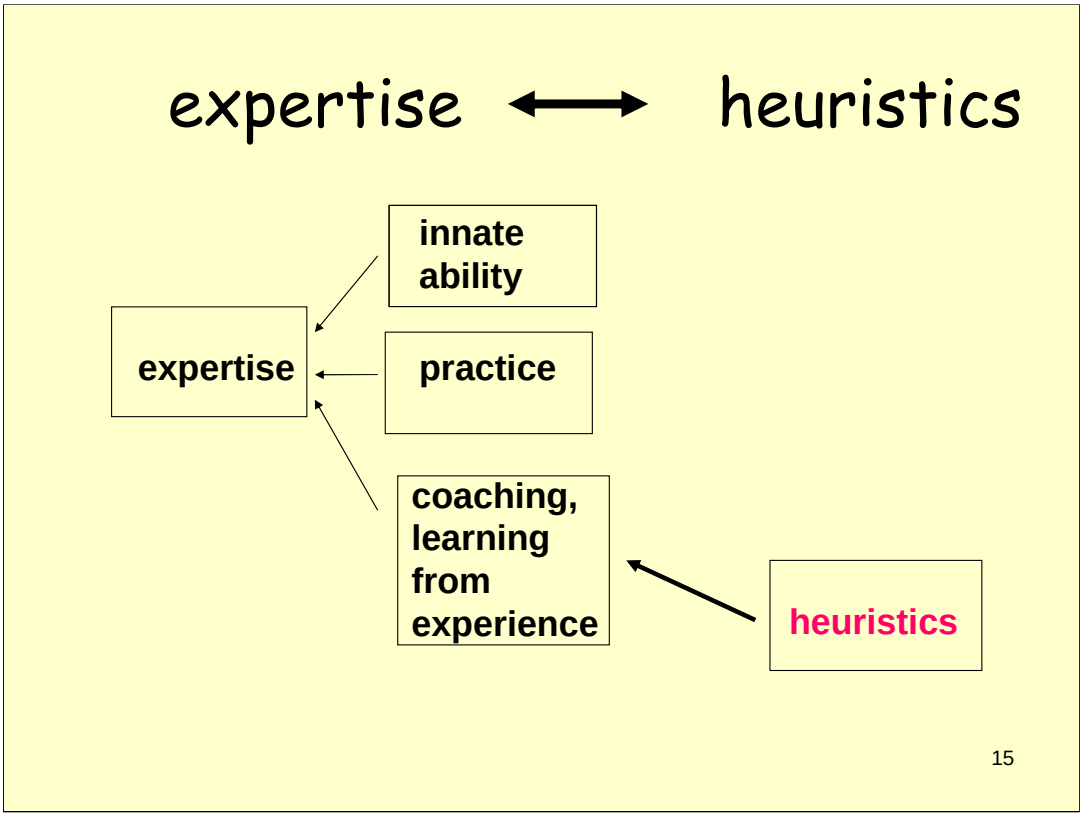
As discussed earlier, heuristics and expertise apply at different stages in skill acquisition.

Intuition.a process which seems almost mystical to the observer, is a result of both of these.



This analysis explains the role of heuristics even more specifically

An early heuristic

Archimedes principle

a body surrounded by fluid is buoyed up by a force equal to the weight of the displaced fluid

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“Eureka” was reputedly shouted by Archimedes as he ran naked through the streets of ancient Athens after he discovered the principle known by his name.

The king had set him the task of determining whether his new gold crown was pure or had lead in it. Lead is less dense than gold and is buoyed up less when immersed in a liquid.

a heuristic is not :

- algorithm [sequence of steps, except in computing when it refers to "a set of rules for performing a calculation"]
- law [causal explanation]
- hypothesis [more than a hunch, less than a law]

- admonition, superstition, mistaken belief

There may be **competing heuristics**, like proverbs which contradict one another

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An algorithm is a step by step procedure for reaching a clinical decision or diagnosis, often set out in the form of a flow chart, in which the answer to each question determines the next question to be asked.

Examples of **competing heuristics** for appendicitis:

if in doubt do nowt

if in doubt take it out

You need a third algorithm. How do you know if a laparoscopically normal-looking appendix doesn't have mucosal appendicitis? An appendicolith may be the problem. Many recent papers on this topic exist.

A surgical admonition might be considered a heuristic, for example "Never use diathermy near the common bile duct"

One more pair of differences

- Expertise is rhythmic
- A heuristic is usually a one-off

- Either may be "ballistic" – or not

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A ballistic movement is one where the object continues to move when it is no longer held, by the hand or by a mechanism, for example throwing a ball, firing an arrow or any movements which relies on the momentum of the body or part of it.

It comes from the ancient war machine "ballista" used for throwing rocks, and also gives its name to the science of ballistics for identifying the source of fired bullets.

types of heuristics in surgery

- cognitive (2 slides with 5 examples)
- perceptual (1 slide)
  recognizing landmarks
- motor (33 slides)
  accuracy [including tremor control]

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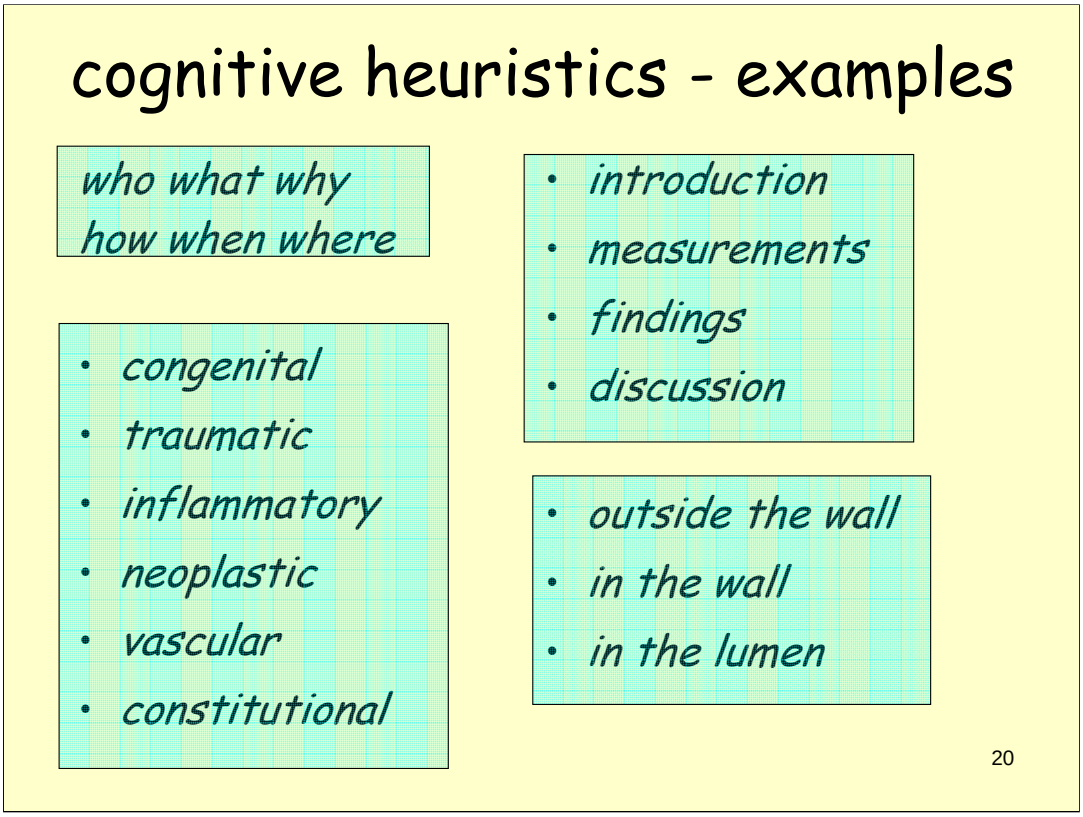
Non surgical examples were given earlier, and you can find many examples in your personal daily life. You can also learn them from others (“tips”).

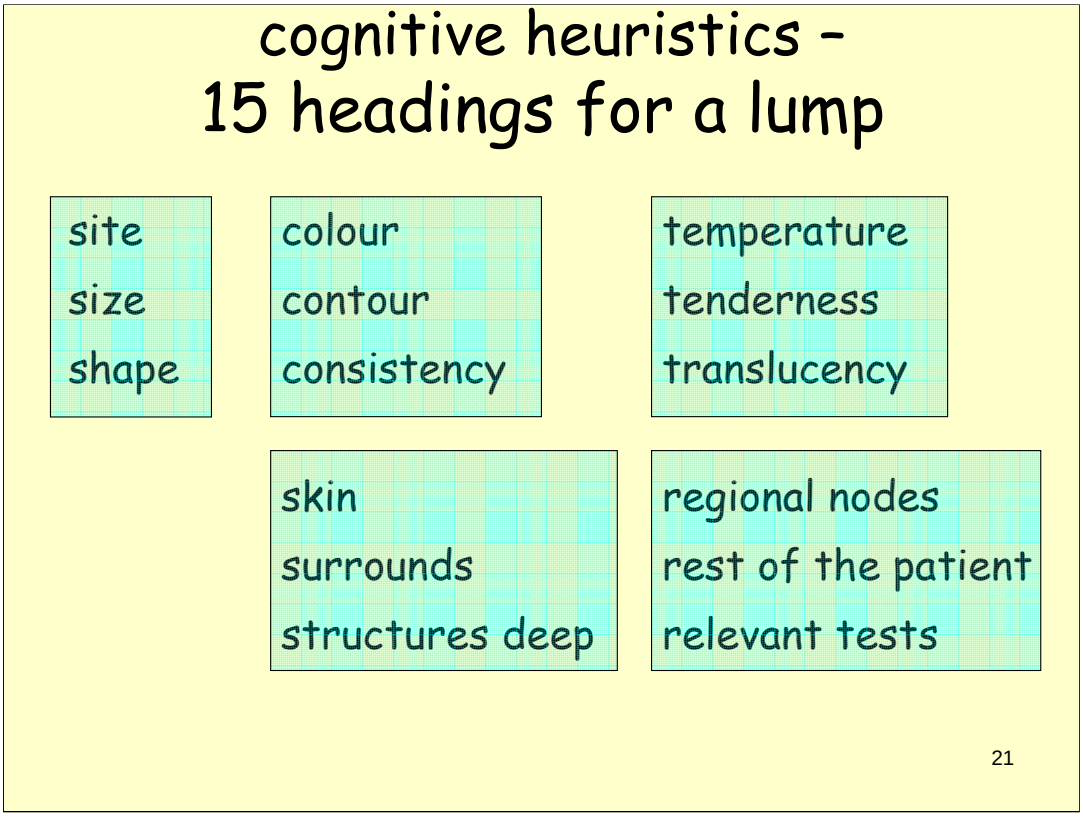
Surgical heuristics are rarely written down, but learned (if at all) by imitation which may be unconscious or by discusssion across the operating table or during a coffee break.



Such mental check-lists go back to Aristotle's categories, discussed in his major work of the same name:

> Substance, Quantity, Quality, Relation, Place, Time, Position, State, Action, Passion or Affection

Unlike these examples, they do not seem to have been used for memorising.



This has been a well-known mnemonic to earlier generations of medical students, but when asked, they would often peter out after the first few terms. I gradually compiled what seemed to me an exhaustive list – until the next suggestion comes along.

perceptual heuristics

- subtle clues to identification -

(visual)	right crus	dimple
"	oesophagus, vagal trunks	traction on stomach, moving it from side to side
"	general	anatomical landmarks, imaging
"	test anastomosis	leak bubbling under water
(auditory)	NG tube in stomach	auscultating injected air
(tactile)	hollow structures	•intubation (probe, catheter, bougie, illuminated rod) •inserted finger
(smell)	punctured bowel	
- more		

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These are clues or cues or tricks to identify structures.

I was operating on a 94 year old patient with a strangulated hernia and replacing small intestine in the abdomen using de Bakey forceps. I suddenly smelled faeces, though no once else did. Withdrawing the last loop of bowel replaced showed a small perforation caused by the forceps. I oversewed it and replaced the rest of the bowel using sponge forceps.

You can palpate the recurrent laryngeal nerves more easily by running the back of the end of the fingernail over them.

To identify the position of the end of an instrument at laparoscopy, press lightly to see tissue dimple (touch-confirm of Zoley Szabo)

Sometimes you can hear the twang of a tense structure being cut.

motor heuristics

hands
- thread needle, steady hand or instrument
- funnelling

tissues
- cut at right angles to lines of tension
- timing in piercing or splitting tissue
- indenting to grip a flat surface

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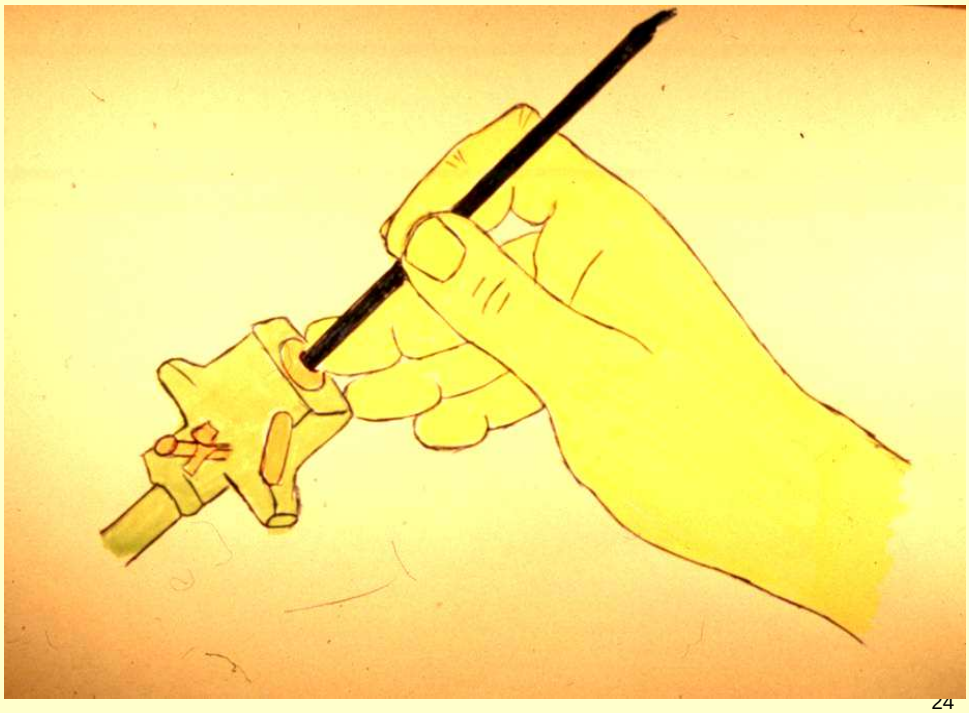
Motor heuristics are illustrated by examples which follow:

Steadying the hand, cutting across lines of tension, displacing or grasping structures, a heuristic for grasping in lap surgery, reaching a target accurately – Fitts Law, funneling, timing

The final topics then considered are (briefly!)

Video analysis, researching heuristics, References

Motor heuristics might be considered the essence of surgery, but dexterity is not the most important part of being a surgeon. Judgement and personal values are equally or more important.



When moving a diathermy hook more deeply at laparoscopy may cause an “oops” when it digs into a structure such as liver. This movement is safer and easier to control if the hand is steadied by resting the tip of a finger on a support.

(I traced this from a slide I took of my long-standing colleague Luis Isabel, a master surgeon).

why cut across lines of tension

1. otherwise just push tissue away e.g. preperitoneal fat
2. continually exposes fresh layer

convexity better than simple lateral tension

- congenital pyloric tumour, cysts [already tense]
- wrapping structure over fingers and pulling up slightly [also controls bleeding]

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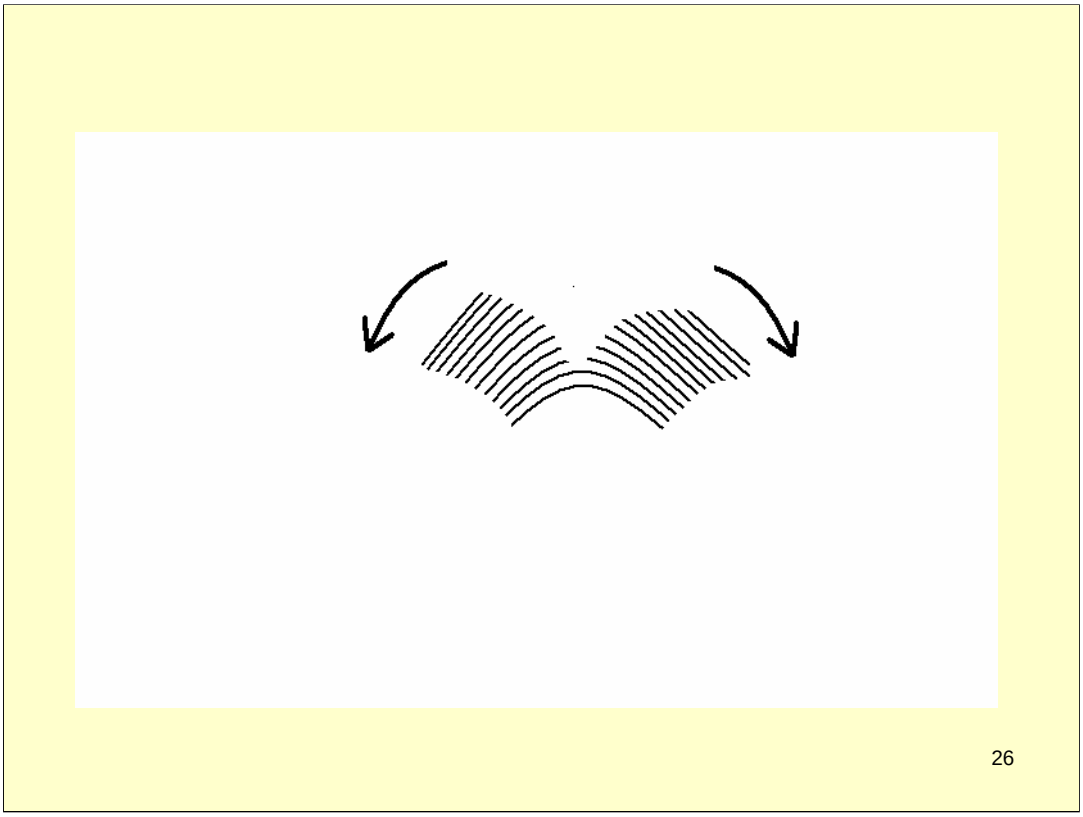
“In praise of tension” is a chapter heading found in Stephen Power’s old textbook “Surgical technique”.

A counter-example is the legendary Saladin’s sword, so incredibly sharp it could slice through a gossamer-thin silk scarf resting on it, or in the following example, a cushion.

Saladin took a silk cushion from the floor and placed it upright on one end. "Can thy weapon, my brother, sever that cushion?" he said to King Richard.

"No, surely," replied the King, "no sword on earth, were it the Excalibur of King Arthur, can cut that which poses no steady resistance to the blow."

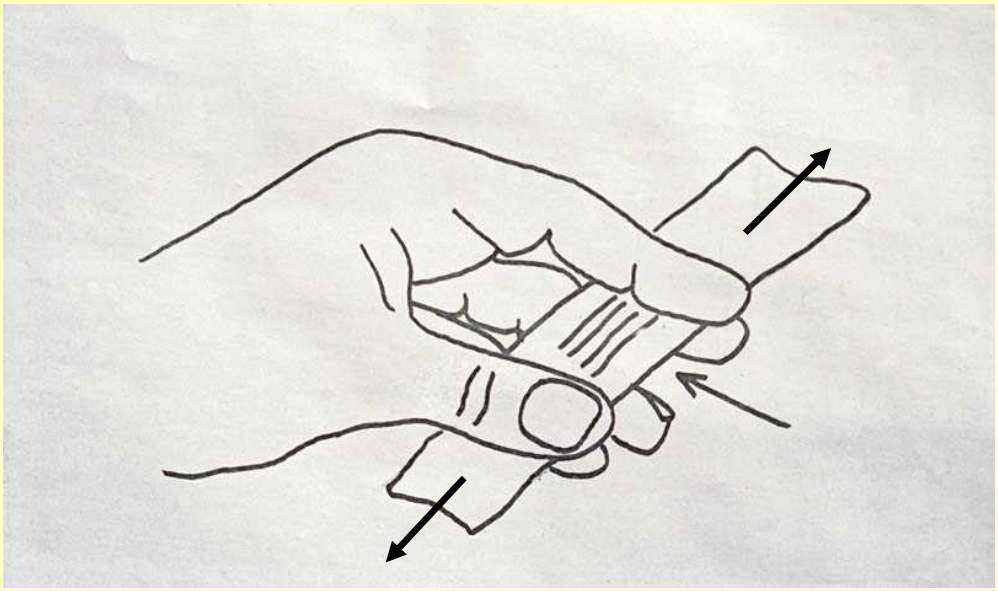
"Mark, then," said Saladin and unsheathed his scimitar, a curved and narrow blade of a dull blue colour, marked with ten millions of meandering lines and drew it across the cushion, applying the edge so dexterously that the cushion seemed rather to fall asunder than to be divided by violence. (Sir Walter Scott - The Talisman).



This diagram shows successive cut laminae sliding outwards either with convexity or lateral pull by friction on surface. This is how the pyloric tumour of congenital obstruction in babies opens up as you get to (but not through) mucosa.

Contrast such antiflexing with flexing. It binds the cutting blade or displaces the cutting target deeper into a fold.

A very pleasing light stroke gives marked effect and a feeling of control. Politically incorrect!



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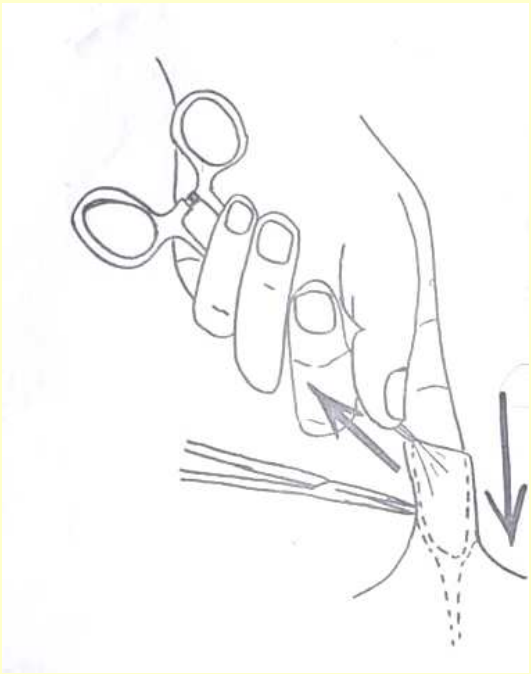
Stretching something to make it possible to cut at right angles to it.



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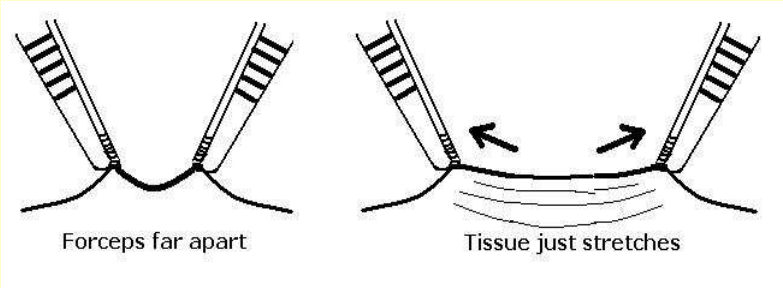
This sketch shows dissecting around a hernia sac where fat starts to obscure the underlying peritoneum.

The fingertip senses the thickness of tissue between it and the scissors, and if they are round-ended and set lightly (screw not tightened beyond just keeping the blades together) then the flimsy peritoneum can be kept intact.

A similar technique of dissecting a fragile layer can be used for a really difficult duodenal stump in a gastrectomy, and for a cholecystectomy, when part of the wall may be left stuck on the liver but with diathermy destruction of the mucosa.

Tearing tissue laparoscopically



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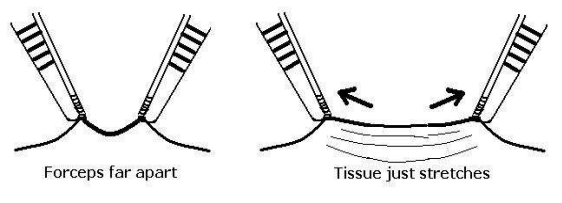
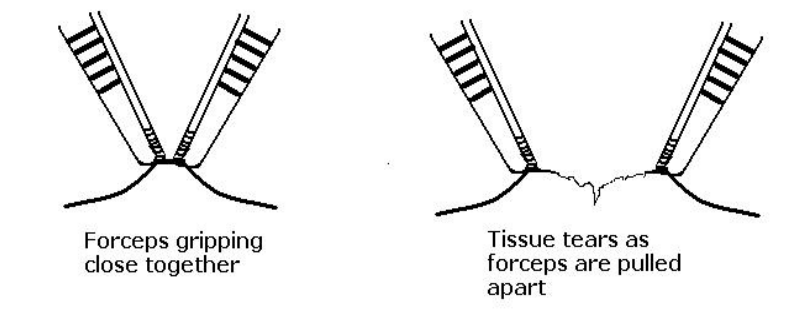
One of the limitations of the laparoscopic environment is the limited view of about 30 degrees in each direction until the scope is moved, compared with normal human field of view of about 150 degrees.

If tissue is gripped and pulled apart, it will merely stretch instead of tearing, if the two gripping points are a distance apart.

Tearing tissue laparoscopically





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By contrast, if the two gripping points are close together, stretching soon exceeds the limits of elastic deformation and the tissue starts to tear.

displace / grasp

- push, pull - encircle, pierce, grip
- suck – venteuse, microchips
- magnetic – foreign body

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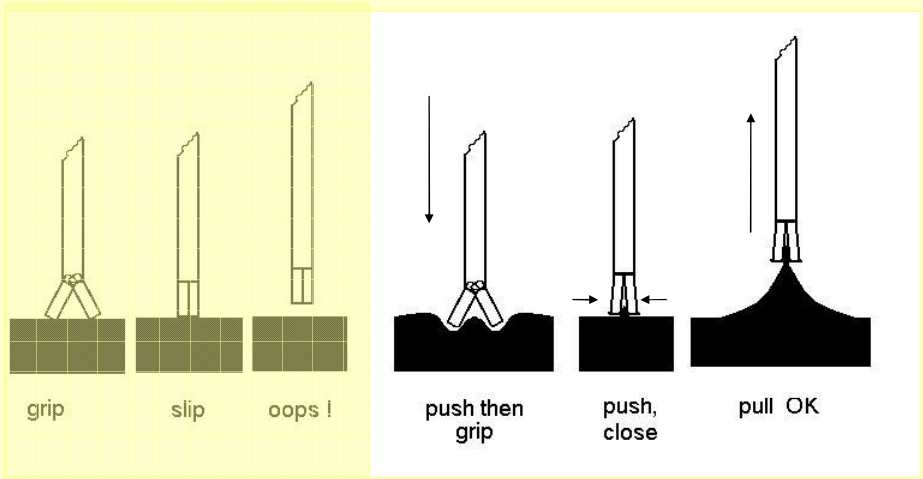
How do you grip something?

See a full discussion in:

http://mpatkin.org/surg_lap/erg_lapsurg_1995.htm

> Methods of grasping

a heuristic for lap grasping



FAILURE !

SUCCESS !

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When trying to grip something by its surface, a common and repeated sequence is grip, slip, oops.

To overcome this problem, the forceps should be pushed in to indent the surface a little, causing two little grooves with a ridge between them.

This can then be gripped.

During a lecture I illustrate this by putting thumb and index on my sleeve, and failing to grip until I press the fingertips to create the grooves and ridge.

reach a target accurately

- Fitts law
- funnel
- control tremor

[stability and equilibrium]

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It seems common sense that reaching a target quickly and accurately depends how far away and how big it is.

These requirements for accurate reaching have a mathematical relationship discovered by an American psychologist called **Paul Fitts** in 1954.

Fitts law

$$t = a + b * \log_2 2 * d / w$$

t = time
a & b are constants
d = distance to target
w = width of target

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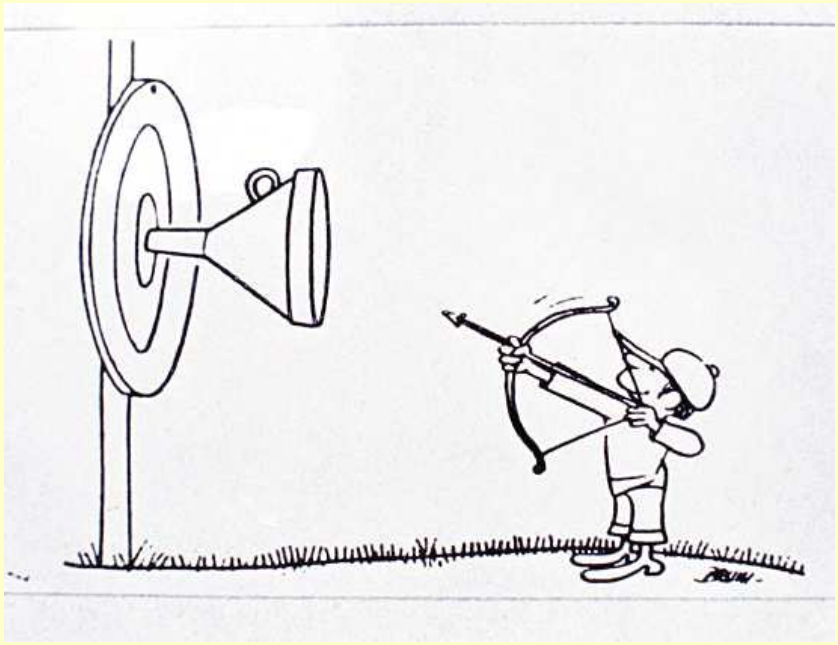
Here is the formal expression of the law.



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It is possible to extend Fitts Law, by making the <u>apparent</u>

size of the target larger, which we commonly do when pouring liquids, or in this case by directing a solid object.

Another way of increasing the apparent size of a target is by optical magnification (using a loupe or operating microscope) or improving visual acuity, for which several methods are available:

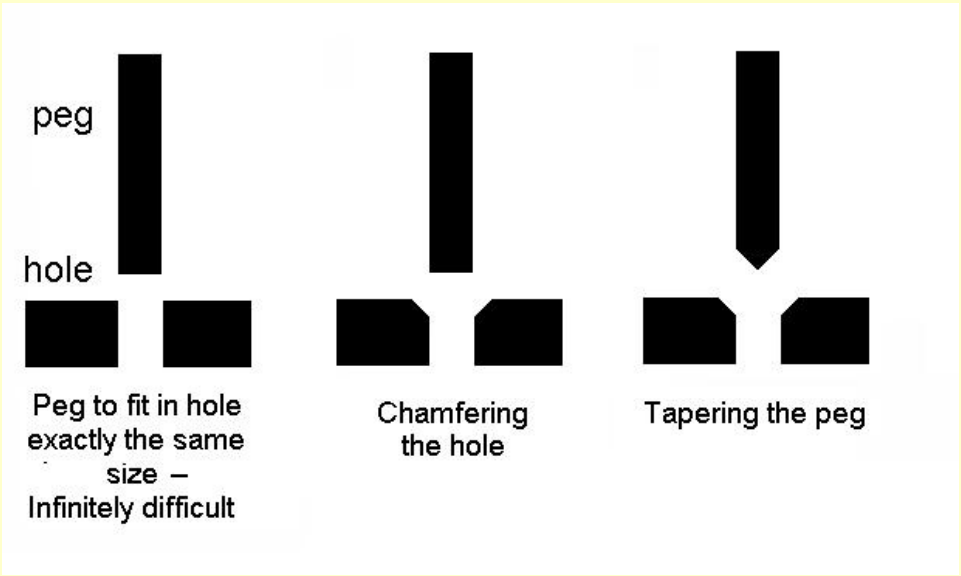
- increasing the lighting

- colour contrast for inside the aperture

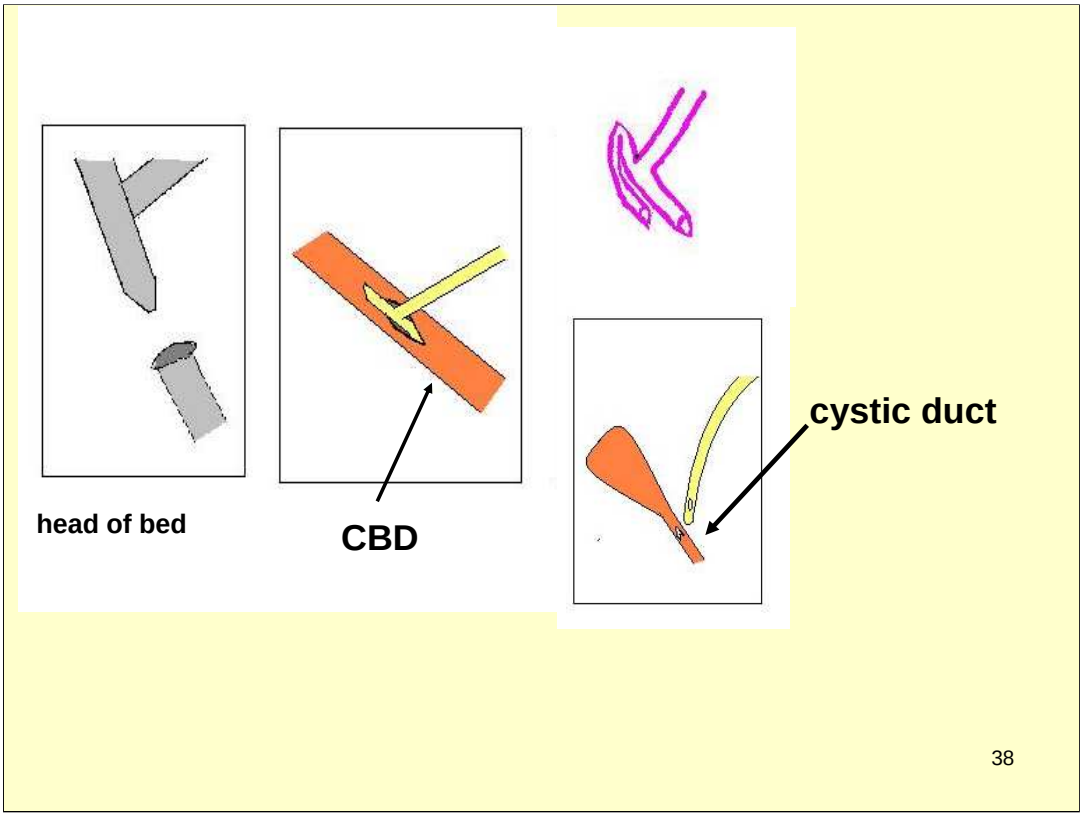
and so on. (See my papers on ergonomics of microsurgery at www.mpatkin.org)

Another example of funneling. A much commoner use of a funnel is pouring petrol into a car fuel tank.

geometry of funneling



Fitting two objects together can be made easier by applying Fitts Law in the form of tapering an object and chamfering its target.



This applies to fitting the head of a bed into place, or inserting a t-tube into a choledochotomy. There should be an easier way to cannulate the cystic duct, though one might use a finer rounded tube or increase the magnification by putting the telescope closer. One problem is catching on the folds of the spiral valve of Heister, when one could use a flexible guide-wire – a fairly decision.

The operations of our intellect tend to geometry

Henry Bergson

quoted in AK Henry "Extensile Exposure"

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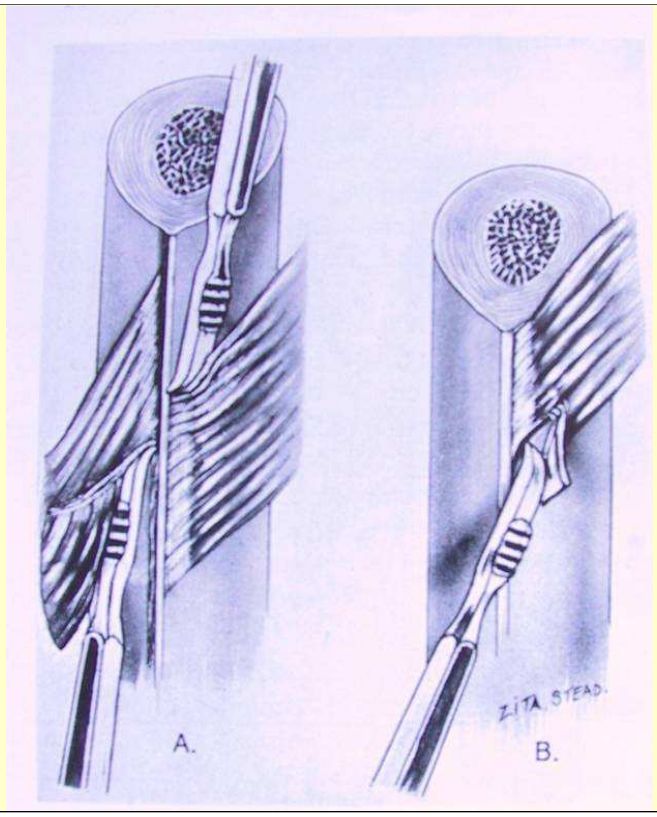
A rich source of surgical thinking is Henry's book, Extensile Exposure, published 50 years ago.



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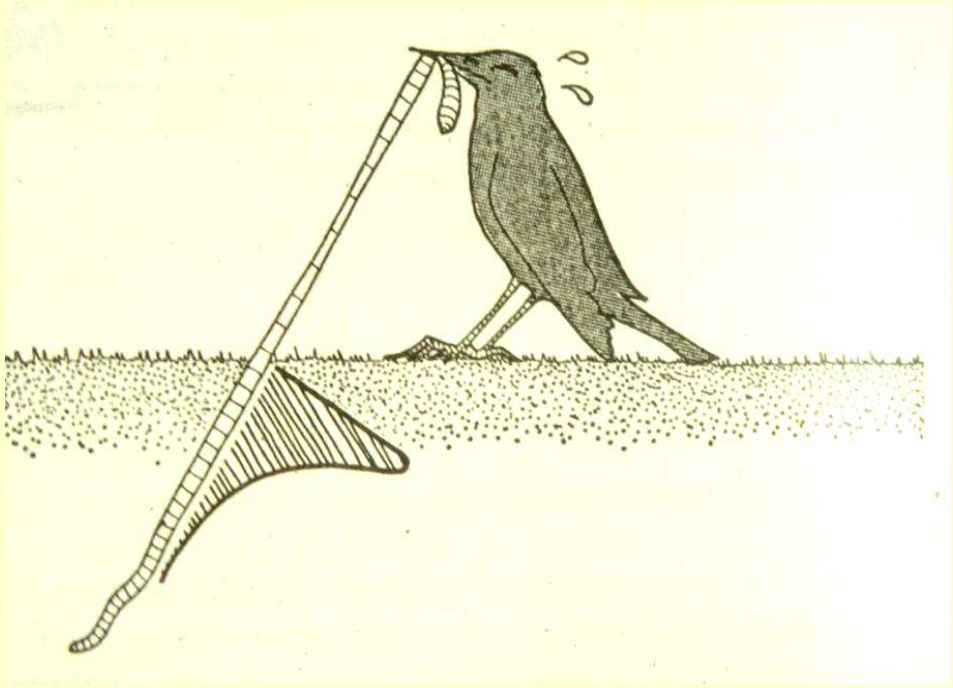
This diagram is copied from Henry's book. It contrasts the ease of two opposite directions in which an oblique muscle attachment might be separated from the bone. Hence one applies a rugine forwards to the upper edge of a rib, and backwards on its lower edge.



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This shows the frustration of trying to get an elastic object to follow the rules of an inelastic object.

Timing

- physical processes
  - slow tearing along a plane
  - quick jab or cut across a plane
  - acceleration eg hammer
- chemical
- biological
- cognitive
- social

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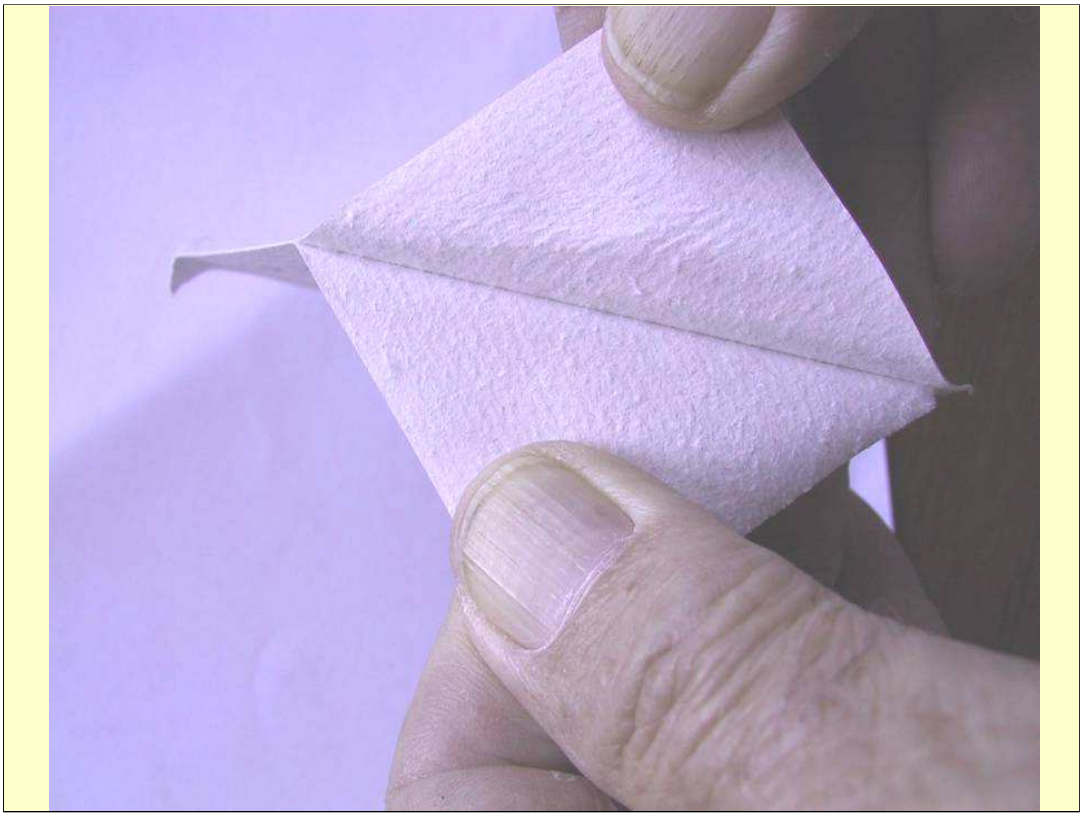
Timing is rated as “good” in describing the work of a master craftsman compared with an amateur. There is not the appearance of haste, but the time taken for a task (as well as its greater accuracy) is less.

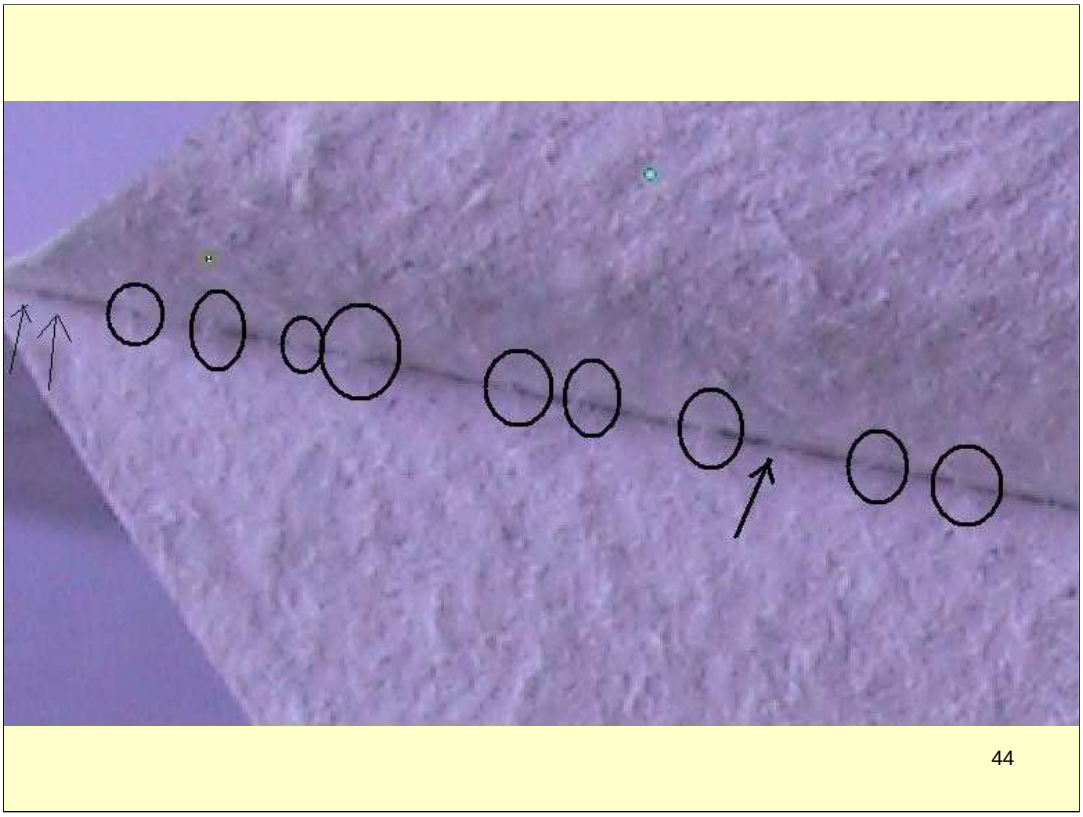
Cooking, setting cement, growing - time for physical and chemical and biological processes - a computer does not boot up in an instant, nor is molecular interaction immediate, but takes a finite time.

Cognition: It takes time, for a thought to "sink in", governed by action potentials which travelling between nodes of Ranvier.

Accelerating an object smoothly requires steadily increasing force rather than a jerk.



A simple physical model of good timing is splitting a business card, once the separation is started at a corner. If they are pulled apart slowly (as well as symmetrically) the separation progresses. If there is a jerky pull, it is likely one or other layer will tear.



The physical explanation is instructive, and apparent if the task is magnified. What happens is that fine fibres, a tenth of a millimetre (100 microns) or so long, have to stretch (even if they don't look elastic to the naked eye) before they fracture and separate.

If the tearing is done too quickly, there is not enough time for the stretching and fracturing so that there is another cohort of fibres to deal with at the same time. The combined strength of the two cohorts of fibres is stronger than either of the two layers so that one tears.

This explains why an expert surgeon appears slower using blunt methods but is quicker because mistakes don't have to be corrected.

Video analysis of surgical dissection

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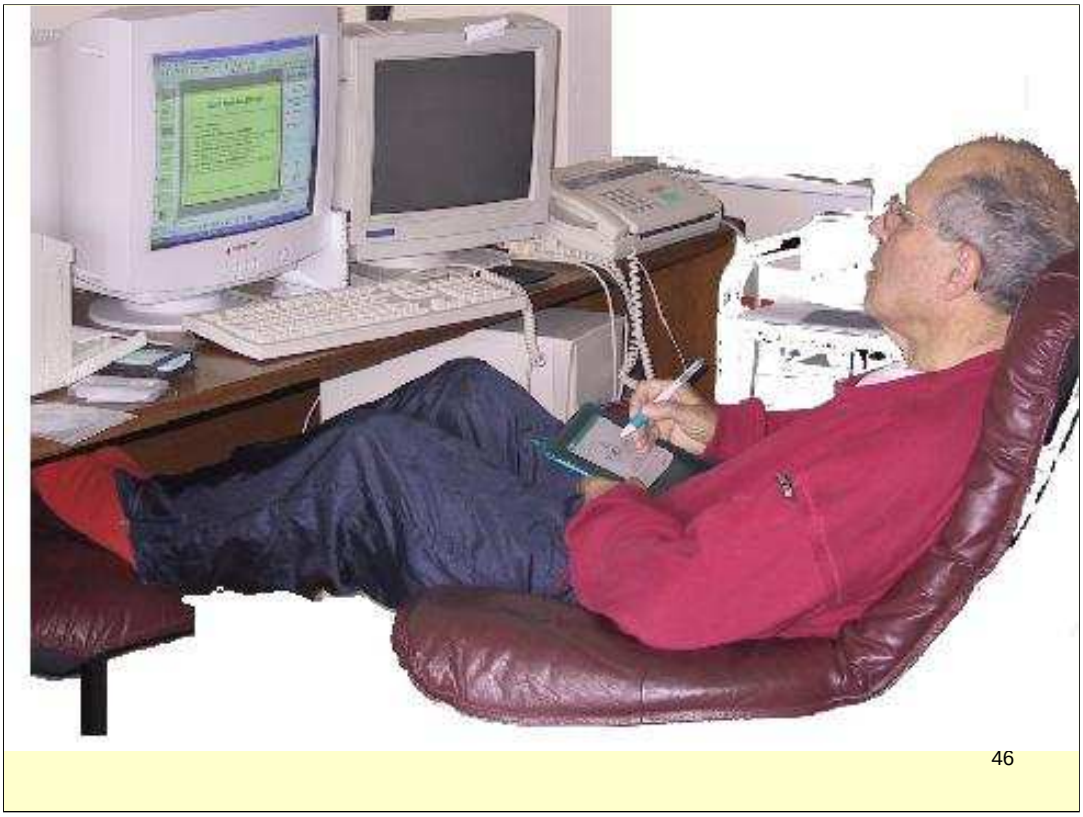
The method used to analyse expertise or lack of it in surgical dissection is recorded in a paper by Leeder et al* and is shown in the photograph which follows.

*Leeder P, Patkin M, Stoddard, Watson D. Dissection efficiency during laparoscopic oesophageal dissection ANZJ Surg. 2005 14,1,8-12. 80

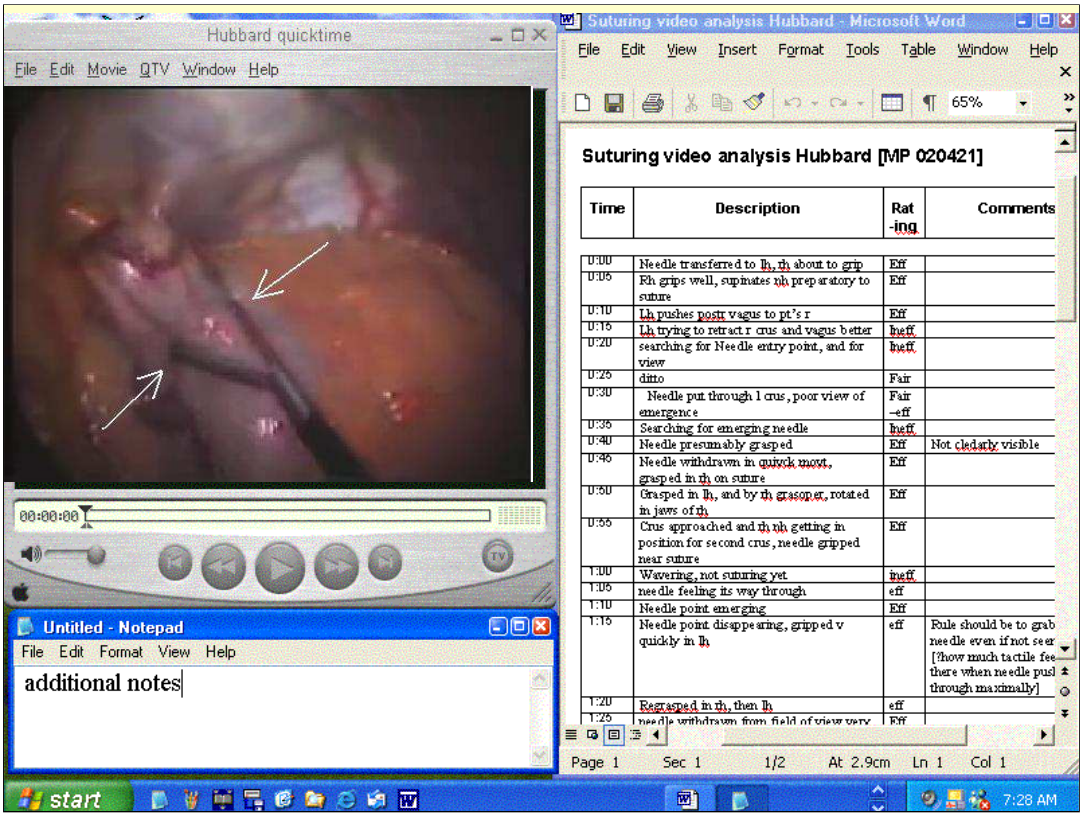


A second monitor is attached to a computer.while a video is replayed of oesophageal mobilisation in preparation for a Nissen fundoplication. (The software used was QuickTime, professional edition).

Every 15 seconds the events for that segment are recorded on a spreadsheet, with columns for segment number, description, rating of skill, and comments.

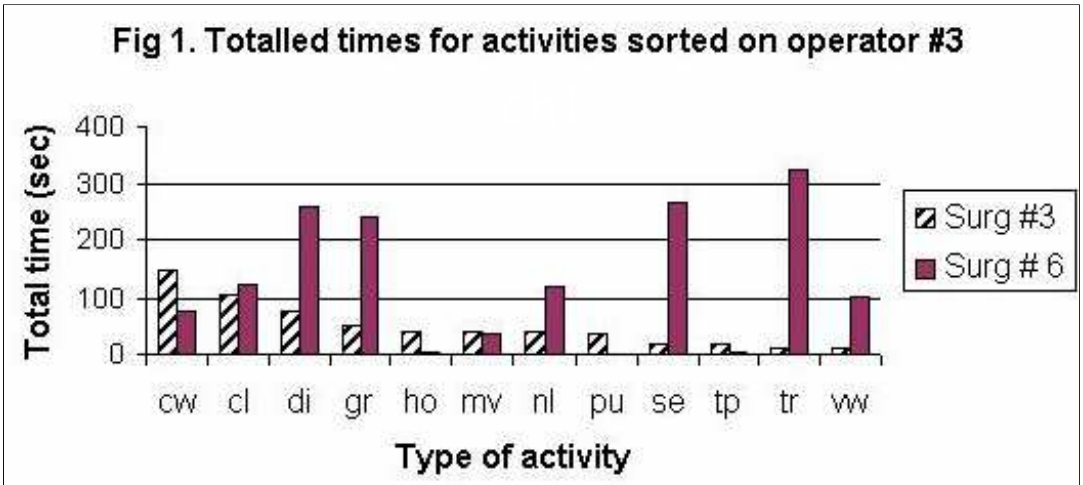
Four observers rated procedures by 6 surgeons, two of them experienced and the others less so. The data was regrouped by descriptors and then analysed simply.

It became clear that better surgeons took less time because a larger proportion of their actions were effective, and not because they hurried. This is in line with some other conclusions in the literature on expertise.



In more detail here are the views, combined on a single monitor for ease of display.

There are special software packages to make it easier to analyse prolonged viewing of dynamic data of this kind, but they are expensive and not used here – perhaps in future studies of this kind.



cw camera time waste	ho hook	tp tape
cl clean scope	mv moving	tr traction
di diathermy	nl nil	vw view
gr grasp	se separate	pu push

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Here is the data for two surgeons, one experienced and the other not. The better surgeon just got on with the job more consistently.

Discovering heuristics, elements of expertise

- literature, unpublished experience
- direct observation, introspection & analysis
- video, EMG, other special techniques
- lateral thinking, Koestler's bisociation

- think-aloud protocol

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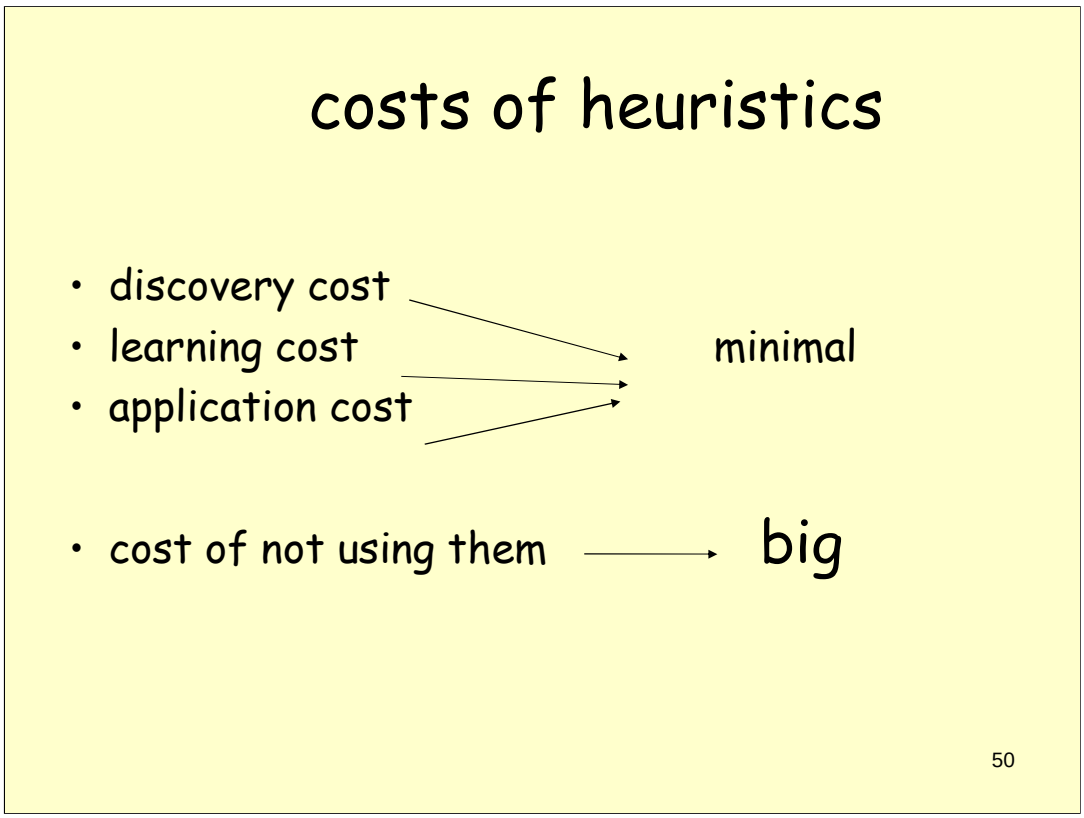
Other than using tools like video, there are more methods of researching this subject.

Another research project has suggested the value of "thinking aloud". An experienced surgeon sits comfortably and imagines in detail carrying out an operative procedure. While doing so, he or she says aloud what they are thinking as they proceed. This narrative is recorded on a dictaphone, transcribed, and the transcript analysed in a table with similar headings to the ones quoted earlier.

The surgeon is primed with the idea of heuristics, and from time to time is prompted by the interviewer to expand on certain points.



Just as surgery has paraprofessional skills - speaking, photography, managing a team, communicating, leadership, so operative surgery has heuristics – the tricks of the trade, rules of thumb and so on.

They are not expensive to investigate or teach, and may save significantly on suffering and resources.

The future will tell.

references

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- Power S Surgical technique 1951 Heinemann, London

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A handful of references are quoted here. There are many more in the papers on heuristics at www.mpatkin.org

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Please email or speak directly to me if you have comments, whether supportive or critical, on this work.

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