

UTA FRITH, CHRIS FRITH AND ALEX FRITH  
ART BY DANIEL LOCKE

# Two Heads

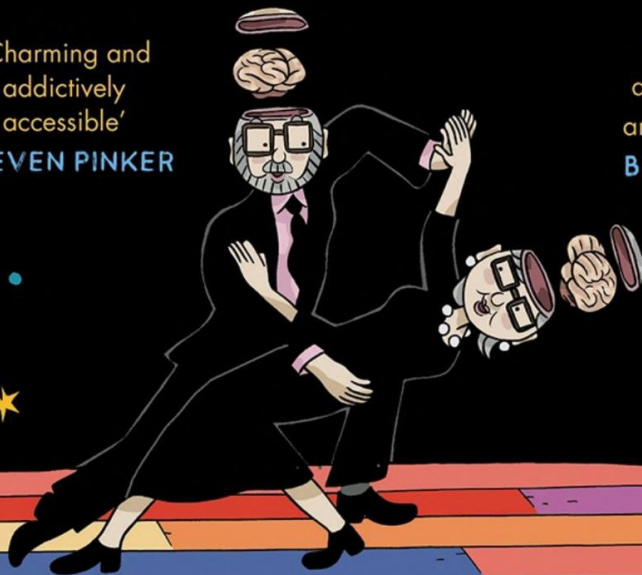
Where Two Neuroscientists  
Explore How Our Brains  
Work With Other Brains

'Charming and  
addictively  
accessible'

STEVEN PINKER

'Original,  
authoritative  
and beautiful'

BRIAN COX



BLOOMSBURY

# Contents

<b>Prologue:</b> In which we meet the Friths.	4
<b>Chapter 1:</b> What your brain is, what it can do, how it works, and all that.	14
<b>Chapter 2:</b> The Friths: who they are, and how they came to be.	32
<b>Chapter 3:</b> How brains know what they know.	46
<b>Chapter 4:</b> Teaching is a tool, copying is an instinct.	70
<b>Chapter 5:</b> Explaining empathy: the latest chapter in the history of neuroscience.	94
<b>Chapter 6:</b> How the brain knows about itself.	119
<b>Interlude:</b> Doing science properly is DIFFICULT.	140

<b>Chapter 7: Think, and think again.</b>	<b>158</b>
<b>Chapter 8: Watching brains at work.</b>	<b>176</b>
<b>Chapter 9: Two heads really are better than one.</b>	<b>194</b>
<b>Chapter 10: When cooperation breeds confusion.</b>	<b>220</b>
<b>Chapter 11: Free will and regret.</b>	<b>238</b>
<b>Chapter 12: In-groups and out-groups.</b>	<b>260</b>
<b>Chapter 13: Reputation matters.</b>	<b>284</b>
<b>Epilogue:</b> <b>In which the Friths host a party.</b>	<b>310</b>
<b>Acknowledgments</b>	<b>319</b>
<b>References</b>	<b>321</b>
<b>Index</b>	<b>337</b>



PSSST!

HEY YOU!

DO YOU WANT  
TO KNOW A  
SECRET?

HERE IT IS: NO ONE  
UNDERSTANDS HOW THE  
BRAIN WORKS.

ALEX FRITH,  
AUTHOR

OH, SURE, PEOPLE HAVE  
WRITTEN MANY BOOKS  
ABOUT THE TOPIC, BUT THEY  
DON'T REALLY KNOW.



I DON'T KNOW EITHER, I'M NOT EVEN A  
NEUROSCIENTIST, BUT I HAVE SPENT MY LIFE  
AROUND TWO VERY GOOD ONES.



LOOK, HERE'S  
ME, PICKING UP  
METAPHORICAL CRUMBS  
OF KNOWLEDGE.

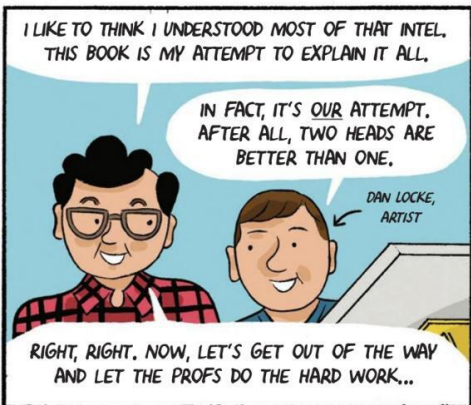
CRUMBS GATHERED  
FROM THE DINNER  
TABLE I GREW UP  
EATING AT.



THESE ARE MY PARENTS, PROFESSORS UTA AND  
CHRIS FRITH, THEY ARE NEUROSCIENTISTS, HAVE  
BEEN FOREVER! (AS FAR AS I'M CONCERNED.)

EVEN AS A BABY, I  
PICKED UP BITS ABOUT THE  
LATEST DEVELOPMENTS IN  
NEUROSCIENCE.\*

\*YES, SOME GOSSIP ABOUT PEOPLE, TOO - BUT HONESTLY, MUCH  
OF THEIR CONVERSATION REALLY WAS ABOUT THE SCIENCE.



I LIKE TO THINK I UNDERSTOOD MOST OF THAT INTEL.  
THIS BOOK IS MY ATTEMPT TO EXPLAIN IT ALL.

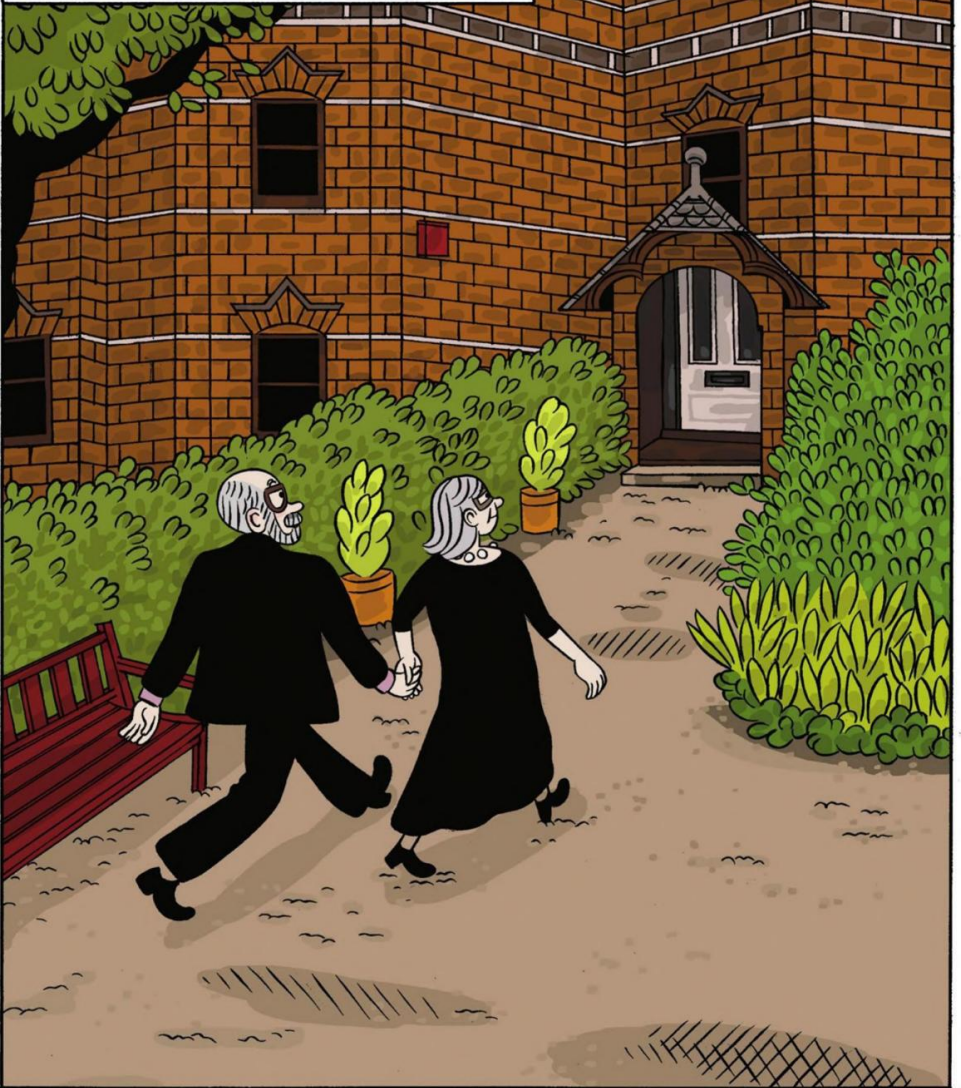
IN FACT, IT'S OUR ATTEMPT.  
AFTER ALL, TWO HEADS ARE  
BETTER THAN ONE.

DAN LOCKE,  
ARTIST

RIGHT, RIGHT. NOW, LET'S GET OUT OF THE WAY  
AND LET THE PROFS DO THE HARD WORK...



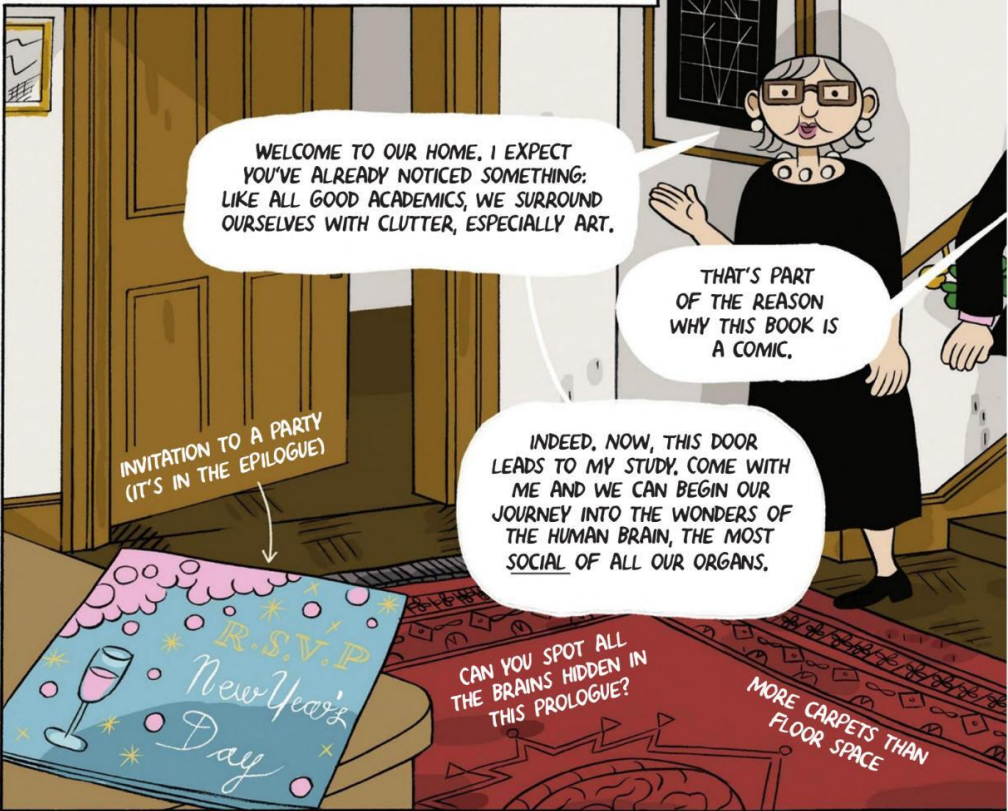
LOOK, HERE THEY ARE NOW. LET'S FOLLOW THEM INTO THEIR HOME, IN NORTH WEST LONDON, WHERE THEY'VE LIVED FOR MORE THAN 30 YEARS.





UTA FRITH,  
NÉE AURNHAMMER  
(1941 - ?)

CHRIS FRITH,  
(1942 - ?)



WELCOME TO OUR HOME. I EXPECT YOU'VE ALREADY NOTICED SOMETHING: LIKE ALL GOOD ACADEMICS, WE SURROUND OURSELVES WITH CLUTTER, ESPECIALLY ART.

THAT'S PART OF THE REASON WHY THIS BOOK IS A COMIC.

INDEED, NOW, THIS DOOR LEADS TO MY STUDY, COME WITH ME AND WE CAN BEGIN OUR JOURNEY INTO THE WONDERS OF THE HUMAN BRAIN, THE MOST SOCIAL OF ALL OUR ORGANS.

CAN YOU SPOT ALL THE BRAINS HIDDEN IN THIS PROLOGUE?

MORE CARPETS THAN FLOOR SPACE

INVITATION TO A PARTY  
(IT'S IN THE EPILOGUE)







WALLS COVERED WITH ART...

...MOSTLY ABSTRACT

HIGH-END CHRISTMAS DECORATIONS

BUT FIRST, A QUICK VISIT TO MY STUDY, UP THESE STAIRS...

ROBEY SPINKS! BOYTEL BROWMAN CAN

LADDER TO REACH BOOKS

TOWERING BOOKSHELVES LOOM JUST OUT OF SIGHT...

PROFESSOR FRITH'S\* STUDY



I'VE BEEN A RESEARCH PSYCHOLOGIST SINCE THE 1960S, FOR MANY YEARS I STUDIED SCHIZOPHRENIA, BEFORE TURNING MY ATTENTION TO BRAIN SCANNING.



PROFESSOR FRITH'S\* STUDY



\*MAKE A GENDER-BASED NAME DISTINCTION AT YOUR PERIL!

SHELVES FILLED WITH ART HISTORY BOOKS

COLLECTION OF ASSORTED ARTIFACTS AND PLATES

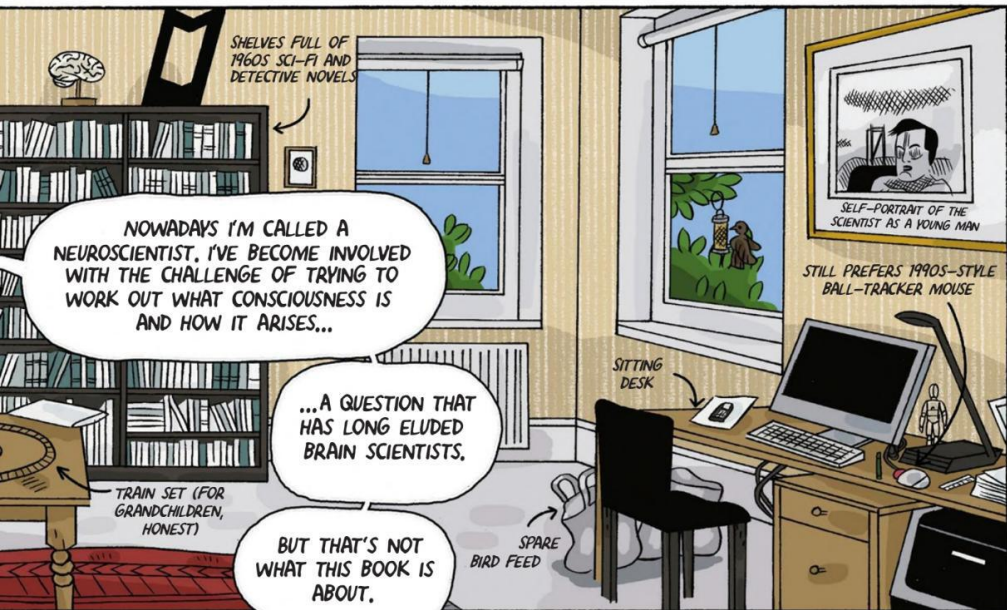
SINCE I BECAME A RESEARCH PSYCHOLOGIST IN THE 1960S, I'VE SPENT A LOT OF TIME STUDYING AUTISM...

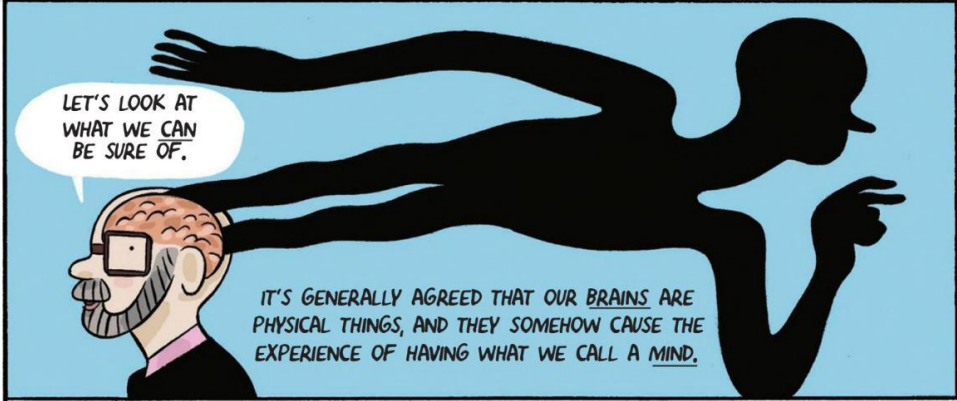
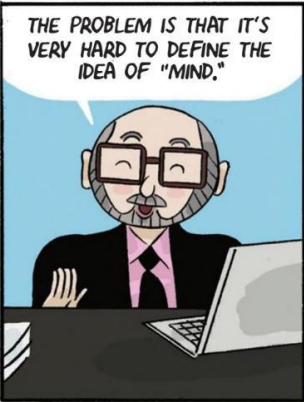
...A CONDITION PRACTICALLY DEFINED BY THE FACT THAT IT HINDERS PEOPLE'S ABILITY TO RELATE TO AND COMMUNICATE WITH OTHERS.

LATELY, I'VE BEEN COMING AT THE QUESTION OF HUMAN INTERACTIONS FROM ANOTHER ANGLE, BY WORKING WITH TEAMS OF PEOPLE TO STUDY HOW WE COOPERATE WITH EACH OTHER.

THE ROLE THAT COGNITIVE PROCESSES PLAY IN SOCIAL INTERACTIONS.





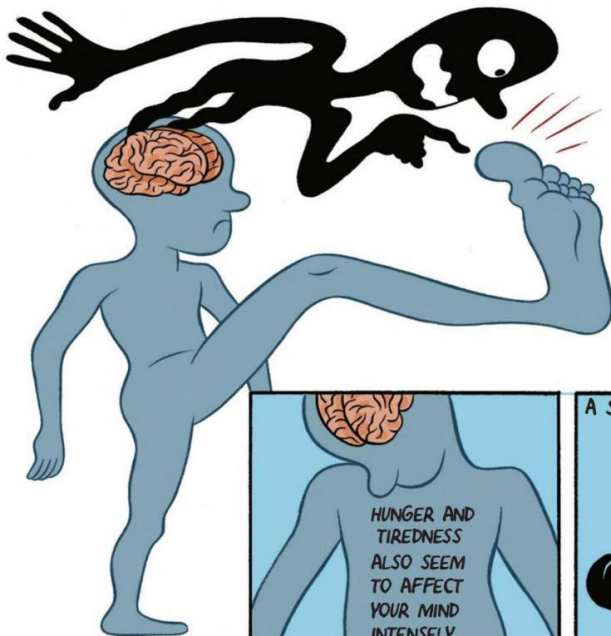




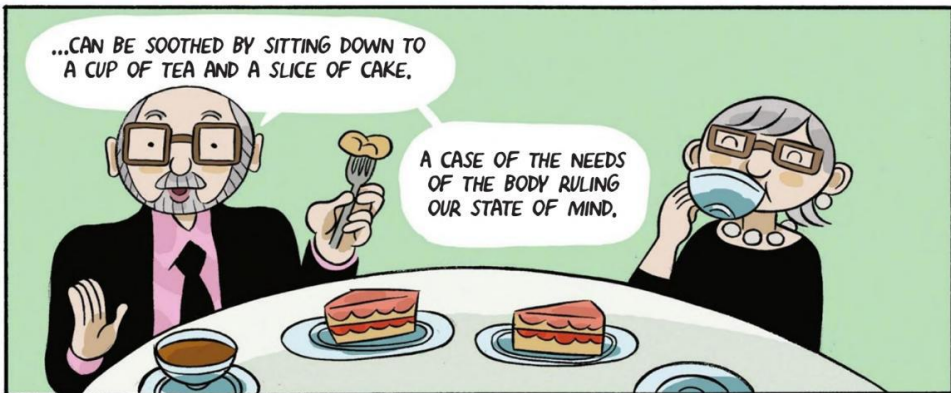
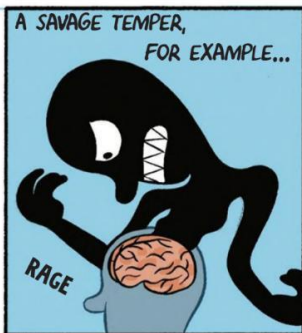
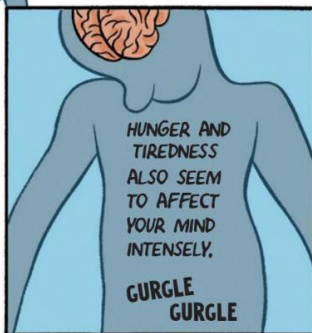
MORE THAN THAT, THE MIND IS AFFECTED BY THE WHOLE BODY, NOT JUST THE BRAIN.

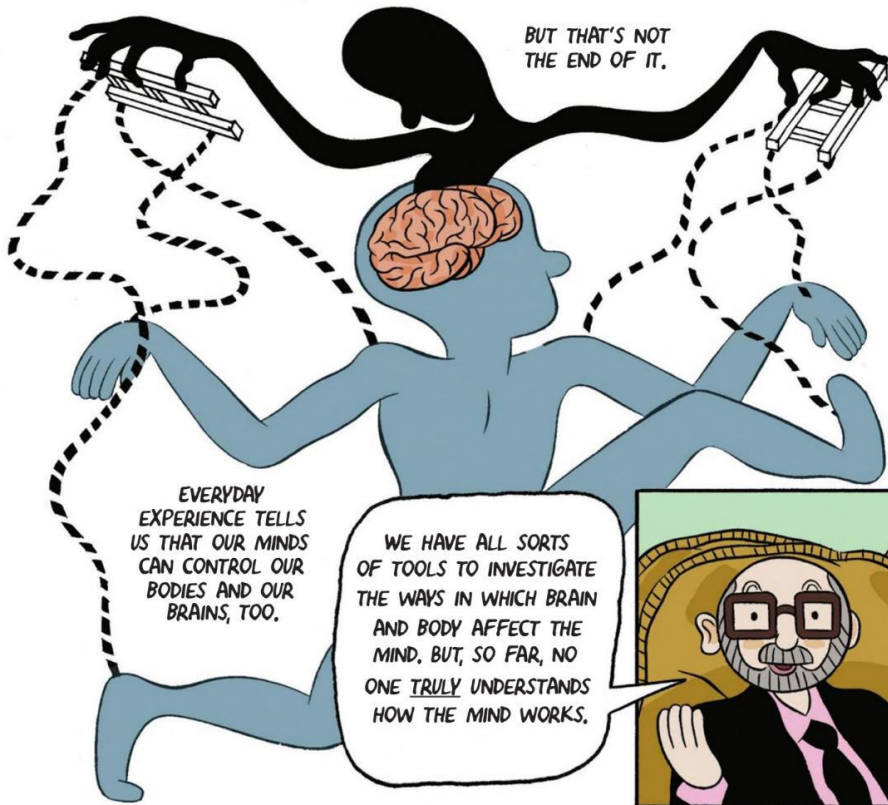
FOR INSTANCE, IMAGINE YOU'VE JUST STUBBED A TOE.

1) YOUR BRAIN SIMPLY REGISTERS PAIN, BUT CARRIES ON WITH ITS OTHER BUSINESSES.



2) YOUR MIND IS, FOR A MOMENT, ABSOLUTELY OVERWHELMED BY THE SENSATION, AND YOU FEEL YOU CAN BARELY FUNCTION.

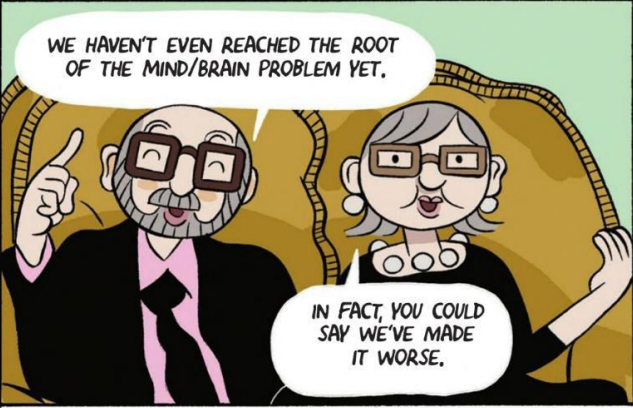




BUT THAT'S NOT THE END OF IT.

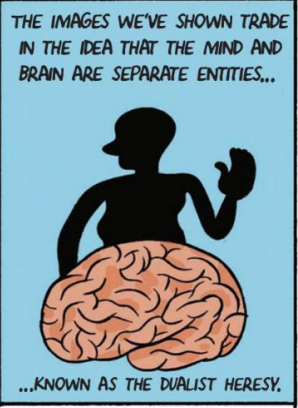
EVERYDAY EXPERIENCE TELLS US THAT OUR MINDS CAN CONTROL OUR BODIES AND OUR BRAINS, TOO.

WE HAVE ALL SORTS OF TOOLS TO INVESTIGATE THE WAYS IN WHICH BRAIN AND BODY AFFECT THE MIND. BUT, SO FAR, NO ONE TRULY UNDERSTANDS HOW THE MIND WORKS.



WE HAVEN'T EVEN REACHED THE ROOT OF THE MIND/BRAIN PROBLEM YET.

IN FACT, YOU COULD SAY WE'VE MADE IT WORSE.



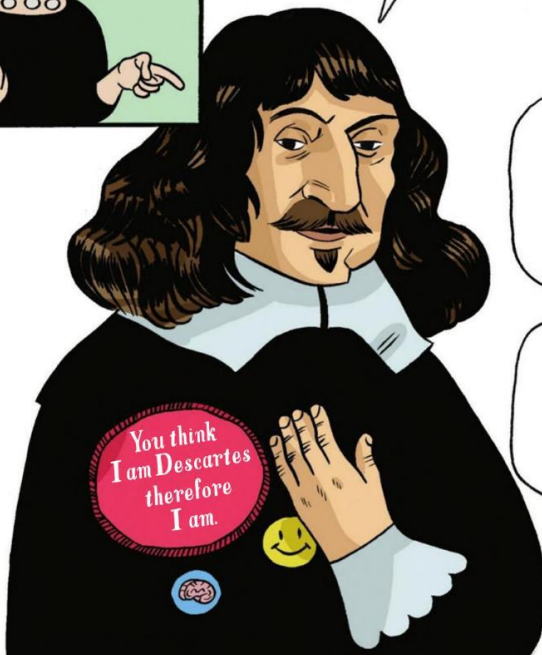
THE IMAGES WE'VE SHOWN TRADE IN THE IDEA THAT THE MIND AND BRAIN ARE SEPARATE ENTITIES...

...KNOWN AS THE DUALIST HERESY.

THIS "HERESY" GOES BACK TO ANTIQUITY, BUT WAS MOST FAMOUSLY ARTICULATED BY RENÉ DESCARTES IN THE 17TH CENTURY.



IT IS CERTAIN THAT I AM REALLY DISTINCT FROM MY BODY, AND CAN EXIST WITHOUT IT.



SCIENCE SAYS HE IS WRONG, WRONG WRONG! IF ANYTHING, HE GOT IT BACKWARDS.\*



ALL AVAILABLE EVIDENCE SAYS THAT THE SENSATION YOU CALL "YOU" - ROUGHLY EQUIVALENT TO YOUR MIND - ABSOLUTELY COULD NOT AND WOULD NOT EXIST WITHOUT YOUR BRAIN.

NOW, BEFORE WE GET INTO OUR STORY ABOUT HOW BRAINS COOPERATE WITH EACH OTHER, WE'RE GOING TO GO OVER SOME BRAIN BASICS NICE AND QUICKLY.

THE THINGS WE DO KNOW, THAT IS, DON'T WORRY, WE'LL KEEP IT SIMPLE...

\*ALTHOUGH I WILL SAY, IN A FOOTNOTE, THAT DESCARTES WASN'T LITERALLY TALKING ABOUT HUMAN PHYSIOLOGY, HE WAS FOCUSED INSTEAD ON A SEMANTIC ARGUMENT ABOUT THINGS IN THEMSELVES,\*



AND I DON'T WANT TO BE TOO HARSH ON OLD RENÉ EITHER - THE DUALIST HERESY COMES NATURALLY TO ALL OF US.

BE WARNED - PLENTY MORE FOOTNOTES TO COME IN THIS BOOK!



# Chapter 1

ONE OF OUR FAVORITE BRAIN ANALOGIES IS CALLED "THE COOK AND THE DINER."

YOUR CONSCIOUS BRAIN IS LIKE A DINER, WHO CAN ONLY EAT THANKS TO A COOK – THE UNCONSCIOUS BRAIN.

YOU NEED THIS COMBINATION TO HAVE A MIND.

What your brain is,  
what it can do,



THIS RELATIONSHIP HAPPENS IN EVERY INDIVIDUAL'S  
BRAIN. (NOT TO MENTION IN SOME HOUSEHOLDS.)

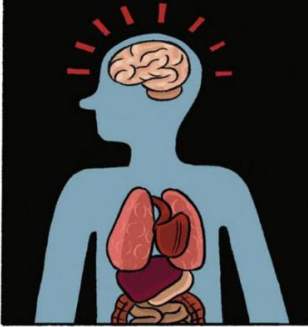
YOU MIGHT THINK  
WE'RE SAYING THAT THE  
DINER IS IN CHARGE...



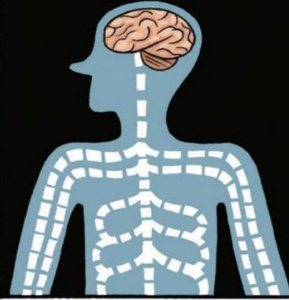
...BUT THAT'S NOT THE CASE. AS WE'LL SEE, EACH  
PART OF YOUR BRAIN IS MADE OF THE SAME STUFF,  
AND IT ALL WORKS IN THE SAME WAY.

how it works,  
and all that.

LESSON 1:  
WHAT THE BRAIN DOES



THE BRAIN IS THE  
CONTROL HUB OF THE  
BODY'S NERVOUS SYSTEM.



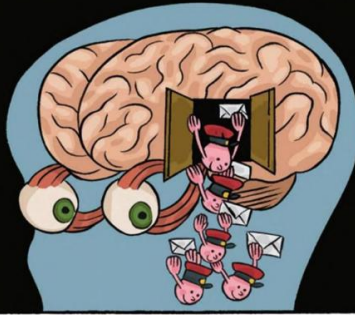
IT SENDS AND  
RECEIVES SIGNALS  
FROM ALL OVER  
THE BODY.



THE VAST MAJORITY OF THESE  
SIGNALS ARE CONTAINED IN  
CHEMICAL MESSENGERS KNOWN  
AS NEUROTRANSMITTERS.



ON A BASIC LEVEL, MUCH OF YOUR BRAIN'S JOB IS TO CREATE  
AND MOVE AROUND THESE NEUROTRANSMITTERS.



TO FUNCTION, THE BRAIN  
NEEDS ENORMOUS AMOUNTS  
OF ENERGY...



...WHICH IS SUPPLIED BY A VAST NETWORK OF BLOOD VESSELS.



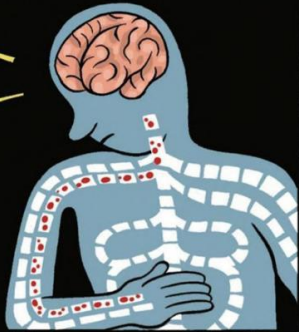
NEARLY ONE-FIFTH OF ALL THE BLOOD IN YOUR BODY  
IS IN YOUR BRAIN AT ANY GIVEN MOMENT.



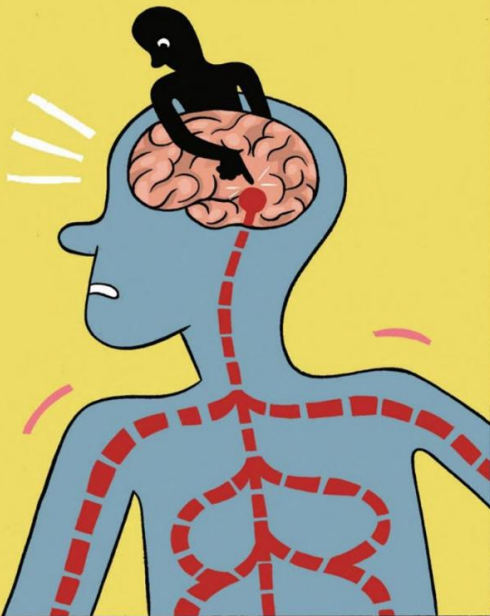


BLOOD ALSO CARRIES HORMONES TO AND FROM THE BRAIN.

HORMONES CONTROL ALL SORTS OF BODILY FUNCTIONS, SUCH AS HUNGER.



HORMONES OFTEN DETERMINE OUR EMOTIONS, TOO. SOMETIMES, THE TRIGGER TO RELEASE THEM SEEMS TO START IN YOUR "MIND." FOR EXAMPLE, WHEN YOU PERCEIVE A PROBLEM...



...YOUR BRAIN STARTS TO RELEASE HORMONES THAT RAISE YOUR STRESS LEVELS.

THIS IS YOUR BRAIN WORKING PROPERLY (UNPLEASANT THOUGH IT CAN BE).

THE QUESTION REMAINS, IS IT YOUR MIND OR YOUR BRAIN THAT CAUSES THE FEELING OF BEING STRESSED OUT? ANSWER: UNKNOWN.



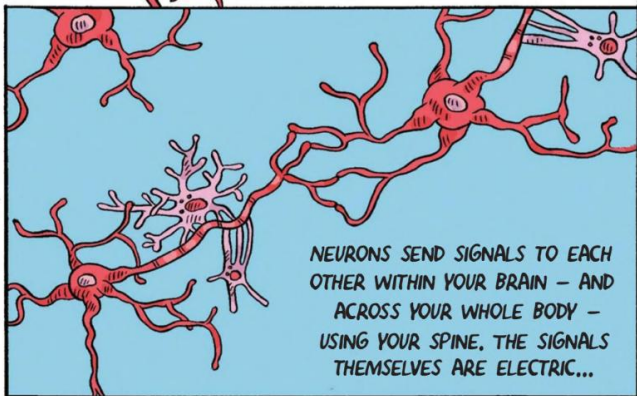
AND INDEED, SOME WOULD SAY THE QUESTION ITSELF IS FAULTY - REMEMBER, OUR BEST GUESS AT THE MOMENT IS THAT THE MIND AND BRAIN ARE NOT SEPARATE ENTITIES!

LESSON 3:  
WHAT THE BRAIN  
IS MADE OF

BY WEIGHT, BRAINS ARE  
MOSTLY FAT AND BLOOD, BUT IF  
YOU ZOOM IN CLOSE ENOUGH WITH A  
MICROSCOPE, YOU'LL MAKE OUT LOTS  
AND LOTS OF KEY ITEMS, NOTABLE  
FOR THEIR HAIRLIKE STRANDS.



THESE ARE BRAIN CELLS, MORE  
PROPERLY CALLED NEURONS.

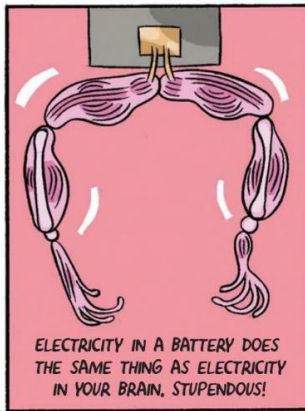
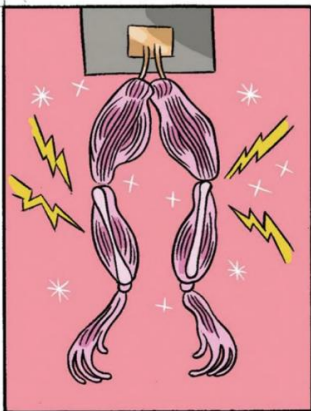


NEURONS SEND SIGNALS TO EACH  
OTHER WITHIN YOUR BRAIN – AND  
ACROSS YOUR WHOLE BODY –  
USING YOUR SPINE, THE SIGNALS  
THEMSELVES ARE ELECTRIC...

...A FACT DISCOVERED BY  
ITALIAN BIOLOGIST LUIGI  
GALVANI TWO CENTURIES AGO.



I PROVED THAT MUSCLES CAN BE  
CONTROLLED USING ELECTRICITY  
AFTER I WIRED UP A DEAD FROG'S  
LEGS TO A BATTERY.\*



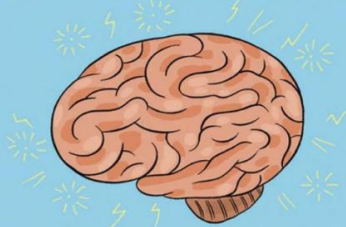
ELECTRICITY IN A BATTERY DOES  
THE SAME THING AS ELECTRICITY  
IN YOUR BRAIN, STUPENDOUS!

\*NO ETHICS COMMITTEES IN THE 18TH CENTURY!

ELECTRICITY IS THE MEDIUM, BUT DON'T FORGET ABOUT NEUROTRANSMITTERS. THEY ARE WHAT TELL ONE NEURON TO STIMULATE THE NEXT NEURON, AND IN WHICH DIRECTION.

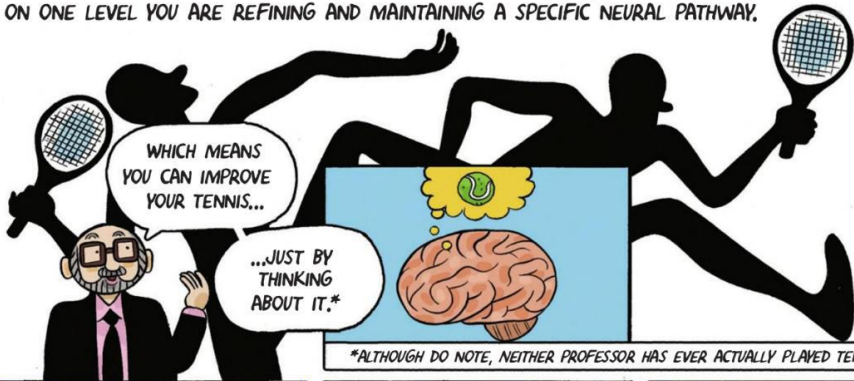


SO FAR, OVER 100 DISTINCT NEUROTRANSMITTERS HAVE BEEN IDENTIFIED, BUT NONE ARE ESPECIALLY WELL UNDERSTOOD.



THE THING TO NOTE IS THAT OUR ABILITY TO THINK IS THE RESULT OF A SET OF SIGNALS SCURRYING BETWEEN NEURONS, FOLLOWING A PARTICULAR PATHWAY ACROSS OUR BRAIN.

THIS IS TRUE OF ALL THOUGHTS. WHEN YOU PRACTICE AN ACTIVITY, SUCH AS TENNIS, ON ONE LEVEL YOU ARE REFINING AND MAINTAINING A SPECIFIC NEURAL PATHWAY.



AS A BABY, YOUR BRAIN CONSTANTLY WIRES UP NEW PATHWAYS AND CONNECTIONS ACROSS THE BRAIN. THESE GET OVERGROWN, SO YOU THEN HAVE TO PRUNE DOWN EXCESS CONNECTIONS.



SOMETHING YOU DO A LOT OF AS AN INFANT...



...AND AGAIN AS AN ADOLESCENT.

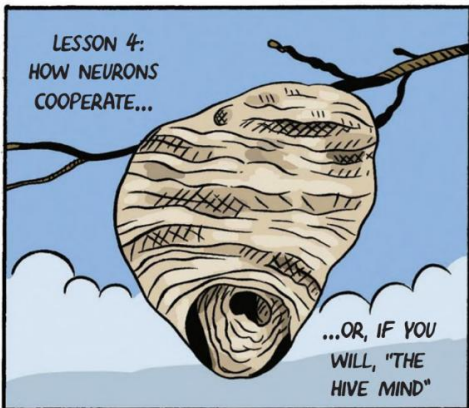
FOR THE REST OF YOUR LIFE, YOU AND YOUR BRAIN ARE CONSTANTLY REFINING THOSE CONNECTIONS - AS WELL AS MAKING NEW ONES.



INDEED, WHEN A BRAIN STOPS MAKING NEW CONNECTIONS, IT'S A SIGN OF DEMENTIA.

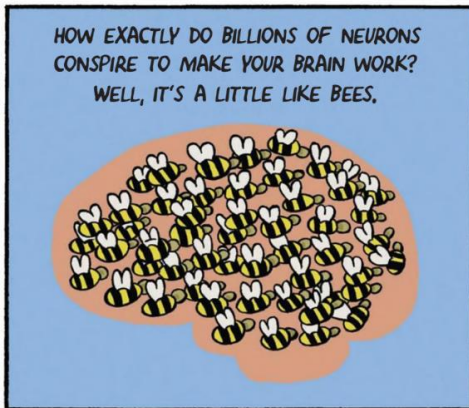


LESSON 4:  
HOW NEURONS  
COOPERATE...



...OR, IF YOU  
WILL, "THE  
HIVE MIND"

HOW EXACTLY DO BILLIONS OF NEURONS  
CONSPIRE TO MAKE YOUR BRAIN WORK?  
WELL, IT'S A LITTLE LIKE BEES.



WHEN A  
COLONY OF  
BEES NEEDS  
A NEW NEST,  
THE HIVE  
SENDS OUT A  
FEW HUNDRED  
SCOUTS.



EACH SCOUT IS LOOKING FOR A GOOD-QUALITY SITE.



THE SCOUTS RETURN TO THE HIVE  
WITH A REPORT TO EACH OTHER  
IN THE FORM OF A WAGGLE-DANCE.



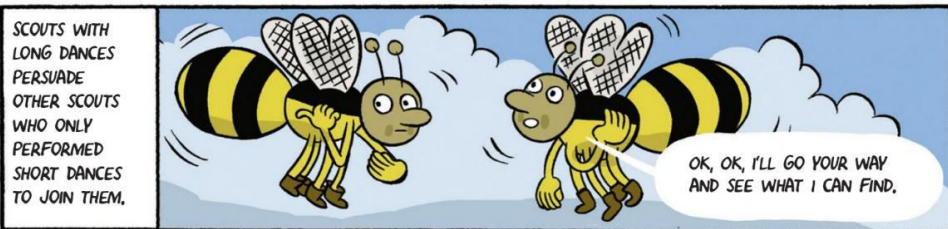
THE PATTERN OF THE DANCE  
SHOWS WHICH DIRECTION TO GO  
TO FIND THE NEW SITE.



I'M TELLING YOU, IT'S REALLY GREAT!



SCOUTS WITH  
LONG DANCES  
PERSUADE  
OTHER SCOUTS  
WHO ONLY  
PERFORMED  
SHORT DANCES  
TO JOIN THEM.



INSTEAD OF DANCING, SOME DISRUPT ANY BEES WHO ARE DANCING TO PROMOTE A DIFFERENT SITE.



HEY! I'M DANCIN' HERE.

OVER TIME, MORE AND MORE SCOUTS ARE PERSUADED TO GO AND SEE A NEW SITE FOR THEMSELVES. WHEN THEY RETURN, THEY'LL JOIN ONE TEAM, AND HELP TO EITHER DANCE OR DISRUPT.



JOIN US!  
JOIN US!

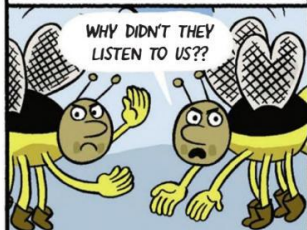
NO, YOU  
JOIN US!

EVENTUALLY, A CRITICAL MASS OF SCOUTS ALL DANCE FOR ONE TEAM. THIS PERSUADES THE ENTIRE HIVE TO FLY TO THEIR CHOSEN SITE TO SET UP THEIR NEW HOME.\*



OK, DONE HERE. LET'S  
MOVE OUT, YOU BEES.

IT'S POSSIBLE THAT THE HIVE IS WRONG, AND THE OTHER SITE WAS A BETTER OPTION.



WHY DIDN'T THEY  
LISTEN TO US??

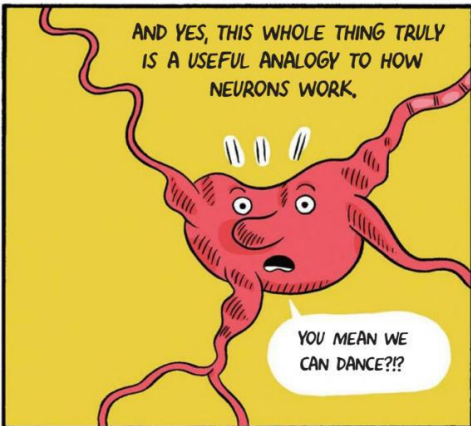
BUT OBSERVERS REPORT THAT  
IT USUALLY IS THE BEST SITE.

IT'S A QUESTION OF PERSUADING ENOUGH BEES TO AGREE, RATHER THAN AIMING TO MAKE THE LITERAL "BEST" DECISION.



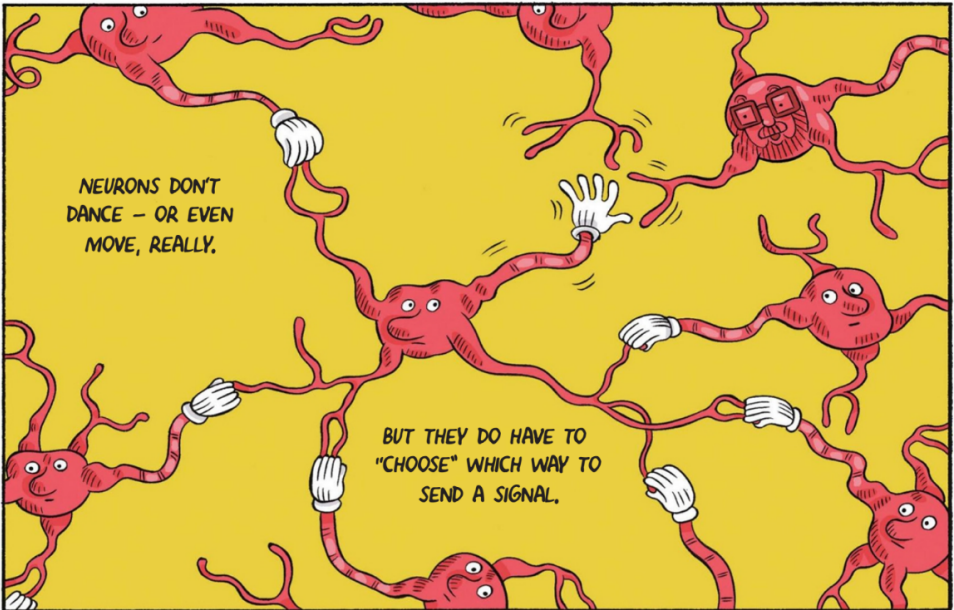
WHAT EVEN IS  
"BEST" WHEN YOU  
THINK ABOUT IT?

AND YES, THIS WHOLE THING TRULY IS A USEFUL ANALOGY TO HOW NEURONS WORK.



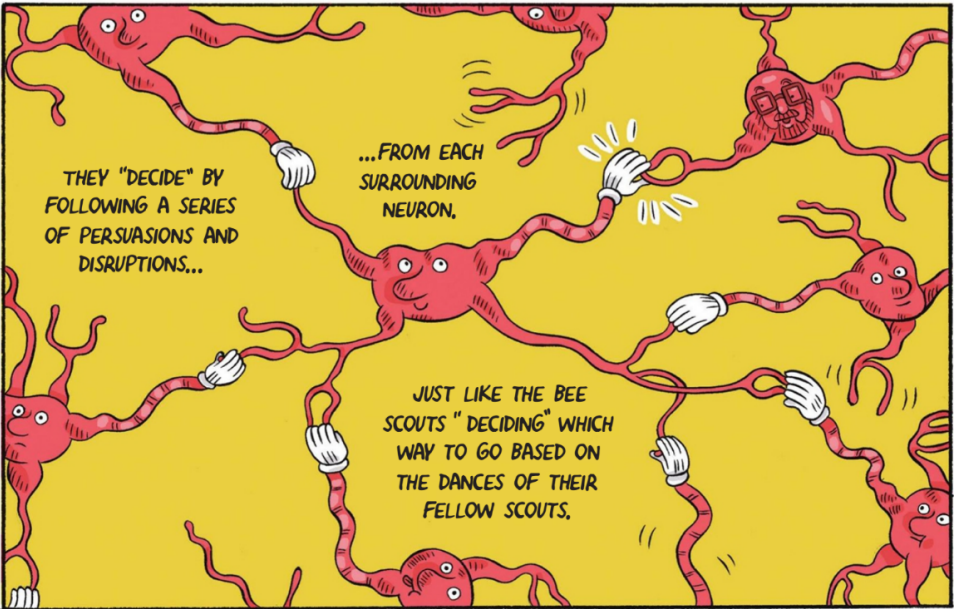
YOU MEAN WE  
CAN DANCE???





NEURONS DON'T  
DANCE - OR EVEN  
MOVE, REALLY.

BUT THEY DO HAVE TO  
"CHOOSE" WHICH WAY TO  
SEND A SIGNAL.



THEY "DECIDE" BY  
FOLLOWING A SERIES  
OF PERSUASIONS AND  
DISRUPTIONS...

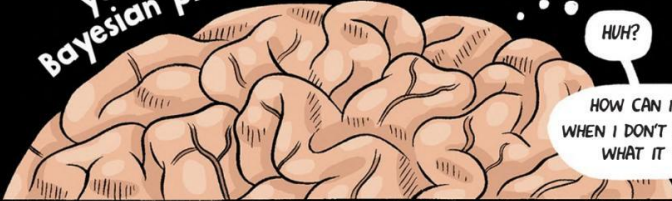
...FROM EACH  
SURROUNDING  
NEURON.

JUST LIKE THE BEE  
SCOUTS "DECIDING" WHICH  
WAY TO GO BASED ON  
THE DANCES OF THEIR  
FELLOW SCOUTS.



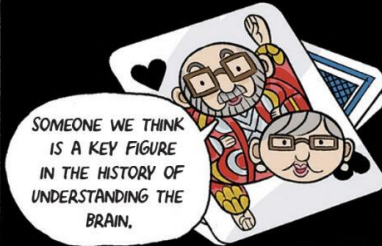
YOUR BRAIN WORKS BY MAKING ASSUMPTIONS ABOUT THE WORLD AND THEN USING YOUR SENSES TO CONFIRM, OR, LESS OFTEN, DENY THOSE ASSUMPTIONS. WHEN FACED WITH AN OPTICAL ILLUSION LIKE THE CIRCLES, THE ASSUMPTIONS YOU MAKE ARE SO STRONG THAT YOUR SENSES AREN'T ENOUGH TO DENY THEM! BUT OVERALL, OUR BEST DESCRIPTION FOR THE WAY IT WORKS IS TO SAY:

your brain is a Bayesian prediction engine.



HUH?  
HOW CAN I BE THAT WHEN I DON'T EVEN KNOW WHAT IT MEANS?

LET US EXPLAIN! "BAYESIAN" AS IN "BASED ON THE WORK OF REVEREND THOMAS BAYES.\*\*



SOMEONE WE THINK IS A KEY FIGURE IN THE HISTORY OF UNDERSTANDING THE BRAIN.

BAYES WAS AN 18TH-CENTURY NONCONFORMIST MINISTER WHO, IN FACT, NEVER GAVE THE BRAIN ITSELF ANY PARTICULAR THOUGHT, HE WAS INTERESTED IN PROBABILITY.



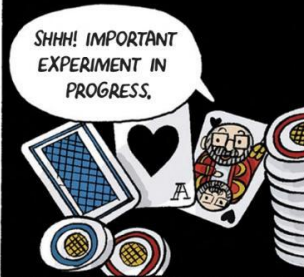
PICK A BALL FROM MY BAG.

\*THERE ARE NO KNOWN PORTRAITS OF BAYES, SO THE LIKELIHOOD THAT ANY OF OUR PICTURES HERE REPRESENT BAYES HIMSELF IS  $P(A/B)$  ETC., ETC. (LITTLE PROBABILITY JOKE FOR YOU THERE.)



HUH, A WHITE BALL. WHAT ARE THE CHANCES OF THAT?

HIS WORK ON PROBABILITY GOT HIM ELECTED AS A "FELLOW" OF THE UK'S ROYAL SOCIETY – MOSTLY, ONE SUSPECTS, BECAUSE MANY FELLOWS WERE KEEN GAMBLERS.



SHHH! IMPORTANT EXPERIMENT IN PROGRESS.

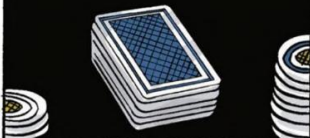
BAYES BEGAN TO BECOME POPULAR AGAIN IN THE 1950S. TODAY HE IS EMBRACED ACROSS THE INTERNET.



WHAT MATTERS IS THAT BAYES IS COOL, AND IF YOU DON'T KNOW BAYES YOU AREN'T COOL.\*

\*WE'RE QUOTING NOTED BAYES ENTHUSIAST ELIEZER S. YUDKOWSKY.

BAYES DEVELOPED A WAY TO MEASURE PROBABILITIES THAT TAKES ACCOUNT OF PEOPLE'S INTUITION AND BELIEFS, AS WELL AS LOOKING AT THE PURE ARITHMETIC OF PROBABILITY.

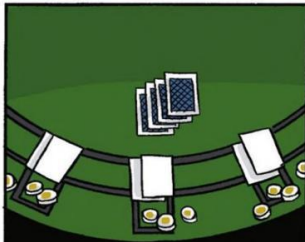


MY CALCULATOR TELLS ME THERE'S A 1 IN 13 CHANCE THIS CARD WILL BE AN ACE.

BUT MY CALCULATOR DOESN'T KNOW THAT THE HAND BELONGS TO JAMES BOND, IN THE PIVOTAL FINAL SCENE OF A MOVIE.



THE BAYESIAN PROBABILITY, TAKING INTO ACCOUNT THIS KEY PIECE OF KNOWLEDGE, IS 1 IN 1.

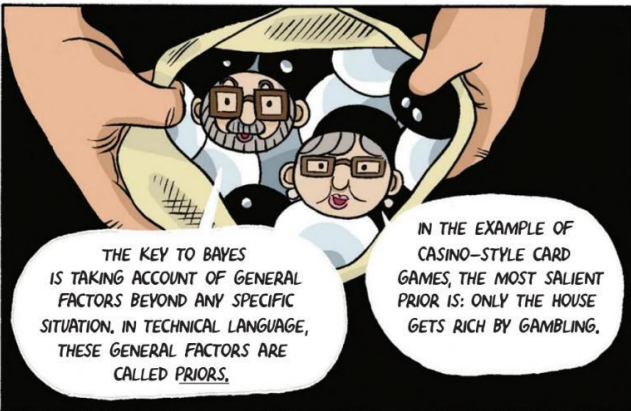


IF YOU'RE PLAYING AN ACTUAL GAME (NOT MERELY ACTING OUT A PLOT POINT), BAYES DOESN'T HELP YOU CALCULATE THE ODDS.



THE AIM OF THE GAME SHOWN HERE IS TO GET CLOSE TO, BUT NOT MORE THAN, 21. MATHEMATICS CAN HELP YOU CALCULATE THE LIKELIHOOD OF DRAWING A GOOD OR BAD CARD.

WHERE BAYES CAN HELP IS BY POINTING OUT THAT, IN GENERAL, YOU WILL LOSE MORE GAMES OF CARDS THAN YOU WILL WIN.



THE KEY TO BAYES IS TAKING ACCOUNT OF GENERAL FACTORS BEYOND ANY SPECIFIC SITUATION. IN TECHNICAL LANGUAGE, THESE GENERAL FACTORS ARE CALLED PRIORS.

IN THE EXAMPLE OF CASINO-STYLE CARD GAMES, THE MOST SALIENT PRIOR IS: ONLY THE HOUSE GETS RICH BY GAMBLING.

ONCE YOU TAKE THIS INTO ACCOUNT, IT IS ARGUABLY NOT WORTH CALCULATING THE ODDS OF ANY GIVEN CARD GAME.



BAYES CREATED A WAY TO BUILD THE IDEA OF PRIORS INTO A MATHEMATICAL FORMULA USED IN A BRANCH OF MATH KNOWN AS BAYESIAN STATISTICS.

YOU DON'T NEED AN 18TH-CENTURY MATHEMATICIAN TO TELL YOU GAMBLING IS A FOOLISH WAY TO MAKE MONEY, BUT THE THING IS, BAYES'S METHOD OF USING PRIORS TO HELP CALCULATE ODDS APPLIES TO EVERYTHING - NOT LEAST THE BRAIN.

WE'VE BEEN BAYESIANS SINCE WE EVOLVED!

WHEN THE VISUAL CORTEX IS PREDICTING WHAT YOUR EYES WILL SEE, IT IS CONSTANTLY REFERRING TO A SET OF BAYESIAN-STYLE PRIORS.

WHAT DID I SEE THE LAST 10,000 TIMES I LOOKED AT THE WORLD?

NEUROSCIENTISTS ARE BEGINNING TO UNDERSTAND HOW THIS WORKS ON A NEURON-BY-NEURON BASIS.



PROFESSOR KARL FRISTON

WHAT NEURONS DO IS: COMPARE THE PREDICTED MODEL OF THE WORLD AROUND YOU TO THE DATA THAT COMES IN, AND ADJUST TO MAKE THE DIFFERENCE BETWEEN THE TWO AS SMALL AS POSSIBLE.



IT TURNS OUT THAT BAYESIAN STATISTICS IS THE BEST WAY TO DO THIS WITH THE LEAST AMOUNT OF EFFORT. AS WE SAID, THE BRAIN IS A BAYESIAN PREDICTION ENGINE.

BAYESIAN THINKING IS REALLY JUST A MATHEMATICAL WAY TO TAKE ACCOUNT OF HOW PEOPLE ACTUALLY BEHAVE.



FOR INSTANCE, YOU'VE PROBABLY GOT TWO PRIOR BELIEFS ABOUT THIS BOOK THAT WILL AFFECT THE WAY YOU READ IT:



1. YOU MIGHT EXPECT TO LEARN SOME ACTUAL SCIENCE.

2. BECAUSE IT'S A COMIC, YOU CAN REASONABLY EXPECT TO CHUCKLE A FEW TIMES.





*image*

*not*

*available*

SOME OF THE THINGS WE FIND ESPECIALLY INTERESTING ABOUT ALL THIS:

NEURONS, INDIVIDUALLY, HAVE NO FREE WILL OR ABILITY TO MAKE CHOICES...

...BUT THE WAY IN WHICH THEY WORK TOGETHER GIVES RISE TO THE PHENOMENON WE CALL THE MIND.

WHAT DOES THAT MEAN FOR US AS INDIVIDUALS? IF THE SMALLEST UNITS OF OUR BRAINS HAVE NO FREE WILL, DOES THAT MEAN OUR BRAINS AND MINDS HAVE NONE EITHER?

DOES THE WAY OUR NEURONS COOPERATE HAVE ANYTHING TO DO WITH THE WAY INDIVIDUAL PEOPLE COOPERATE WITH EACH OTHER?

BUT FOR NOW, WE'RE GOING TO TELL YOU A LITTLE MORE ABOUT OURSELVES, AND HOW WE FELL IN LOVE WITH NEUROSCIENCE.

WE'LL GET INTO THAT SOON ENOUGH.

AND EACH OTHER.

LET'S PAUSE THE BIOGRAPHY FOR A LITTLE MORE SCIENCE.



HOW CAN WE PROVE, PHYSICALLY, THAT THE BRAIN CAN AND DOES CHANGE WITH ITS OWNER'S SITUATION?

HERE'S ELEANOR MAGUIRE, ONE OF CHRIS'S FORMER POSTDOCS,\* TO GIVE A CLEAR-CUT EXAMPLE.



\*POSTDOC: SOMEONE WHO HAS COMPLETED A PHD AND, TYPICALLY, JOINS A RESEARCH TEAM BEFORE STRIKING OUT ON THEIR OWN.

THE SECRET IS TO USE BRAIN SCANNING MACHINES, ONE THING THEY'RE VERY GOOD AT IS MEASURING DIFFERENCES BETWEEN BRAINS.



I ARRANGED FOR A NUMBER OF LONDON TAXI DRIVERS TO COME IN AND BE SCANNED, ALONGSIDE LOTS OF NON-TAXI DRIVERS.



WE DISCOVERED THAT IN MOST TAXI DRIVERS ONE PART OF THE HIPPOCAMPUS WAS ENLARGED, COMPARED TO OTHER PEOPLE...



...TO MAKE SPACE FOR THE SPECIALIZED WORKING MEMORY OF LONDON'S JUMBLED STREETS (CALLED "THE KNOWLEDGE").



(YOU HAVE TWO HIPPOCAMPI, NEAR THE BASE OF THE BRAIN. THEY'RE INVOLVED WITH STORING MEMORY.)

WE ALSO FOUND THAT ANOTHER PART OF THE HIPPOCAMPUS WAS REDUCED IN SIZE, MOST INTERESTING OF ALL, AFTER A DRIVER RETIRED, BOTH REGIONS "SNAPPED BACK" TO TYPICAL SIZES.



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