Innovation in Neurosurgery:

A Celebration, an Invitation, and an Obligation

Richard W. Byrne MD

71st Annual Meeting of the Neurosurgical Society of America

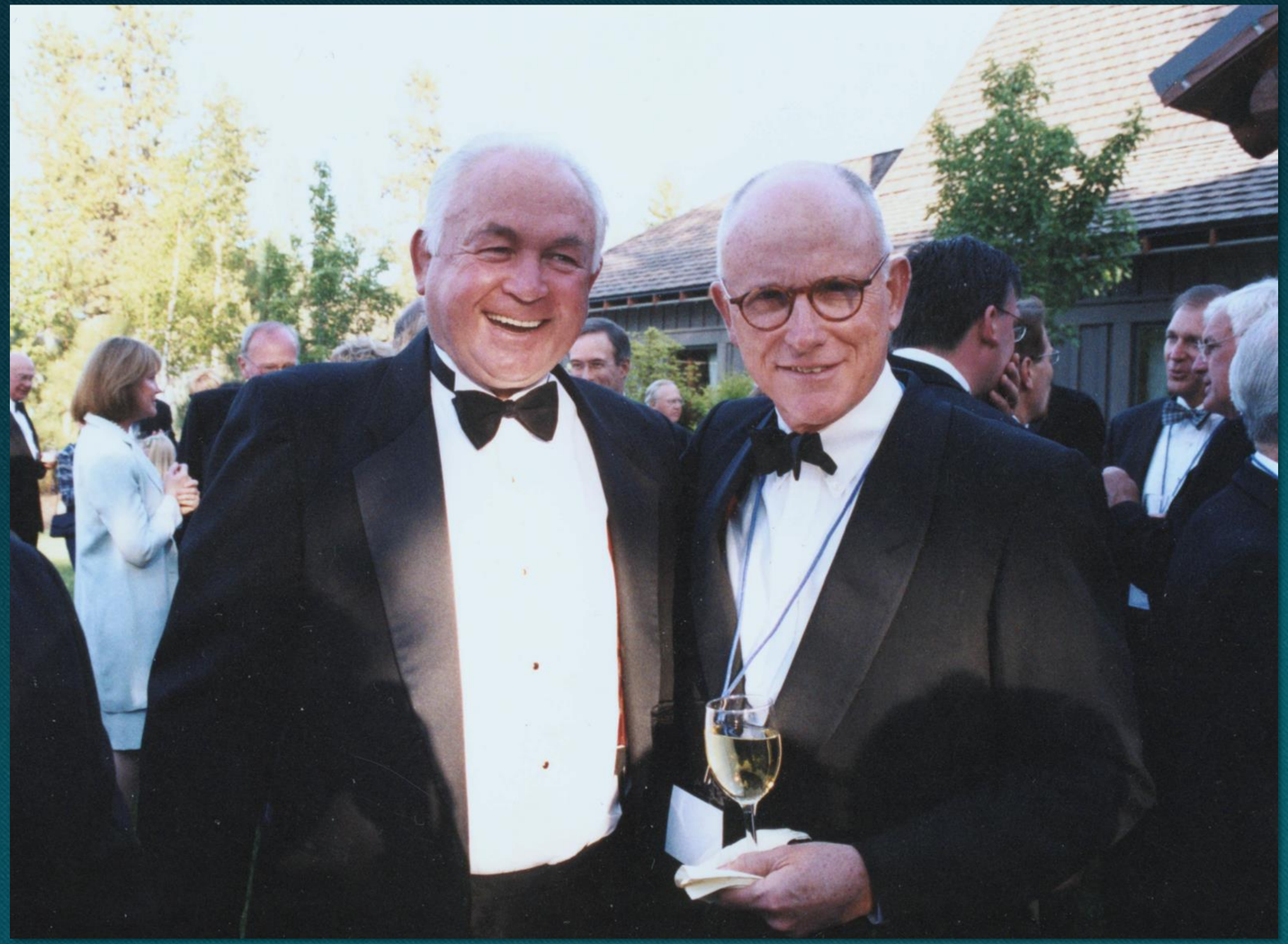
Jackson Hole, Wyoming

June 12th, 2018

NEUROSURGICAL SOCIETY OF AMERICA

Charles M. D'Angelo MD

NSA Vice President 1989



Larry Ferguson, MD Gerry Luken, MD

NSA Committees

Executive Committee

- Richard W. Byrne, President
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- Matthew Smyth, Chair (2014-2019)
- Bernard Bendok (2018-2022)
- Kimberly Walpert (2014-2018)
- Julian Wu (2015-2019)
- Aviva Abosch (2016-2021)

Site Selection

- Eldan Eichbaum, Chair
- Richard Byrne
- Paul Camarata
- Robert Lacin
- Iain Kalfas
- Lisa Mulligan
- Aviva Abosch

Long Range Planning

- Christopher Wallace, Chair
- Mitesh Shah
- Theodore Schwartz
- Robert Heim
- Paul J. Camarata

Leisure Activities

- Iain Kalfas - Golf
- Ken Brewington - Fishing, Water Sports
- David Hart - Tennis
- Philip Yazbak - Cycling

Audit and Finance

- Richard Perrin, Chair
- Christopher Winfree
- Anand Germanwala
- Kimberly Walpert

Bylaws

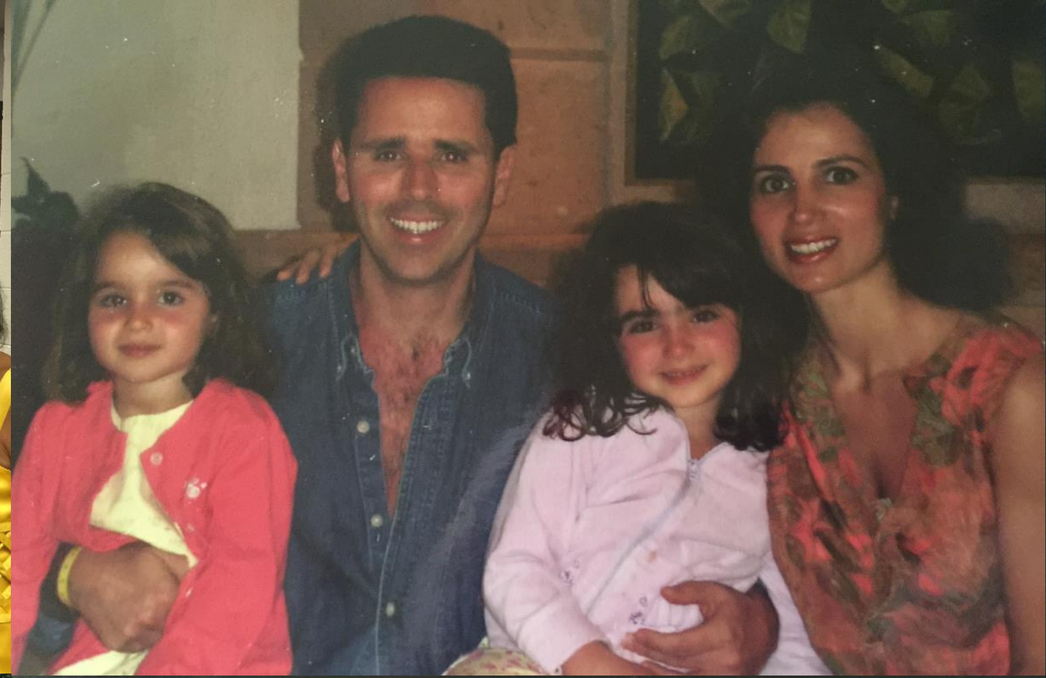
- David Hart, Chair
- Bernard Bendok
- Michael Boland
- David Shafron
- Linda Sternau

Local Arrangements

- Eldan Eichbaum, Chair, 2018 Annual Meeting Local Host
- Stephen Pirris - Fishing
- Bob Wharen - Golf
- Donald Quest - Music
- Thomas Kenefick - Wine


JOHNNIE FOX'S PUB
ESTABLISHED 1798
"National Pride"
THE CREAM OF HOUSEHOLD FLOUR
St BRUNO FLAKE
PARK DRIVE
SHUT & FASTEN GATE


NMCSD
Capt. (Dr.) Jeffrey M. Tomlin
Specialty Leader, Neurosurgery

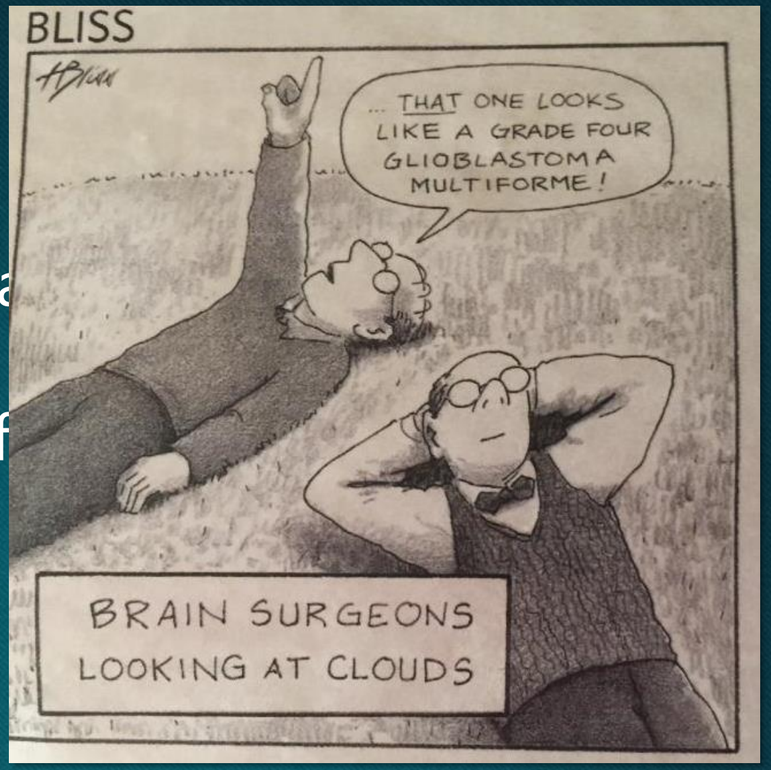



accenture
Chicago Triathlon
6534

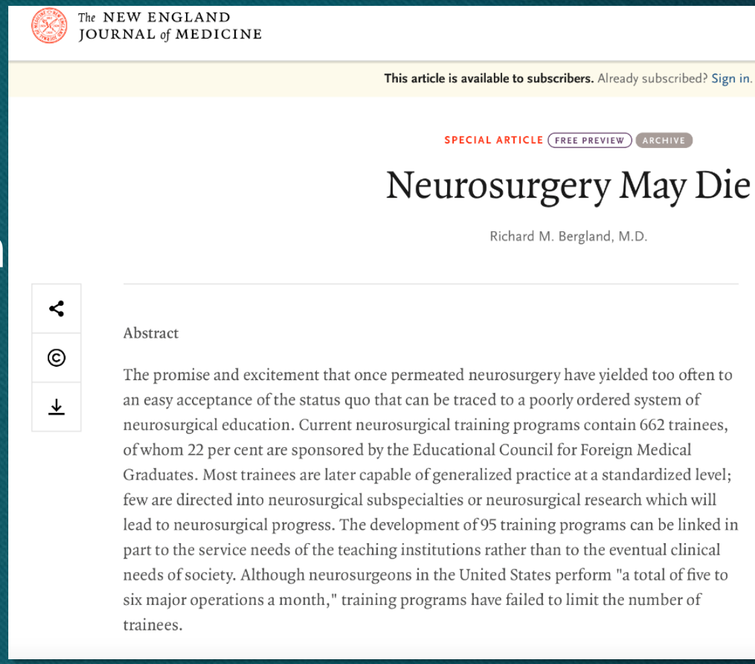
NSA Organizational Meeting, June 5th, 1948

It was inevitable that a special interest in so hazardous a field a
neurosurgery would form an automatic bond among the few
venturesome souls who struggled the trying formative days of
our specialty.

William Meacham



New NSA members in 1971-2: John Jane, Peter Janetta, Al Rhoton, Anthony Raimondi, Mel Shafron, Jim Story, George Tindall, Julian Youm Donlin Long, Yost Michelsen, John Tew, Donald Becker

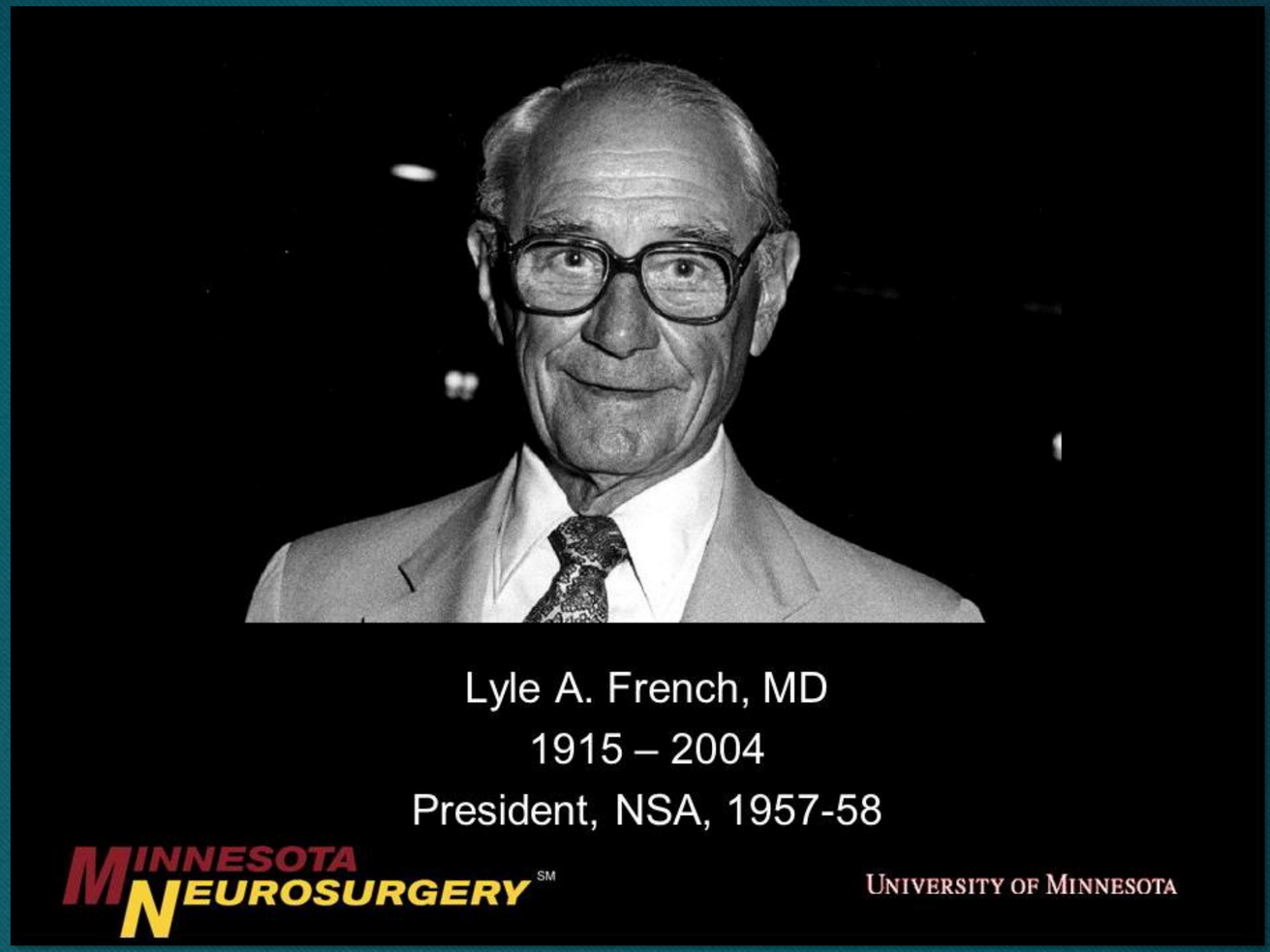


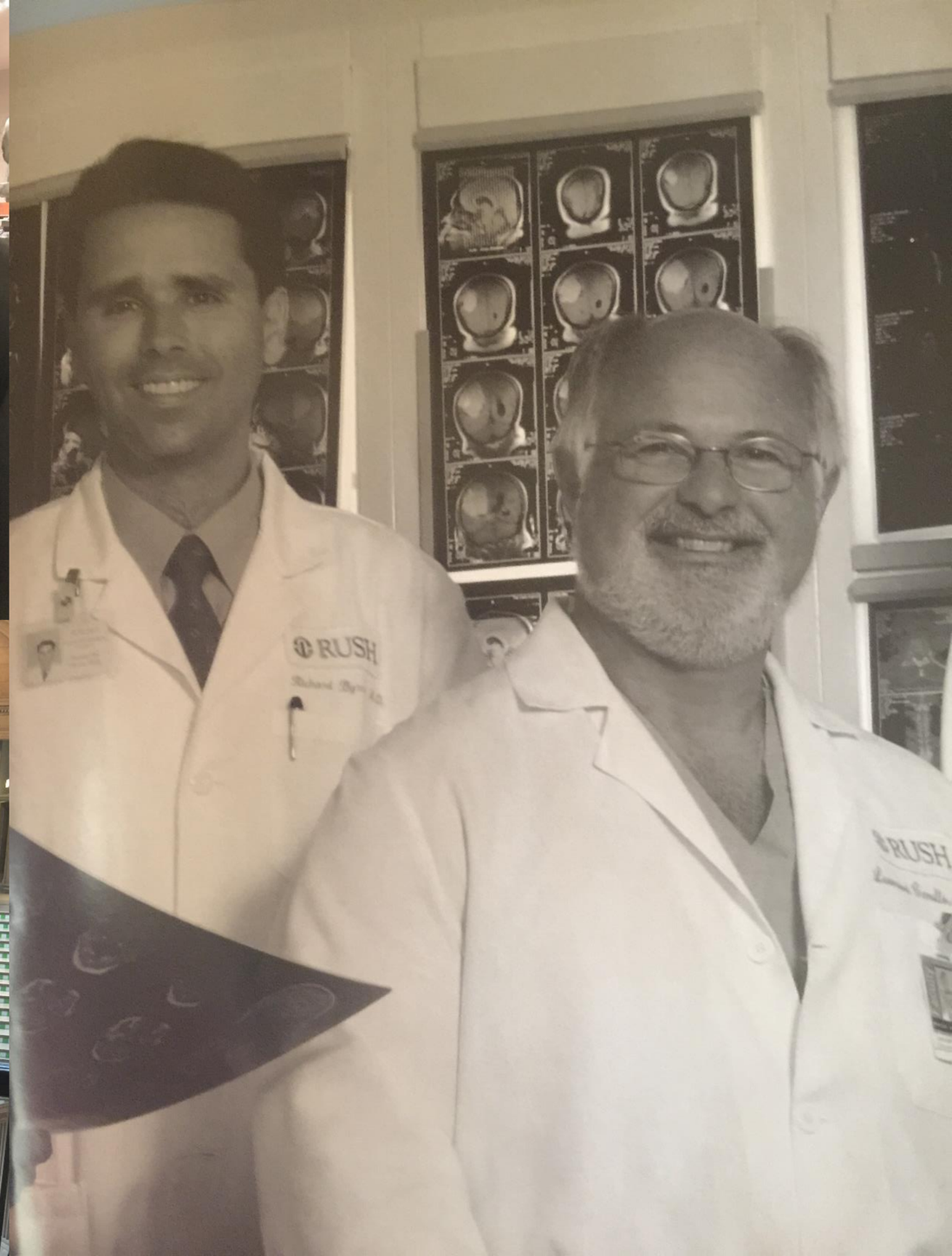
A Celebration and an Invitation

innovare, dating to 1540, stemming from the Latin ***innovatus***, "to renew or change"

Lyle French 1958 NSA Presidential Address

In the field of medicine we are all young. And youth, by it's nature is imaginative….. Why not foster, first in ourselves, then in our fellow students, a general spirit to look imaginatively into our knowledge…. By the welding together of imagination and experience.




RUSH

iMRI

MRI

Baclofen pump

Skull base endoscopy

DBS

Ultrasonic aspirator

VNS

Responsive neurostimulator

Spinal instrumentation

1980 **1990** **2000**

Radiosurgery

MIS

Frameless radiosurgery

Endovascular coiling

fMRI

BMP

Frameless stereotaxy

Programmable shunt valves

Surgical robotics

Pipeline

Gamma brain mapping

embolectomy

LITT

2010 **2020** **2030**

MGUS

Disc replacement

Optune

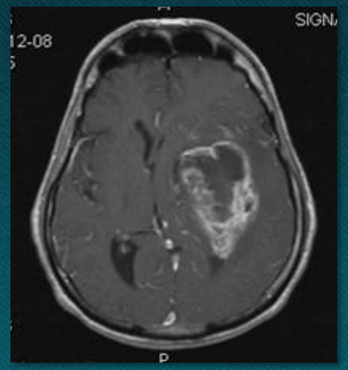
Biologic glues

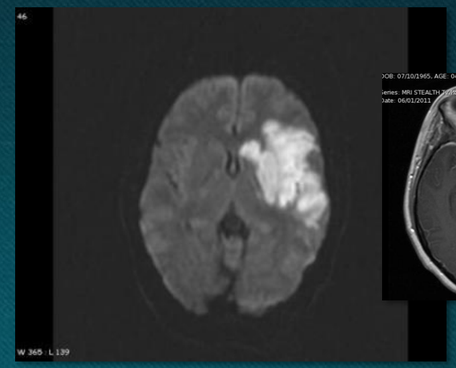
Surgical robotics

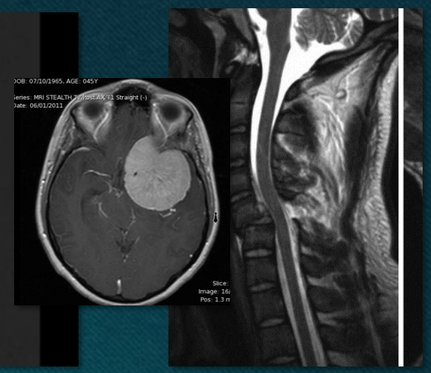
Pipeline

Gamma brain mapping

embolectomy







LITT

We are far from done. How do we make the future even better for our patients?

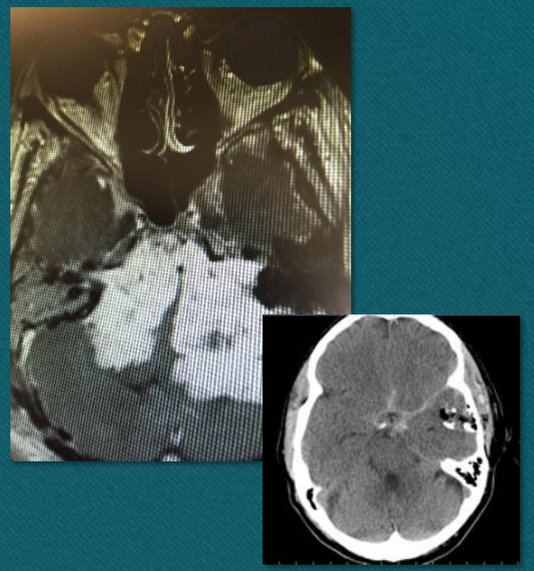
2010 **2020** **2030**

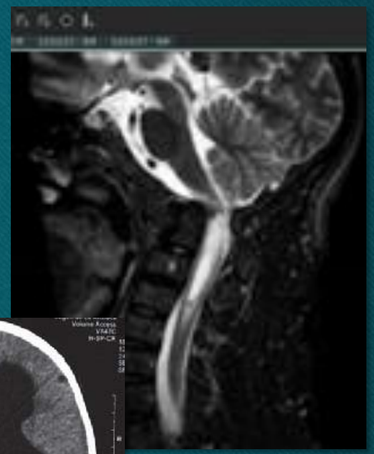
MGUS

Disc replacement

Optune

Biologic glues

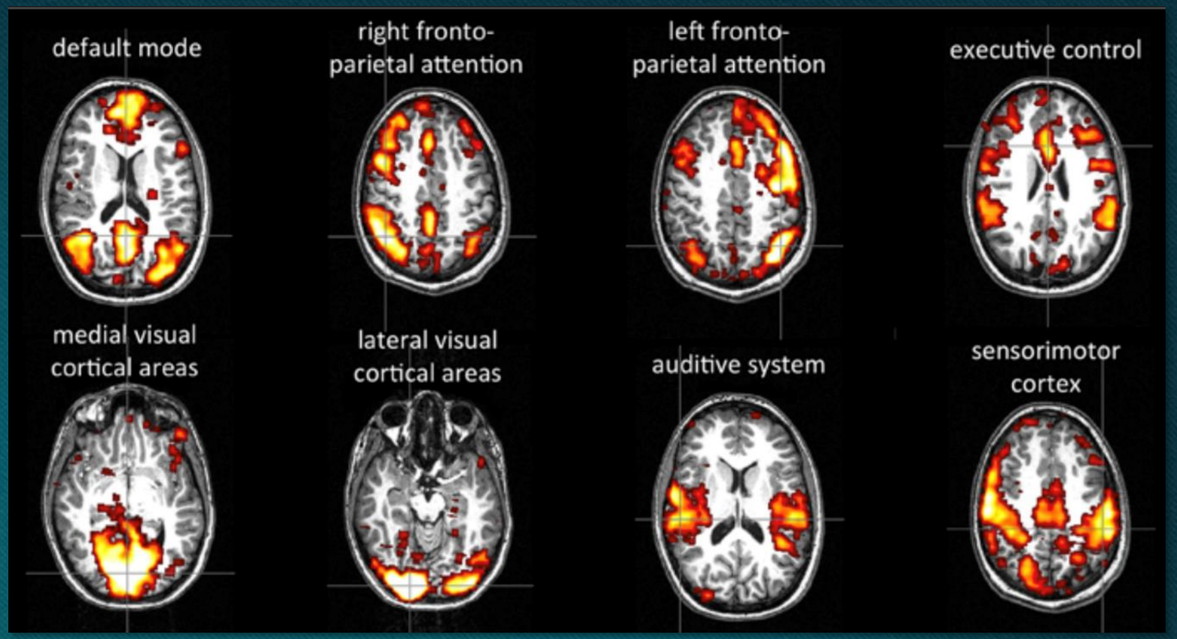


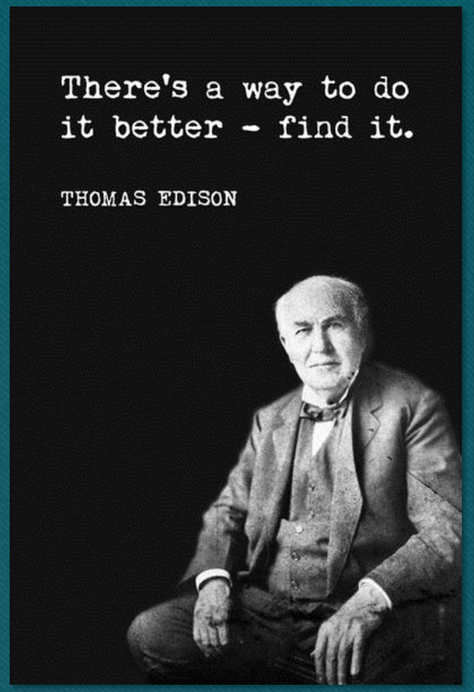


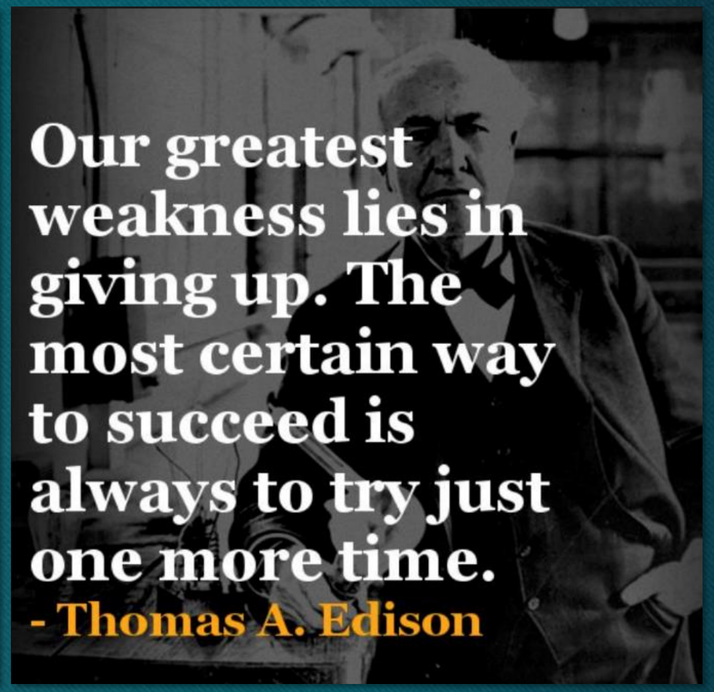
The neuroscience of creativity: How the brains of innovators are wired differently

Rich Haridy | January 17th, 2018

A new study suggests a person's creativity can be identified by examining how connected neural activity in the brain is (Credit: vectorguru/Depositphotos)







PNAS

Robust prediction of individual creative ability from brain functional connectivity

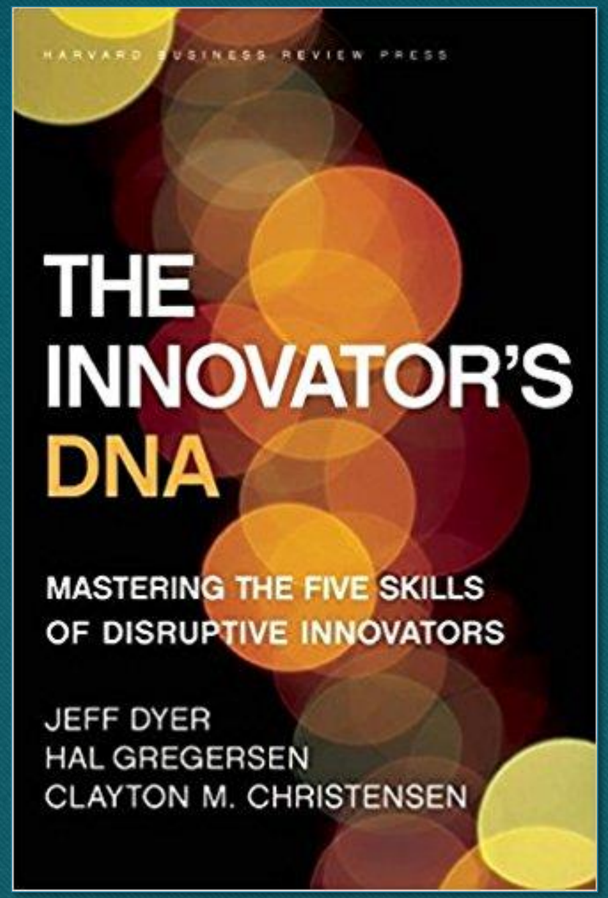
Roger E. Beaty[a,1], Yoed N. Kenett[b], Alexander P. Christensen[c], Monica D. Rosenberg[d], Mathias Benedek[e], Qunlin Chen[f], Andreas Fink[e], Jiang Qiu[f], Thomas R. Kwapil[g], Michael J. Kane[c], and Paul J. Silvia[c]

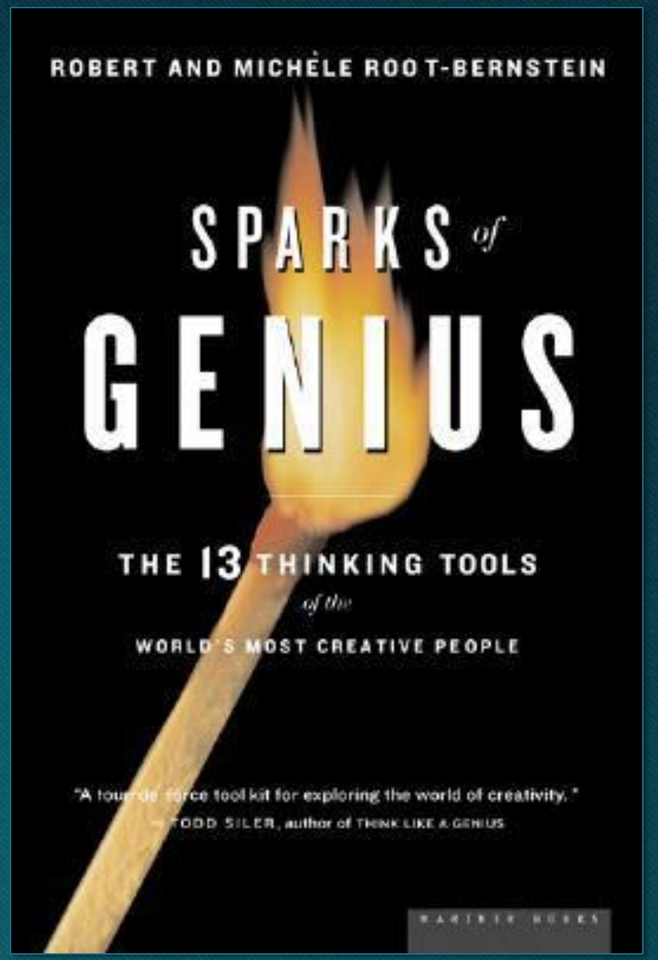
[a]Department of Psychology, Harvard University, Cambridge, MA 02143; [b]Department of Psychology, University of Pennsylvania, Philadelphia, PA 19104; [c]Department of Psychology, University of North Carolina at Greensboro, Greensboro, NC 27402; [d]Department of Psychology, Yale University, New Haven, CT 06520; [e]Department of Psychology, University of Graz, 8010 Graz, Austria; [f]School of Psychology, Southwest University, Chongqing 400715, China; and [g]Department of Psychology, University of Illinois at Urbana–Champaign, Champaign, IL 61820

Edited by Olaf Sporns, Indiana University, Bloomington, IN, and accepted by Editorial Board Member Michael S. Gazzaniga December 4, 2017 (received for review July 31, 2017)

People's ability to think creatively is a primary means of technological and cultural progress, yet the neural architecture of the highly creative brain remains largely undefined. Here, we across multiple distributed brain regions (i.e., functional connectivity) during various tasks that assess creative cognition and artistic performance, including divergent thinking, figurative

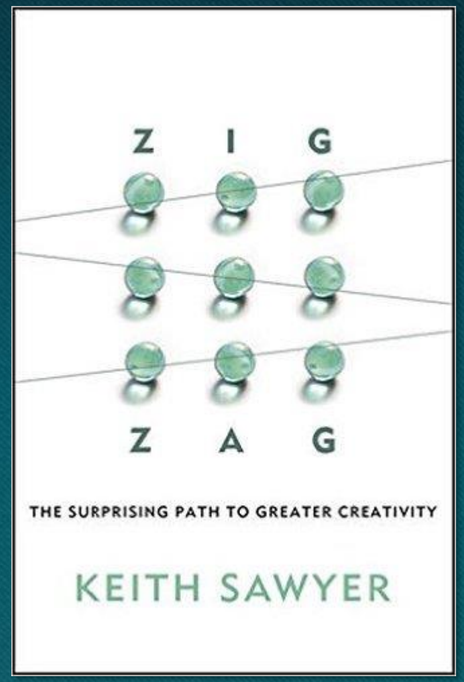
- Associating
- Questioning
- Observing
- Networking
- Experimenting
- Abstracting
- Pattern recognition

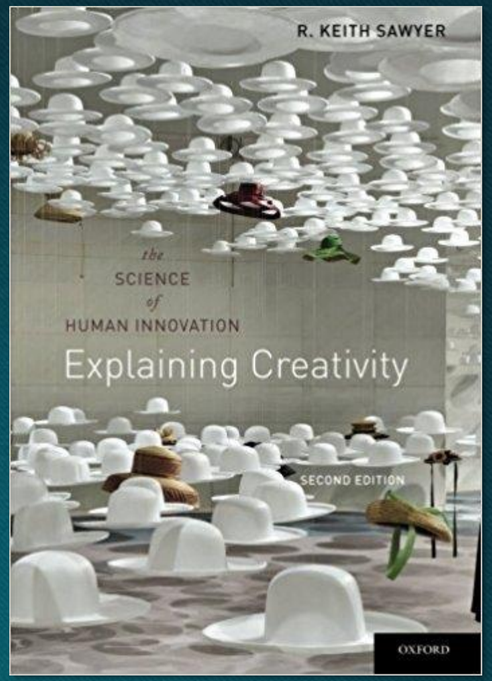


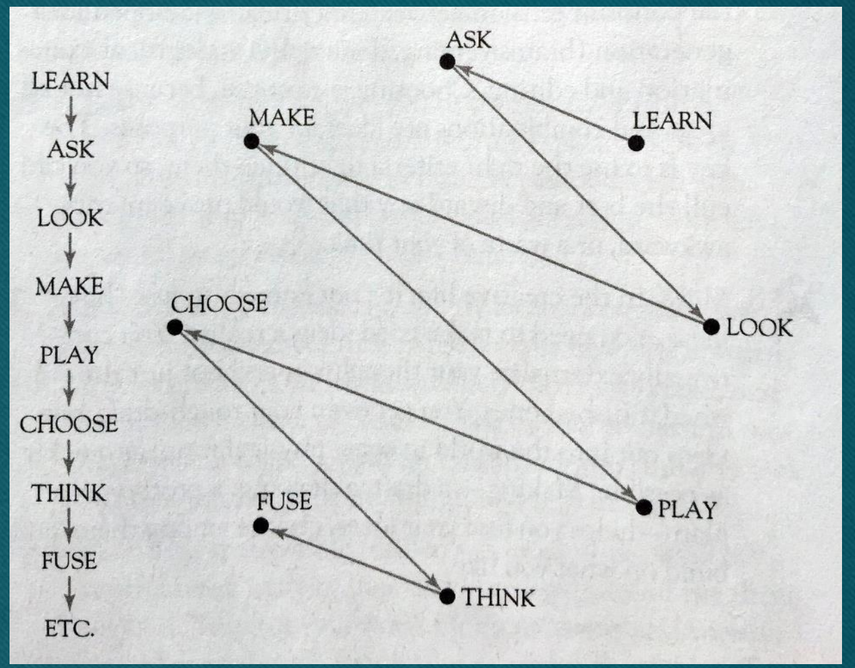


SCAMPER

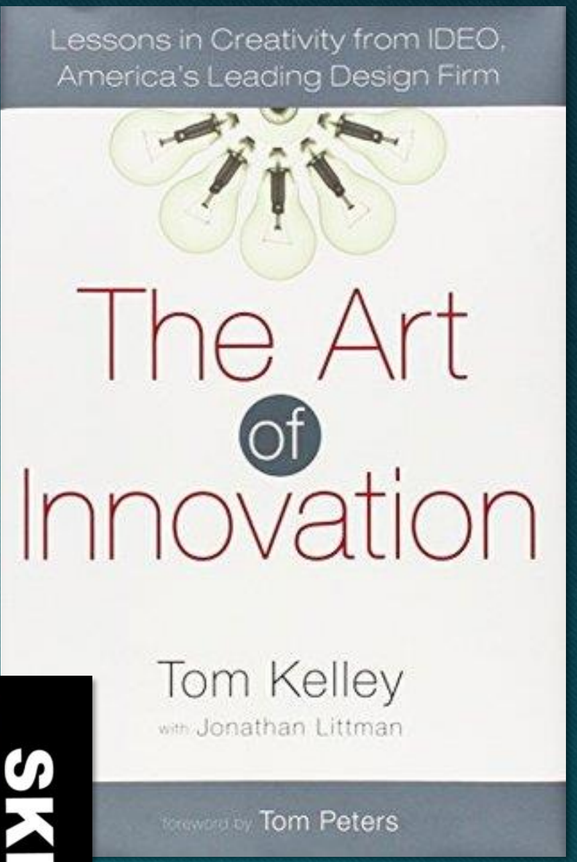
- **S** Substitute
- **C** Combine
- **A** Adapt
- **M** Modify
- **P** Put to other uses
- **E** Eliminate
- **R** Rearrange







- “Routine is the enemy of innovation”
- “Fail often to succeed sooner”
  does not translate into neurosurgery!



- Historically the purview of isolated single individuals
- More recent creation of centers of surgical innovation- combining surgeons, engineers, design teams
- Five Centers of Surgical Innovation in 2006

REVIEW

Innovation in Surgery

A Historical Perspective

Daniel J. Riskin, MD, MBA, Michael T. Longaker, MD, MBA,† Michael Gertner, MD,† and Thomas M. Krummel, MD†*

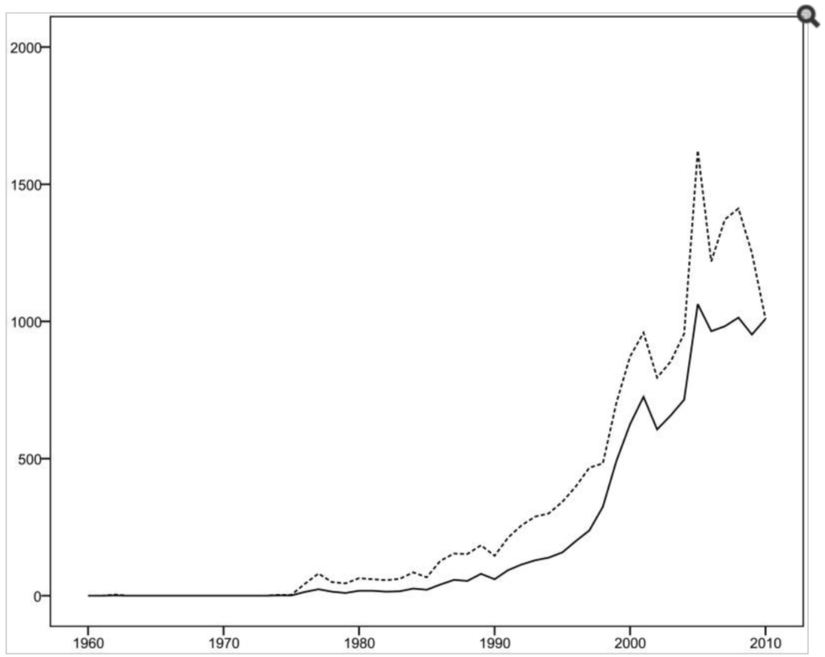
TECHNOLOGICAL INNOVATION IN NEUROSURGERY: A QUANTITATIVE STUDY

Hani J Marcus, MRCS[1,2,*], **Archie Hughes-Hallett, MRCS**[1], **Richard M Kwasnicki, BSc**[1], **Ara Darzi, FRS**[1], **Guang-Zhong Yang, FREng**[1], and **Dipankar Nandi, D. Phil.**[2]

[1]The Hamlyn Centre, Institute of Global Health Innovation, Imperial College London, London, UK

[2]Department of Neurosurgery, Imperial College Healthcare NHS Trust, London, UK

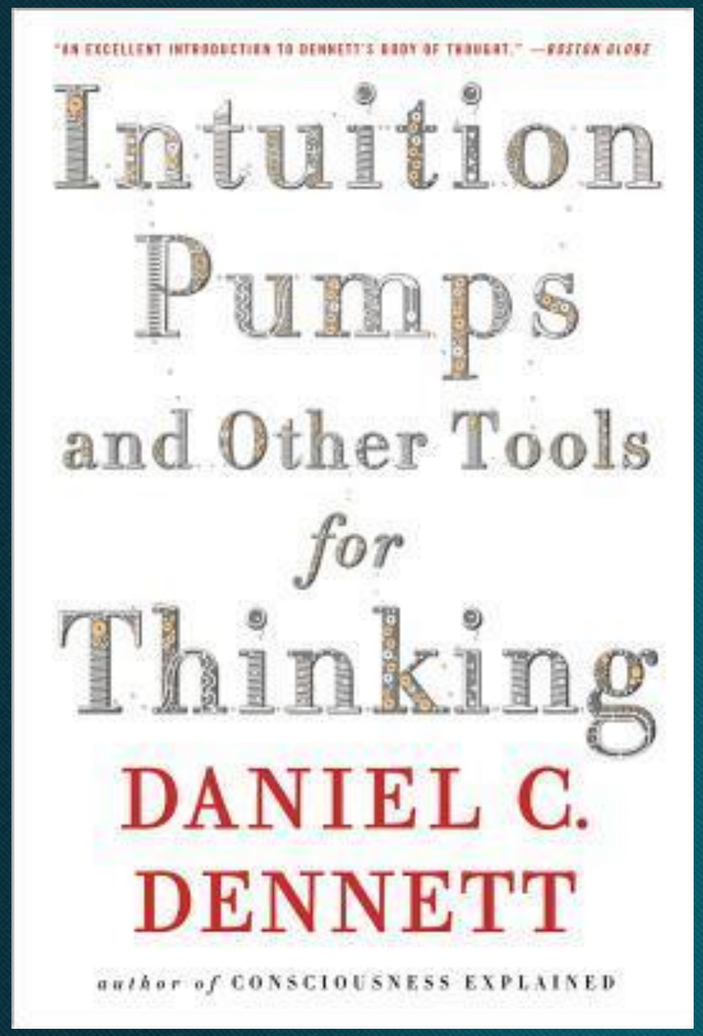
Figure 1



	2005 – 2010		
1	Image Guidance Systems	9	1110 (46.0%)
2	Clinical Neurophysiology Devices, including those measuring Motor Evoked Potentials and Somatosensory Evoked Potentials	5	532 (22.0%)
3	Neuromodulation Devices, including those for Deep Brain Stimulation, Spinal Cord Stimulation, and Peripheral Nerve Stimulation	3	517 (21.4%)
4	Endoscopes	2	152 (6.3%)
5	Operating Microscopes	1	103 (4.3%)
6	Miscellaneous	5	391 (16.2%)

"Intuition is a product of experience. It is the difference between what we know and what we can express."

Gary Kasparov



Jootsing-jumping out of the system. Questioning basic premises.

Re-purposing

Become a connoisseur of your own **mistakes**.

Applying new **technology**

Beware Occam's Broom, the misguided cousin of Occam's Razor

IgNobel Prize in Neuroscience: The Dead Salmon Study

(Pastacurus)

WHEN YOU SEE A CLAIM THAT A

Ne
An
Cra
1 Psy
3 Dep

METHODS

Subject. One mature Atlantic Salmon (Salmo salar) participated in the fMRI study. The salmon was approximately 18 inches long, weighed 3.8 lbs, and was not alive at the time of scanning.

Task. The task administered to the salmon involved completing an open-ended mentalizing task. The salmon was shown a series of photographs depicting human individuals in social situations with a specified emotional valence. The salmon was asked to determine what emotion the individual in the photo must have been experiencing.

Design. Stimuli were presented in a block design with each photo presented for 10 seconds followed by 12 seconds of rest. A total of 15 photos were displayed. Total scan time was 5.5 minutes.

COMMUNICATIONS BIOLOGY

ARTICLE

DOI: 10.1038/s42003-018-0073-z OPEN

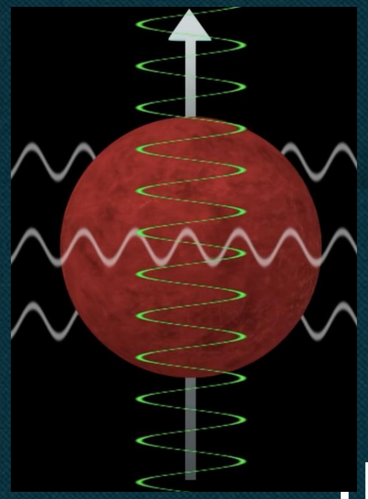
Small sample sizes reduce the replicability of task-based fMRI studies

Benjamin O. Turner[1], Erick J. Paul[2], Michael B. Miller[3] & Aron K. Barbey[4,5,6,7,8,9]

Despite a growing body of research suggesting that task-based functional magnetic resonance imaging (fMRI) studies often suffer from a lack of statistical power due to too-small samples, the proliferation of such underpowered studies continues unabated. Using large independent samples across eleven tasks, we demonstrate the impact of sample size on replicability, assessed at different levels of analysis relevant to fMRI researchers. We find that the degree of replicability for typical sample sizes is modest and that sample sizes much larger than typical (e.g., $N = 100$) produce results that fall well short of perfectly replicable. Thus, our results join the existing line of work advocating for larger sample sizes. Moreover, because we test sample sizes over a fairly large range and use intuitive metrics of replicability, our hope is that our results are more understandable and convincing to researchers who may have found previous results advocating for larger samples inaccessible.

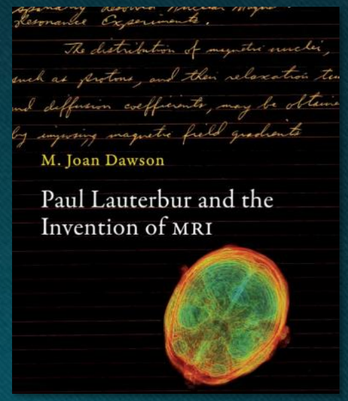
with a specified emotional valence. The salmon was

Jootsing



Invention of Zeugmatography

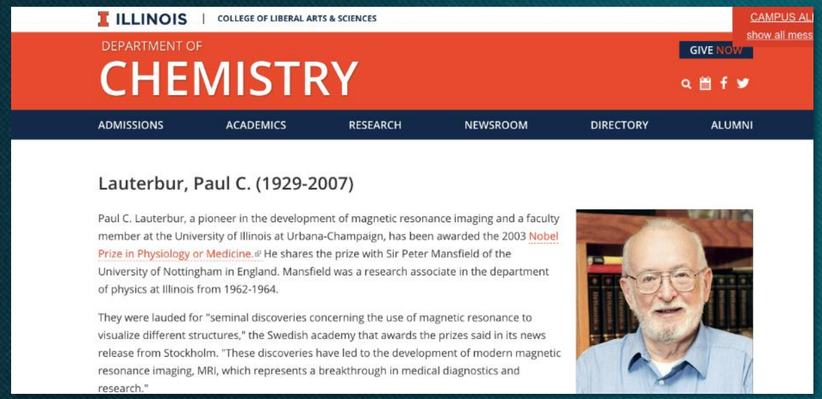
(combining RF gradients and magnetic fields)

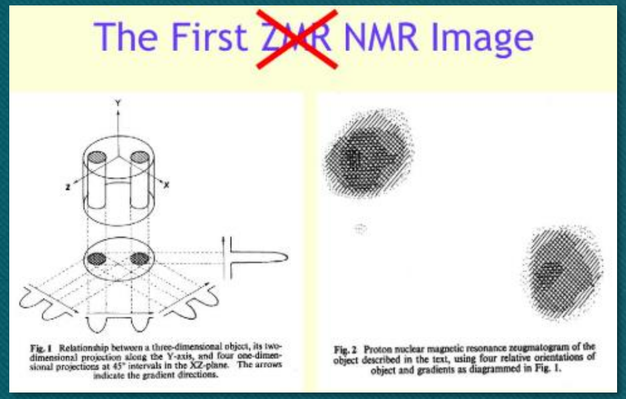


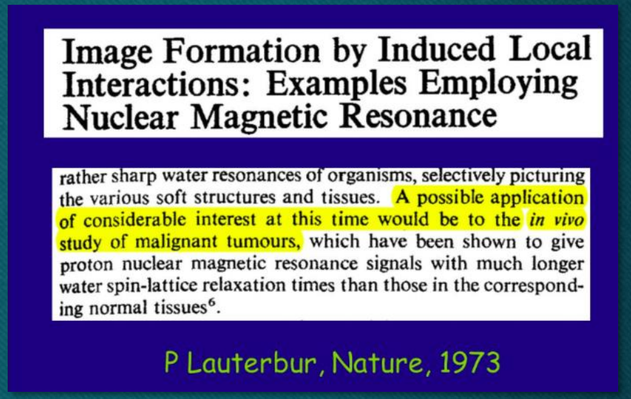
MRI invention

- Several involved:
  - Raymond Damadian – 1971, idea still very sketchy, no images produces.
  - Paul Lauterbur – 1973-4, mature technique for 2D and 3D imaging. Produced first image of a living mouse.
  - Peter Mansfield - developed a mathematical technique where scans take seconds rather than hours also producing clearer images.
- Nobel prize 2003,
  - Paul Lauterbur
  - Sir Peter Mansfield
  - (Damadian left out, protests of him and colleagues).

From top: Damadian, Lauterbur, Mansfield.







Applying New Technology

David Roberts, MD

Richard Bucholz, MD

Other early contributors:
Pat Kelly
Peter Heilbrun
Ron Young
Gene Barnett
YS Kwon
Eiju Watanabe

1980 **1990** **2000**

Frameless Stereotaxy of the Brain

JAMES MCINERNEY, M.D., AND DAVID W. ROBERTS, M.D.

Abstract

Today's neurosurgical journals are replete with advertisements for systems designed to provide image guidance during surgery. These so-called "frameless" stereotactic systems provide the surgeon with navigational information, relatin imaging data. Such information tory to the lesion, ensures more removal of a lesion. To achieve t registration of the patient with an

This review will trace the d stereotaxy to its current use as techniques and available system surgical navigation. Finally, son

Key Words: Computer-assisted

(1 of 1)

United States Patent **4,722,056**
Roberts , et al. **January 26, 1988**

Reference display systems for superimposing a tomagraphic image onto the focal plane of an operating microscope

Abstract

A reference display system that receives information from an imaging system (e.g., a CT scanner or the like), that extracts or derives three-dimensional anatomical and/or pathological information about a part of a body (e.g., the brain or other organ) of a patient. The information is digitized in the imaging system and is introduced to a computer that is programmed to reformat the digitized information to provide as output electric signal representative of the digitized information. An optical display system (e.g., a cathode ray tube, CRT, and related circuitry) is connected to receive the output of the computer and is operable to present the reformatted information at a determined plane during an operative procedure. An operating microscope is freely located in the operative location relative to the patient during the operative procedure, the focal plane of the microscope establishing the determined plane. A way is provided to establish the spatial relationship among the imaging system, the patient, and the focal plane of the microscope; and a mechanism is provided to project the reformatted imaging system information into the optics and onto the focal plane of the operating microscope during the operative procedure, the reformatted image being displayed as an overlay upon the optical image of the body part on which the operation is being performed.

Inventors: **Roberts; David W.** (Hanover, NH), **Strohbehn; John W.** (Norwich, VT), **Hatch; John F.** (Shrewsbury, MA)
Assignee: **Trustees of Dartmouth College** (Hanover, NH)
Family ID: **25256392**
Appl. No.: **06/830,140**
Filed: **February 18, 1986**

Current U.S. Class: **606/130**; 600/372; 600/414; 600/426
Current CPC Class: G06T 11/60 (20130101); A61B 90/36 (20160201); A61B 90/10 (20160201); A61B 2034/2063 (20160201); A61B 34/20 (20160201);

Patents:

"System for Indicating the Position of a Surgical Probe within a Head on an Image of the Head." U.S. patent #5,383,454, January 1995.

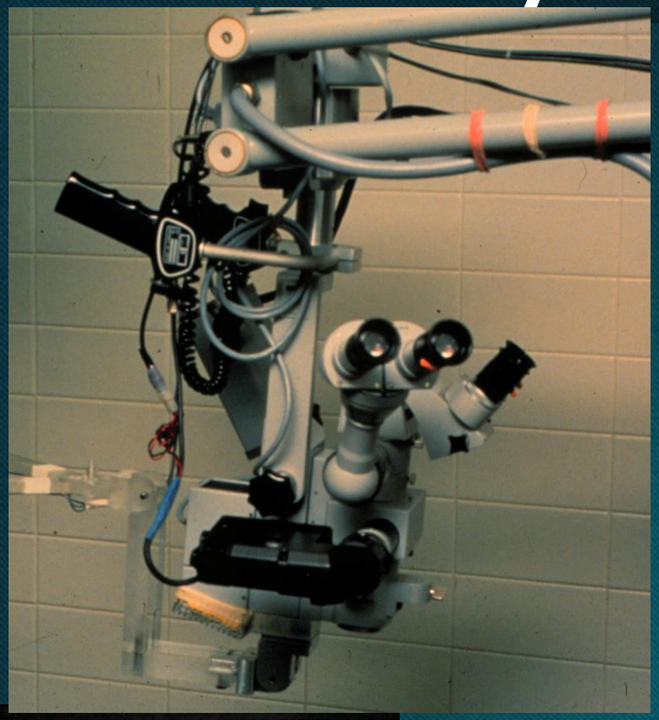
"Ventriculostomy Probe." U.S. patent #387,429, December 1997.

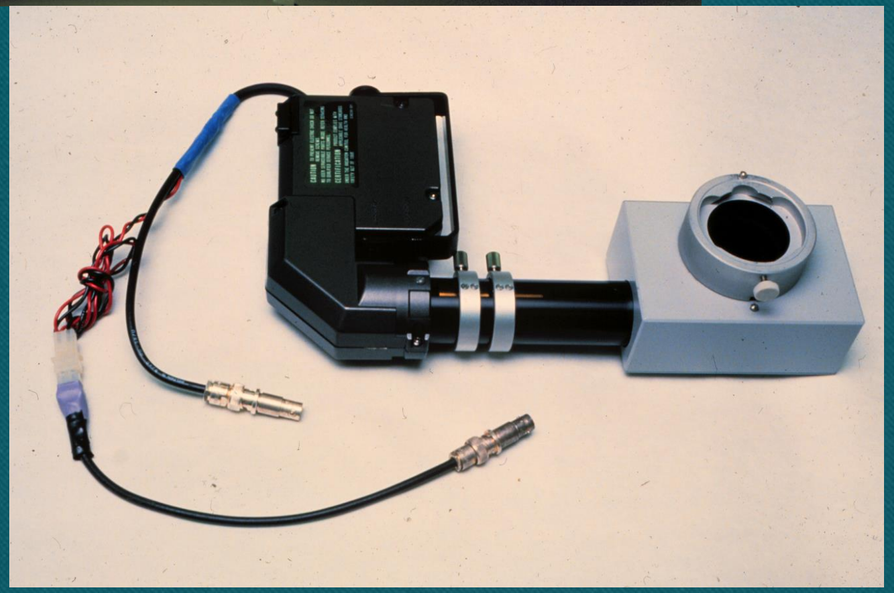
"System for Indicating the Position of a Surgical Probe within a Head on an Image of the Head." U.S. patent #5,851,183, December 1998.

"System for Indicating the Position of a Surgical Probe within a Head on an Image of the Head." U.S. patent #5,871,445, February 1999.

"System for Indicating the Position of a Surgical Probe within a Head on an Image of the Head." U.S. patent #5,891,034, April 1999.

Early Frameless Stereotaxy





Repurposing: Intrathecal Drug Delivery

500,000 patients with severe spasticity

Richard D. Penn, MD

Implanted pump for morphine

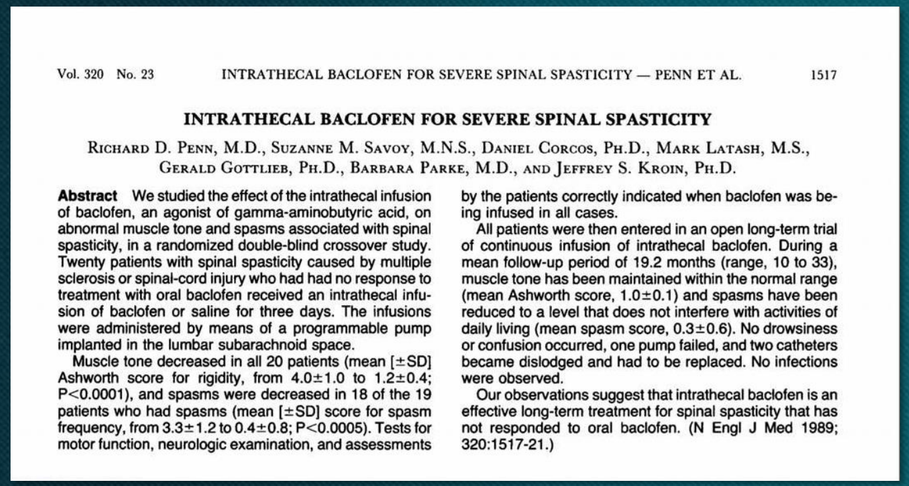
Orphan drug award

1980 **1990** **2000**

Baclofen

FDA approval

60,000



Vol. 320 No. 23 INTRATHECAL BACLOFEN FOR SEVERE SPINAL SPASTICITY — PENN ET AL. 1517

INTRATHECAL BACLOFEN FOR SEVERE SPINAL SPASTICITY

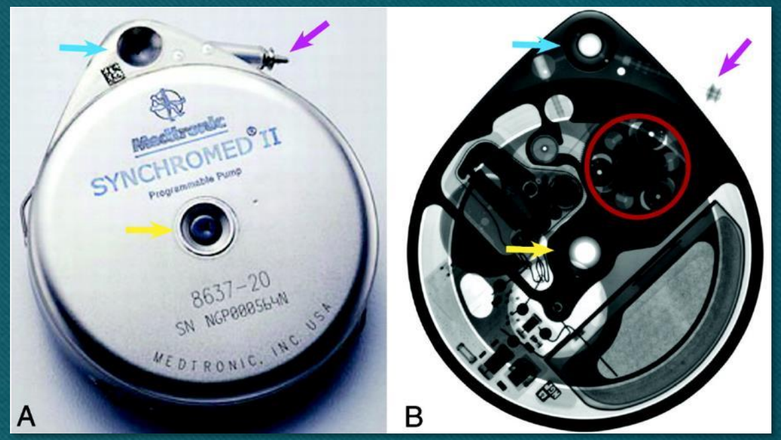
RICHARD D. PENN, M.D., SUZANNE M. SAVOY, M.N.S., DANIEL CORCOS, PH.D., MARK LATASH, M.S., GERALD GOTTLIEB, PH.D., BARBARA PARKE, M.D., AND JEFFREY S. KROIN, PH.D.

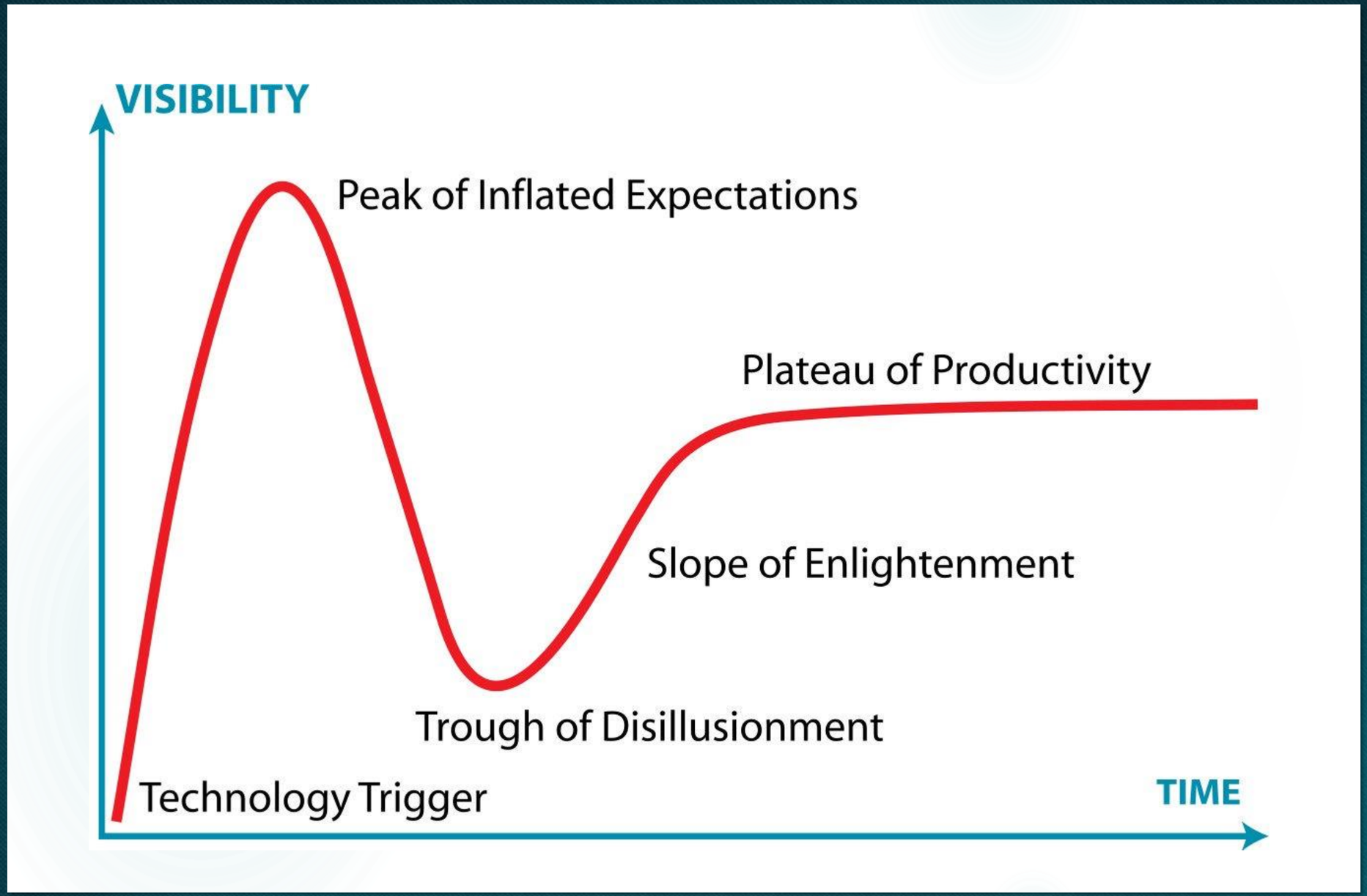
Abstract We studied the effect of the intrathecal infusion of baclofen, an agonist of gamma-aminobutyric acid, on abnormal muscle tone and spasms associated with spinal spasticity, in a randomized double-blind crossover study. Twenty patients with spinal spasticity caused by multiple sclerosis or spinal-cord injury who had had no response to treatment with oral baclofen received an intrathecal infusion of baclofen or saline for three days. The infusions were administered by means of a programmable pump implanted in the lumbar subarachnoid space.

Muscle tone decreased in all 20 patients (mean [±SD] Ashworth score for rigidity, from 4.0±1.0 to 1.2±0.4; P<0.0001), and spasms were decreased in 18 of the 19 patients who had spasms (mean [±SD] score for spasm frequency, from 3.3±1.2 to 0.4±0.8; P<0.0005). Tests for motor function, neurologic examination, and assessments by the patients correctly indicated when baclofen was being infused in all cases.

All patients were then entered in an open long-term trial of continuous infusion of intrathecal baclofen. During a mean follow-up period of 19.2 months (range, 10 to 33), muscle tone has been maintained within the normal range (mean Ashworth score, 1.0±0.1) and spasms have been reduced to a level that does not interfere with activities of daily living (mean spasm score, 0.3±0.6). No drowsiness or confusion occurred, one pump failed, and two catheters became dislodged and had to be replaced. No infections were observed.

Our observations suggest that intrathecal baclofen is an effective long-term treatment for spinal spasticity that has not responded to oral baclofen. (N Engl J Med 1989; 320:1517-21.)




VISIBILITY
Peak of Inflated Expectations
Plateau of Productivity
Slope of Enlightenment
Trough of Disillusionment
Technology Trigger
TIME

THE SCIENCE NEWS CYCLE

Start Here

Your Research

Conclusion: **A is correlated with B (ρ=0.56)**, given C, assuming D and under E conditions.

...is translated by...

UNIVERSITY PR OFFICE
(YES, YOU HAVE ONE)

FOR IMMEDIATE RELEASE: SCIENTISTS FIND POTENTIAL LINK BETWEEN A AND B (UNDER CERTAIN CONDITIONS).

...which is then picked up by...

NEWS WIRE ORGANIZATIONS

A CAUSES B, SAY SCIENTISTS.

...who are read by ...

THE INTERNETS

Scientists out to kill us again.
POSTED BY RANDOM DUDE
Comments (377)
OMG! i kneeew it!!!
WTH???????

...then noticed by...

We saw it on a Blog!
A causes B all the time
What will this mean for Obama?
BREAKING NEWS BREAKING NEWS BREA

...and caught on ...

CNC Cable NEWS

...eventually making it to...

4 LOCAL EYEWITLESS NEWS

WHAT YOU DON'T KNOW ABOUT "A"... CAN KILL YOU! MORE AT 11...

A: KILLER AMONG US??
LOCAL EYEWITLESS NEWS

YOUR GRANDMA

I'M WEARING THIS TO WARD OFF "A"

WWW.PHDCOMICS.COM

Repurposing Neuropace

DOI: 10.3171/2014.1.JNS131592

Chronic unlimited recording electrocorticography–guided resective epilepsy surgery: technology-enabled enhanced fidelity in seizure focus localization with improved surgical efficacy

Clinical article

DANIEL J. DILORENZO, M.D., PH.D., M.B.A.,[1] ERWIN Z. MANGUBAT, M.D.,[1] MARVIN A. ROSSI, M.D., PH.D.,[2] AND RICHARD W. BYRNE, M.D.[1]

Departments of [1]Neurosurgery and [2]Neurology, Rush University Medical Center, Chicago, Illinois

Object. Epilepsy surgery is at the cusp of a transformation due to the convergence of advancements in multiple technologies. Emerging neuromodulatory therapies offer the promise of functionally correcting neural instability and ... Chronic implanted neurological monitoring tech-

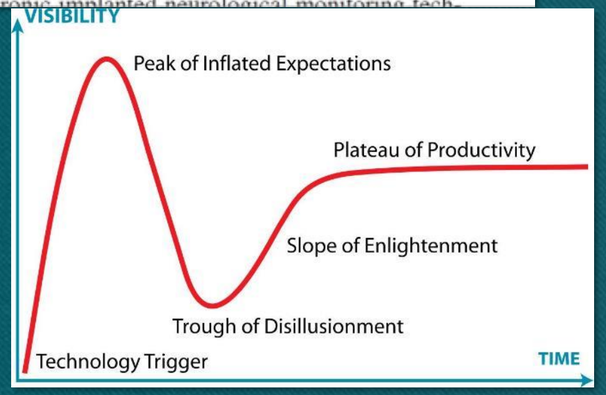
PROVISIONAL PATENT APPLICATION

METHOD, APPARATUS, AND SURGICAL TECHNIQUE FOR CHRONIC OR ACUTE RECORDING OR MONITORING FOR PRE-SURGICAL ASSESSMENT, DIAGNOSIS, SURGICAL PLANNING, AND VALIDATION FOR RESECTIVE SURGERY, MODULATORY SURGERY, OR ABLATIVE SURGERY

Inventor(s): DANIEL J. DILORENZO, MD, PhD, MBA
A Citizen of the United States, residing at:
1506 West Harrison Street, Suite 1B
Chicago, IL 60607

Richard W. Byrne, MD
A Citizen of the United States, residing in:
Oak Brook, IL

Marvin A. Rossi, MD, PhD
A Citizen of the United States, residing in:
Oak Park, IL



Science News ... from universities, journals, and other research org

Neurosurgeons At Rush First In Midwest To Implant Brain Neurostimulator To Suppress Seizures In Patient With Medically Refractory Epilepsy

Aug. 9, 2004 — CHICAGO -- Neurosurgeons at Rush University Medical Center are the first in Chicago to implant a new investigational neurostimulator in a patient with medically refractory epilepsy. The neurostimulator may be able to suppress seizures in patients with epilepsy before any symptoms appear, much like the commonly implanted heart pacemakers which stop heart arrhythmias before any symptoms occur.

Dr. Richard W. Byrne, neurosurgeon at Rush and member of the Chicago Institute of Neurosurgery and Neuroresearch Medical Group (CINN), performed the first implant on Tuesday, June 29, on an Indiana man unlikely to benefit from surgical resection.

Byrne says this is the "Holy Grail" in epilepsy surgery and the most exciting thing he's seen. "This device might help epilepsy patients who do not respond to current medical treatment, testing an entirely new concept in treating medically refractory epilepsy."

"Our first implanted patient has two distinct epileptic foci, one on each side of the brain, producing two different seizures so traditional surgical resection was not an option," said neurologist Dr. Michael C. Smith, the patient's physician and co-principal

The art of medicine

The ethical challenges of surgical innovation for patient care

International Journal of Surgery (2013) **11**(S1), S2–S5

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

REVIEW

Ethics and surgical innovation: challenges to the professionalism of surgeons

Peter Angelos

[a] *Linda Kohler Anderson Professor of Surgery and Surgical Ethics, Chief, Endocrine Surgery, Associate Director, MacLean Center for Clinical Medical Ethics, The University of Chicago, USA*

- Informed consent
- The learning curve
- Financial costs of innovations
- Conflicts of interest
- When to “jump on the bandwagon”

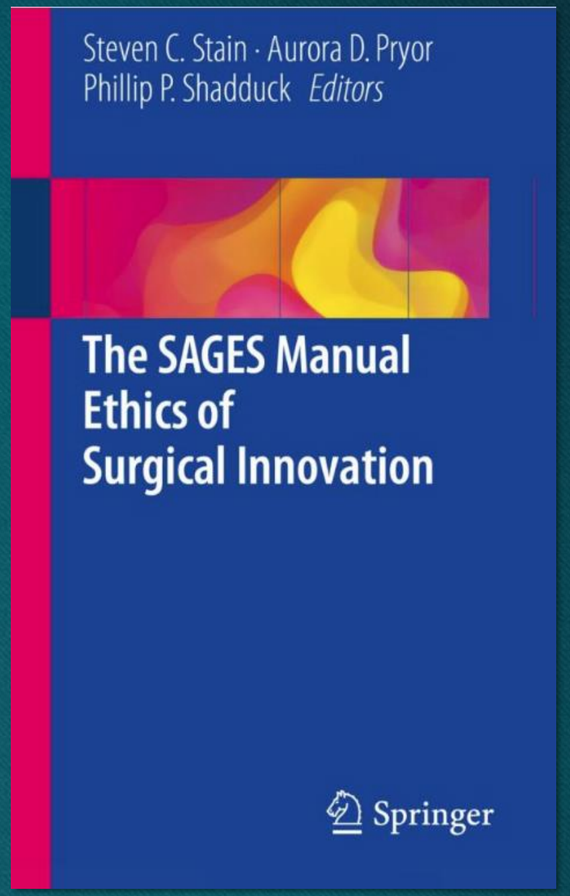
AMA Journal of Ethics®

Illuminating the art of medicine

Responsible Progress in Surgical Innovation: A Balancing Act

- Innovation in surgery has its costs to patients and surgeons as well. Thomas Starzl, one of the fathers of transplant surgery, notes that “hardly a transplant surgeon in that era [of the 1960s] escaped infection [with hepatitis]. My chief research technician…died from hepatitis and so did many others.

- Potential hazards of radiation in spine and endovascular neurosurgery



Lack of alignment between FDA approval, CMS approval, insurance approval, and AMA generated codes

Cumbersome and expensive regulatory approval and reimbursement

Clinical trials outsourced to Europe

PMA (pre-market approval) vs 510(k).
In 2012--39 vs 5000

Media and public backlash due to flurry of hundreds of class 2 FDA recalls leading the IOM to suggest ending 510(k)

Commentary

The FDA approval process for medical devices: an inherently flawed system or a valuable pathway for innovation?

Kyle M Fargen,[1] Donald Frei,[2] David Fiorella,[3] Cameron G McDougall,[4] Philip M Myers,[5] Joshua A Hirsch,[6] J Mocco[7]

INTRODUCTION

Medical devices, developed through physician and industry partnerships, have

innovation is monumental for those invested in advancing medicine through cutting edge technologies. Recently, there

for new devices. Finally, we will review possible alternative pathways towards improving the safety and effectiveness of new devices through regulation that both encourages innovation among clinicians and [illegible] monitors new devices after their release.

RECENT DEVICE FAILURES

Adoption of new technologies is not without risk. While initial experience may demonstrate benefit, further experience [illegible] longitudinal measures may [illegible] [illegible] design or manufacturing flaws that were [illegible] evident. The most prominent of such devices is the ASR XL Acetabular System (DePuy, Johnson & Johnson, Warsaw, Indiana, USA), which was approved for use by the FDA through 510(k) clearance (described

Cigar protector

Spine

SPINE Volume 41, Number 14, pp 1119–1121

EDITORIAL

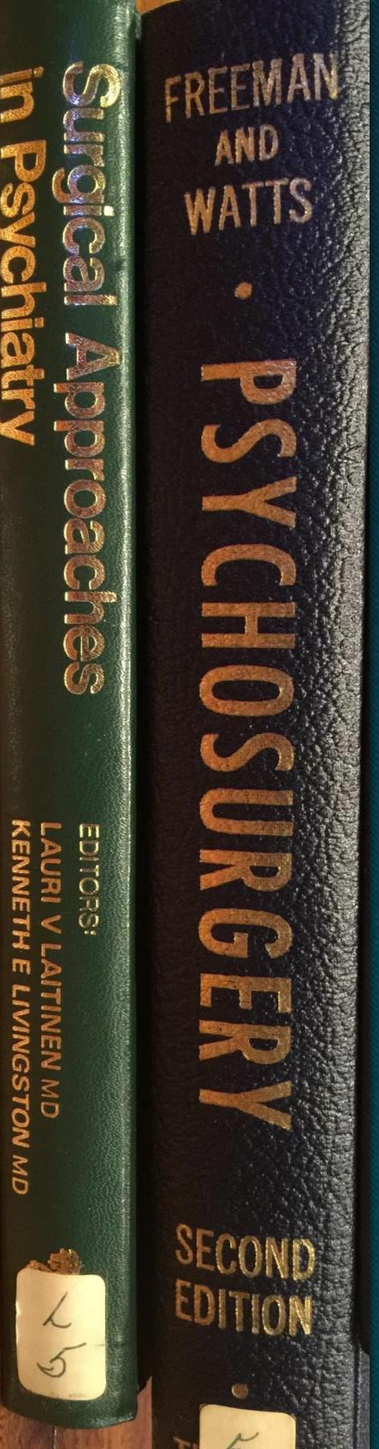
Medical Device Innovation in the United States

Why Are We Falling Behind?

Gunnar B.J. Andersson, MD, PhD

Many US citizens feel that patients deserve a pathway that enables cutting-edge treatment options in the era of modern healthcare. Historically, the United States has led the world in medical device innovation[1] and millions of patients have benefited from these

Contrastingly, start-up device companies operate on limited capital and often rely on the success of a single device or technology to become successful.[3] Of more than 5000 device manufacturers in the United States, about 75% have fewer than 20 employees. Small device companies have



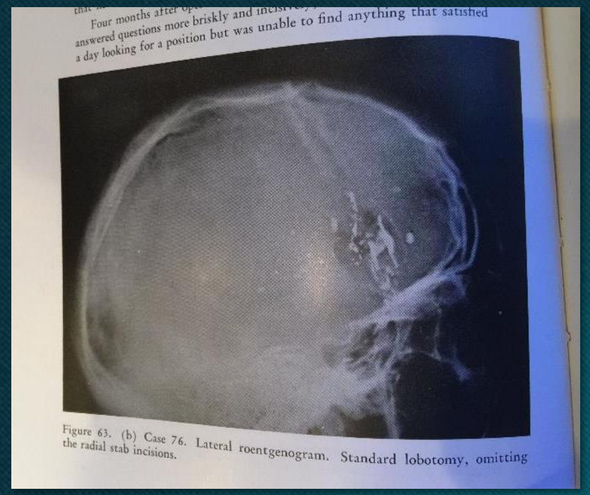
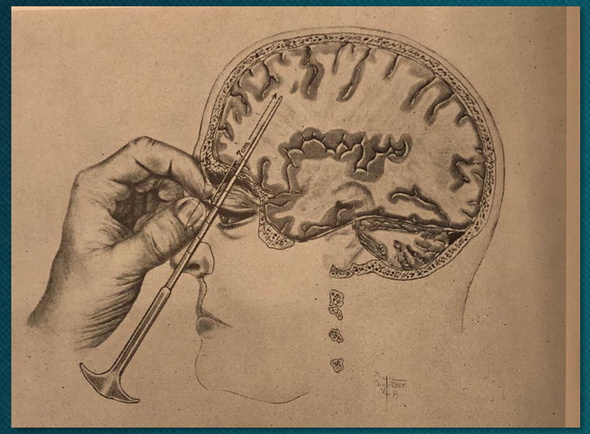


Figure 63. (b) Case 76. Lateral roentgenogram. Standard lobotomy, omitting the radial stab incisions.



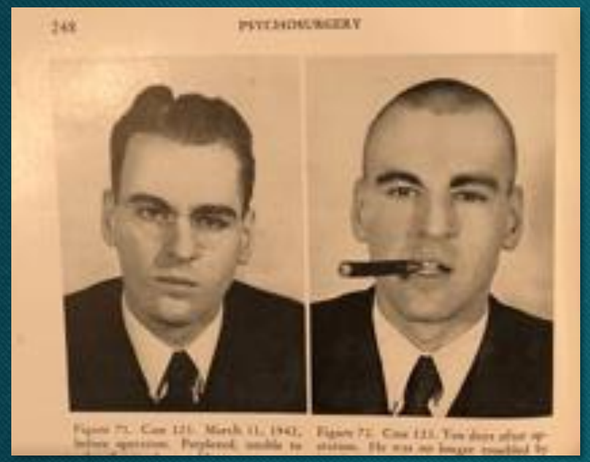
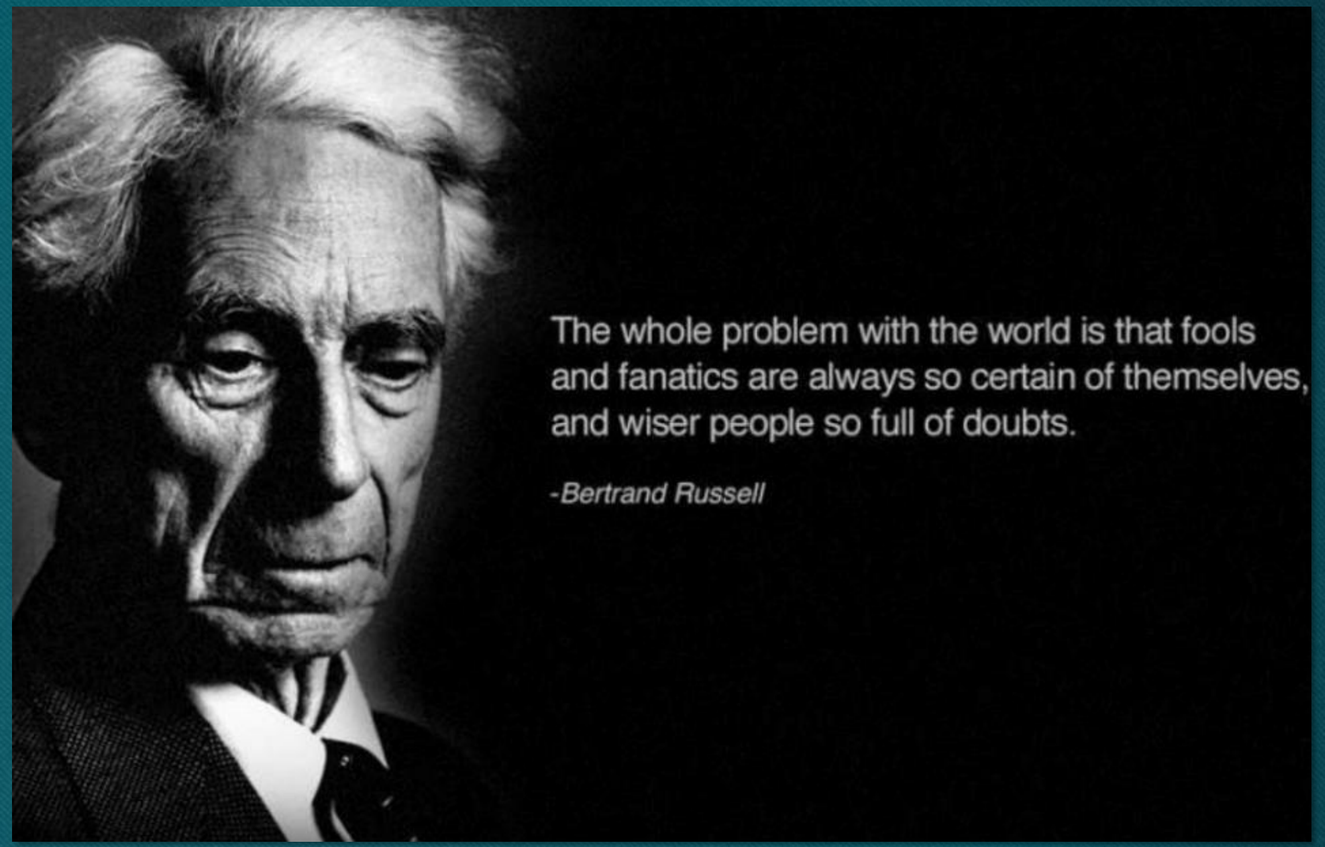


Figure 71. Case 121. March 11, 1942. Before operation. Perplexed, unable to

Figure 72. Case 121. Ten days after operation. He was no longer troubled by

Innovation requires oversite.

Many innovative ideas do not work or are unsafe.



Surgical robotics

Pipeline

Gamma brain mapping

LITT

embolectomy

Who will lead the next wave of innovation?

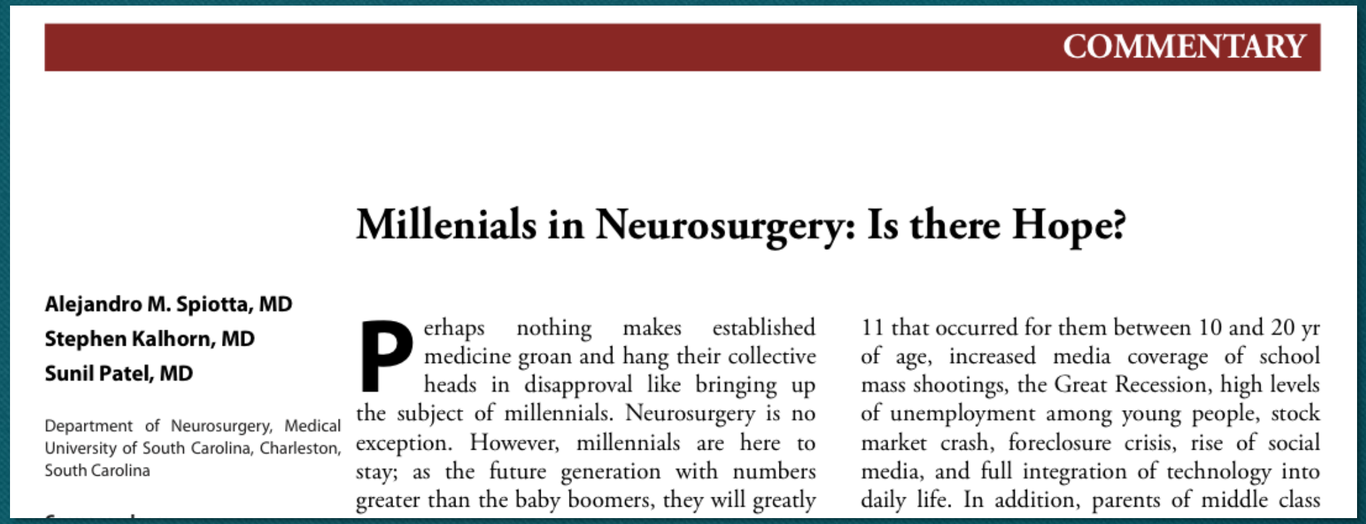
2010 **2020** **2030**

MGUS

Optune

Disc replacement

Biologic glues



COMMENTARY

Millenials in Neurosurgery: Is there Hope?

Alejandro M. Spiotta, MD
Stephen Kalhorn, MD
Sunil Patel, MD

Department of Neurosurgery, Medical University of South Carolina, Charleston, South Carolina

Perhaps nothing makes established medicine groan and hang their collective heads in disapproval like bringing up the subject of millennials. Neurosurgery is no exception. However, millennials are here to stay; as the future generation with numbers greater than the baby boomers, they will greatly

11 that occurred for them between 10 and 20 yr of age, increased media coverage of school mass shootings, the Great Recession, high levels of unemployment among young people, stock market crash, foreclosure crisis, rise of social media, and full integration of technology into daily life. In addition, parents of middle class


I WAS A MILLENNIAL


I Replaced 'Cat' With 'Millennial' in a Bunch of Cat Facts and it Turns Out They're All True!


WHEN YOU SCOLD YOUR DOG
WHEN YOU SCOLD YOUR CAT

Hesiod, 8th Century BC

"I see no hope for the future of our people if they are dependent on frivolous youth of today, for certainly all youth are reckless beyond words. When I was young, we were taught to be discreet and respectful of elders, but the present youth are exceedingly disrespectful and impatient of restraint."

Socrates, 5th century BC

"The children now love luxury. They have bad manners, contempt for authority; they show disrespect for elders and love to chatter in place of exercise."

Assyrian Clay Tablet, 2800 BC

"Our Earth is degenerate in these later days; there are signs that the world is speedily coming to an end; bribery and corruption are common; children no longer obey their parents; every man wants to write a book and the end of the world is evidently approaching."

Seneca, 1st Century AD

"Our young men have grown slothful. There is not a single honorable occupation for which they will toil night and day. They sing and dance and grown effeminate and curl their hair and learn womanish tricks of speech; they are as languid as women and deck themselves out with unbecoming ornaments. Without strength, without energy, they add nothing during life to the gifts with which they were born – then they complain of their lot."

3,000,000 BC

Complaint of an australopithecine father:
Kids today! All they wanna do is walk erect.

Edward Chilton.

ORIGINAL INVESTIGATION

Burnout and Satisfaction With Work-Life Balance Among US Physicians Relative to the General US Population

Tait D. Shanafelt, MD; Sonja Boone, MD; Litjen Tan, PhD; Lotte N. Dyrbye, MD, MHPE; Wayne Sotile, PhD; Daniel Satele, BS; Colin P. West, MD, PhD; Jeff Sloan, PhD; Michael R. Oreskovich, MD

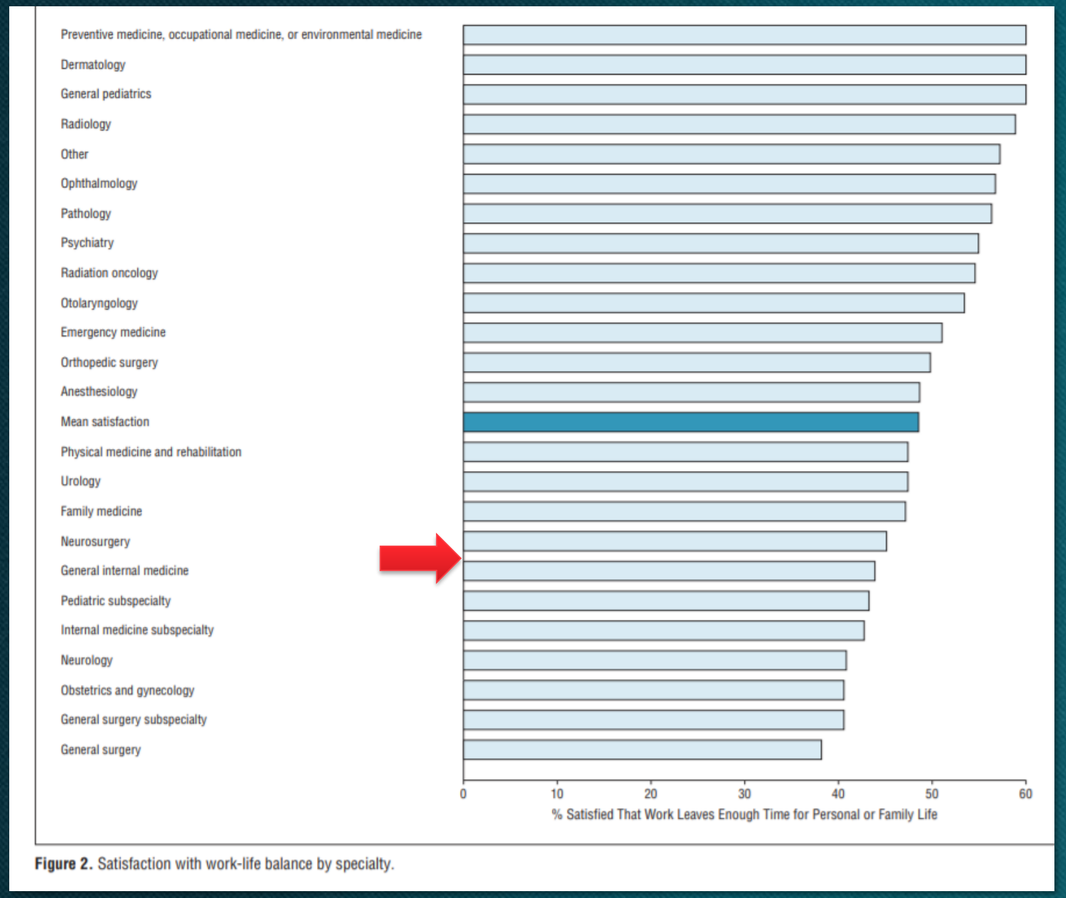


Figure 2. Satisfaction with work-life balance by specialty.

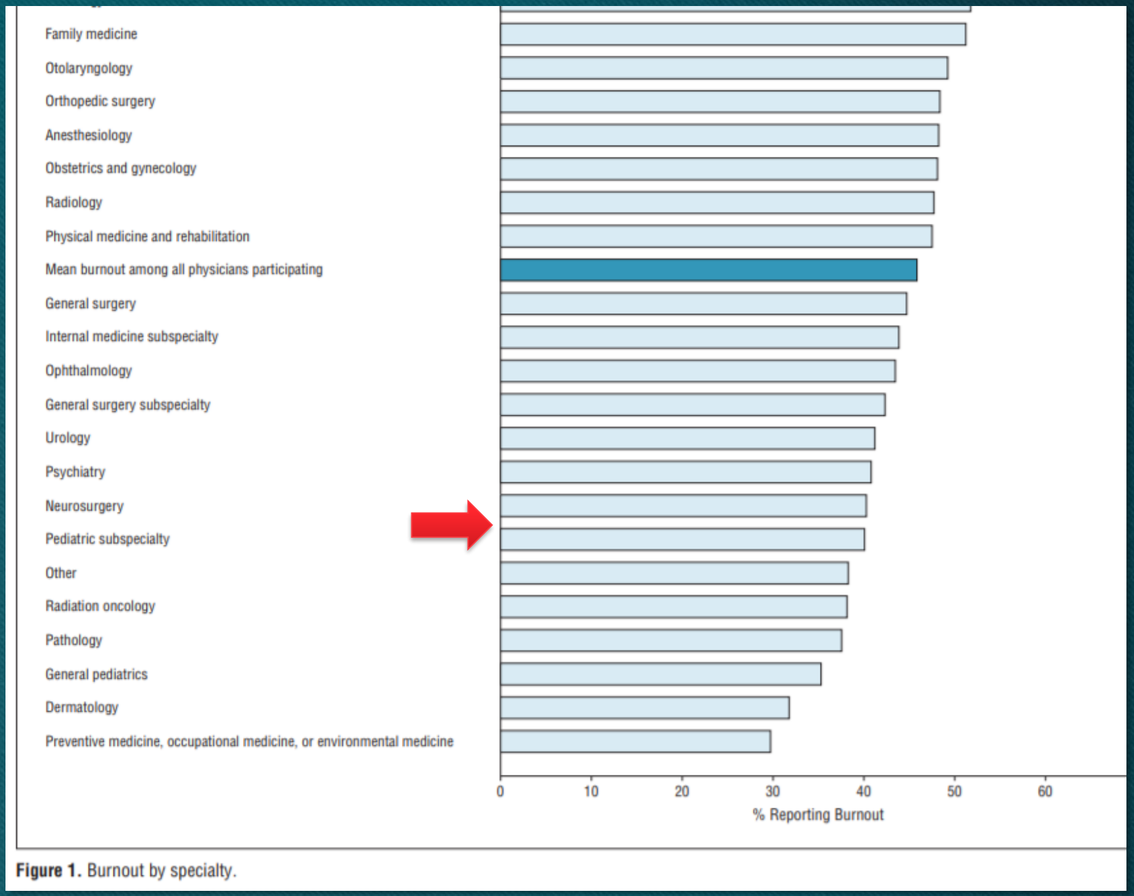
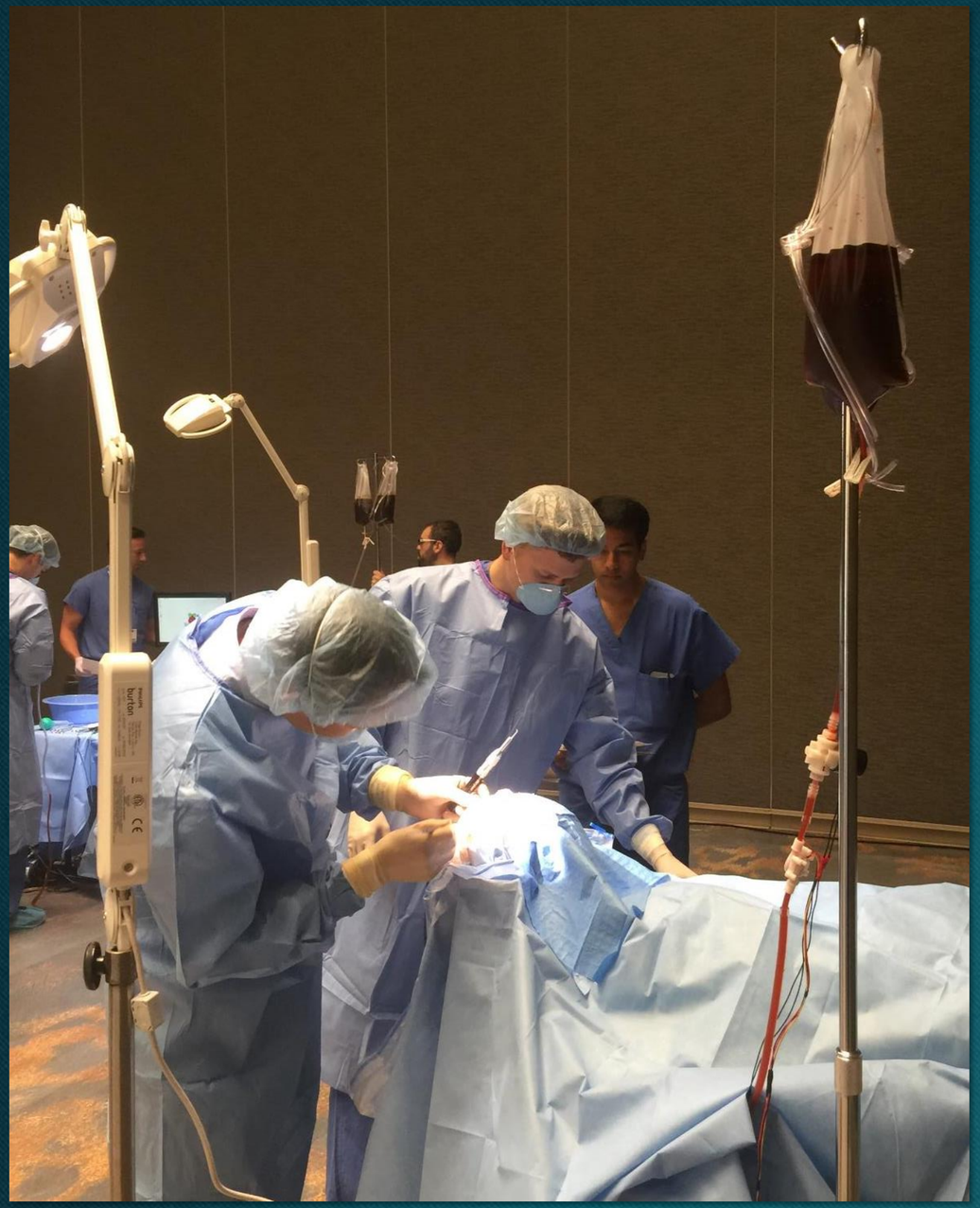


Figure 1. Burnout by specialty.

Passing neurosurgery from one generation to the next is the highest calling you have.

Thomas J Nasca, MD
CEO, ACGME



PNAS

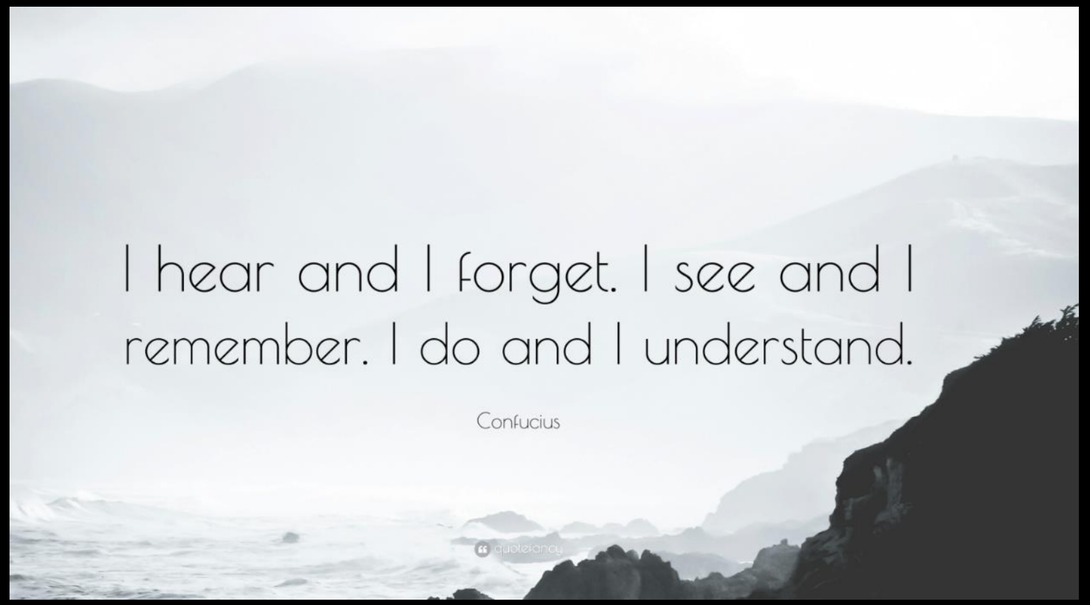
Active learning increases student performance in science, engineering, and mathematics

Scott Freeman[a,1], Sarah L. Eddy[a], Miles McDonough[a], Michelle K. Smith[b], Nnadozie Okoroafor[a], Hannah Jordt[a], and Mary Pat Wenderoth[a]

[a]Department of Biology, University of Washington, Seattle, WA 98195; and [b]School of Biology and Ecology, University of Maine, Orono, ME 04469

Edited* by Bruce Alberts, University of California, San Francisco, CA, and approved April 15, 2014 (received for review October 8, 2013)

To test the hypothesis that lecturing maximizes learning and course performance, we metaanalyzed 225 studies that reported 225 studies in the published and unpublished literature. The active learning interventions varied widely in intensity and implementa-



INNOVATIONS IN PILOT TRAINING

Faced with Congressional inaction on the military's budget, Air Force leaders try innovative solutions to ensure pilot training continues.

Assessment of the Interrater Reliability of the Congress of Neurological Surgeons Microanastomosis Assessment Scale

Andrew R. Pines, MA, Mohammed S. Alghoul, MD, Youssef J. Hamade, MD, MSCI, Mithun G. Sattur, MD, Rami James N. Aoun, MD, MPH, Tariq K. Halasa, MD, Chandan Krishna, MD, Samer G. Zammar, MD, MPH, Najib E. El Tecle, MD, MS, Tarek Y. El Ahmadieh, MD Salah G. Aoun, MD, Richard W. Byrne, MD, James S. Harrop, MD, Brian T. Ragel, MD, Daniel K. Resnick, MD, Russell R. Lonser, MD, Nathan R. Selden, MD, PhD, Bernard R. Bendok, MD, MSCI

Operative Neurosurgery, Volume 13, Issue 1, 1 February 2017, Pages 108–112, https://doi.org/10.1227/NEU.0000000000001403

Neuro-Critical Care Skills Training Using a Human Patient Simulator

Michael J. Musacchio Jr. · Adam P. Smith · Christopher A. McNeal · Lorenzo Munoz · David M. Rothenberg · Kelvin A. von Roenn · Richard W. Byrne

HISTORY AND DEVELOPING SIMULATION IN MEDICINE

Model-Based Simulation for Early Neurosurgical Learners

Nathan R. Selden, MD, PhD*
Thomas C. Origitano, MD‡
Costas Hadjipanayis, MD, PhD§
Richard Byrne, MD¶

BACKGROUND: Restrictions on duty hours and shift length by the Accreditation Council for Graduate Medical Education and public pressure to reduce complications and to improve outcomes in the clinical educational environment have enhanced interest in the use of procedural and surgical simulation to train neurosurgical residents.
OBJECTIVE: To introduce simple, available, and, when possible, inexpensive model-based simulation for early learners into the initial stages of neurosurgical residency training

Practice on an Augmented Reality/Haptic Simulator and Library of Virtual Brains Improves Residents' Ability to Perform a Ventriculostomy

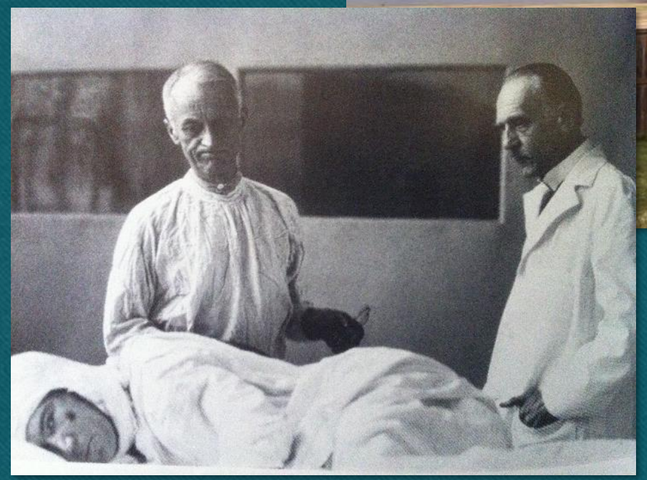
Rachel Yudkowsky, MD, MHPE;
Cristian Luciano, PhD;
Pat Banerjee, PhD;
Alan Schwartz, PhD;
Ali Alaraj, MD;
G. Michael Lemole, Jr, MD;
Fady Charbel, MD;
Kelly Smith, PhD;
Silvio Rizzi, MS;
Richard Byrne, MD;
Bernard Bendok, MD, FACS;
David Frim, MD, PhD

Introduction: Ventriculostomy is a neurosurgical procedure for providing therapeutic cerebrospinal fluid drainage. Complications may arise during repeated attempts at placing the catheter in the ventricle. We studied the impact of simulation-based practice with a library of virtual brains on neurosurgery residents' performance in simulated and live surgical ventriculostomies.
Methods: Using computed tomographic scans of actual patients, we developed a library of 15 virtual brains for the ImmersiveTouch system, a head- and hand-tracked augmented reality and haptic simulator. The virtual brains represent a range of anatomies including normal, shifted, and compressed ventricles. Neurosurgery residents participated in individual simulator practice on the library of brains including visualizing the 3-dimensional location of the catheter within the brain immediately after each insertion. Performance of participants on novel brains in the simulator and during actual surgery before and after intervention was analyzed using generalized linear mixed models.
Results: Simulator cannulation success rates increased after intervention, and live procedure outcomes showed improvement in the rate of successful cannulation on the first pass. However, the incidence of deeper, contralateral (simulator) and third-ventricle (live) placements increased after intervention. Residents reported that simulations were realistic and helpful in improving procedural skills such as aiming the probe, sensing the pressure change when entering the ventricle, and estimating how far the catheter should be advanced within the ventricle.
Conclusions: Simulator practice with a library of virtual brains representing a range of anatomies and difficulty levels may improve performance, potentially decreasing complications due to inexpert technique.
(*Sim Healthcare* 8:25–31, 2013)

Journal of Surgical Education

Fostering and Assessing Professionalism and Communication Skills in Neurosurgical Education

Ricardo B.V. Fontes, PhD, Nathan R. Selden, PhD, Richard W. Byrne, MD



Future Neurosurgical Innovation

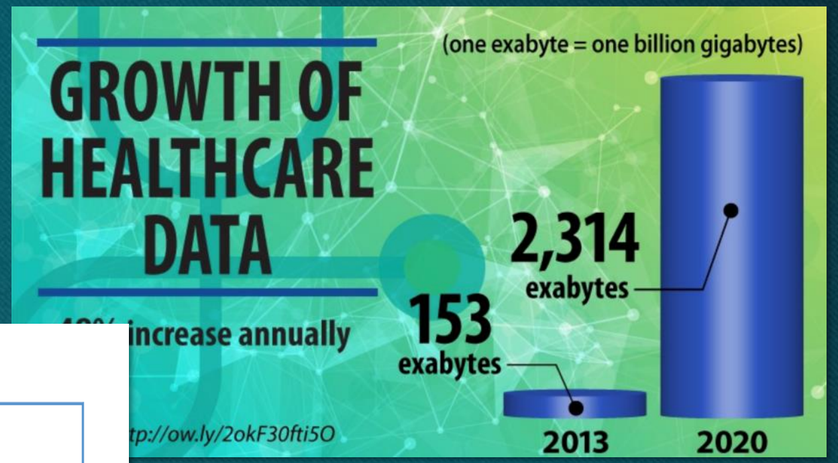
1,962 papers on machine learning in cancer in the past 5 years.
Revolutionizing prognosis, diagnosis and pre-operative planning.

Predicting the Future — Big Data, Machine Learning, and Clinical Medicine

Ziad Obermeyer, M.D., and Ezekiel J. Emanuel, M.D., Ph.D.

By now, it's almost old news: big data will transform medicine. It's essential to remember, however, that data by themselves are useless. To be useful, data must be analyzed, interpreted, and acted on. Thus, it is algorithms — not data sets — that will prove transformative. We believe, therefore, that attention has to shift to new statistical tools from the field of machine learning that will be critical for anyone practicing medicine in the 21st century.

First, it's important to understand what machine learning is not. Most computer-based algorithms in medicine are "expert systems" — rule sets encoding knowledge on a given topic, which are applied to draw conclusions



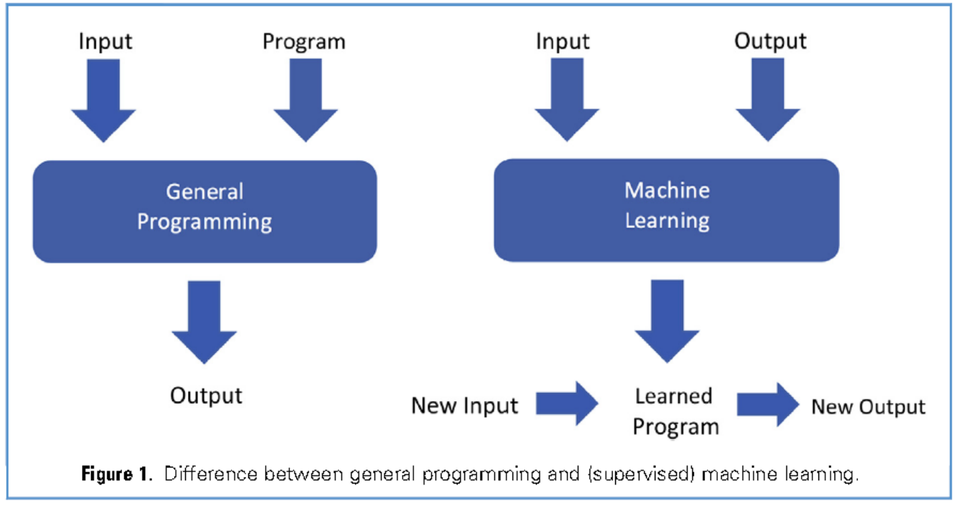


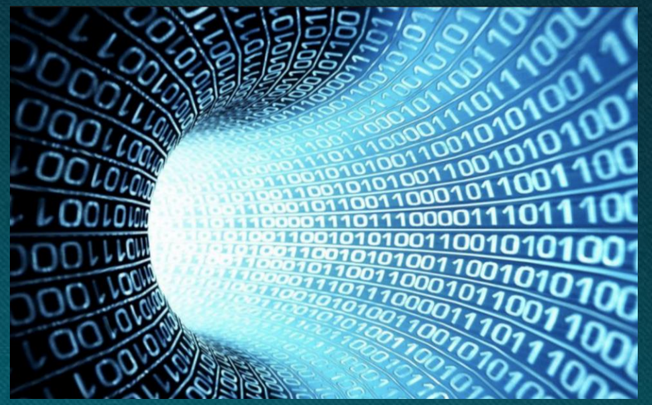
Figure 1. Difference between general programming and (supervised) machine learning.

Claude Shannon

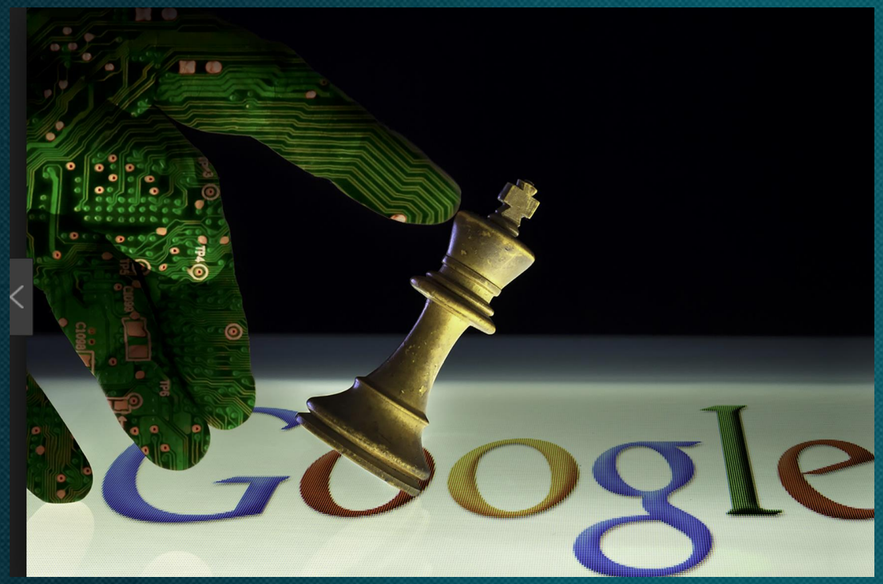
A Mathematical Theory of Communication
By C.E. SHANNON

$$\lambda = \operatorname*{Lim}_{\delta\to 0} \operatorname*{Lim}_{\epsilon\to 0} \operatorname*{Lim}_{T\to\infty} \frac{\log N(\epsilon,\delta,T)}{T\log\epsilon}.$$

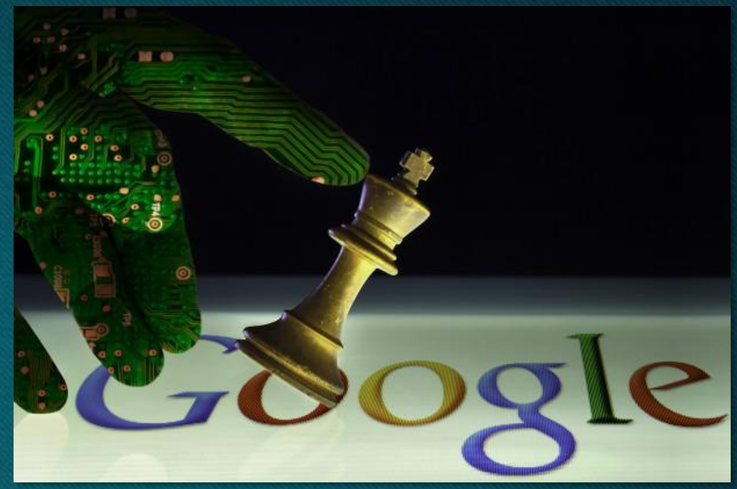
This is a generalization of the measure type definitions of dimension in topology, and agrees with the intuitive dimension rate for simple ensembles where the desired result is obvious.

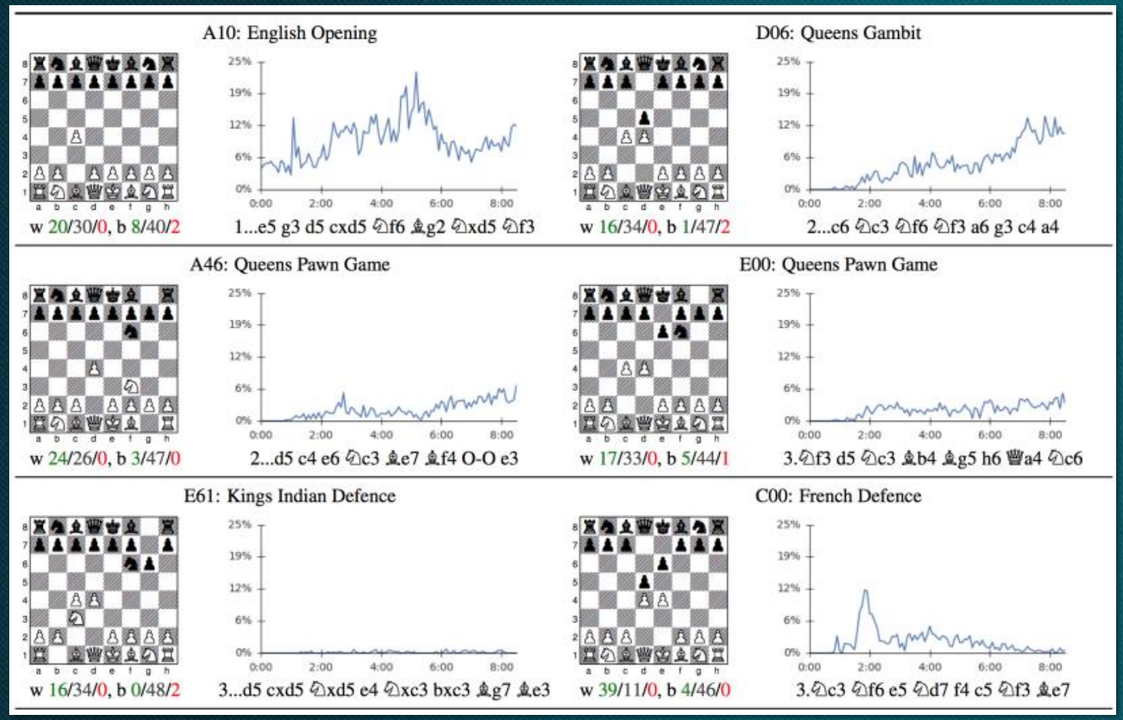


Deep Mind (AI)	28	9 hours of AI training
Stockfish	0	60 years of standard computing



Google’s ‘superhuman’ Deep Mind AI claims chess crown





Google Deep Mind’s ‘alien’ chess computer reveals game’s deeper truths

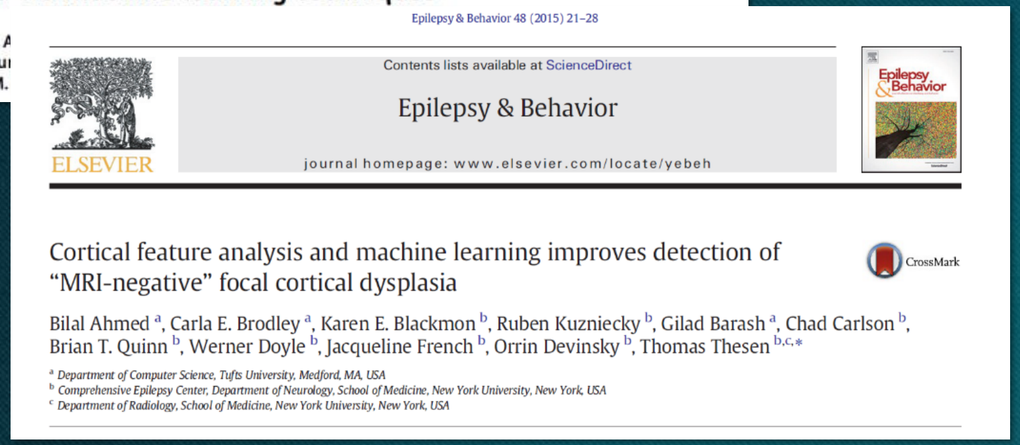
The self-taught AlphaZero’s performance was the biggest paradigm shift in chess computing since Deep Blue defeated Garry Kasparov in 1997.

Neuro-Oncology

Neuro-Oncology 18(3), 417–425, 2016
doi:10.1093/neuonc/nov127
Advance Access date 16 July 2015

Imaging patterns predict patient survival and molecular subtype in glioblastoma via machine learning techniques

Luke Macyszyn†, Hamed A
Ramana V. Davuluri, Lau
Michel Bilello, Donald M.



Epilepsy & Behavior 48 (2015) 21–28

Contents lists available at ScienceDirect

Epilepsy & Behavior

journal homepage: www.elsevier.com/locate/yebeh

ELSEVIER

Cortical feature analysis and machine learning improves detection of "MRI-negative" focal cortical dysplasia

CrossMark

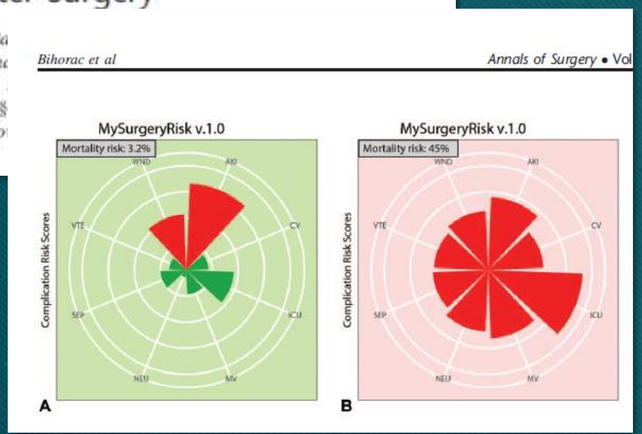
Bilal Ahmed [a], Carla E. Brodley [a], Karen E. Blackmon [b], Ruben Kuzniecky [b], Gilad Barash [a], Chad Carlson [b], Brian T. Quinn [b], Werner Doyle [b], Jacqueline French [b], Orrin Devinsky [b], Thomas Thesen [b,c,*]

[a] Department of Computer Science, Tufts University, Medford, MA, USA
[b] Comprehensive Epilepsy Center, Department of Neurology, School of Medicine, New York University, New York, USA
[c] Department of Radiology, School of Medicine, New York University, New York, USA

ORIGINAL ARTICLE

MySurgeryRisk: Development and Validation of a Machine-learning Risk Algorithm for Major Complications and Death After Surgery

Azra Bihorac, MD, MS,¶¶ Tezcan Ozrazgat-Ba*
Amir Motaei, PhD,¶¶ Mohcine Madkour, PhD,*¶¶ Pan*
William R. Hogan, MD, MS,§¶¶ Philip A. Efron, MD,¶
*Daisy Zhe Wang, PhD,||¶¶ Charles E. Hobson, MD,**§§*
and Petar Momcilo



"We are quickly approaching a time in which an AI program will read medical imaging, pathology, and skin lesions better than physicians."

Darrell Kirch, MD,
CEO of the Association of American Medical Colleg

Diabetic retinopathy, the leading reversible cause of blindness in the US

Opinion

EDITORIAL

Artificial Intelligence With Deep Learning Technology Looks Into Diabetic Retinopathy Screening

Tien Yin Wong, MD, PhD; Neil M. Bressler, MD

FDA approves diabetic retinopathy-detecting AI algorithm

by Nick Paul Taylor | Apr 13, 2018 7:55am

Automated diabetic retinopathy detection in smartphone-based fundus photography using artificial intelligence

Ramachandran Rajalakshmi ✉, Radhakrishnan Subashini, […] Viswanathan Mohan

Eye (2018)
doi:10.1038/s41433-018-0064-9
Download Citation

Outcomes research | Retinal diseases

Received: 12 January 2018

ARTICLES
https://doi.org/10.1038/s41551-018-0195-0
nature biomedical engineering

Prediction of cardiovascular risk factors from retinal fundus photographs via deep learning

Ryan Poplin[1,4], Avinash V. Varadarajan[1,4], Katy Blumer[1], Yun Liu[1], Michael V. McConnell[2,3], Greg S. Corrado[1], Lily Peng[1,4]* and Dale R. Webster[1,4]

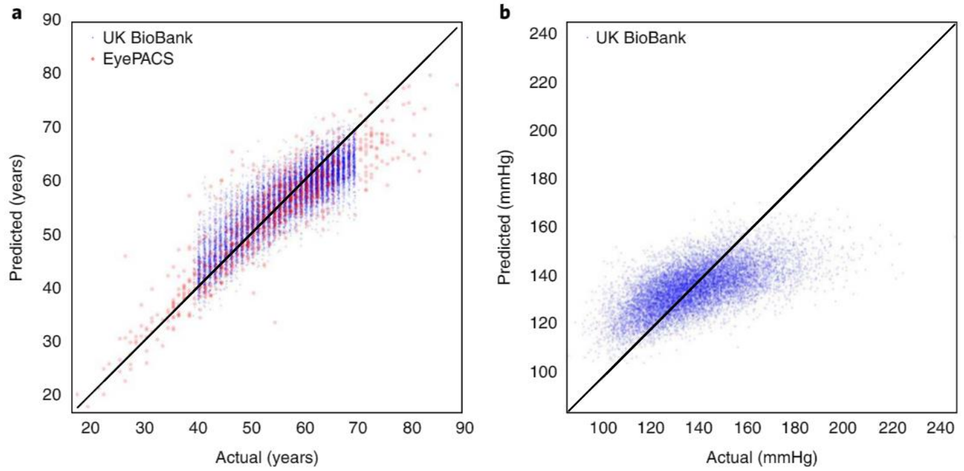
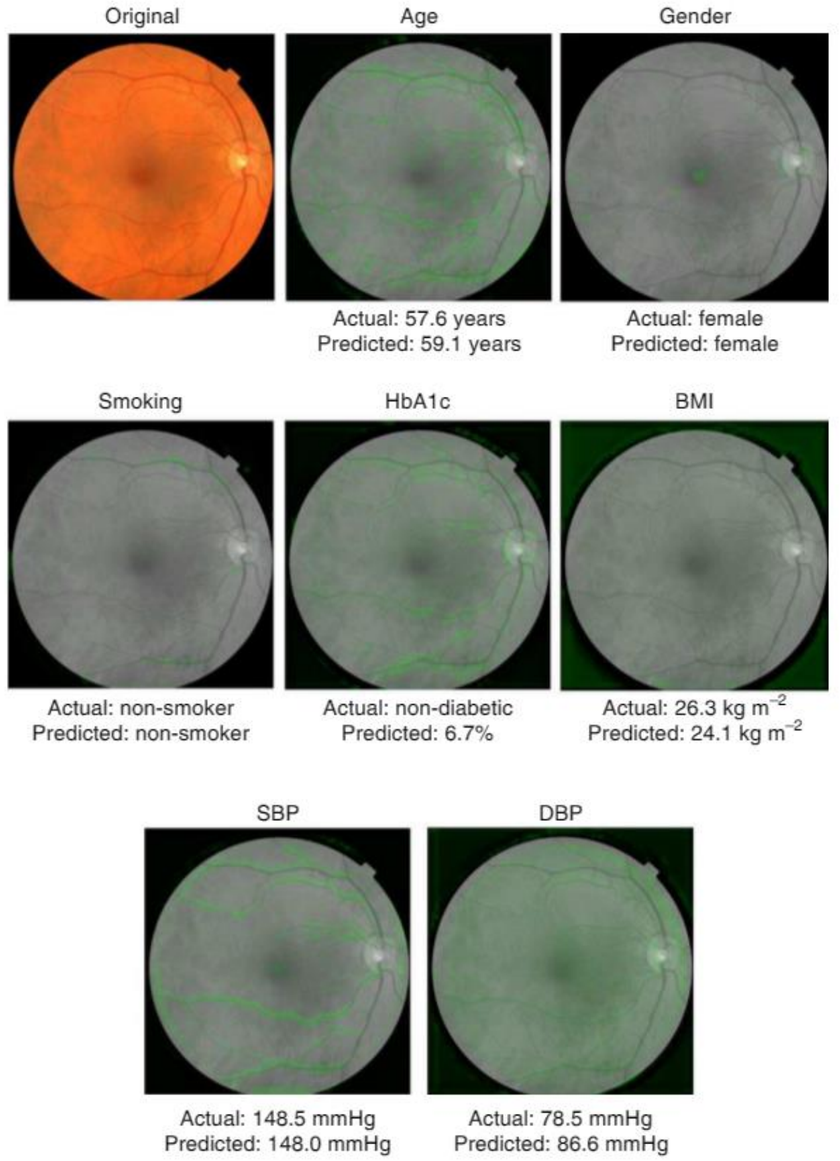


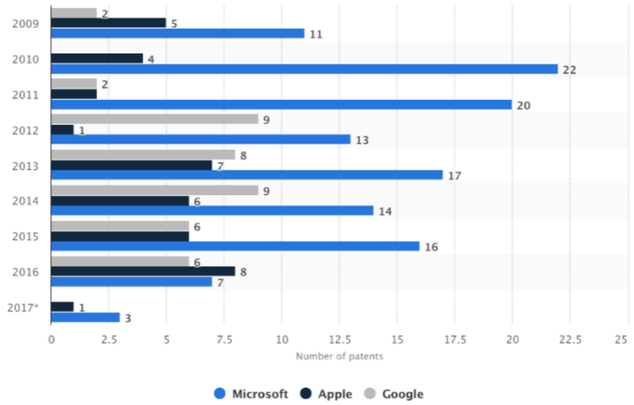
Fig. 1 | Predictions of age and SBP. a, Predicted and actual age in the two validation datasets. For the UK Biobank dataset, age was calculated using the birth year because birth months and days were not available. In the EyePACS-2K dataset, age is available only in units of whole years. **b**, Predicted and actual SBP in the UK Biobank validation dataset. The lines represent $y = x$ values.

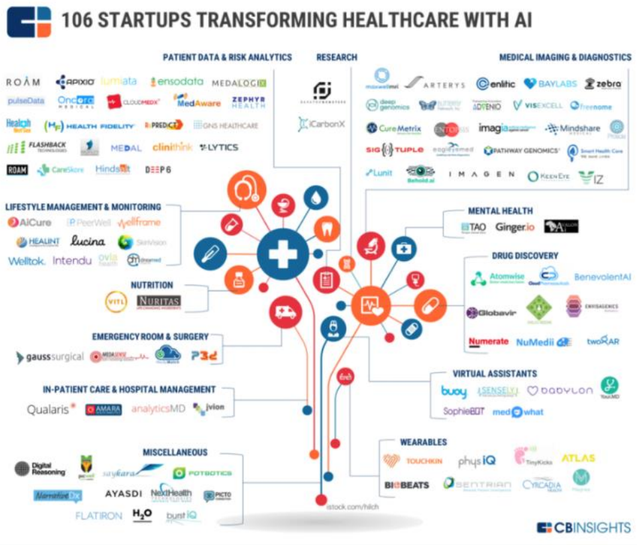
ARTICLES



In medical innovation, quantity has a quality all it's own.

Number of healthcare patents of technology companies Microsoft, Apple, and Google from 2009 to 2017





ARTICLE IN PRESS

Perspective

Toward Augmented Radiologists: Changes in Radiology Education in the Era of Machine Learning and Artificial Intelligence

Shahein H. Tajmir, MD, Tarik K. Alkasab, MD, PhD

Radiology practice will be altered by the coming of artificial intelligence, and the process of learning in radiology will be similarly affected. In the short term, radiologists will need to understand the first wave of artificially intelligent tools, how they can help them improve their practice, and be able to effectively supervise their use. Radiology training programs will need to develop curricula to help trainees acquire the knowledge to carry out this new supervisory duty of radiologists. In the longer term, artificially intelligent software assistants could have a transformative effect on the training of residents and fellows, and offer new opportunities to bring learning into the

Acta Neurochir (2018) 160:29–38
https://doi.org/10.1007/s00701-017-3385-8

REVIEW ARTICLE - NEUROSURGICAL TECHNIQUES

An introduction and overview of machine learning in neurosurgical care

Joeky T. Senders[1,2] · Mark M. Zaki[2] · Aditya V. Karhade[2] · Bliss Chang[2] · William B. Gormley[2] · Marike L. Broekman[1,2] · Timothy R. Smith[2] · Omar Arnaout[2]

In 7 studies analyzed, ML outperformed multivariate analysis on the same dataset ($p<0.001$)

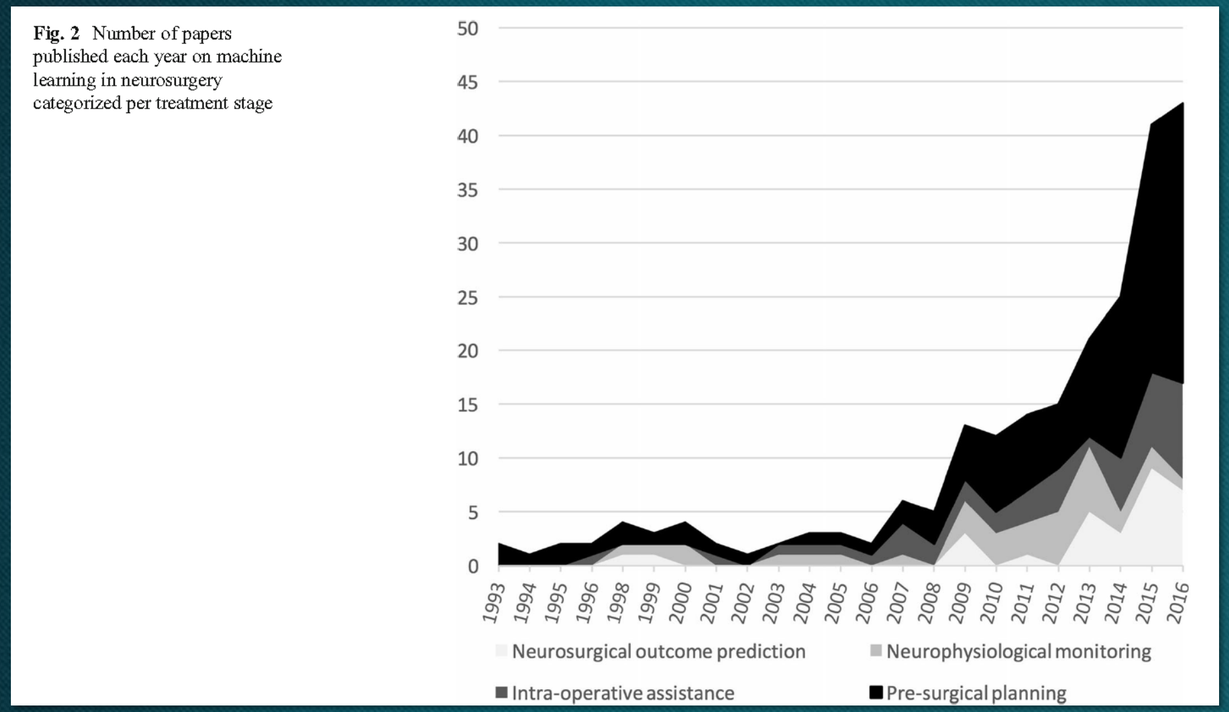
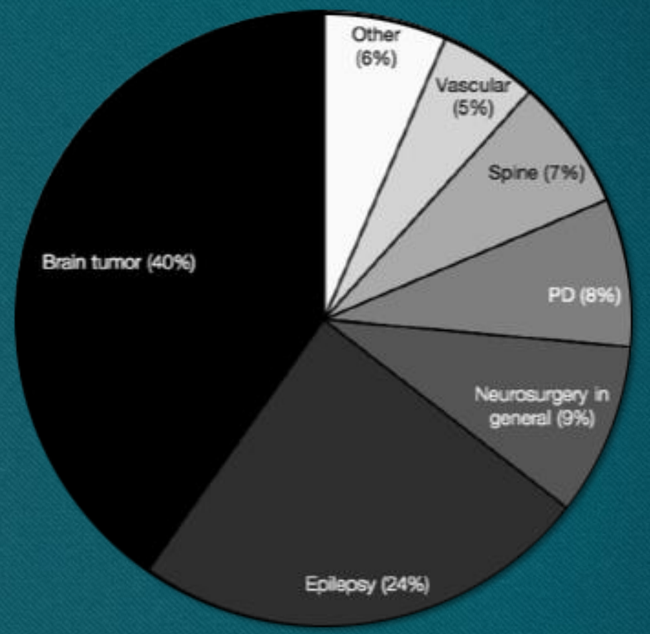
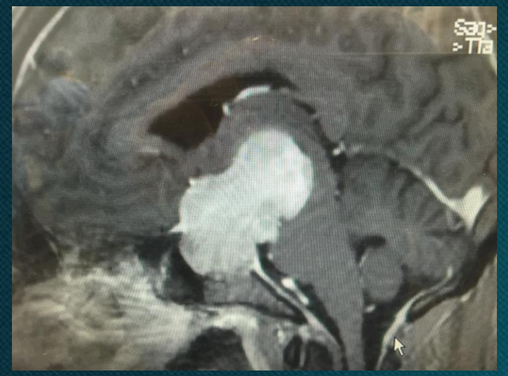


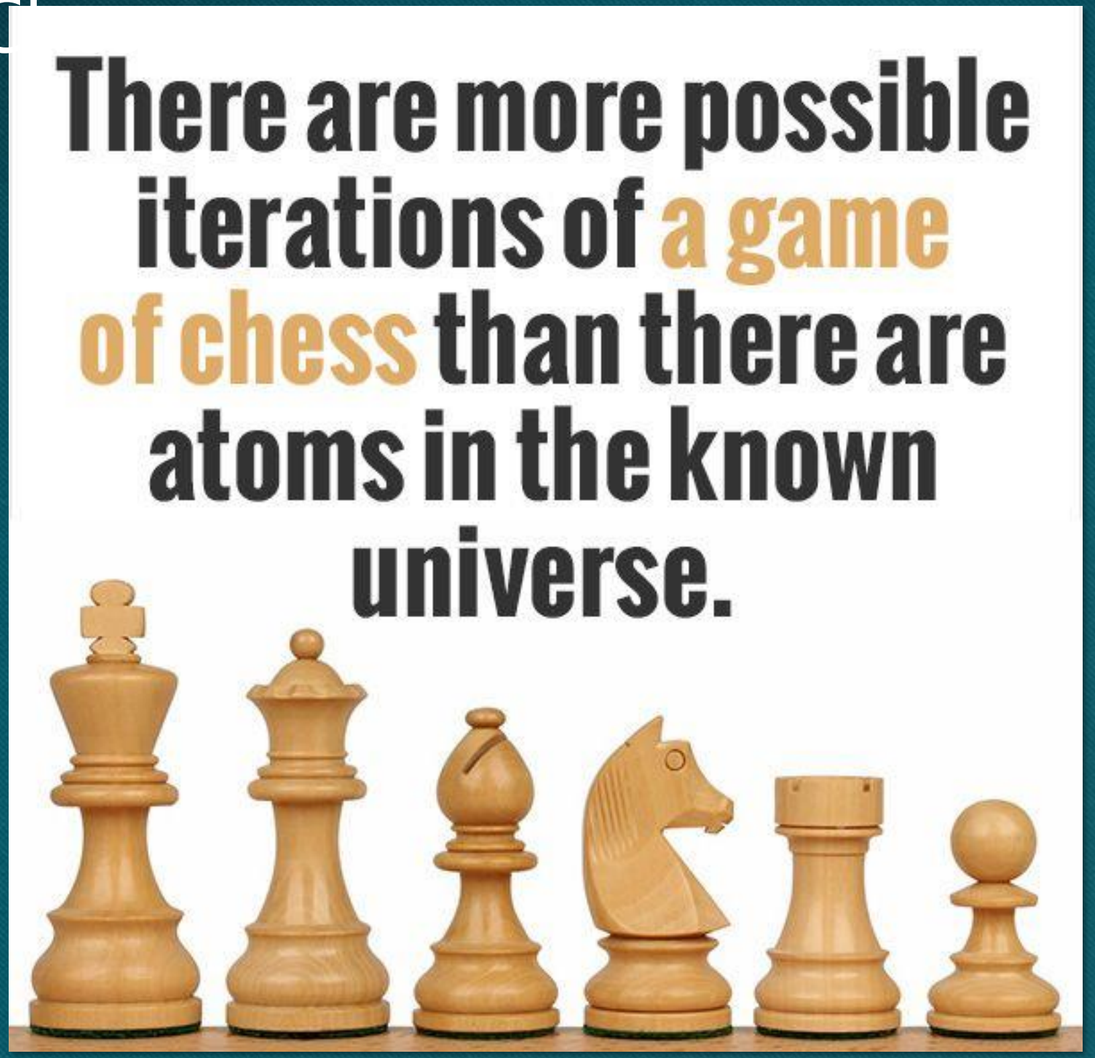
Fig. 2 Number of papers published each year on machine learning in neurosurgery categorized per treatment stage



Neurosurgery Machine Learning?

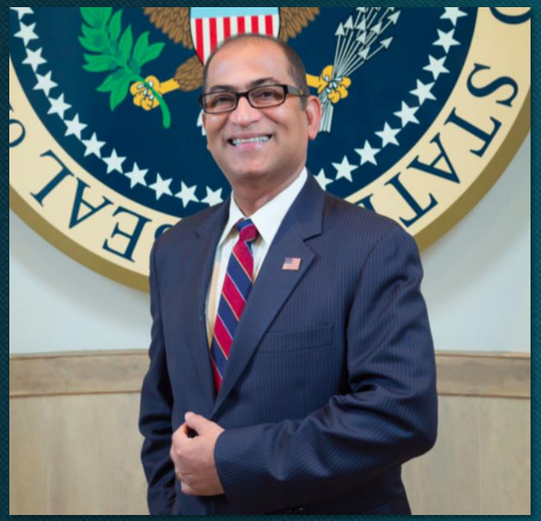
$1x10^{120}$ Possible Positions in C

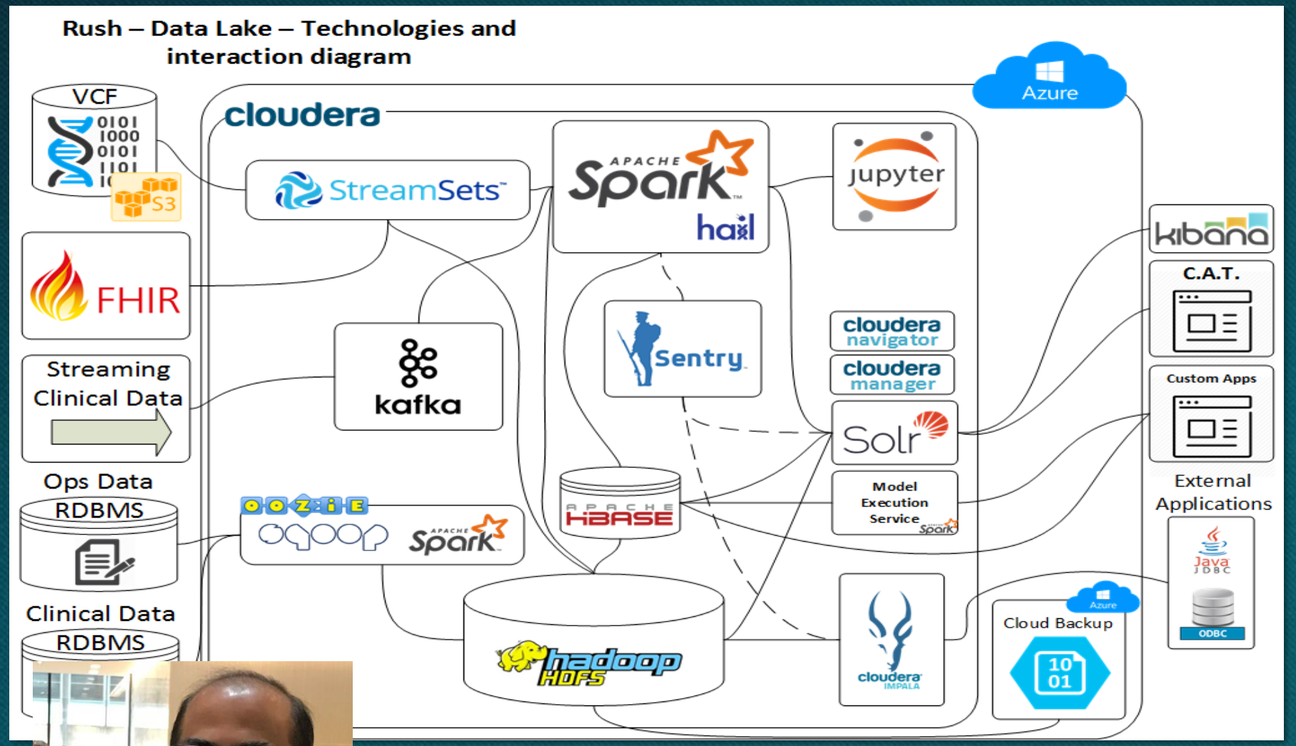


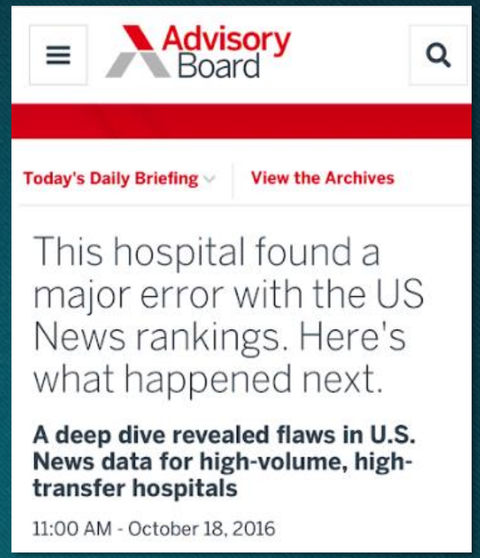


Partner with your IT leaders

THE BIG DEAL ABOUT DATA

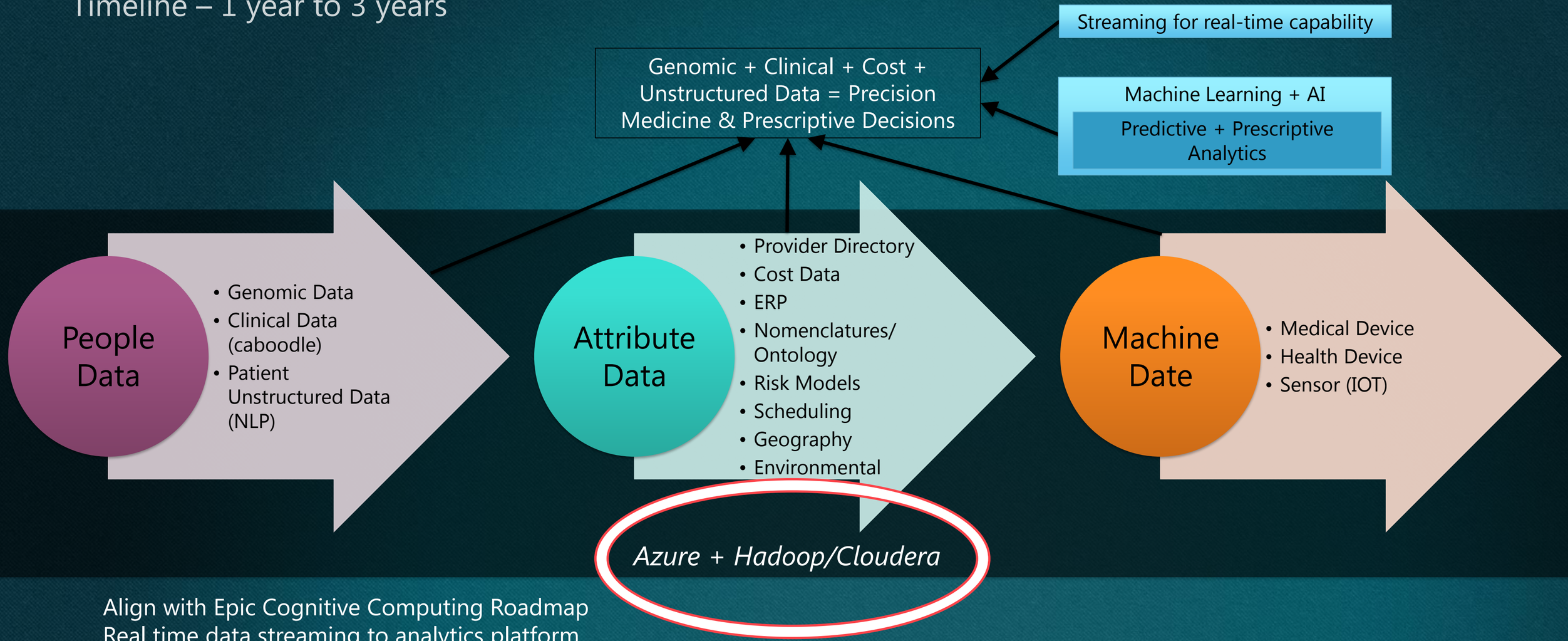




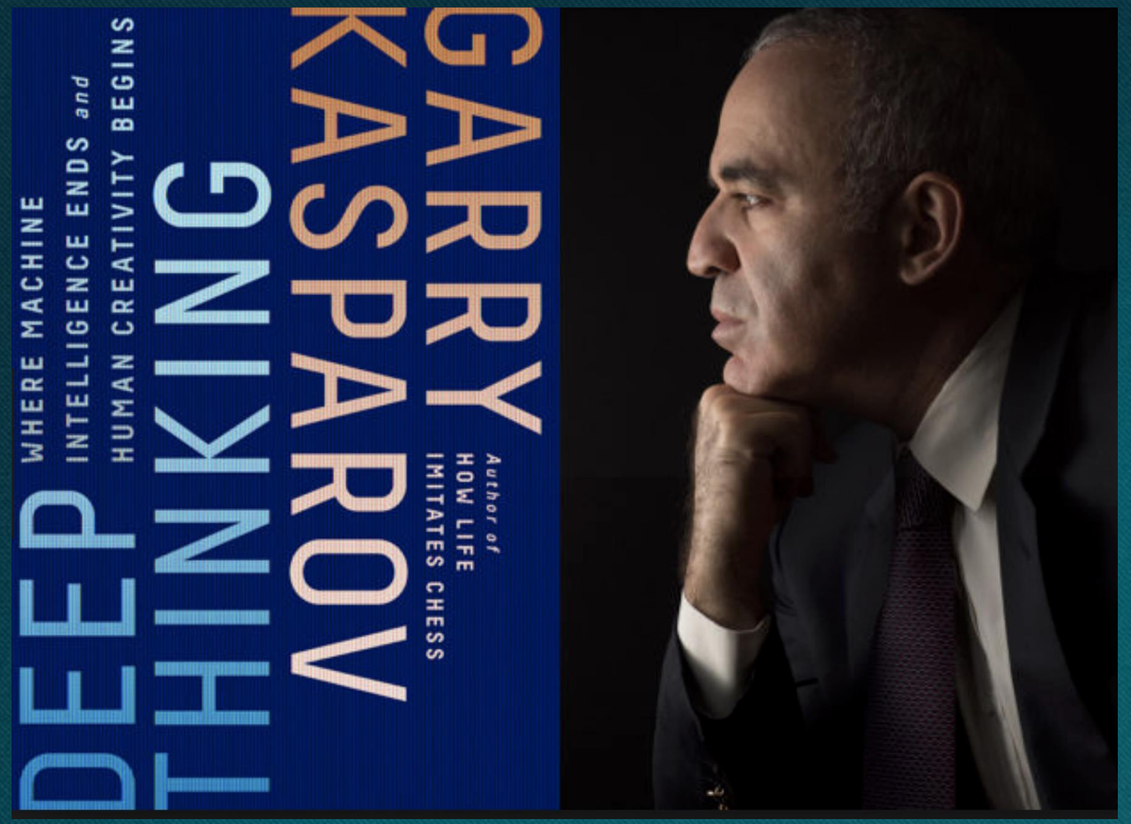


Future State - Strategy

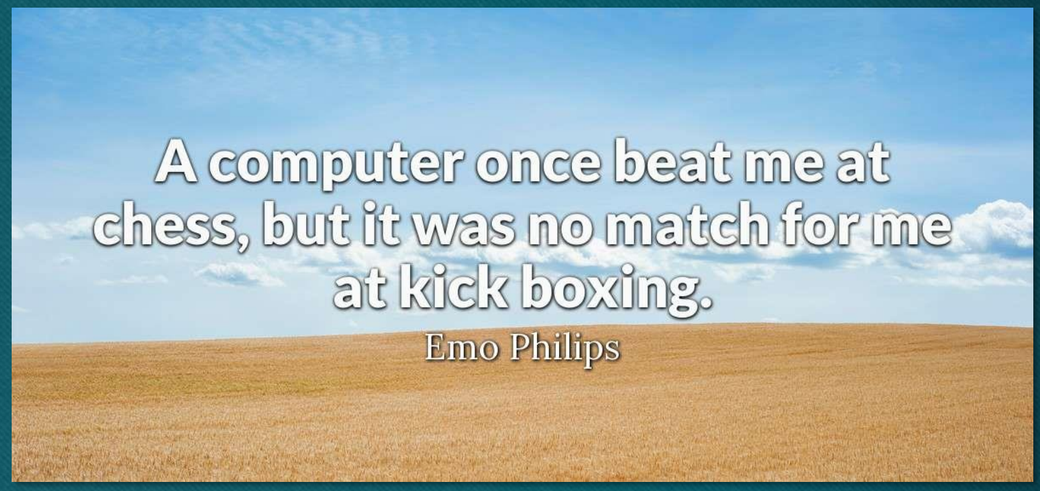
Timeline – 1 year to 3 years



Align with Epic Cognitive Computing Roadmap
Real time data streaming to analytics platform
Rules Engine with Bidirectional Flow of Data to EMR
AI Layer applied to streaming data
API Based App development leveraging FHIR/EMR and Streaming Data/HDFS

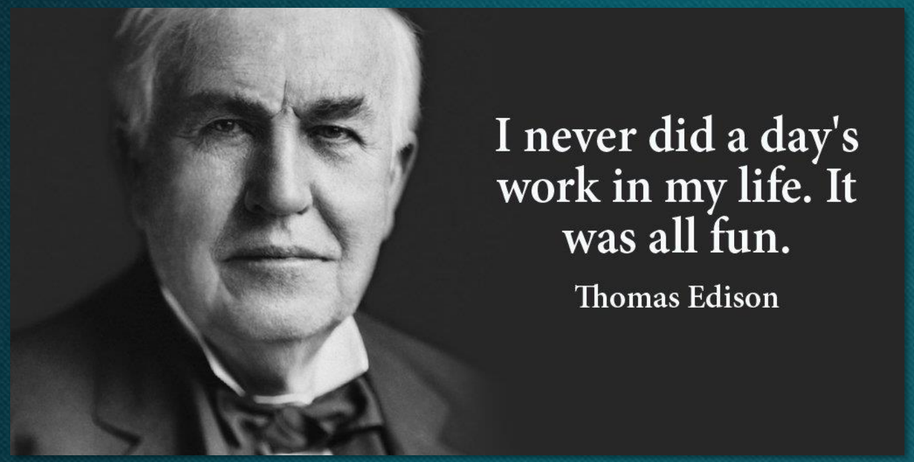


- Machines have calculations, we have understanding.
- Machines have instructions, we have purpose.
- It is up to us to imagine and dream what we can do together that was once impossible.



In the future, innovation will be our chief responsibility.

> *Creativity is intelligence having fun.*
>
> *Albert Einstein*



NSA Presidential Address

Carl Graf MD, 1961

- No man is an island unto himself. This we have learned most of all….
- What is cherished most are the friendships… made in this Society…
- The sincere feeling of camaraderie, the honest sense of pleasure and warmth in meeting fellow neurosurgeons with a mutual respect and regard, are intangibles whose value cannot be measured.

By furnishing a forum for intimate exchange of ideas and information among a group of representative neurosurgeons. ….through further dissemination of new information in the field of neurological surgeons.

Ne Ultima Scientiae

Lest the last of knowledge

- Shelly Chou: experiences with the neurological complications of the treatment of scoliosis
- Irving Cooper: Stereotactic surgery for torticollis and dystonia 1965
- Ehni, G: pituitary stalk section in diabetic neuropathy 1962
- French, L: experiences with hemispherectomy for neoplasms, convulsive disorders, and spastic hemiparesis
- Hunt: Observation on the grading of surgical risk in intracranial aneurysm 1966
- MacCarty CS: some applications of depth electrocorticography in the diagnosis and surgical treatment of focal epilepsy, 1954
- Meirowsky AM: neurosurgical experiences in Korea 1951
- Morris, AA: Treatment of post herpetic intercostal neuralgia by anastomosis of two intercostal nerves:1962
- Nulsen, FE: Use of frontal lobe procaine injection for pain and psychiatric problems 1955
- Selverstone B: Anterior communicating aneurysms: technique and results of coating with adherent plastics 1963. Meningeal artery occlusion in the treatment of vascular headache 1955. Stereotactic injector for massive chemotherapy of gliomas 1968.
- Sherman IJ: Bilateral exposure of the spinal canal through a unilateral hemilaminectomy 1969
- Rhoton A: Microneurosurgery, film and discussion 1971
- Janetta, PJ: Microneurosurgery of the lower cranial nerves 1972

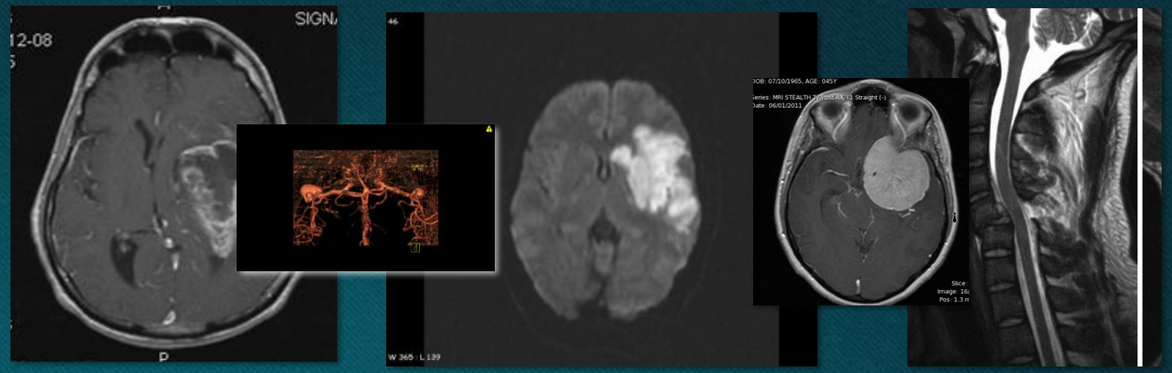
Surgical robotics

Pipeline

Gamma brain mapping

embolectomy

LITT



Who will lead neurosurgical innovation in the future?

2010 **2020** **2030**

MGUS

Optune

Disc replacement

Biologic glues

Innovation is our Obligation