

A Brain Is Not A Computer

(and why this is relevant for software design)

CoSin 2018

Pat Mächler / [@valio_ch](https://twitter.com/valio_ch)

When I was in
Kindergarten...



Your brain is not a computer



Biological neurons or nerve cells

200 billion neurons, 32 trillion interconnections.

Neuron size: 10-6 m.

Energy consumption: 6-10 joules per operation per sec.

Learning capability



Silicon transistors

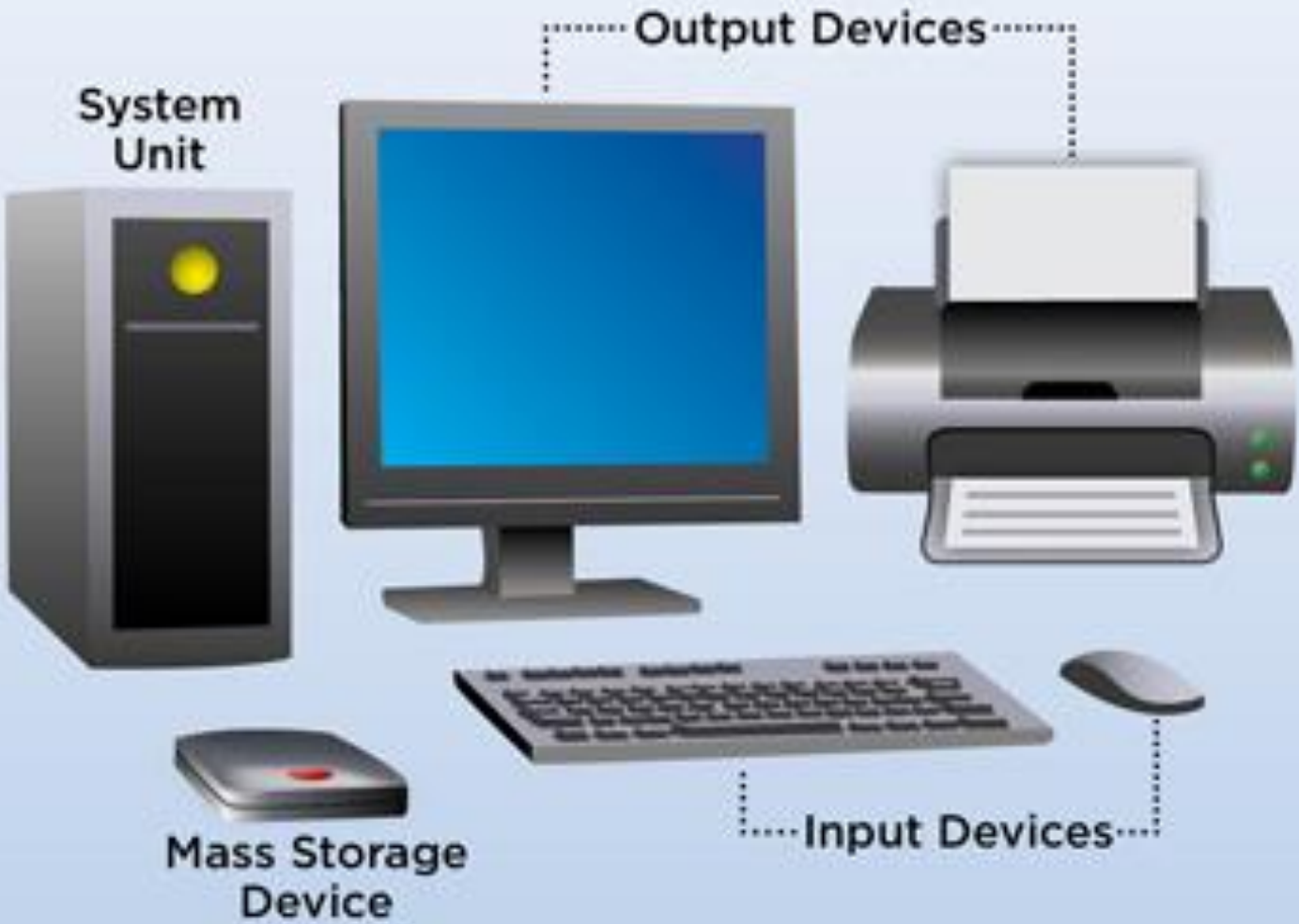
1 billion bytes RAM, trillion of bytes on disk.

Single transistor size: 10-9m.

Energy consumption: 10-16 joules per operation per second.

Programming capability

What is a computer?

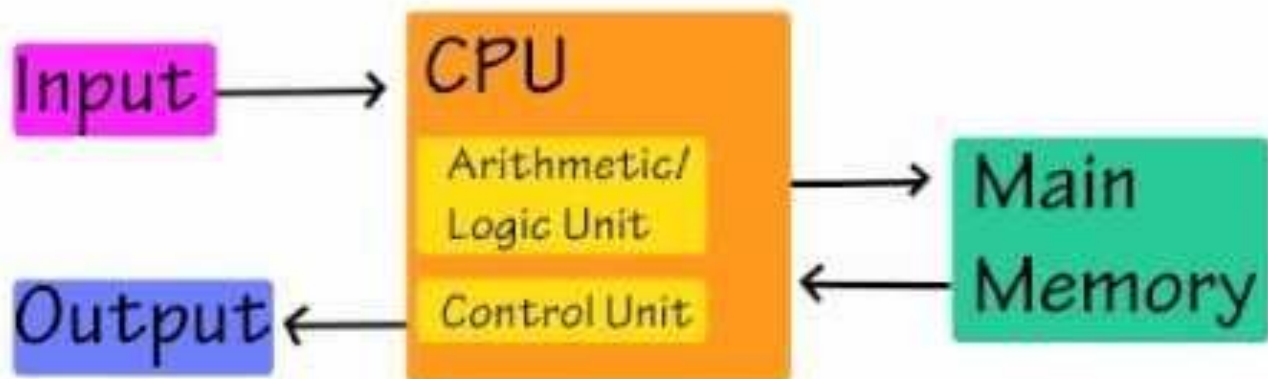


.....Output Devices.....

System Unit

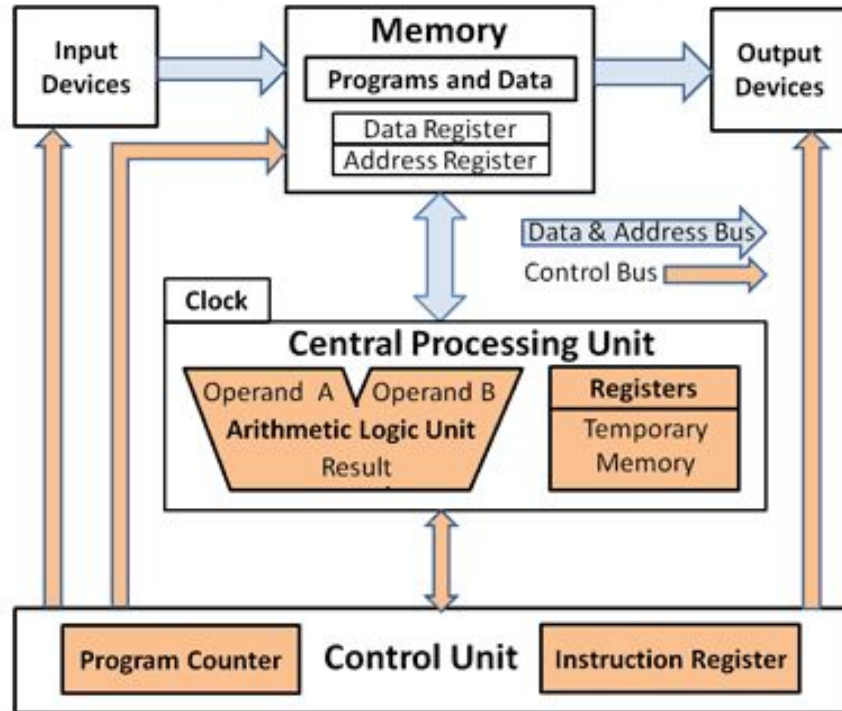
Mass Storage Device

.....Input Devices.....



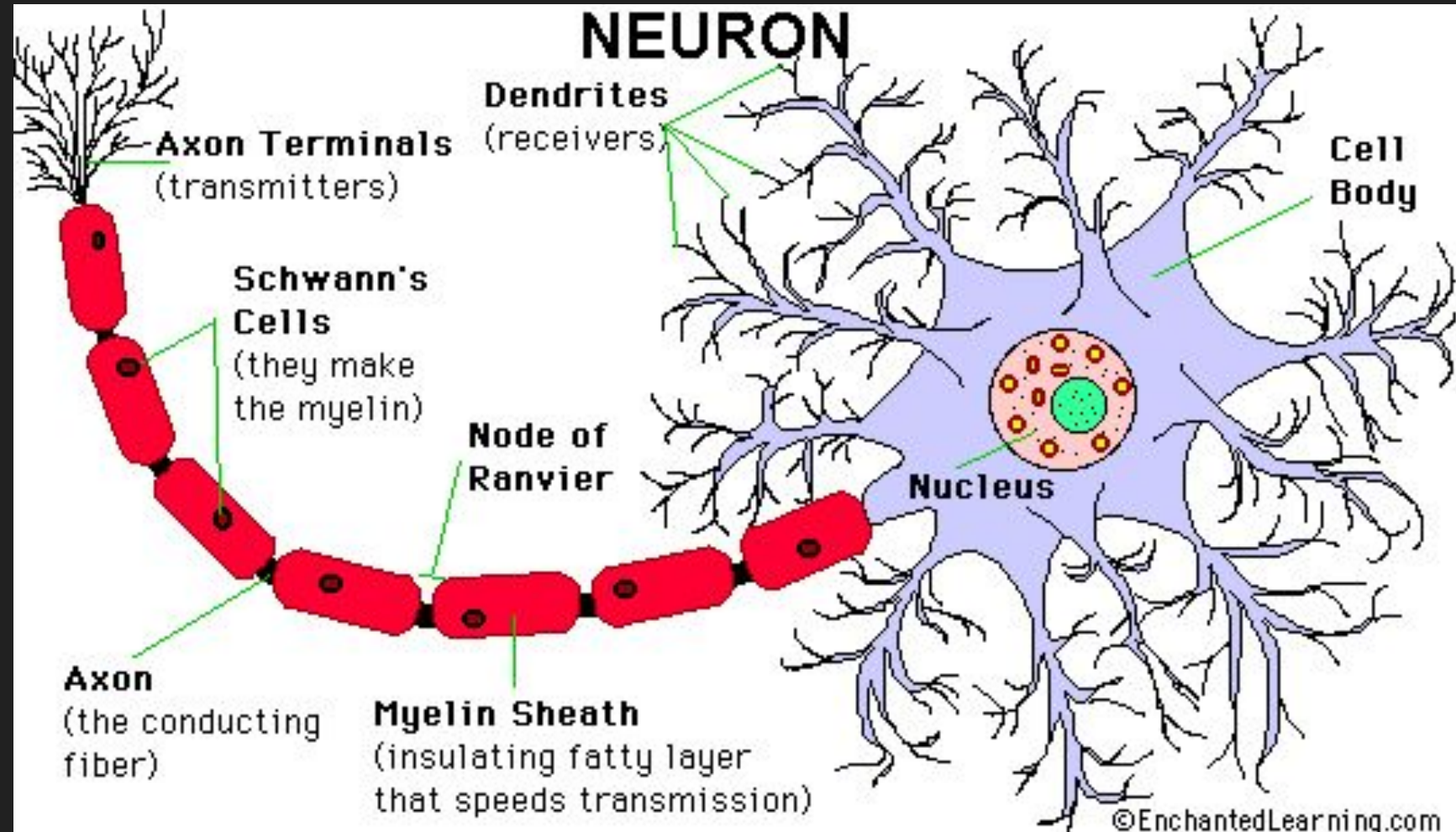
Von Neumann Architecture

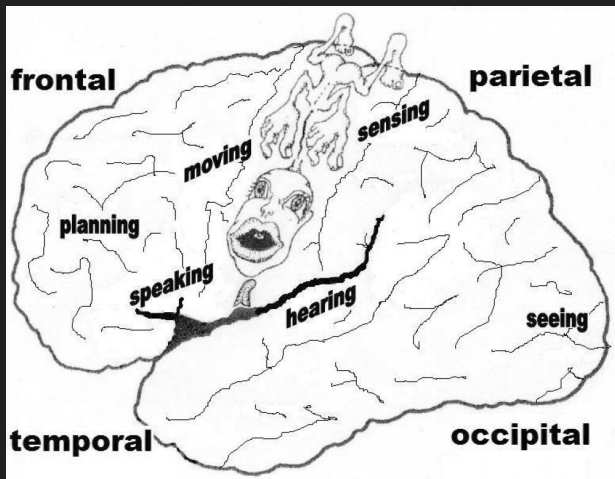
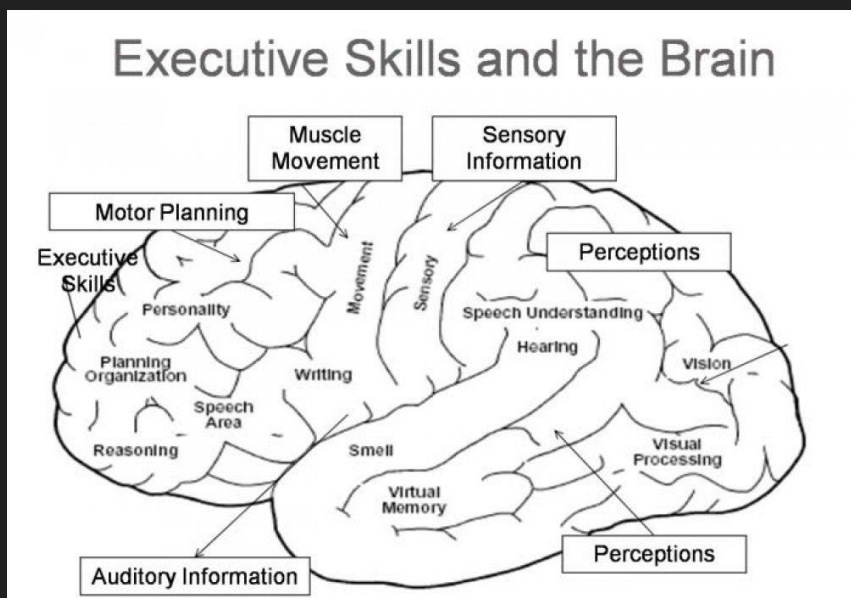
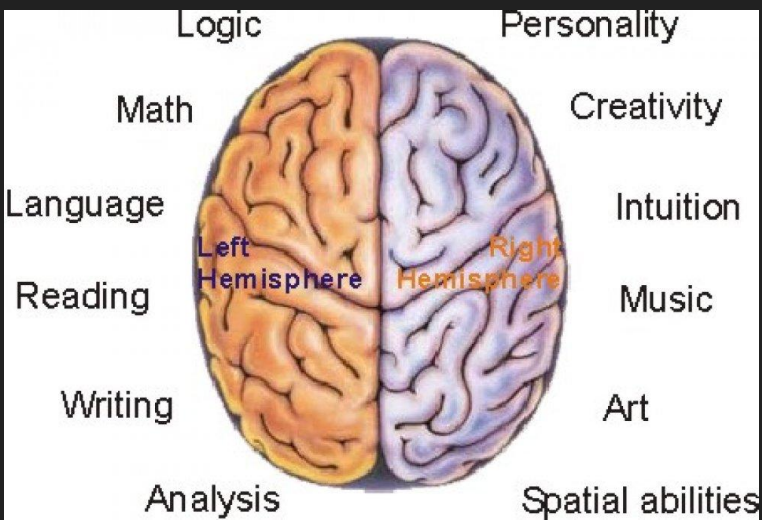
Von Neumann Architecture



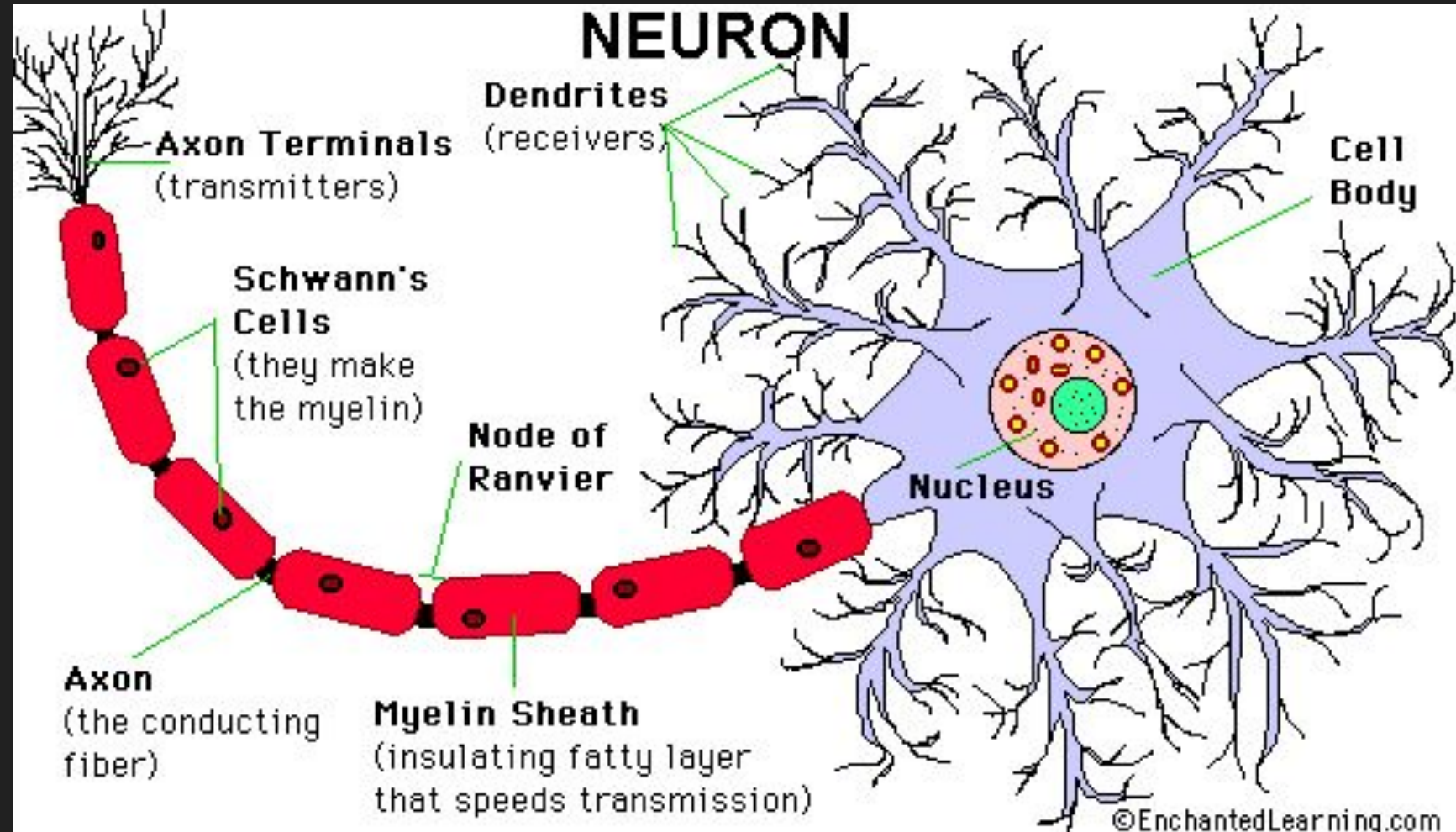
What is a brain?

NEURON





NEURON



Neuroplasticity

The ability of the brain to rewire and rebuild itself to form new neural networks and reinforce familiar neural connections.



Why should you care about your

BDNF ?

Brain Derived Neurotrophic Growth Factor is a key neurochemical responsible for the growth and maintenance of neural connections.

- BDNF helps your brain adapt & learn
- Improves all forms of plasticity

YOU control your BDNF levels

Nutrition

Sugar reduces BDNF Levels while Fasting, Ketosis and Omega-3 fatty acids improve BDNF levels.

Sleep

Poor Sleep reduces BDNF Levels.

Exercise

Movement and exercise at any age improves BDNF levels.

Chronic Stress

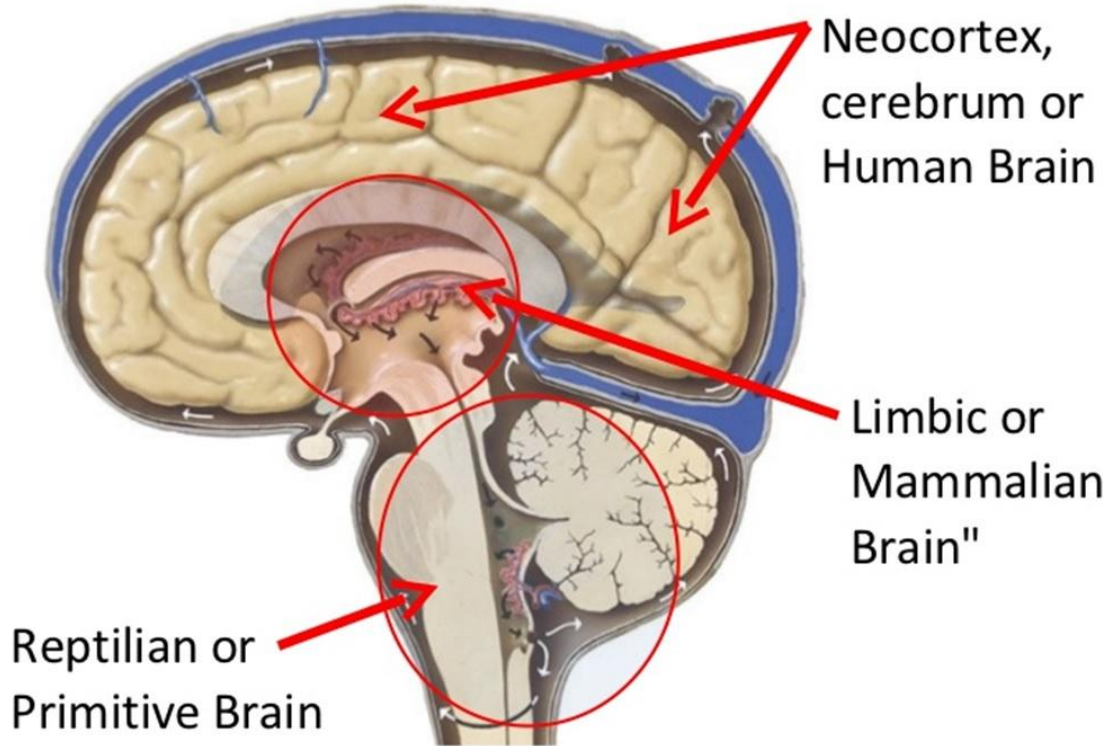
Imbalances in cortisol and adrenaline lower BDNF levels.

The *Triune Brain* model



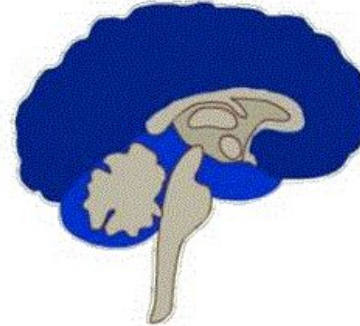
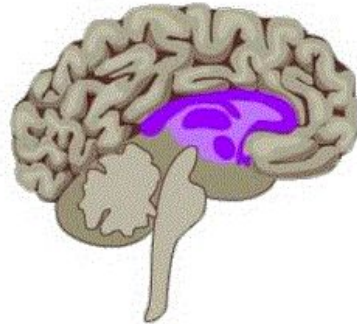
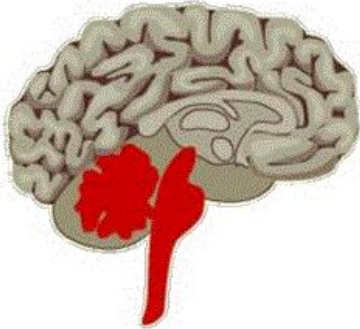
Paul D. MacLean
May 1, 1913 – December 26, 2007
American physician and neuroscientist

Your Three Brains



Triune Brain Theory

Lizard Brain	Mammal Brain	Human Brain
Brain stem & cerebellum	Limbic System	Neocortex
Fight or flight	Emotions, memories, habits	Language, abstract thought, imagination, consciousness
Autopilot	Decisions	Reasons, rationalizes



The Triune Brain



- **Neocortex** - Thought (including planning, language, logic & will, awareness)
- **Limbic System** - Emotion (feelings, relationship/nurturing, images and dreams, play)
- **Reptilian Brain** - Instinct (survival, breathing/swallowing/heartbeat, startle response)

**Three Brains in
One**



Neo-Cortex

“executive brain”
conscious awareness
decision making
working memory

Amygdala
“seat of anxiety”

Hippocampus
“new memories on past experience”

Limbic

“emotional brain”
enabled learning
value judgments
emotional memory

Reptilian

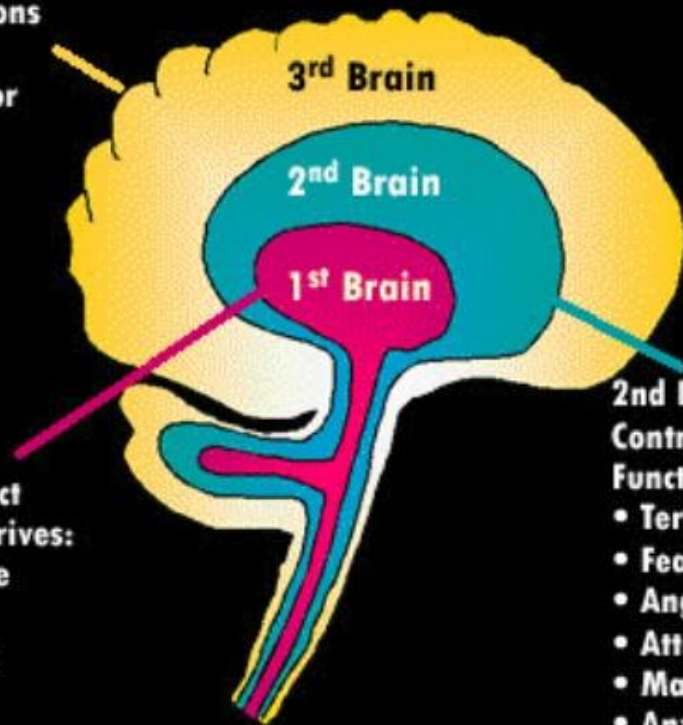
“rudimentary brain”
breathing / heart rate
survival, flight or fight

3rd Brain: High Level

Control: Foresight

Functions and Basic Drives:

- Perception and differentiation of thoughts and emotions
- Discrimination of appropriate behavior
- Self-reflection
- Problem resolution
- Goal satisfaction



1st Brain: Low Level

Control: Reflex/Instinct

Functions and Basic Drives:

- Approach/Avoidance
- Hormonal control
- Temperature control
- Hunger/Thirst
- Reproductive drive
- Respiration and heart rate control

2nd Brain: Mid Level

Control: Hindsight

Functions and Basic Drives:

- Territoriality
- Fear
- Anger
- Attack
- Maternal Love
- Anxiety
- Hate
- Jealousy

PRIMATE "THINKING" BRAIN:

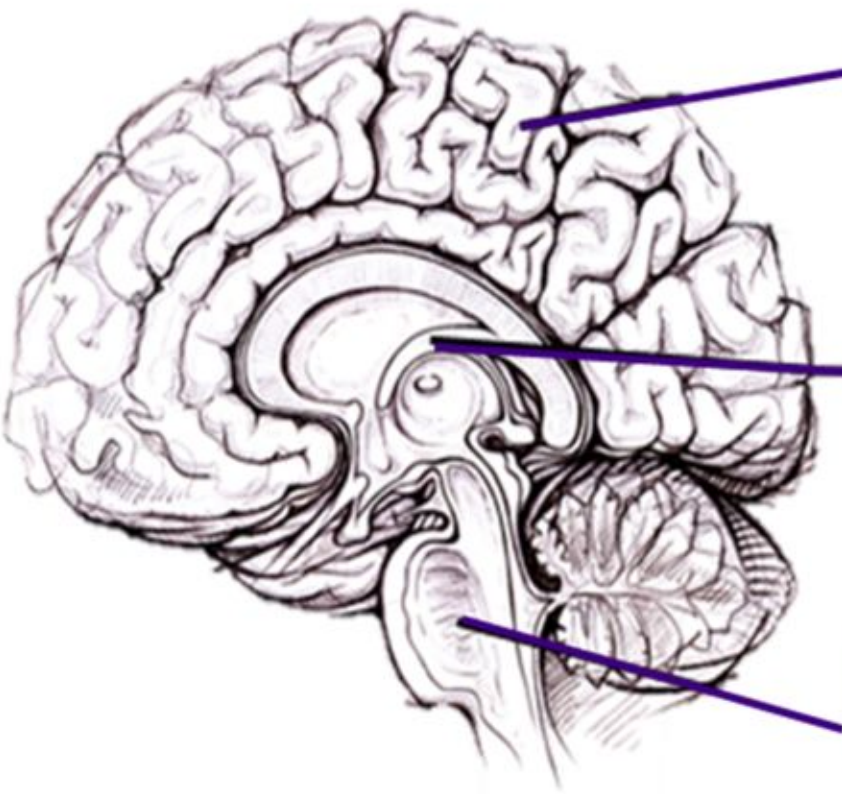
- **Brain region:** Neo cortex
- **Responsible for:** sensory perception, spatial reasoning, generation of motor commands, conscious thought, intellectual memory
- **Happy when:** learning, anticipating future reward, connected to higher purpose, in flow
- **Evolutionary role:** predicting brain that helps the community thrive

MAMMILIAN "FEELING" BRAIN:

- **Brain region:** Limbic system (includes amygdala / fear center & nucleus accumbens / pleasure center.)
- **Responsible for:** (positive) emotions, learning, emotional memory and spirituality
- **Happy when:** feel trust, social bonds, higher status
- **Evolutionary role:** social brain that helps the community survive

REPTILIAN "INSTINCTIVE" BRAIN:

- **Brain region:** brain stem
- **Responsible for:** the 4 F's - fight, flight, feed and fornicate (wired for danger and therefore negative emotions)
- **Happy when:** safe from danger
- **Evolutionary role:** selfish brain that helps us survive individually



The *Triune Brain* model
is a simplification

(especially the evolutionary aspect)

but still a good fit for laymen

Your brain can be in one of
two thinking modes



17 x 24



Nicholas Murray Butler

April 2, 1862 – December 7, 1947

American philosopher, diplomat, and educator.

All the problems of the world could be settled easily if men were only willing to think.

The trouble is that men very often resort to all sorts of devices in order not to think, because thinking is such hard work.

Information Processing in the brain

SYSTEM 1

Intuition & instinct



Unconscious
Fast
Associative
Automatic pilot

SYSTEM 2

Rational thinking



Takes effort
Slow
Logical
Lazy
Indecisive



Source: Daniel Kahneman

DANIEL KAHNEMAN'S SYSTEMS OF THINKING

INSTINCTIVE

QUICK

**SYSTEM 1
THINKING**

LITTLE/NO
EFFORT

EMOTIONAL

NO SENSE
OF VOLUNTARY
CONTROL

AUTOMATIC

COMPLEX
DECISIONS

SLOWER

**SYSTEM 2
THINKING**

CONSCIOUS

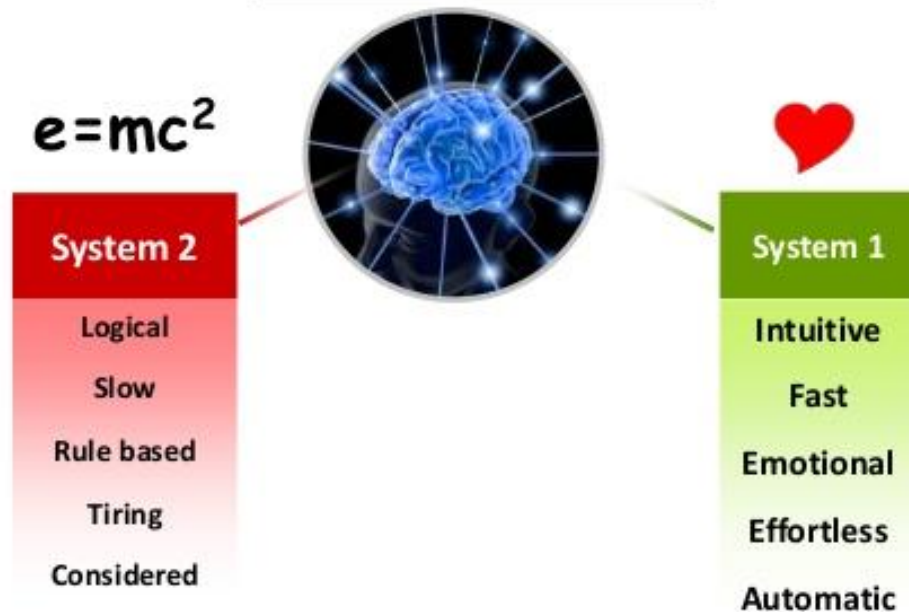
EFFORTFUL

MORE
LOGICAL

MORE
DELIBERATIVE

Myth #1: It's Just Like Left-Brain and Right-Brain

There are huge differences!



If the 2 systems were equal, behaviour change strategies based on triggering System 2 (like giving people more information) would work.

We use two major thinking systems



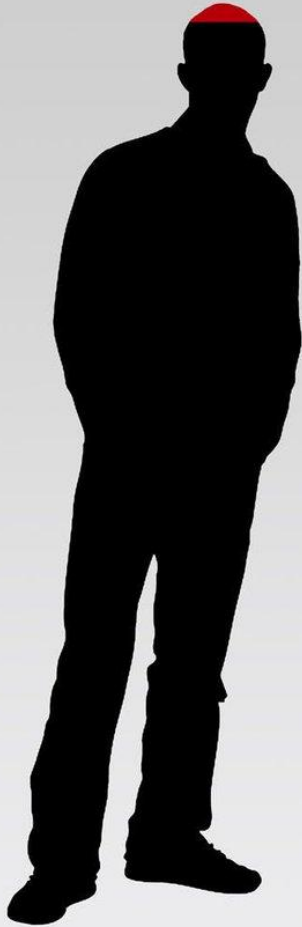
System 1

- conscious
- focused
- precise



System 2

- unconscious
- fast, parallel
- approximate

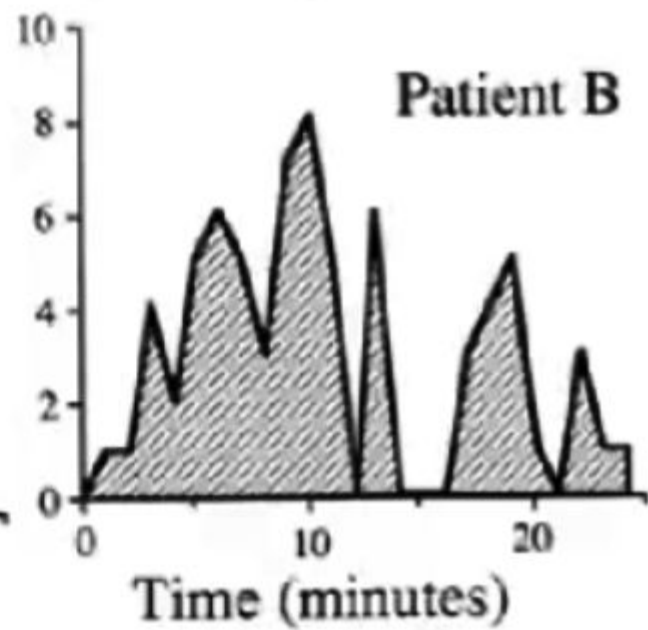
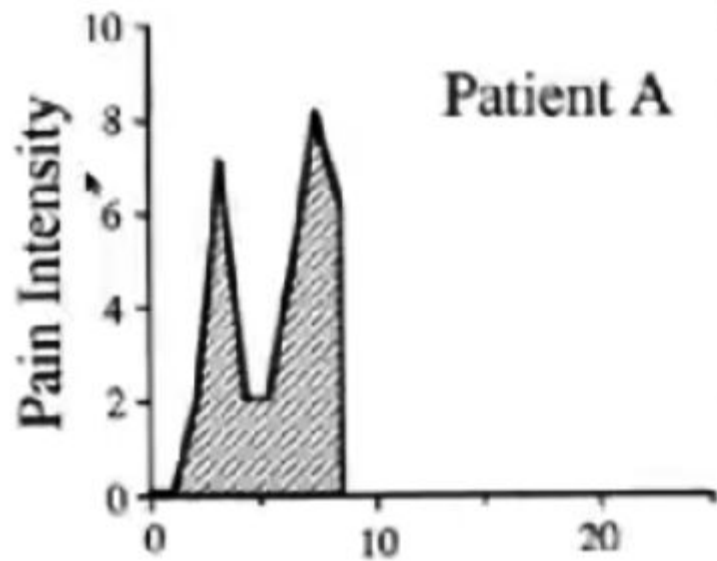


Brain
Size
2%

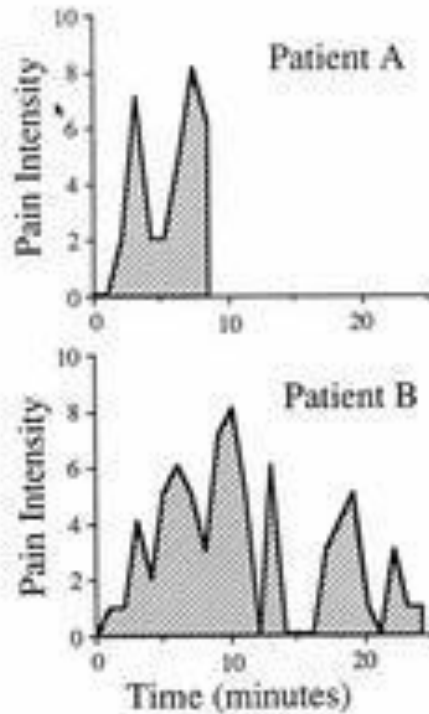
Brain's
Energy
Needs
20%



Memory in the brain



Patients undergoing colonoscopy reported their pain every 60 sec.



How much did these Patients suffer?

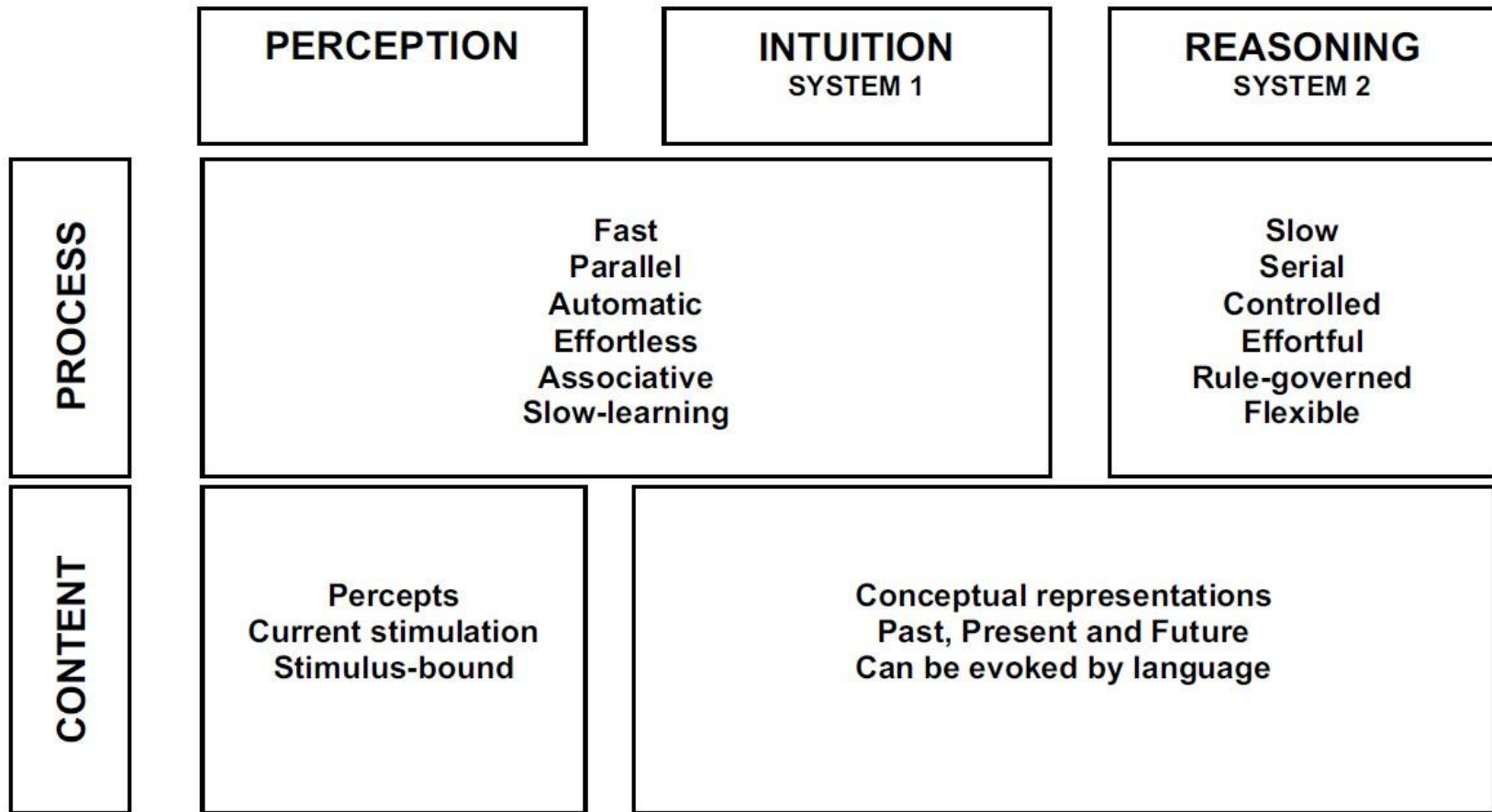


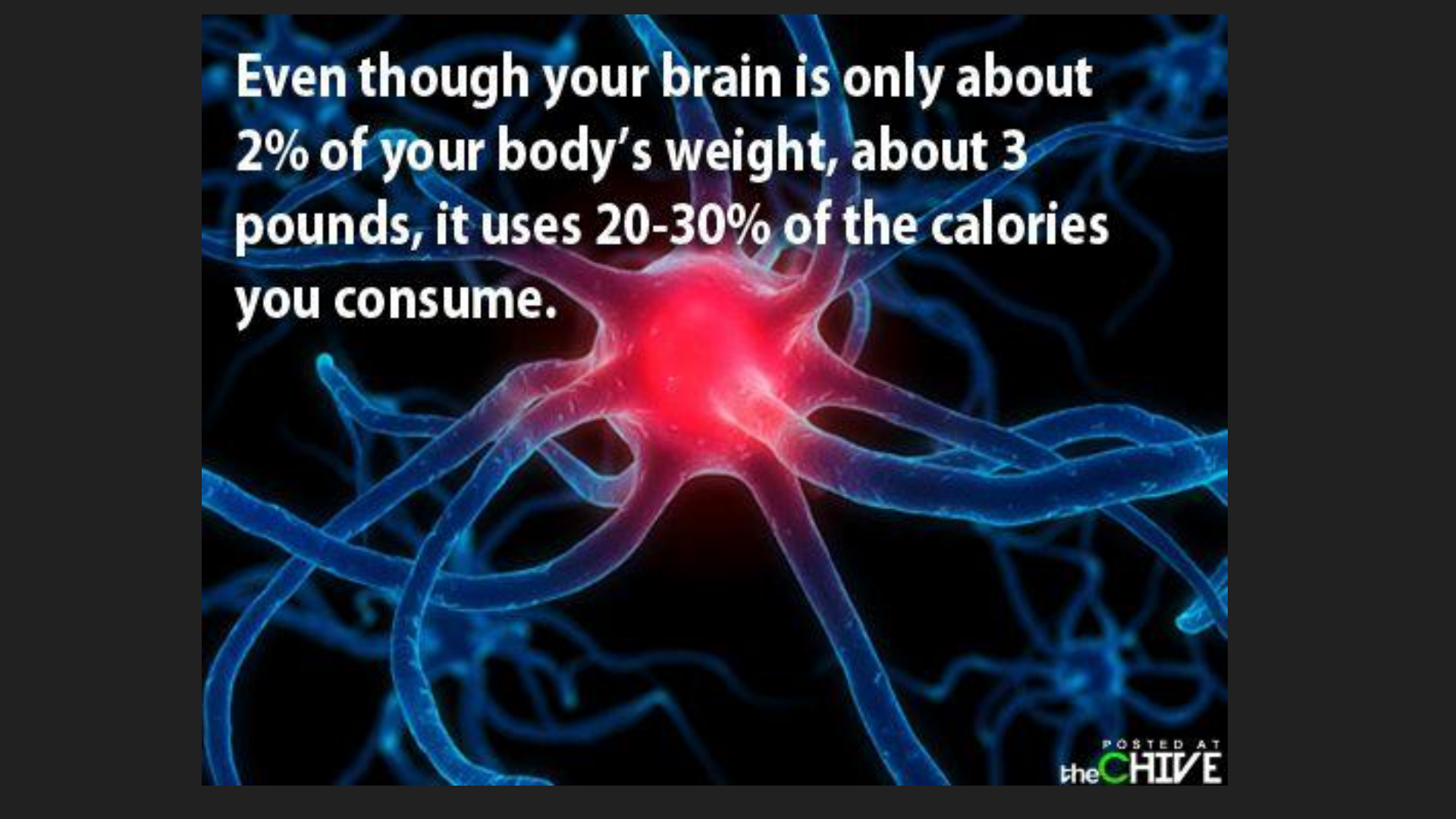
Figure 1.



Alfred North Whitehead
15 February 1861 – 30 December 1947
British mathematician, American philosopher

Civilization advances by extending the number of important operations which we can perform without thinking about them.

Operations of thought are [...] strictly limited in number, [...] and must only be made at decisive moments.

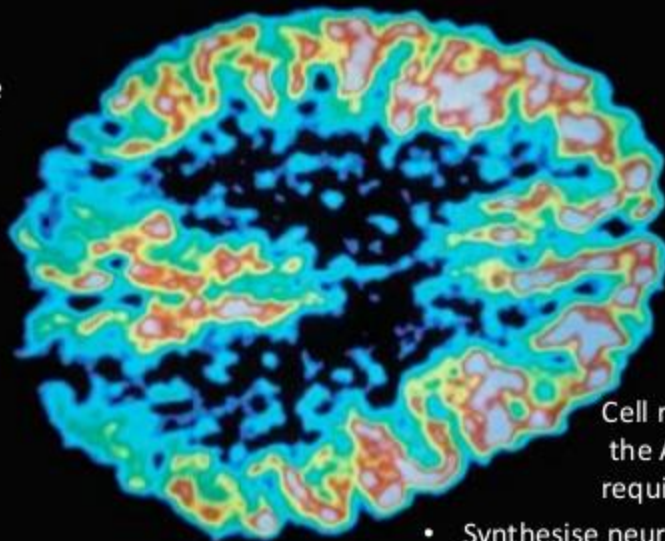
A central neuron is highlighted in a bright red glow, with its cell body and nucleus. Numerous blue, translucent axons and dendrites extend from the neuron, creating a complex, web-like structure against a dark background. The overall appearance is that of a microscopic view of neural tissue.

Even though your brain is only about 2% of your body's weight, about 3 pounds, it uses 20-30% of the calories you consume.

Metabolism of the brain

The energy demands of the brain are high: they account for at least 20% of a human adult's energy consumption.


Studies indicate have linked higher cognitive functions to increased glucose demand.



Cell respiration produces the ATP that is constantly required by neurons to:

- Synthesise neurotransmitters
- carry out the active transport needed to maintain resting potential.

Digital Dementia?

A man in a black tuxedo and white shirt with a black bow tie is sitting on a beach. He is leaning forward, looking towards the camera. He is holding a dark surfboard under his left arm. The background is a vast, sandy beach with gentle waves in the distance. The lighting is bright, suggesting a sunny day. A semi-transparent white box with a drop shadow is overlaid on the image, containing text.

AND NOW FOR SOMETHING COMPLETELY DIFFERENT

(Intentionally unexpected intermission in the narrative arc)

#WUD2018

#WUD2018

UX Design for
Good or Evil?

The three archetypes of *evil* system design: The Good, the Bad & the Ugly

The Ugly

“Just implemented the
Hawaii missile alert”



Just ignorant why critical
systems need careful design

The Bad

“UX design exists
to make more profit”



Intentionally creates dark
patterns for selfish gains

The Good

“I’m a shiny knight
(that is ignorant)”



Tries very hard to do good,
but ends up serving evil

#WUD2014

#WUD2014

Engaged for
Engagement

Engaging design
is actually
addictive design

Facebook Use Predicts Declines in Subjective Well-Being in Young Adults

Ethan Kross^{1*}, Philippe Verduyn², Emre Demiralp¹, Jiyoung Park¹, David Seungjae Lee¹, Natalie Lin¹, Holly Shablack¹, John Jonides¹, Oscar Ybarra¹

¹ Psychology Department, University of Michigan, Ann Arbor, Michigan, United States of America, ² Psychology Department, University of Leuven, Leuven, Belgium

Abstract

Over 500 million people interact daily with Facebook. Yet, whether Facebook use influences subjective well-being over time is unknown. We addressed this issue using experience-sampling, the most reliable method for measuring in-vivo behavior and psychological experience. We text-messaged people five times per day for two-weeks to examine how Facebook use influences the two components of subjective well-being: how people feel moment-to-moment and how satisfied they are with their lives. Our results indicate that Facebook use predicts negative shifts on both of these variables over time. The more people used Facebook at one time point, the worse they felt the next time we text-messaged them; the more they used Facebook over two-weeks, the more their life satisfaction levels declined over time. Interacting with other people "directly" did not predict these negative outcomes. They were also not moderated by the size of people's Facebook networks, their perceived supportiveness, motivation for using Facebook, gender, loneliness, self-esteem, or depression. On the surface, Facebook provides an invaluable resource for fulfilling the basic human need for social connection. Rather than enhancing well-being, however, these findings suggest that Facebook may undermine it.

Citation: Kross E, Verduyn P, Demiralp E, Park J, Lee DS, et al. (2013) Facebook Use Predicts Declines in Subjective Well-Being in Young Adults. PLoS ONE 8(8): e69841. doi:10.1371/journal.pone.0069841

Editor: Cédric Sueur, Institut Pluridisciplinaire Hubert Curien, France

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Funding: The authors have no support or funding to report.

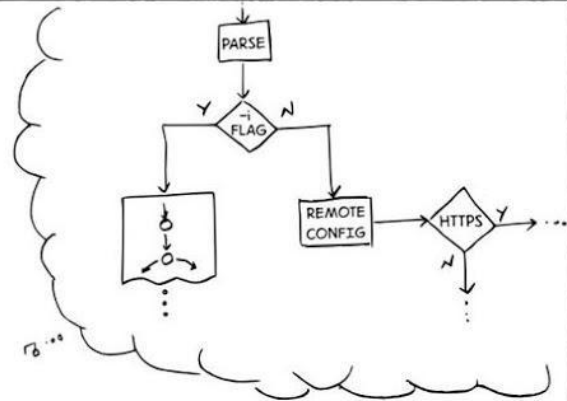
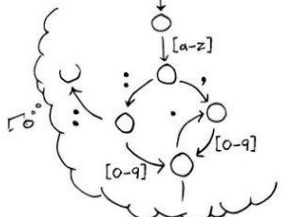
Competing Interests: The authors have declared that no competing interests exist.

* E-mail: ekross@umich.edu

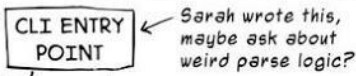
```
if c == ',' :
    backtrack = 1
```

if c == ',' :
backtrack = 1

...so if the current character is a comma, we set the backtracking flag...



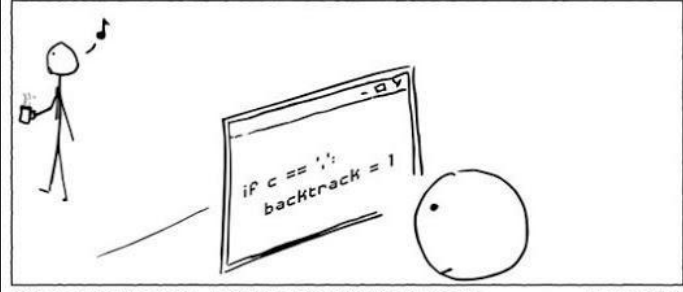
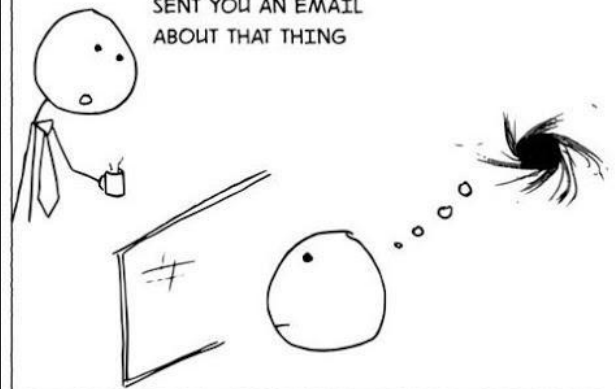
commit #5763 to here
caused bug here
expose it?



Sarah wrote this, maybe ask about weird parse logic?

no access to source - are we just re-calculating its state later?

HEY, SO I JUST SENT YOU AN EMAIL ABOUT THAT THING



Do you remember phone numbers of your immediate family members?



Yes I do **66%**

No I don't **34%**

What would you do if you don't remember something

I whip out my smartphone right away

60%



I try to think hard

40%

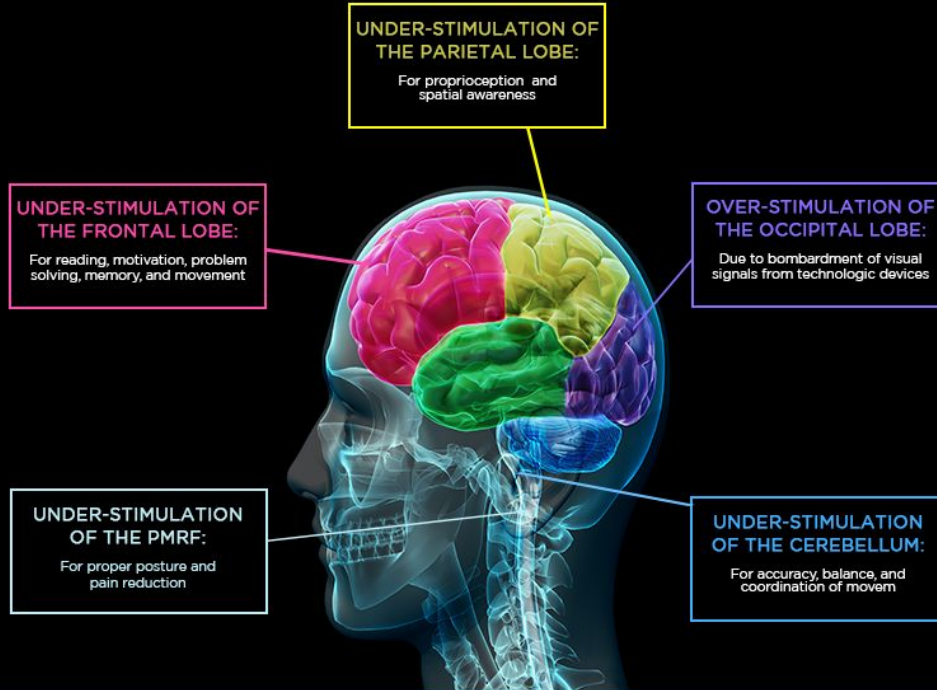




Digital dementia refers to the decline in cognitive function due to excessive use of digital devices, such as smartphones.

DIGITAL DEMENTIA

A sensory mismatch in the brain from over utilization of technology and excessive slouched sitting postures, leading to signs and symptoms of dementia.



Neuroplasticity

The ability of the brain to rewire and rebuild itself to form new neural networks and reinforce familiar neural connections.

Why should you care about your

BDNF

?

Brain Derived Neurotrophic Growth Factor is a key neurochemical responsible for the growth and maintenance of neural connections.

- BDNF helps your brain adapt & learn
- Improves all forms of plasticity

YOU control your BDNF levels

Nutrition

Sugar reduces BDNF Levels while Fasting, Ketosis and Omega-3 fatty acids improve BDNF levels.

Sleep

Poor Sleep reduces BDNF Levels.

Exercise

Movement and exercise at any age improves BDNF levels.

Chronic Stress

Imbalances in cortisol and adrenaline lower BDNF levels.



The alternative?



WITH GREAT POWER COMES
GREAT RESPONSIBILITY

*There's a race
to the bottom to
capture our
attention*



Tristan Harris

former Design Ethicist at Google,
co-founder of [Center for Humane Technology](#)

Take-Home Messages

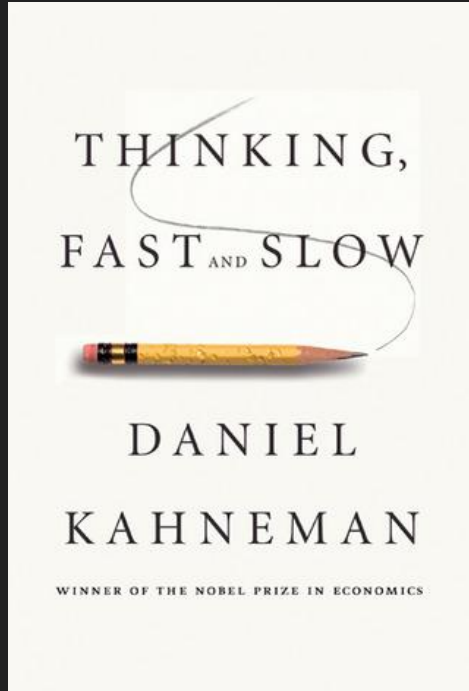
- A brain doesn't work like a computer
- The brain is constantly building new connections
- In the brain "CPU" === "memory"
- There is a shortcut thinking (System 1) and rational thinking (System 2)
- There is a experiencing self and a remembering self
- The brain hasn't evolutionarily adapted to High-Tech over thousands of years
- Excessive tech use may negatively our psychological and neurological health
- Engaging design is actually addictive design

The question is not whether UX designers impact the world.

The hard question is: *How* change it for the better?

THANK YOU!

Read this



The image is a screenshot of a Thrive Global article. The top navigation bar is teal and contains the Thrive Global logo, social media icons for Twitter and Facebook, and a 'Sign in' link. Below the navigation bar, the article is by Tristan Harris, with a 'Follow' button. His bio reads: 'Co-founder, Center for Humane Technology // Ex-Google Design Ethicist // CEO of Aapture (acquired by Google) // Philosopher // Entrepreneur // Friend // Human.' The article title is 'How Technology is Hijacking Your Mind— from a Magician and Google Design Ethicist'. The estimated reading time is '12 minutes'. A quote from 'Unknown' is: 'It's easier to fool people than to convince them that they've been fooled.' The article text begins with 'I'm an expert on how technology hijacks our psychological vulnerabilities. That's why I spent the last three years as a Design Ethicist at Google caring about how to design things in a way that defends a billion people's minds from getting hijacked.' It continues with 'When using technology, we often focus optimistically on all the things it does for us. But I want to show you where it might do the opposite.' The article ends with the question 'Where does technology exploit our minds' weaknesses?'.

Backup slides

Is the OCEAN (or similar
psychological models)
important

Belbin team roles
(or tasks?)

3 types of evil system
design
(WUD topic 2018)

DANIEL
KAHNEMAN
AT THE LSE

THINKING, FAST
AND SLOW

WE MUST
TRUST OUR
INSTINCTS

DON'T LIKE THE
TERM IRRATIONAL



Wellbeing

SYSTEM 1

FAST

intuition
OPERATES
CONTINUOUSLY

SKILLED
BEHAVIORS



ANSWERS

C.O.M.P.L.E.X

QUESTIONS
ABSURDLY

PROBLEMS ARISE
HERE

SO...

RECOGNIZE
WHEN YOU MIGHT
MAKE MISTAKES AND
CALL UP SYSTEM 2



SYSTEM 2

SLOW

Effortfull
MONITORS
SYSTEM 1
THOUGHTS

HOW TO
MEASURE
WELLBEING?

1 HOW SATISFIED ARE
YOU?

1

2 QUALITY OF YOUR
EMOTIONAL
EXPERIENCE

2

WHAT DO YOU
WANT TO OPTIMIZE?



GOVERNMENTS
MUST ASK THEMSELVES

PEOPLE WHO ACCESS
Emotion
MAKE BETTER DECISIONS



SYSTEM 1 UPDATES
CONTINUOUSLY

Cognitive therapy
can
change
reactions



INTERVIEWS HAVE
NO CORRELATION TO
SUCCESS AT UNIVERSITY

FOR HIGH STAKES
DECISIONS WE
NEED TO

Slow down



Complementary VS Competitive Cognitive Artifacts



Vs



Complementary Cognitive Artifacts

These are artifacts that complement human intelligence in such a way that their use amplifies and improves our ability to perform cognitive tasks *and* once the user has mastered the physical artifact they can use a virtual/mental equivalent to perform the same cognitive task at a similar level of skill, e.g. an abacus.

Competitive Cognitive Artifacts

These are artifacts that amplify and improve our abilities to perform cognitive tasks when we have use of the artifact *but* when we take away the artifact we are no better (and possibly worse) at performing the cognitive task than we were before.