Neuroscience meets finance and economics.

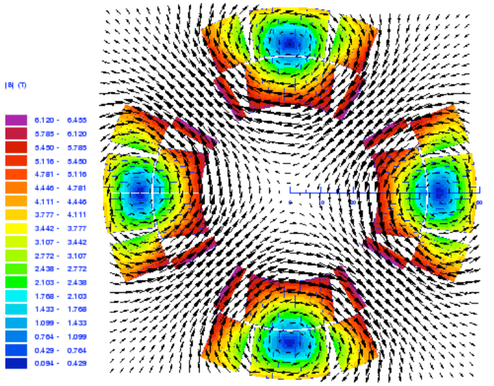
Prof. Dr. Kerstin Preuschoff
Geneva Finance Research Institute, Center for Affective Sciences
Geneva School of Economics and Management, University of Geneva

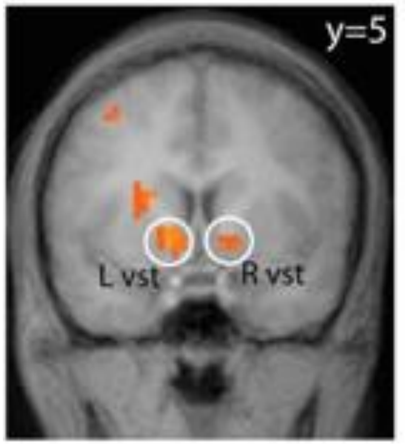
- Dipl.-Ing. Electrical Engineering (TU Berlin)
  “Field Optimization of a Superconducting Quadrupole Corrector Magnet for the LHC Project Using Analytical and Numerical Methods”

- Ph.D. (Caltech)
  Computation and Neural Systems
  “Neural Representations of Expected Reward and Risk During Gambling”

- Postdoc (UZH & EPFL)
  Economics & Computational Neuroscience

- Associate Professor in Neurofinance (UniGe)
  Geneva Finance Research Institute
  & Center for Affective Sciences





Affective Sciences
SWISS NATIONAL CENTER OF COMPETENCE IN RESEARCH

gfri Geneva Finance Research Institute

Psychologist:
“How is the investor’s decision affected by his mental states and emotions?”

Neuroscientist:
“What are the underlying neural circuits and computational mechanisms?”

Economist:
“What is the simplest theory that can explain observed choice?”

Biologist:
“How does this contribute to the evolution and fitness of the organism?”

Financial economist:
“How do individual investments lead to the formation of market prices?”

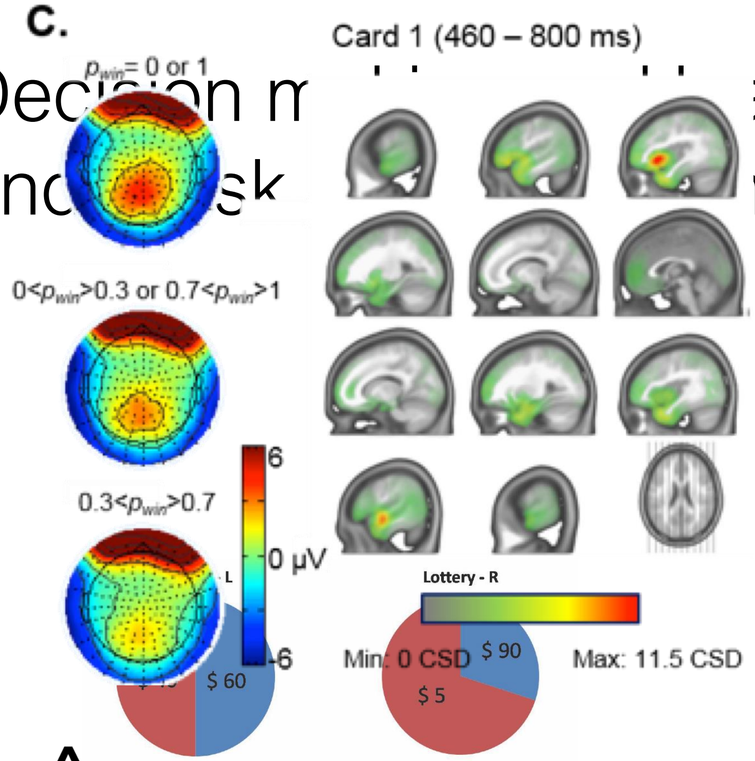
- Goal:

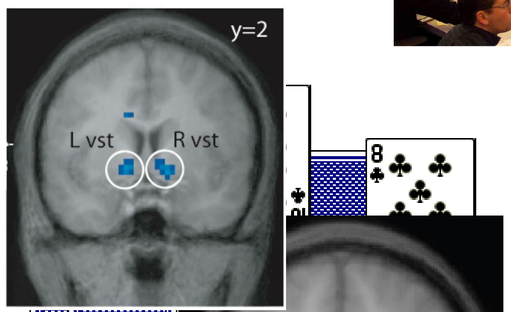
  Understand decision making processes in risky and uncertain situations as well as what happens in our body and brain.

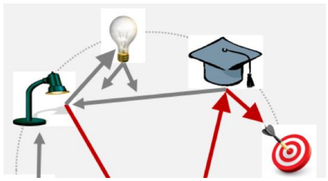
- Approach:

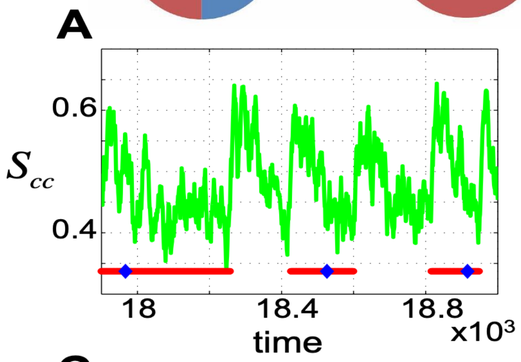
  Study the decision making process using behavioural experiments in lab, neural imaging techniques as well as real life observations

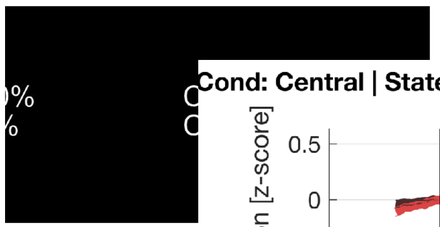
Decision m arning
und sk ity

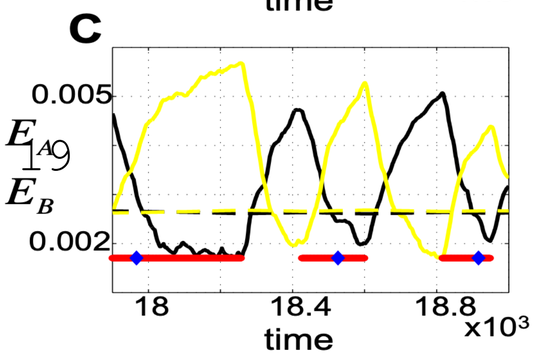


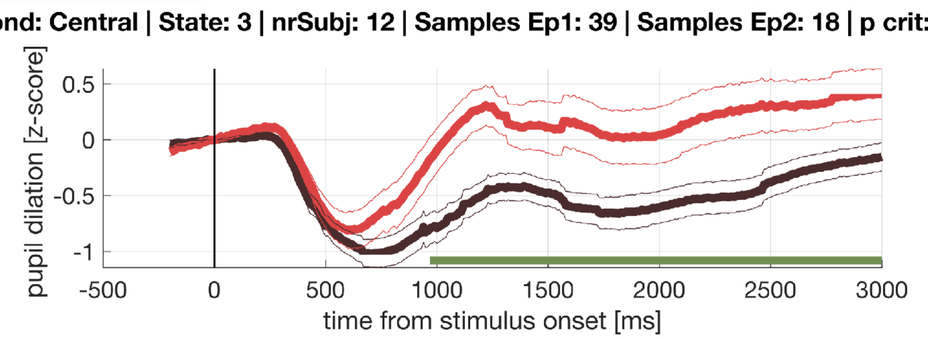




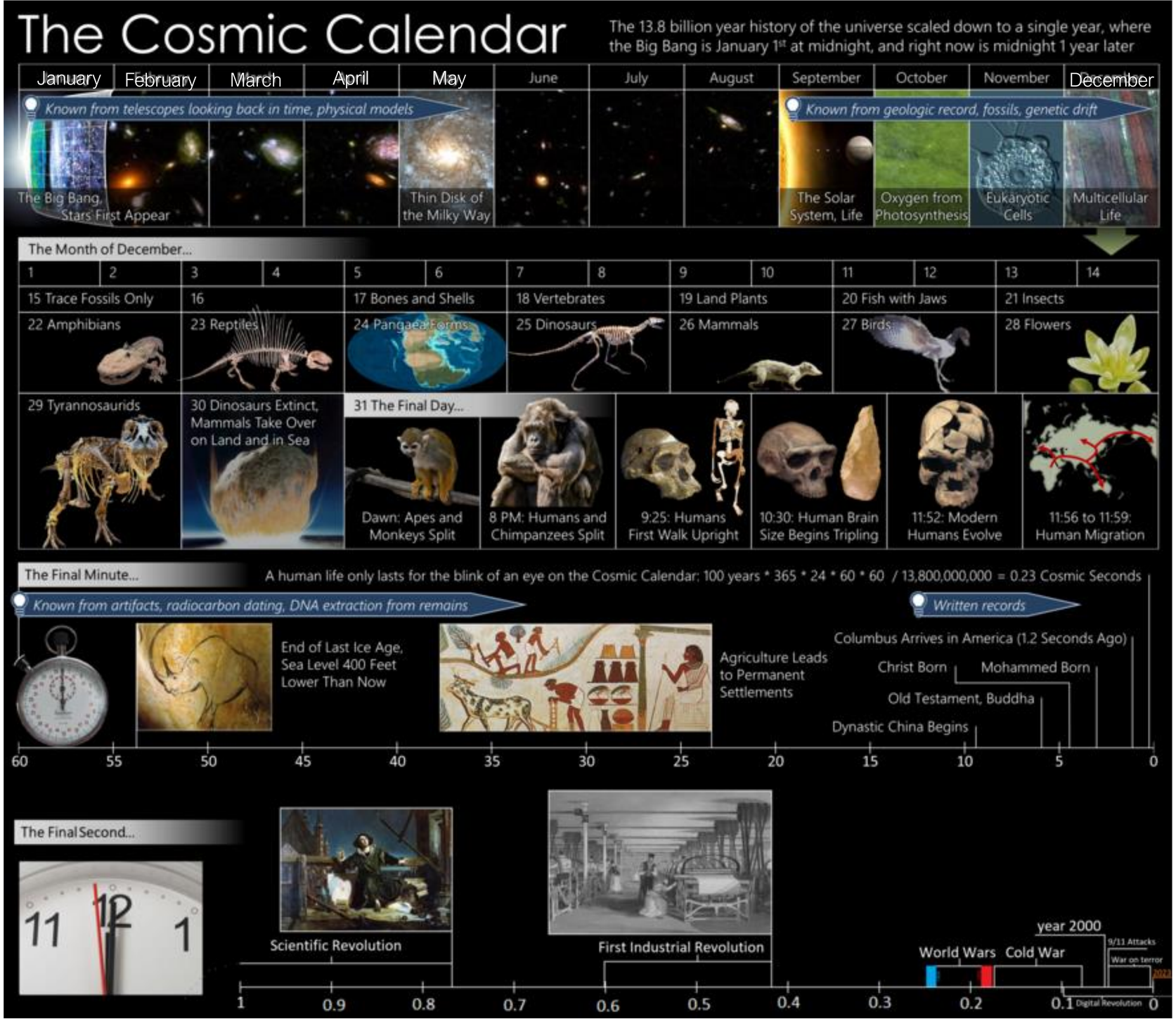








Why do we struggle so much to process, interpret and communicate information?



https://www.wikiwand.com/en/articles/Cosmic_Calendar

The problem with evolution

- The human brain has not evolved to trade in financial markets but to forage and survive in the wild

The problem with evolution

- The human brain has not evolved to trade in financial markets but to forage and survive in the wild

- Fight-or-flight

prediction
risk
neural
learning
brain
reward
information
different
value
perceptual
decision
decisions
values
results
behavior
evidence
playing
imaging
training
VGP
outline
repurchase
computations
goods
Bayesian
additional
effect
error
also
mechanisms
volatility
encodes
choose
model
use
guide
system
markets
Neural
expected
energy
theory
visual
show
emotions
agents
improved
role
variance
performance
uncertainty
video
human
learn
cognitive
signal
neuroeconomic
expectation
task
finance
experience
energy-related
errors
subjects
Human
categories
computation
Action
stocks
previously
cortex
firing
organisms
probabilistic
encoding
high
share
hypothesis
reinforcement
less
biased
compared
noise
processes
stochastic
consistent
correlates
correlating
Risk
idiosyncratic
predicted
consumption
activation
core
action
behaviors
new
previous
models
returns
research
correlated
economic
game
individual
decision-making
functional
activations
may
investors
NVGPs
blocks
Using
possibility
external
vmPFC
TvC
response
standard
value-based
counterfactual
understanding
rates
NVGP
area
data
economy
sensory
appraisal
underlying
focus
sale
much
time
gone
experiment
term
stock
phase
predict
gambling
representations
several
improve
rate
across

Economics

Neuroscience

…

How do we make decisions?

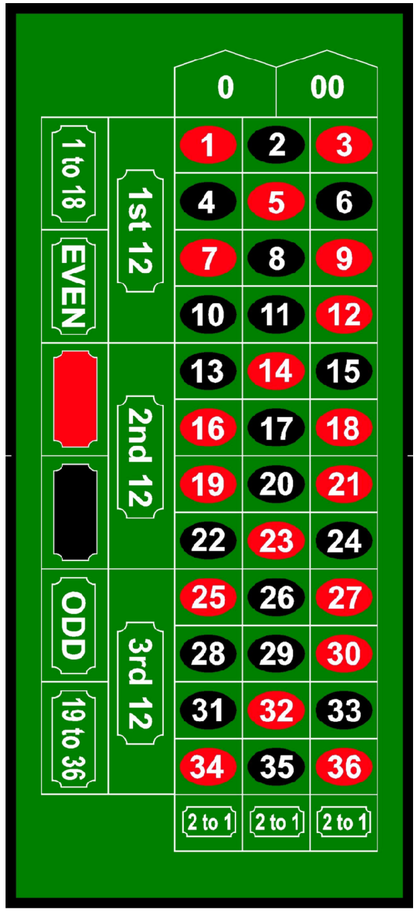
Psychology

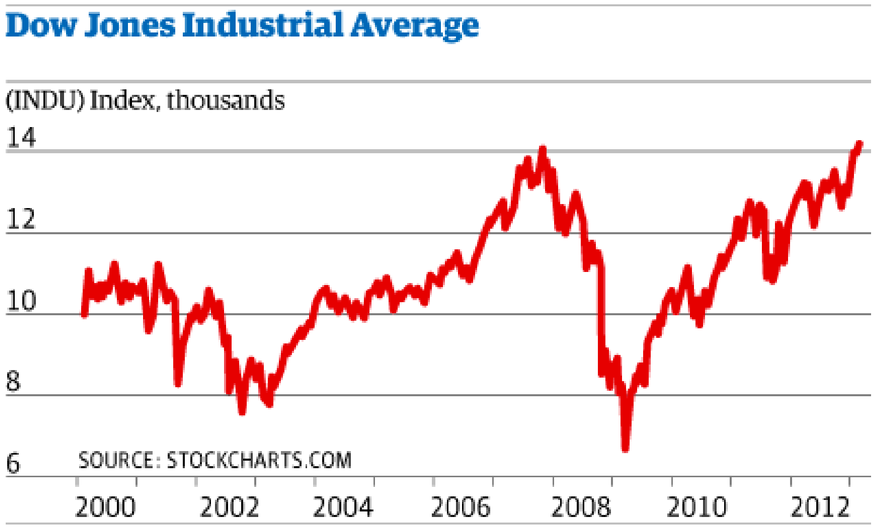
Machine learning

Biology

Finance

Playing roulette vs. playing the market

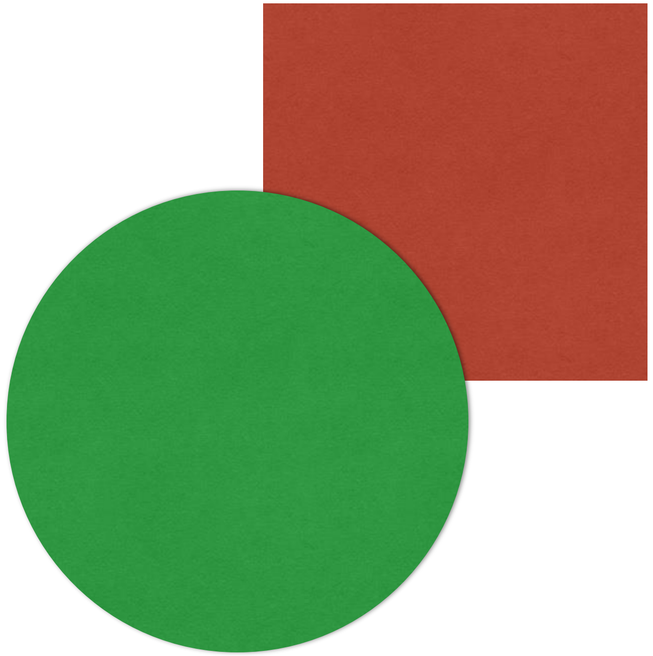


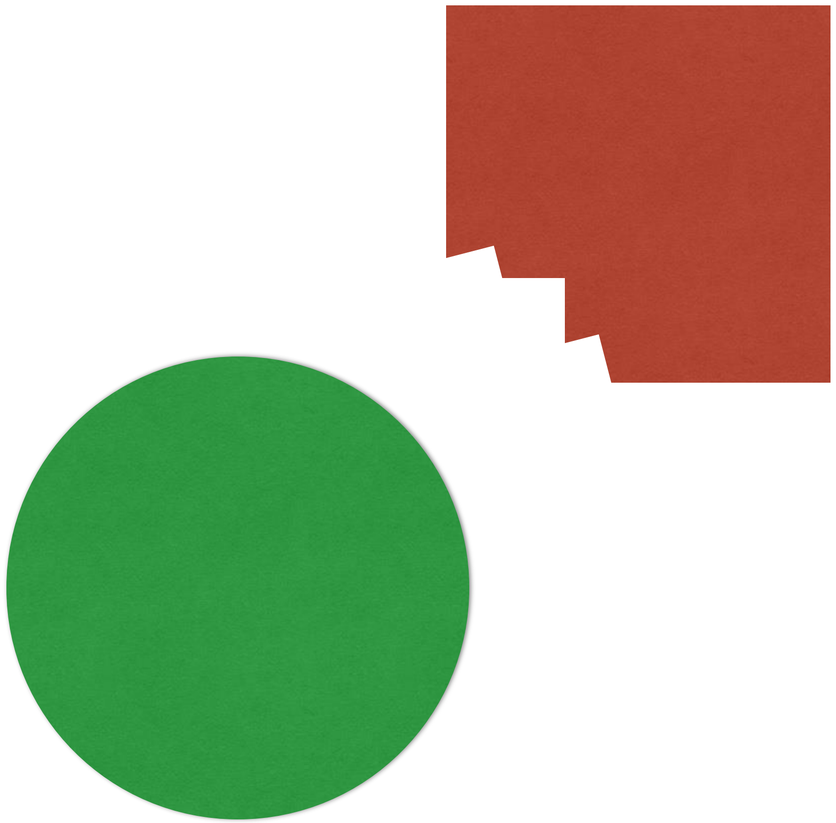


"I knew it."

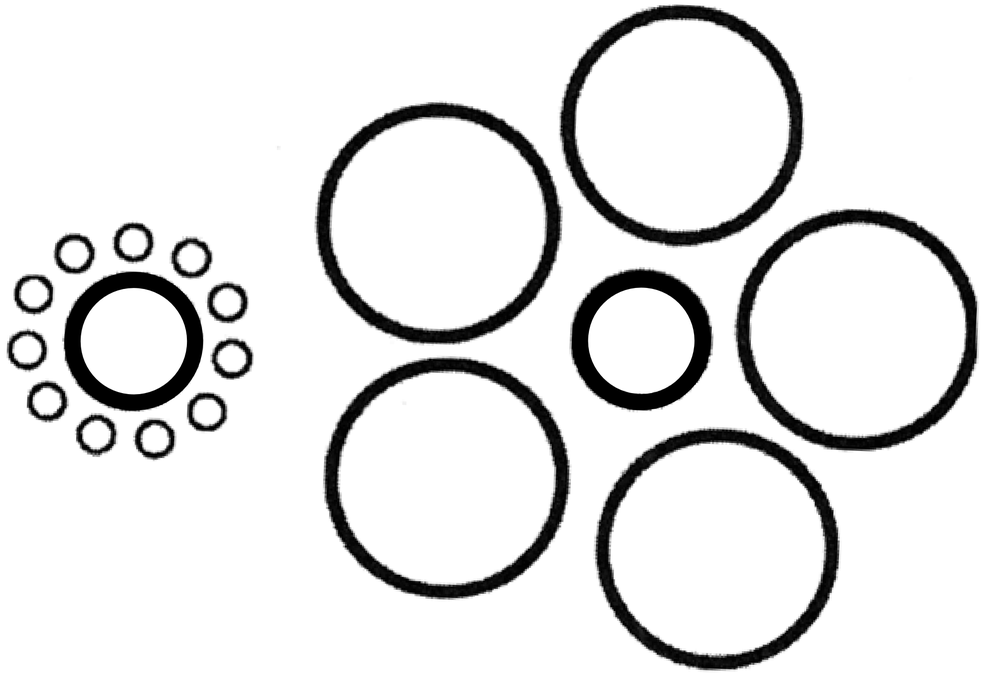
"I knew it."

A quick detour into neuroscience …



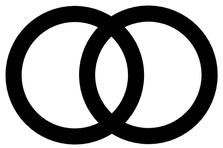


Visual judgements



Which of the two inner circles is larger?

Visual judgements

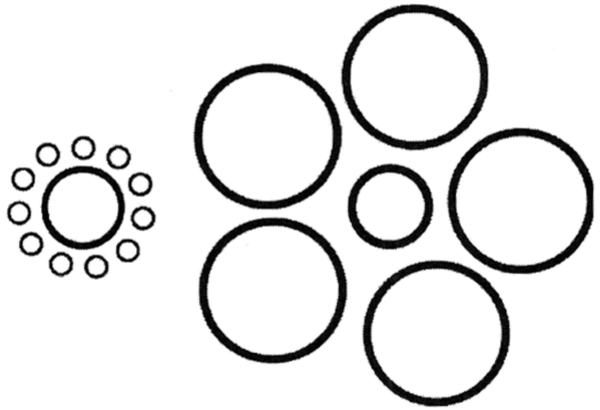


Which of the two inner circles is larger?

What did you answer?

A) The circle on the left.

B) They are equally large.

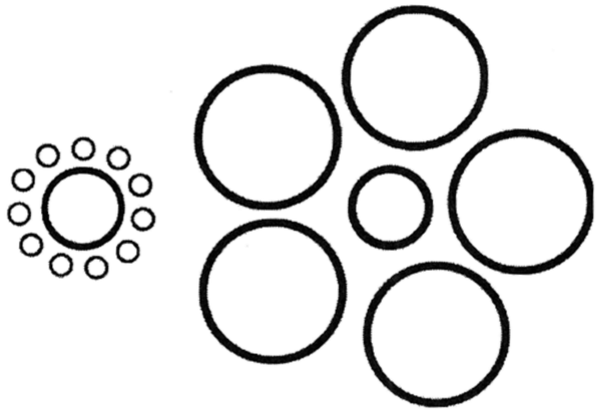


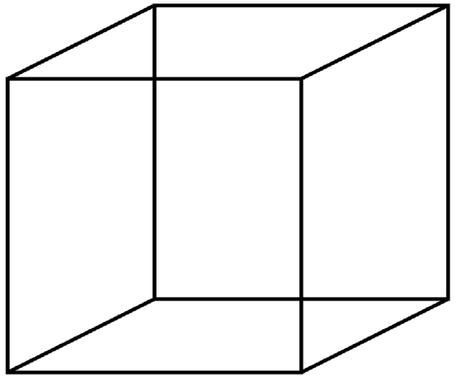
Three lessons

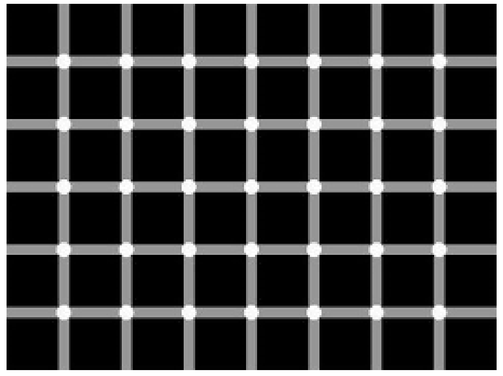
1. The way you perceive things is influenced by other things, in this case surrounding circles.

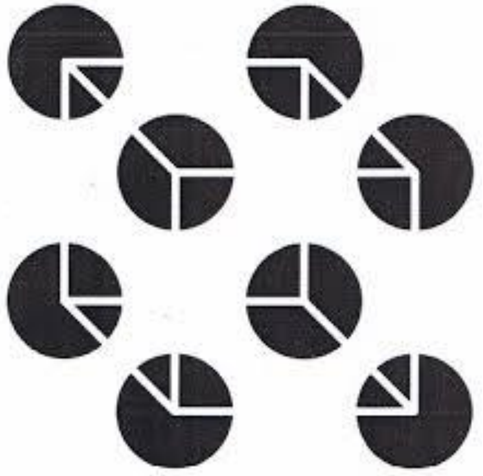
2. Knowing this you can consciously adjust for the difference.

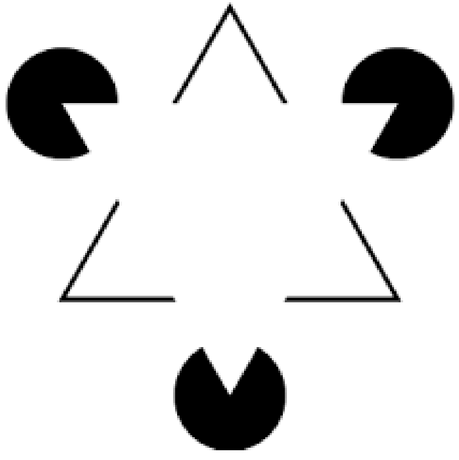
3. This doesn’t necessarily change your actual perception.

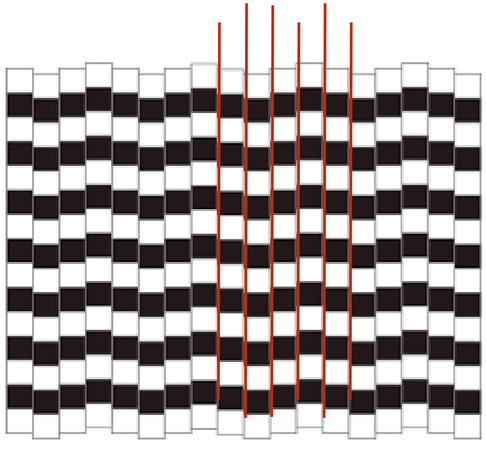


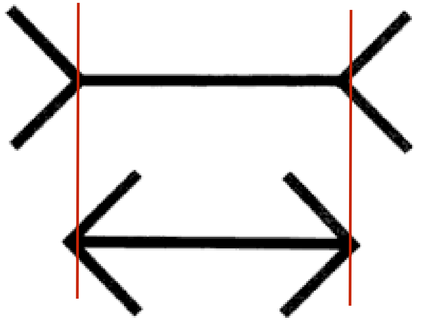












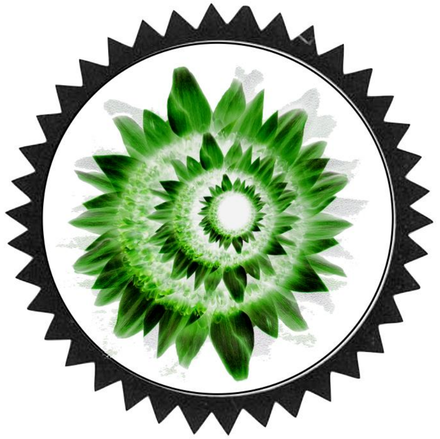
Types of cognitive biases

social biases

memory biases

decision-making biases

probability /belief biases



slideshare

Lessons from Neuroscience

- Your brain has a limited capacity to store, process and access information.
- Your brain is a predictive machine. It constantly fills in missing information to create a coherent picture.
- Your mind hates being wrong! (Tends to try and prove it’s right rather than wrong, opposite to scientific process).
- Your brain constantly learns, whether you notice it or not. (To repeat or not to repeat?)

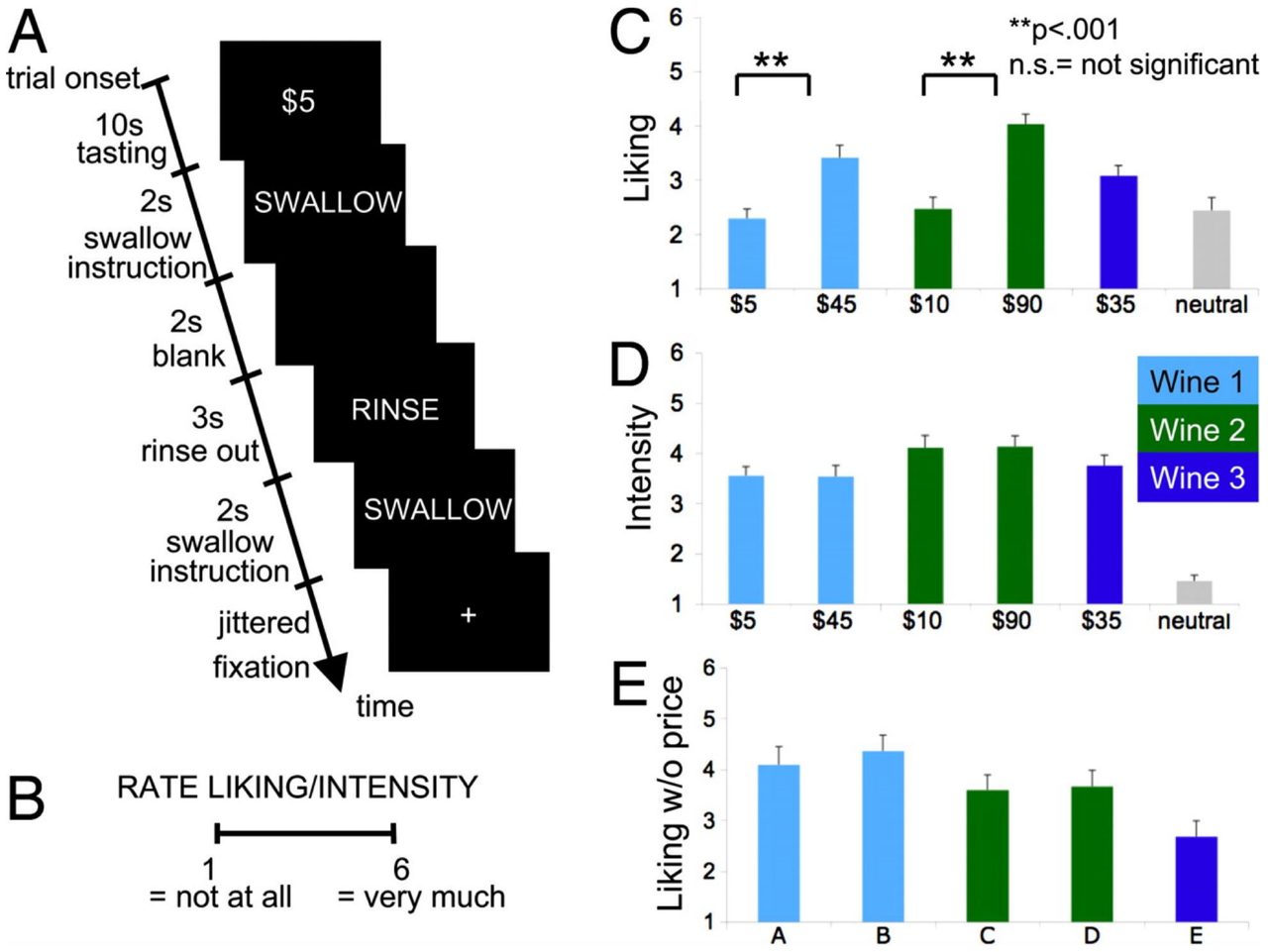
Does the price of wine change your taste? And your brain?

Plassmann, H., O'Doherty, J., Shiv, B., & Rangel, A. (2008). Marketing actions can modulate neural representations of experienced pleasantness. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(3), 1050–1054. https://doi.org/10.1073/pnas.0706929105

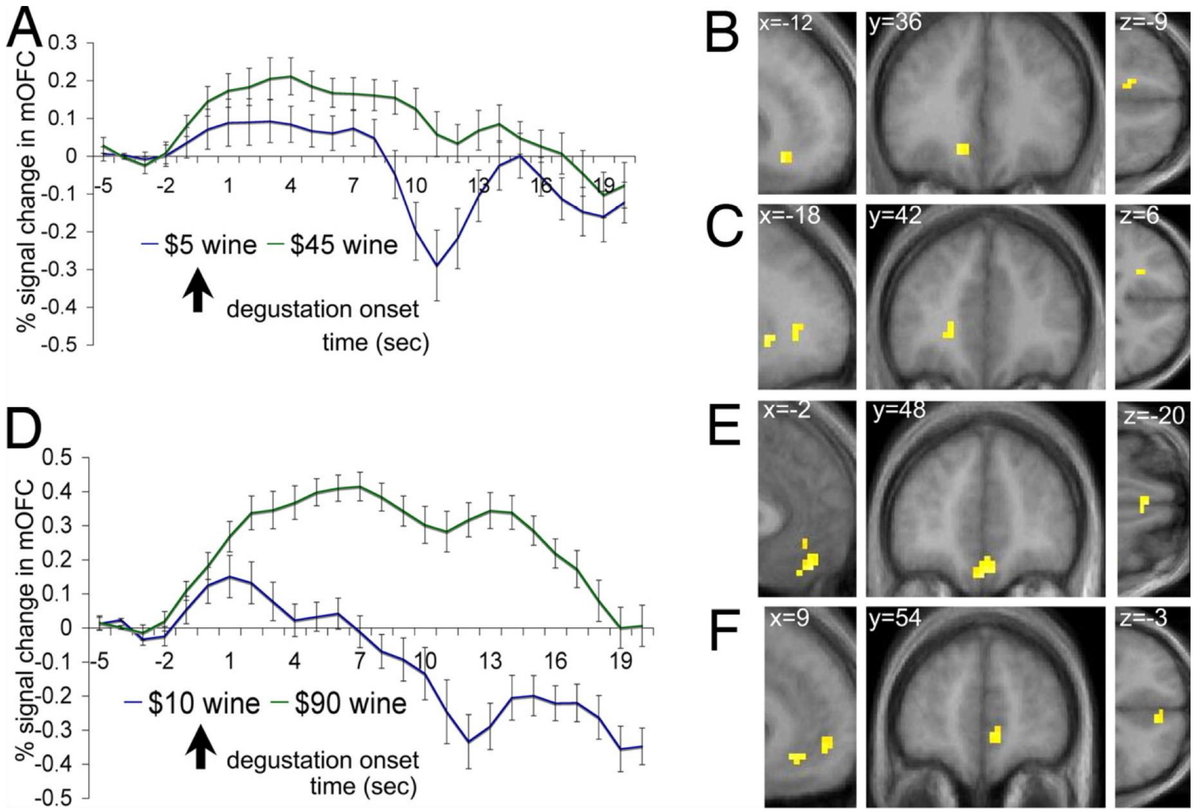
Wine tasting in the scanner …

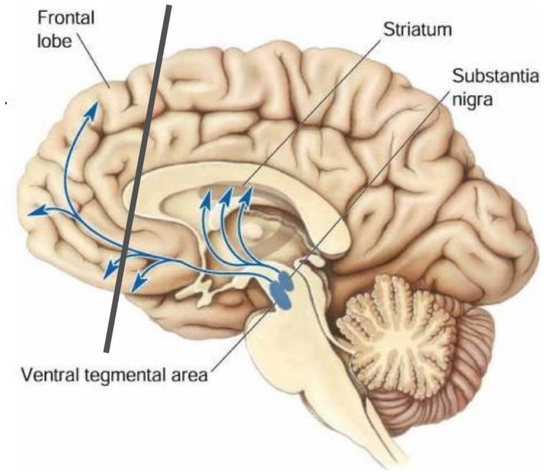
$5 $45 $10 $90 $35

Plassmann, H., O'Doherty, J., Shiv, B., & Rangel, A. (2008). Marketing actions can modulate neural representations of experienced pleasantness. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(3), 1050–1054. https://doi.org/10.1073/pnas.0706929105



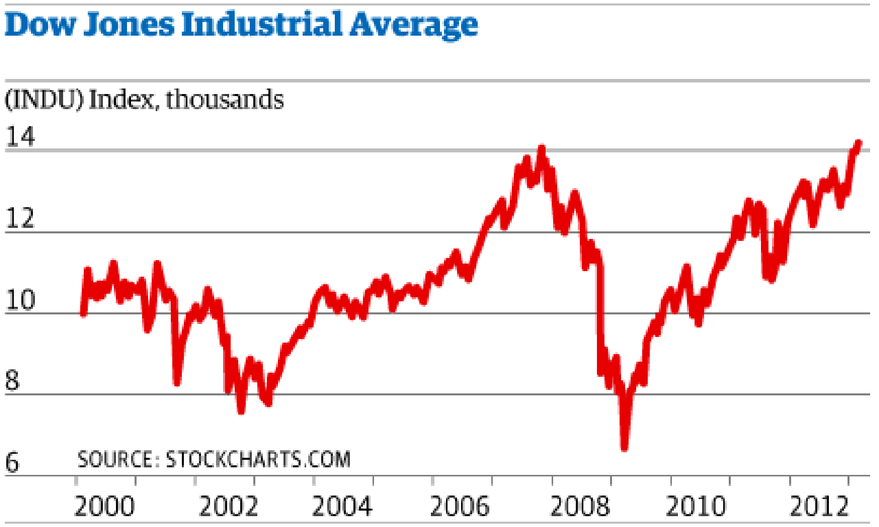
Plassmann, H., O'Doherty, J., Shiv, B., & Rangel, A. (2008). Marketing actions can modulate neural representations of experienced pleasantness. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(3), 1050–1054. https://doi.org/10.1073/pnas.0706929105





Plassmann, H., O'Doherty, J., Shiv, B., & Rangel, A. (2008). Marketing actions can modulate neural representations of experienced pleasantness. *Proceedings of the National Academy of Sciences of the United States of America*, *105*(3), 1050–1054. https://doi.org/10.1073/pnas.0706929105

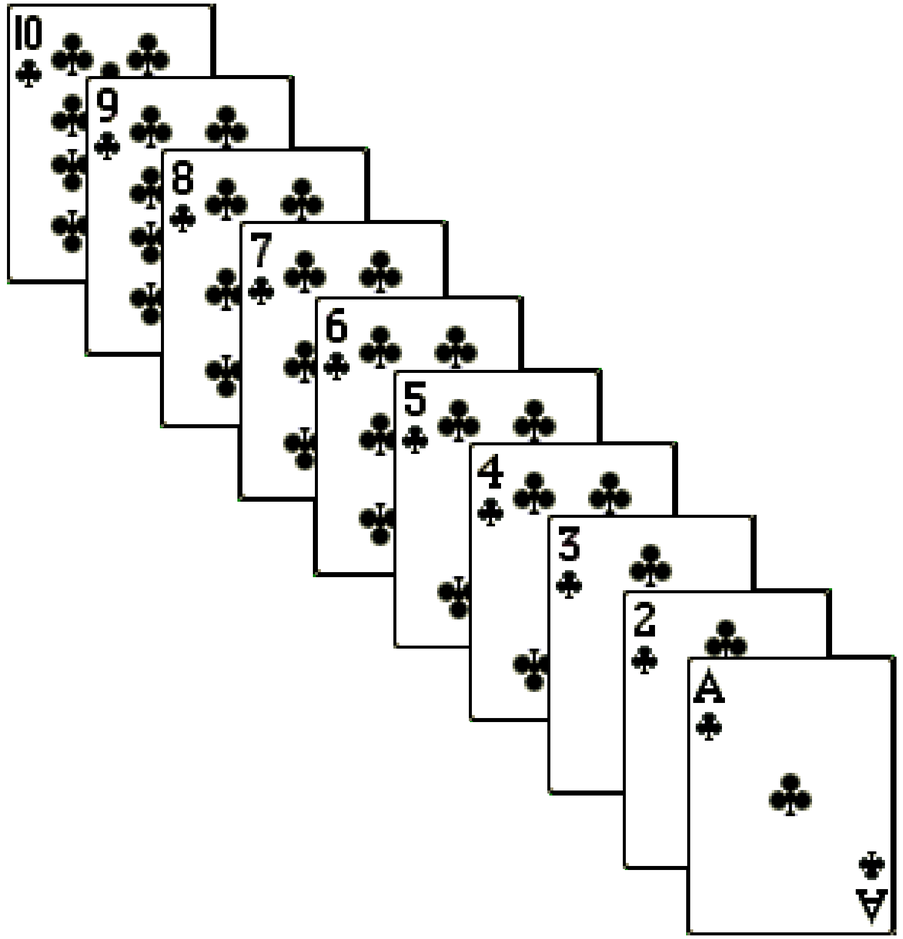
Finance fundamentals & the brain
Neural and physiological representations of reward, risk, ambiguity, volatility



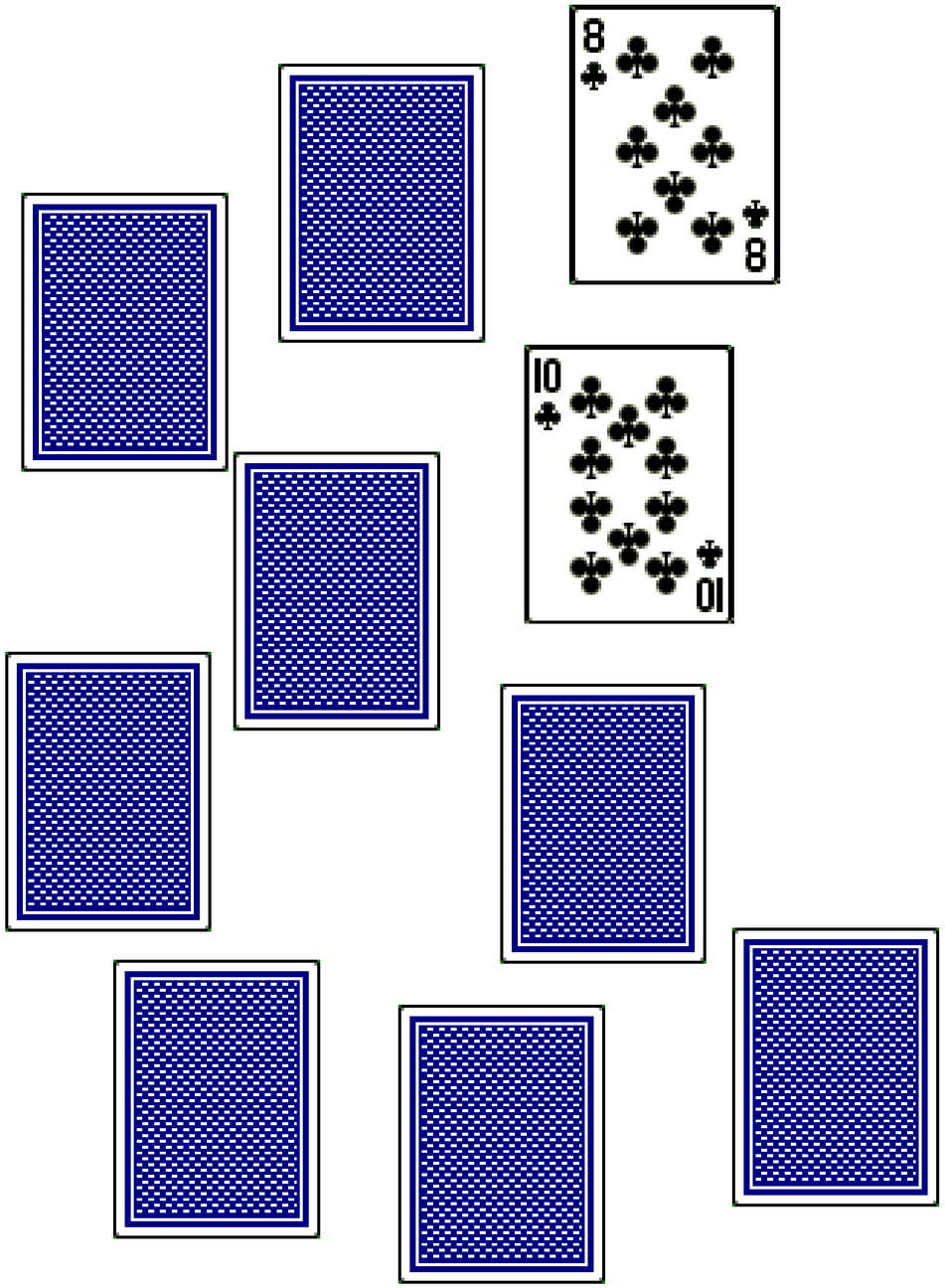
Mean Variance Utility -> The Risk Return Trade-Off

$$U(x) = p_1 x_1^{\rho} + p_2 x_2^{\rho}$$

$$U(x) = \beta_{\mu} Mean(x) + \beta_{\sigma} Variance(x) + \beta_{\gamma_1} Skewness(x)$$



Preuschoff et al, 2006, 2008, 2011
Bruguier et al, 2008
Rudorf et al, 2012



$t_0 = 0$

Will the second card revealed be higher or lower than the first?

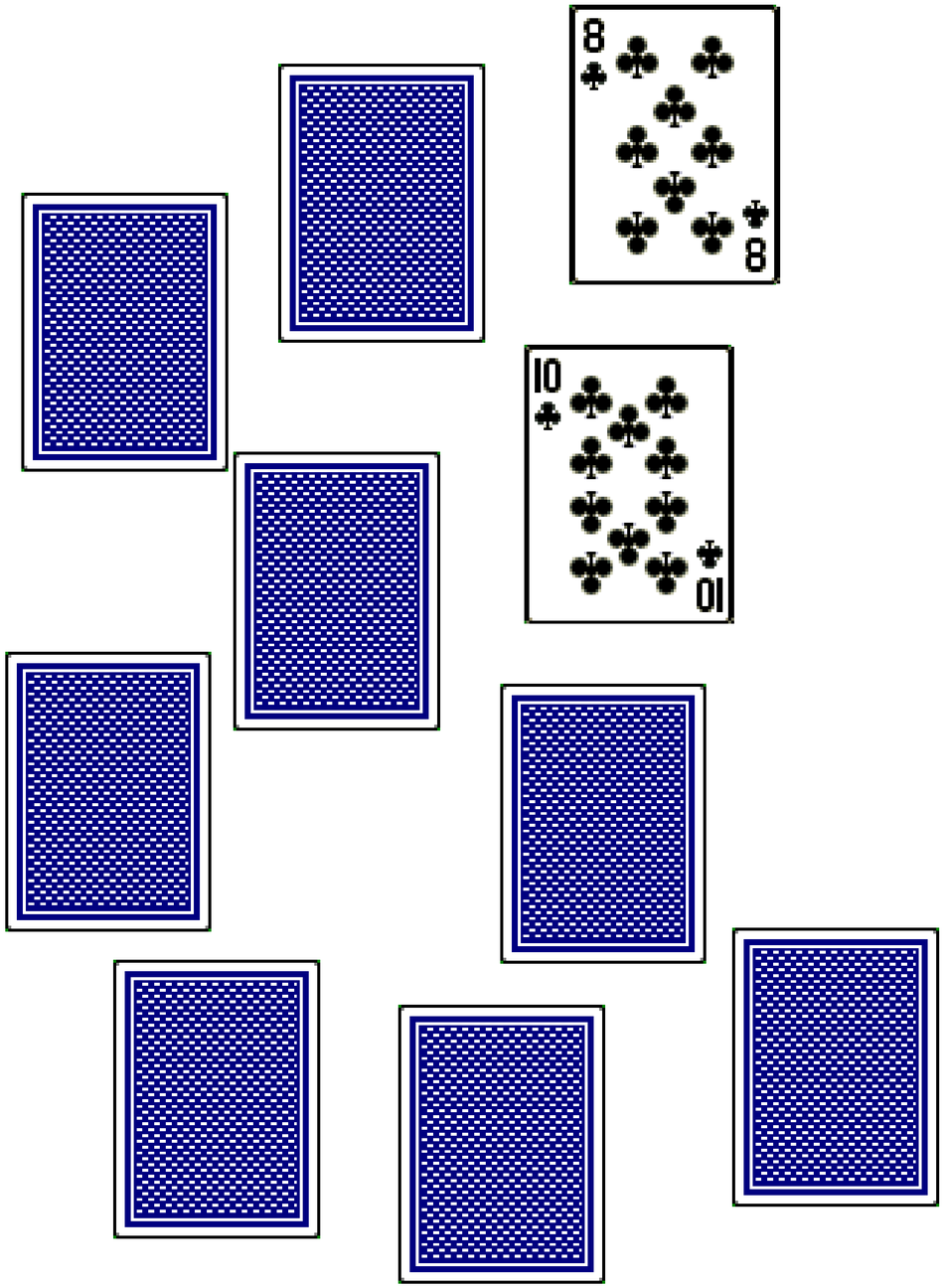
"*LOWER*"

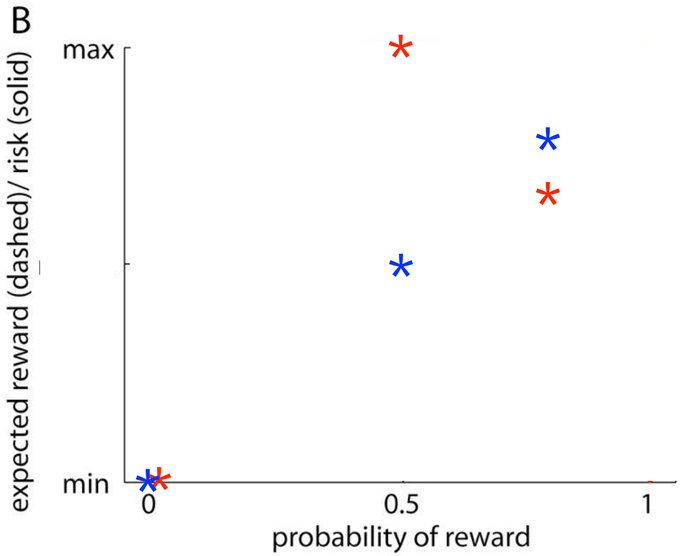
$t_1 = 5s$

Reveal first card.

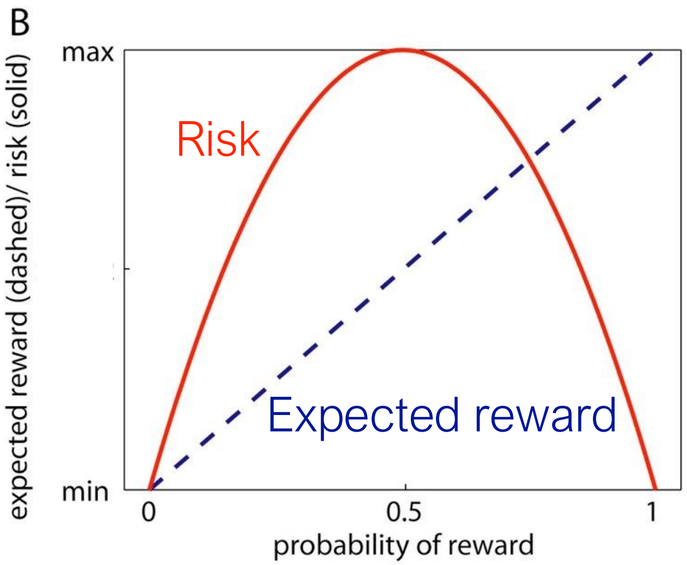
$t_2 = 10s$

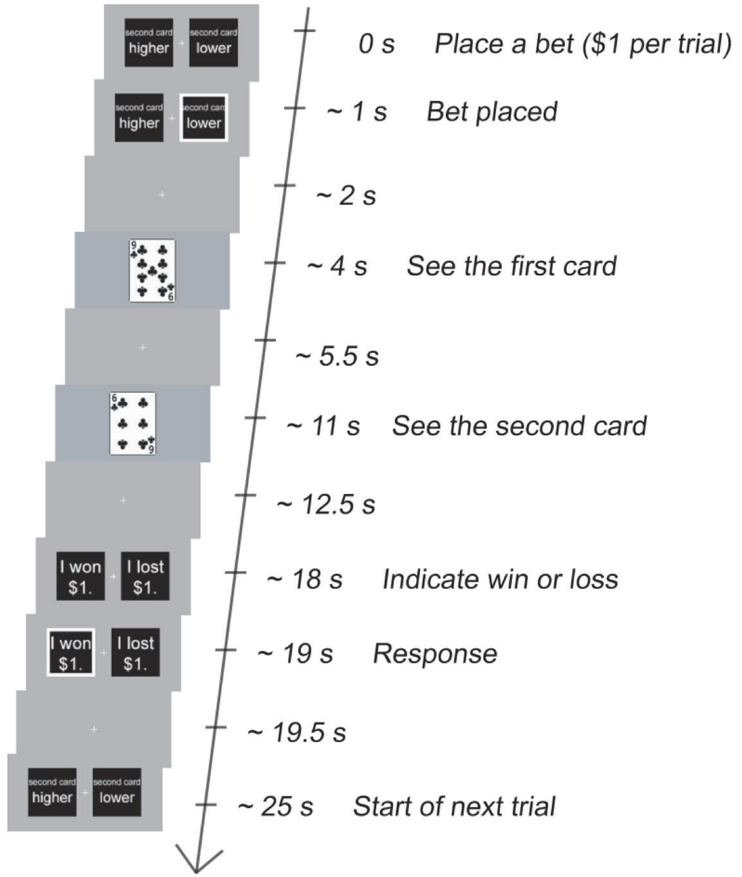
Reveal second card.




B
max
min
expected reward (dashed)/ risk (solid)
0
0.5
1
probability of reward

Prediction



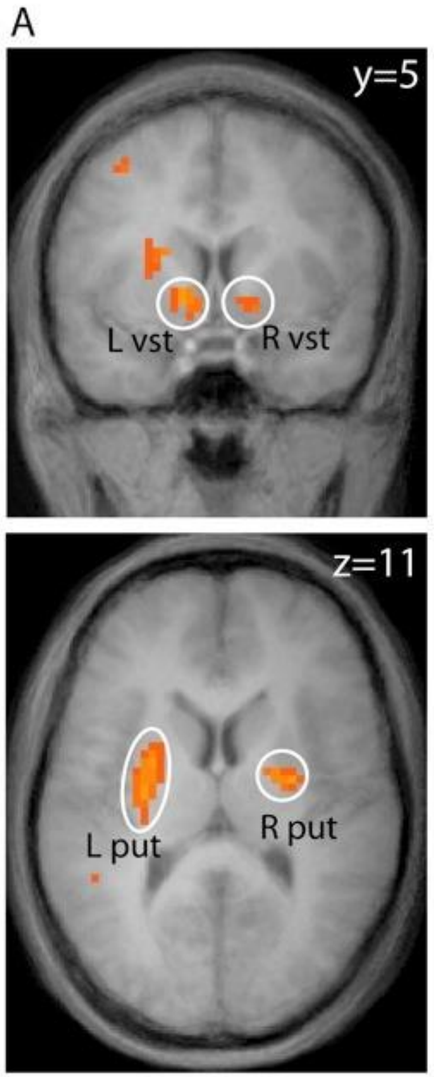


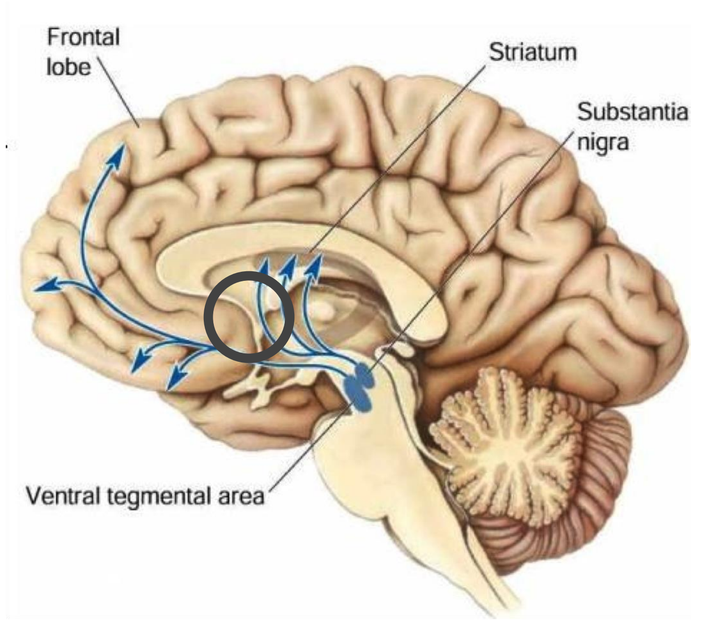
$$U = \mu - \beta Var$$

$$\mu = p_1 v_1 + (1 - p_1) v_2$$

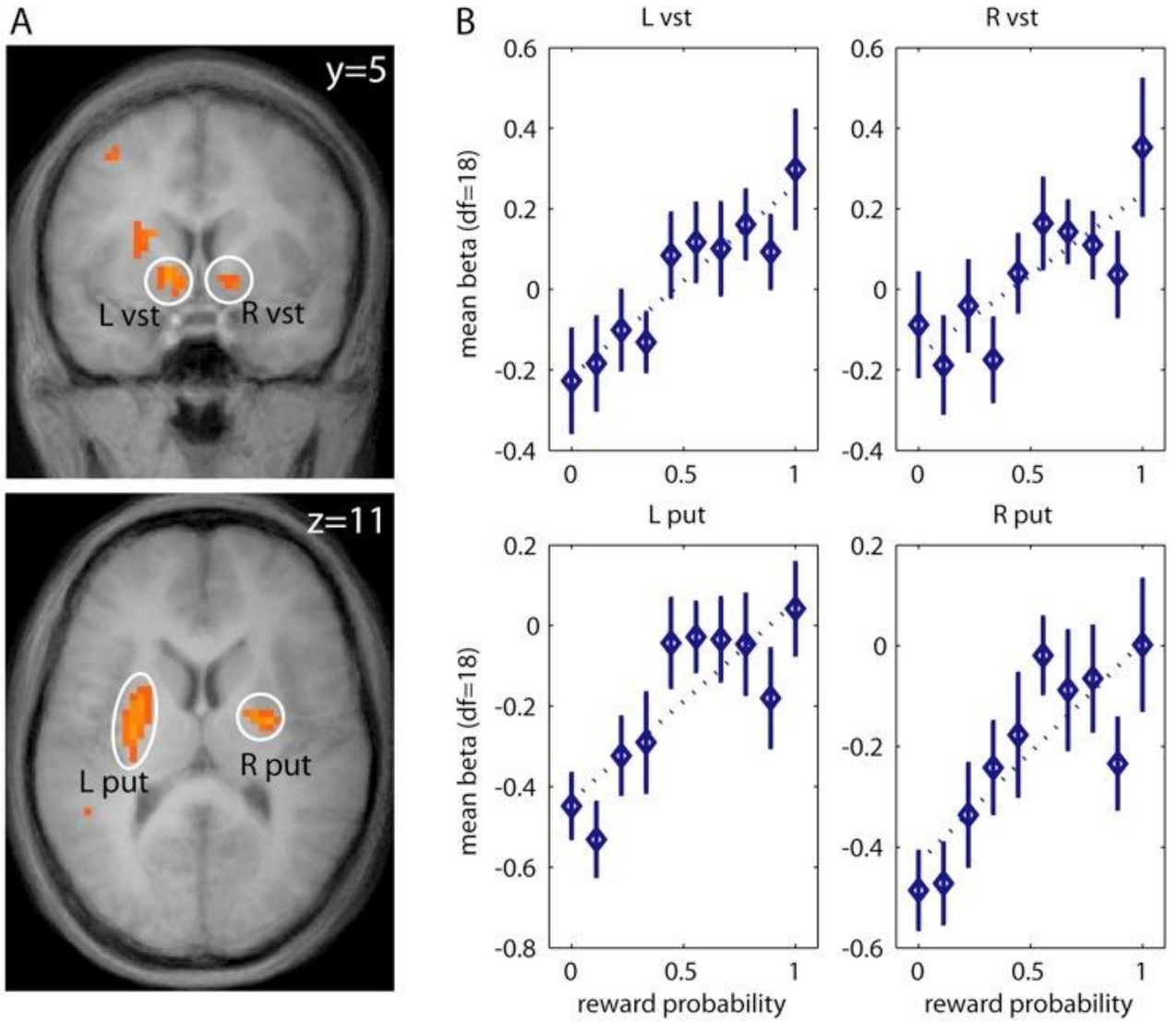
$$Var = p_1(\mu - v_1)^2 + (1 - p_1)(\mu - v_2)^2$$

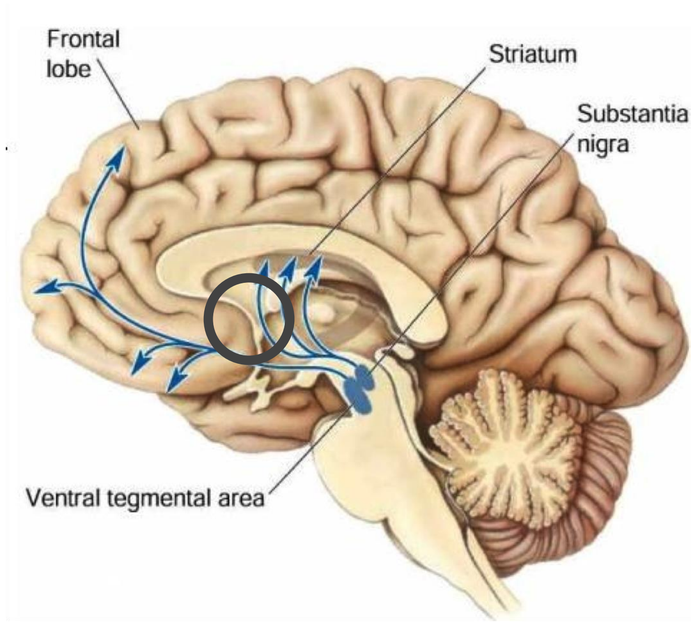

End of session
Final score: $19



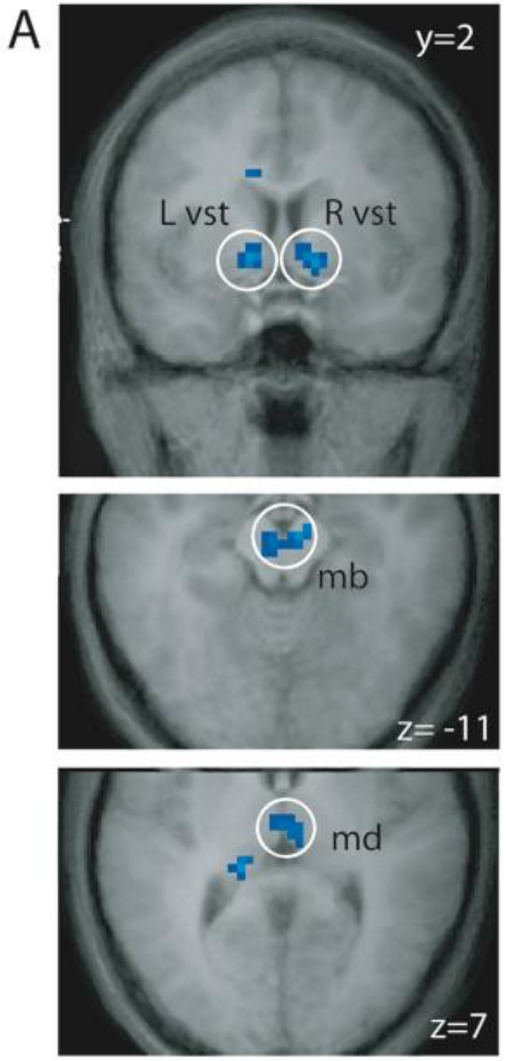


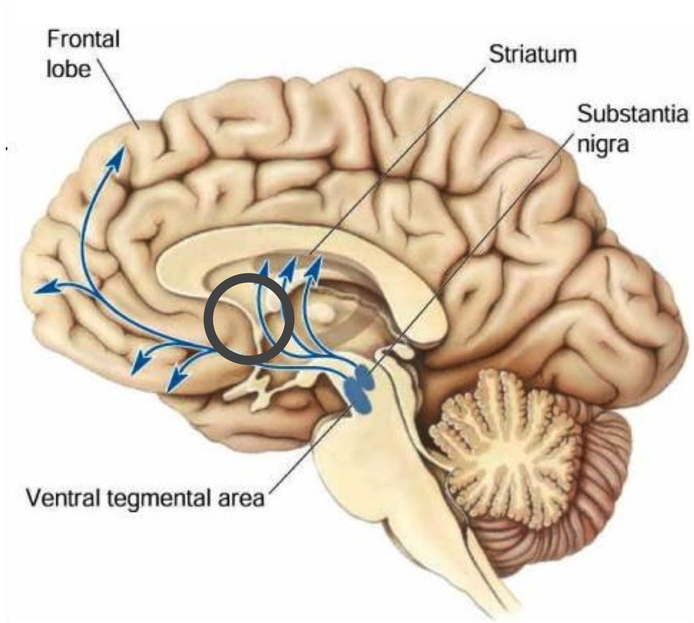
(Phasic) Response to Probability



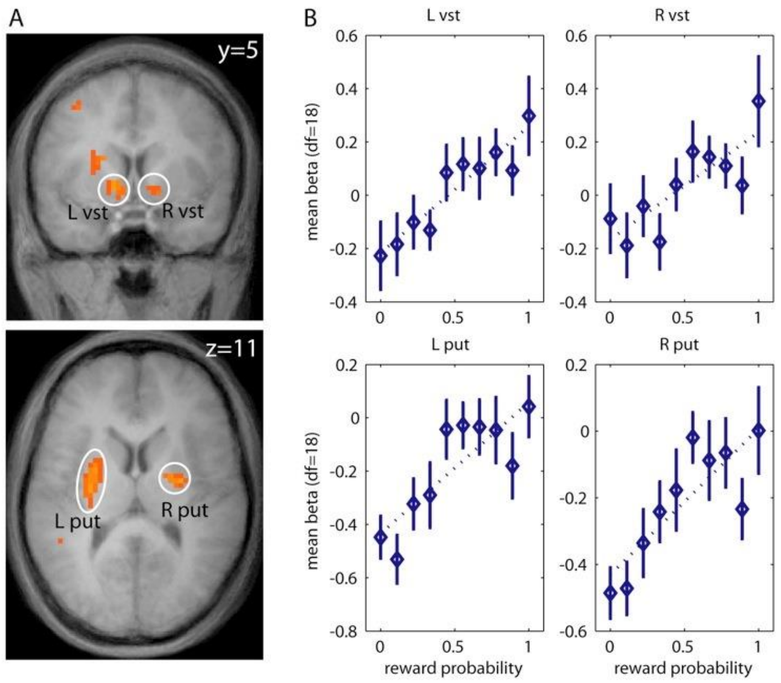


(Phasic) Response to Probability

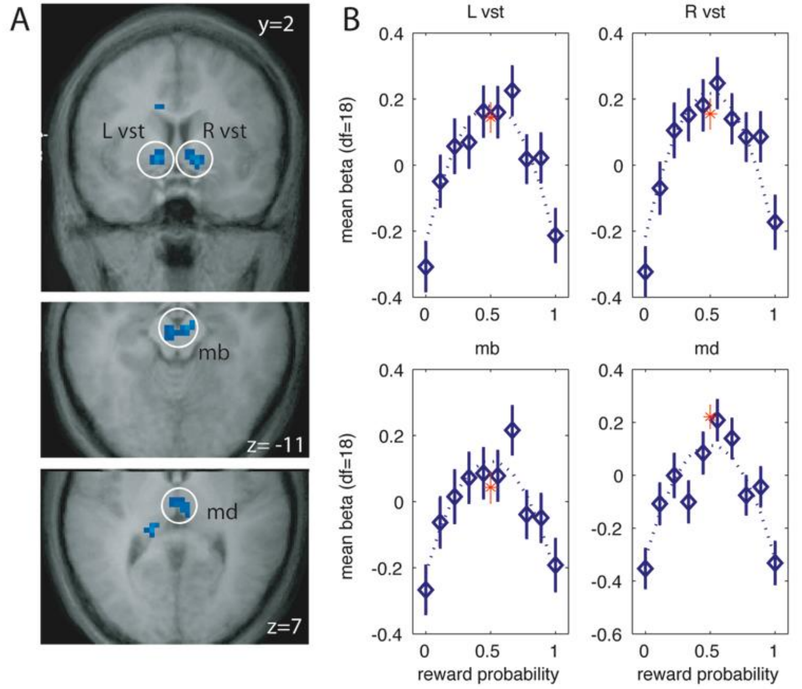




Risk (Sustained)



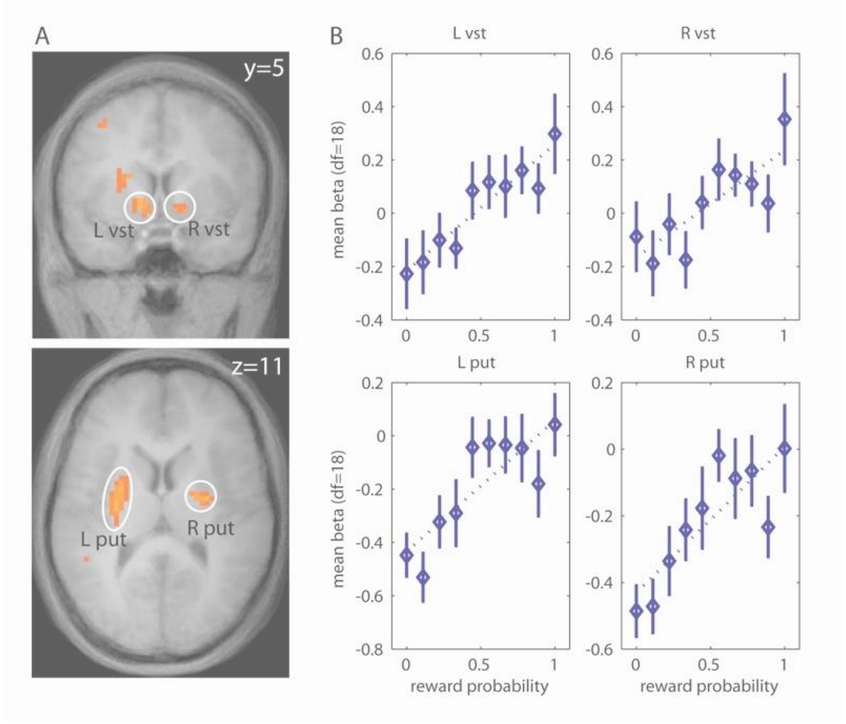
Expected reward



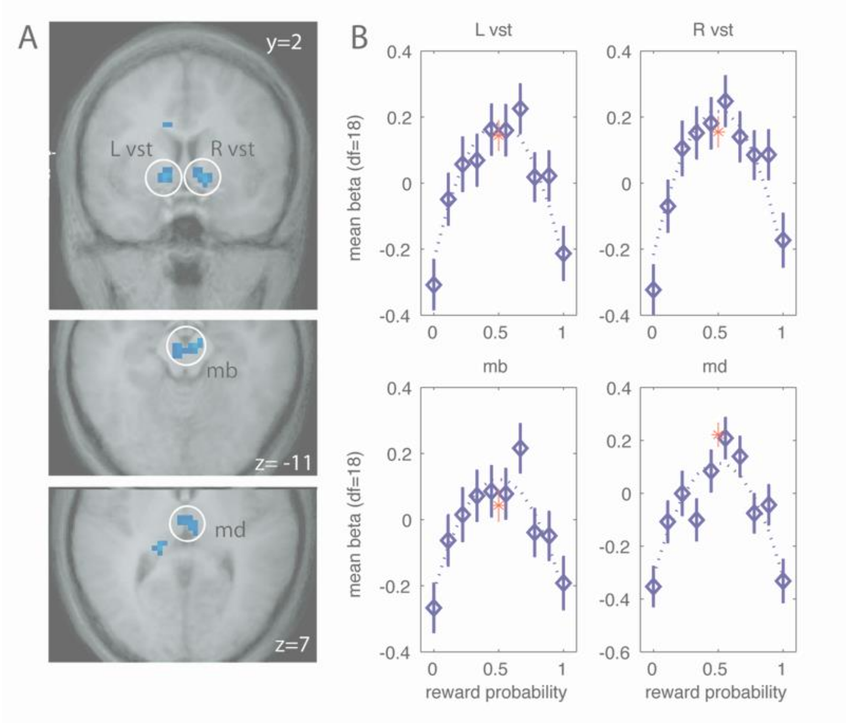
Risk

Where and how are decision variables encoded?

Preuschoff et al, 2006, 2008

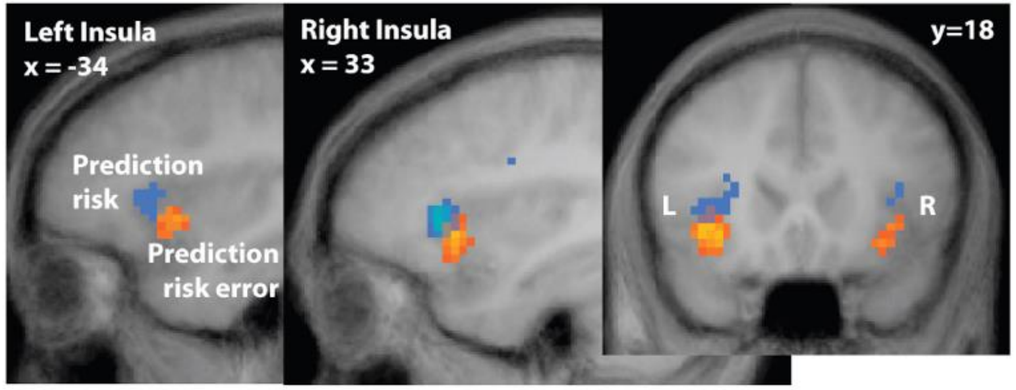


Expected reward



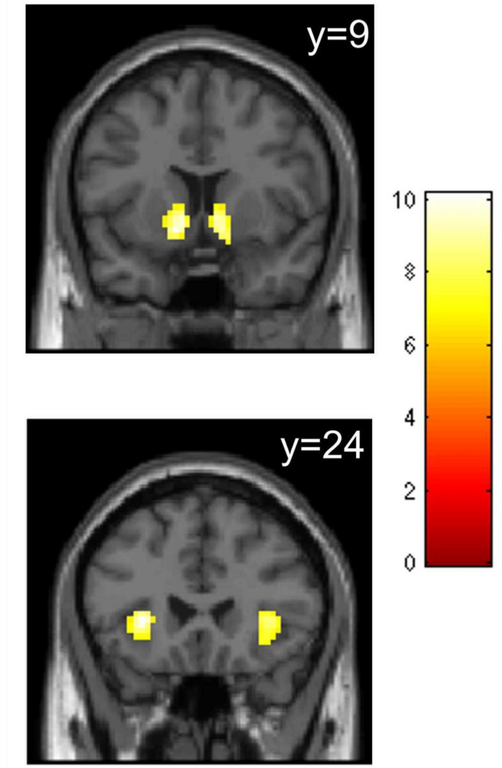
Risk

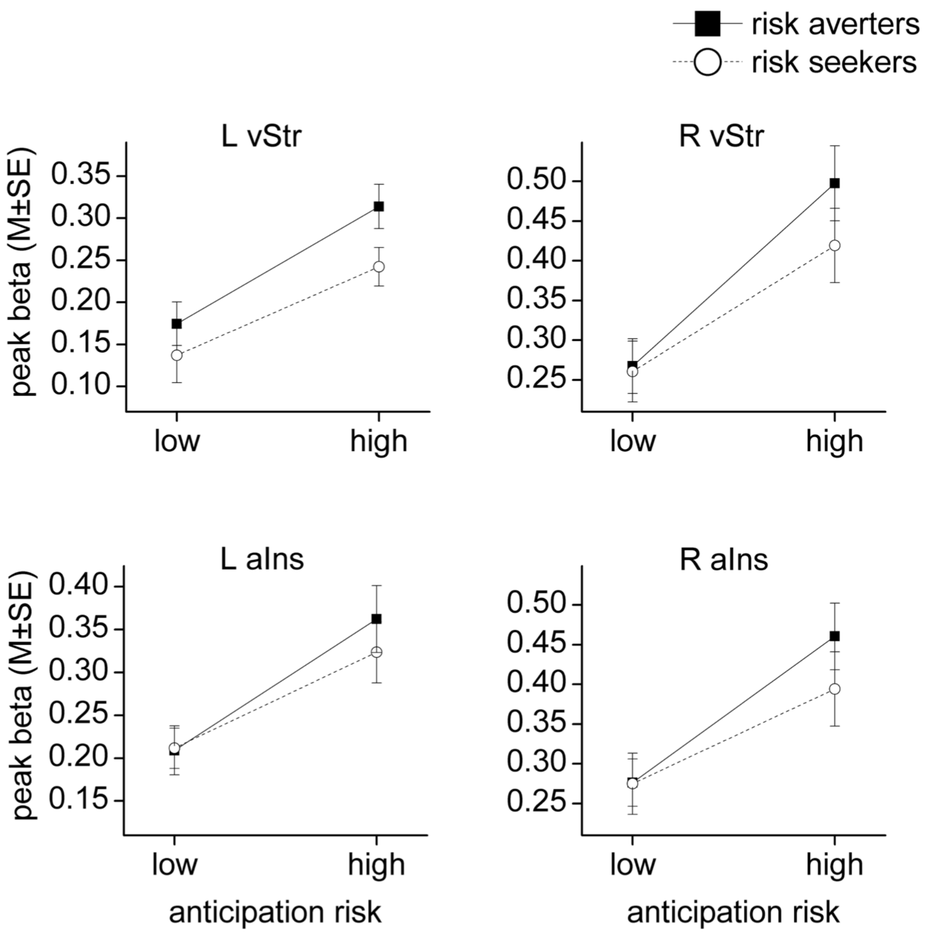
Are there errors relating to risk?



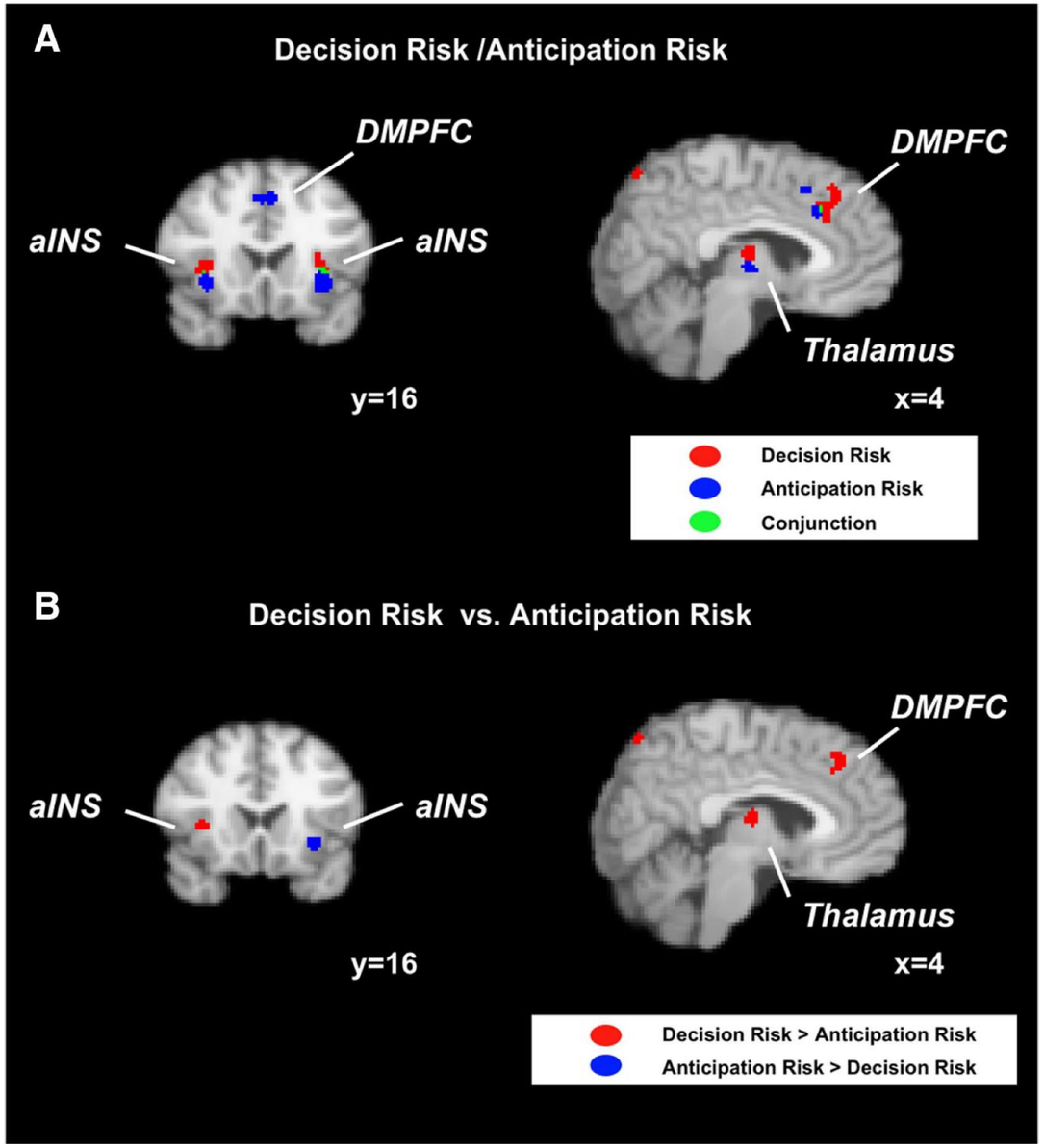
Risk errors / surprise

Are individual preferences reflected in these representations?

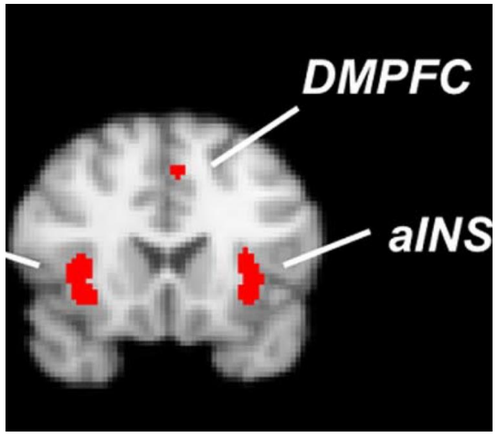


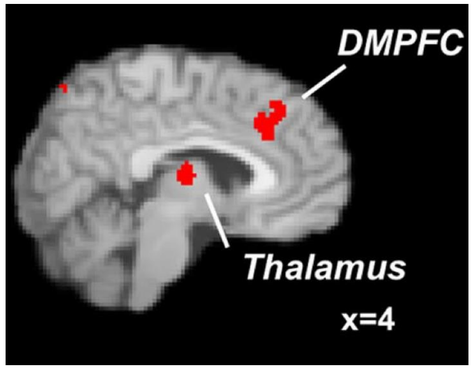


Rudorf et al, 2012



Risk

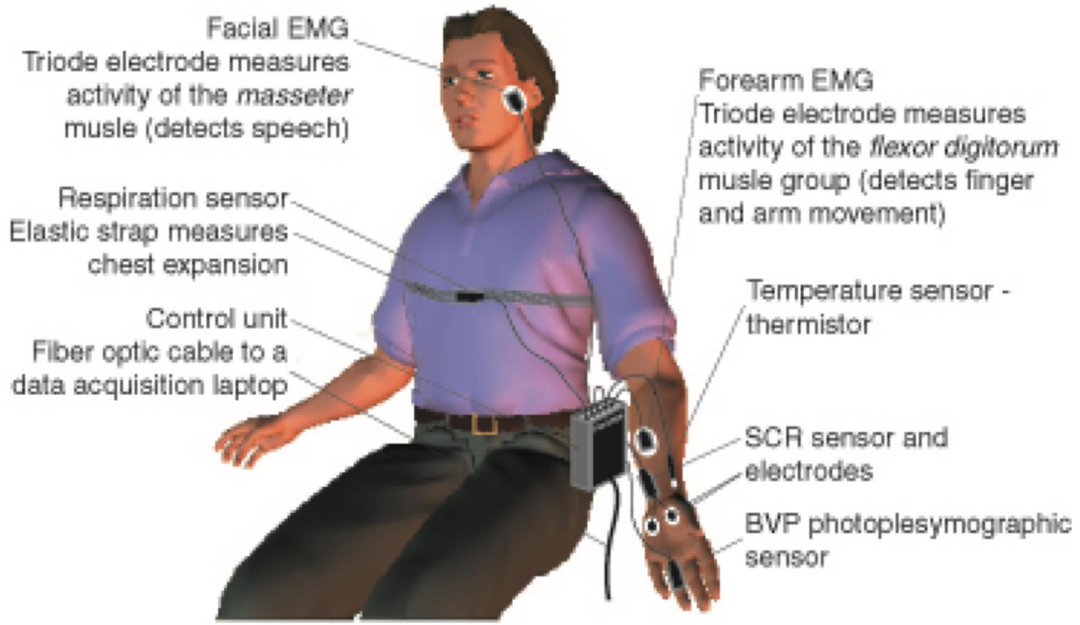


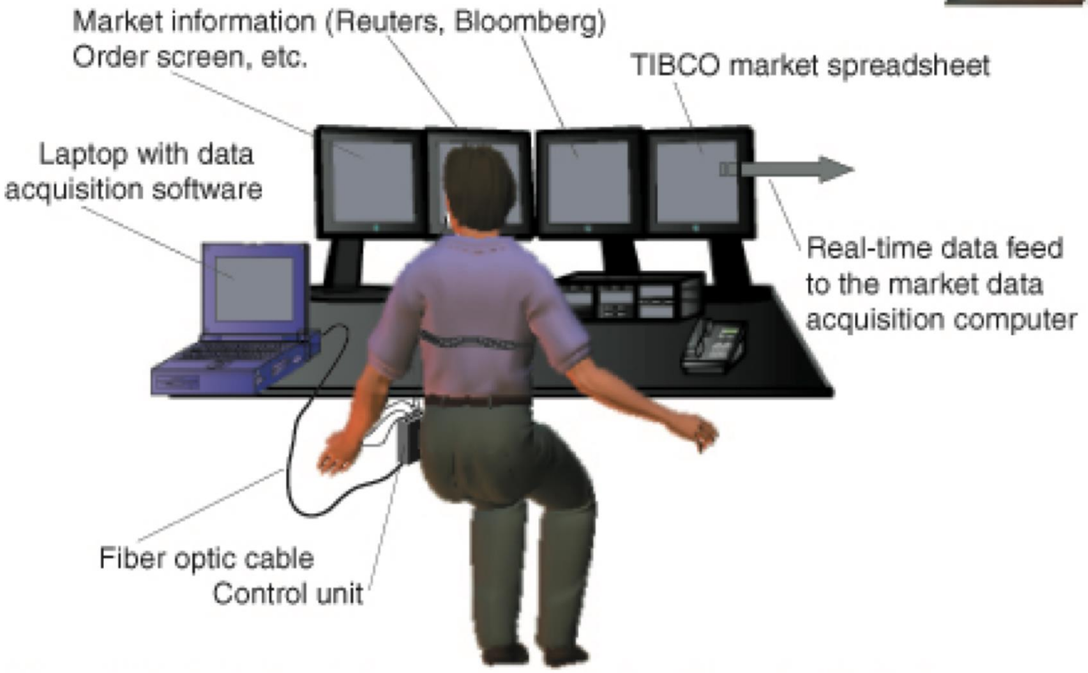


Mohr et al, 2010

Into the wild - professional portfolio managers and experienced traders

- 10 professional securities traders during live trading sessions





- market events: deviations, trend reversals, and volatility events

Lo & Repin, 2001

Interoceptive Ability Predicts Survival on a London Trading Floor

Narayanan Kandasamy[1,*], Sarah N. Garfinkel[2,*], Lionel Page[3,*], Ben Hardy[4], Hugo D. Critchley[2], Mark Gurnell[1] & John M. Coates[4]

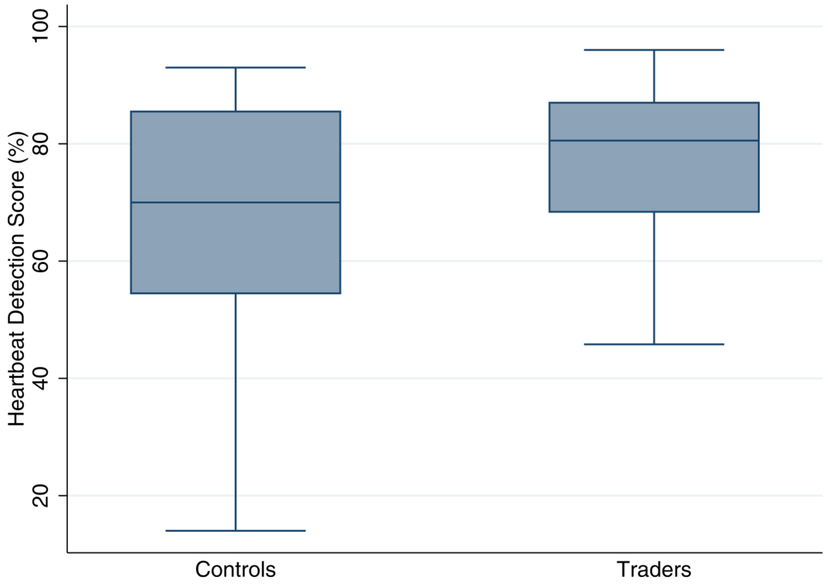
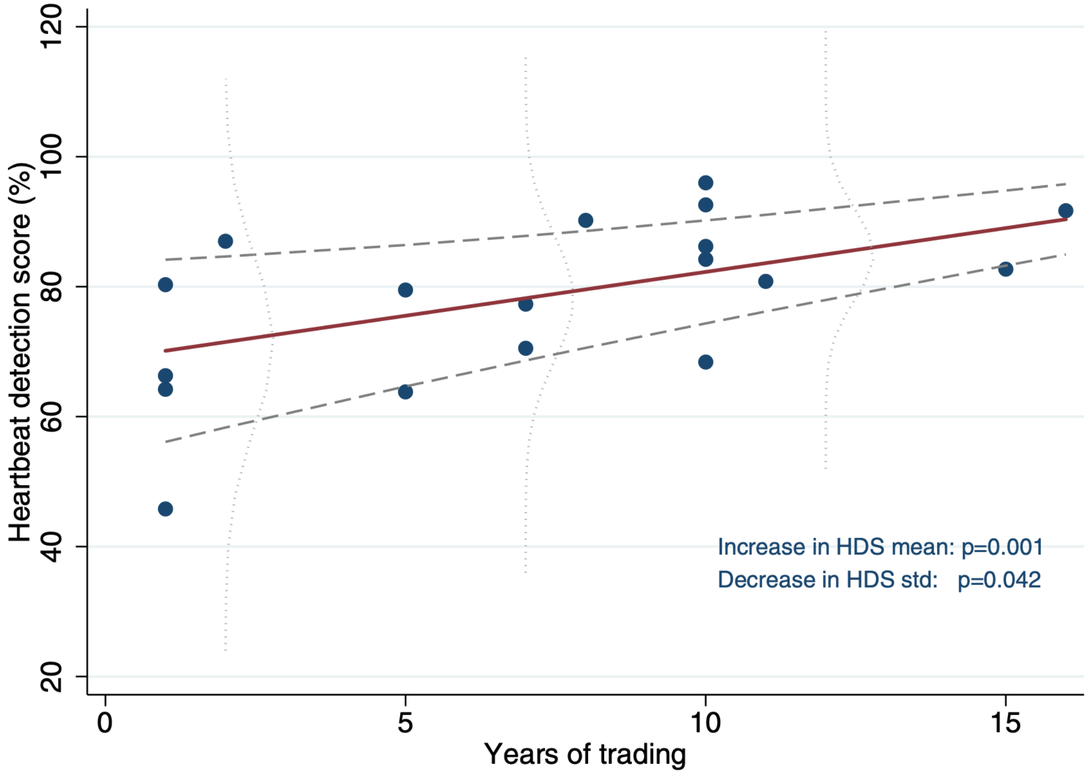


Figure 1. Box plots showing that mean interoceptive accuracy (score on heartbeat counting task) for traders (N = 18) was significantly higher than for a cohort of non-traders (N = 48).

Interoceptive Ability Predicts Survival on a London Trading Floor

Narayanan Kandasamy[1,*], Sarah N. Garfinkel[2,*], Lionel Page[3,*], Ben Hardy[4], Hugo D. Critchley[2], Mark Gurnell[1] & John M. Coates[4]



Interoceptive Ability Predicts Survival on a London Trading Floor

Narayanan Kandasamy[1,*], Sarah N. Garfinkel[2,*], Lionel Page[3,*], Ben Hardy[4], Hugo D. Critchley[2], Mark Gurnell[1] & John M. Coates[4]

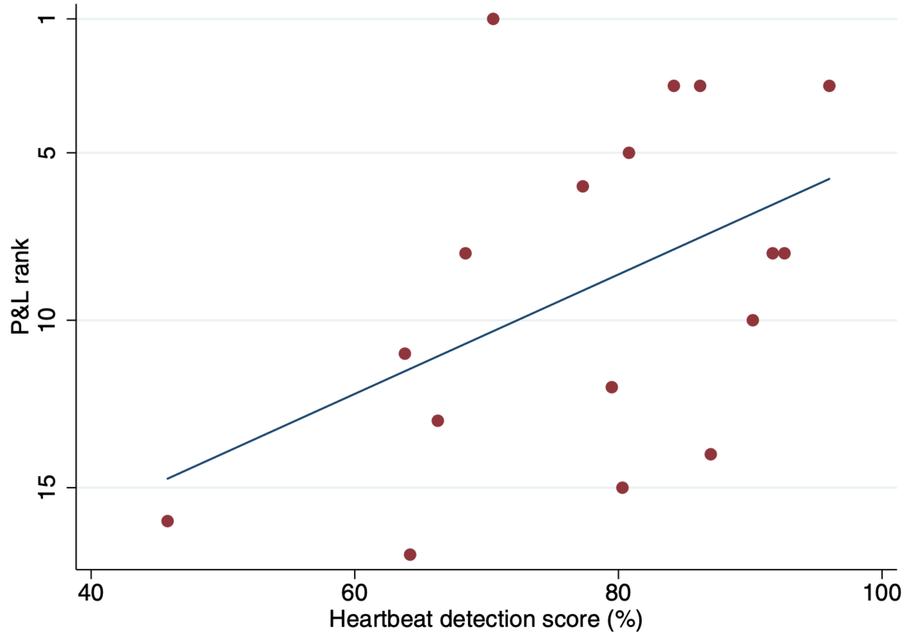
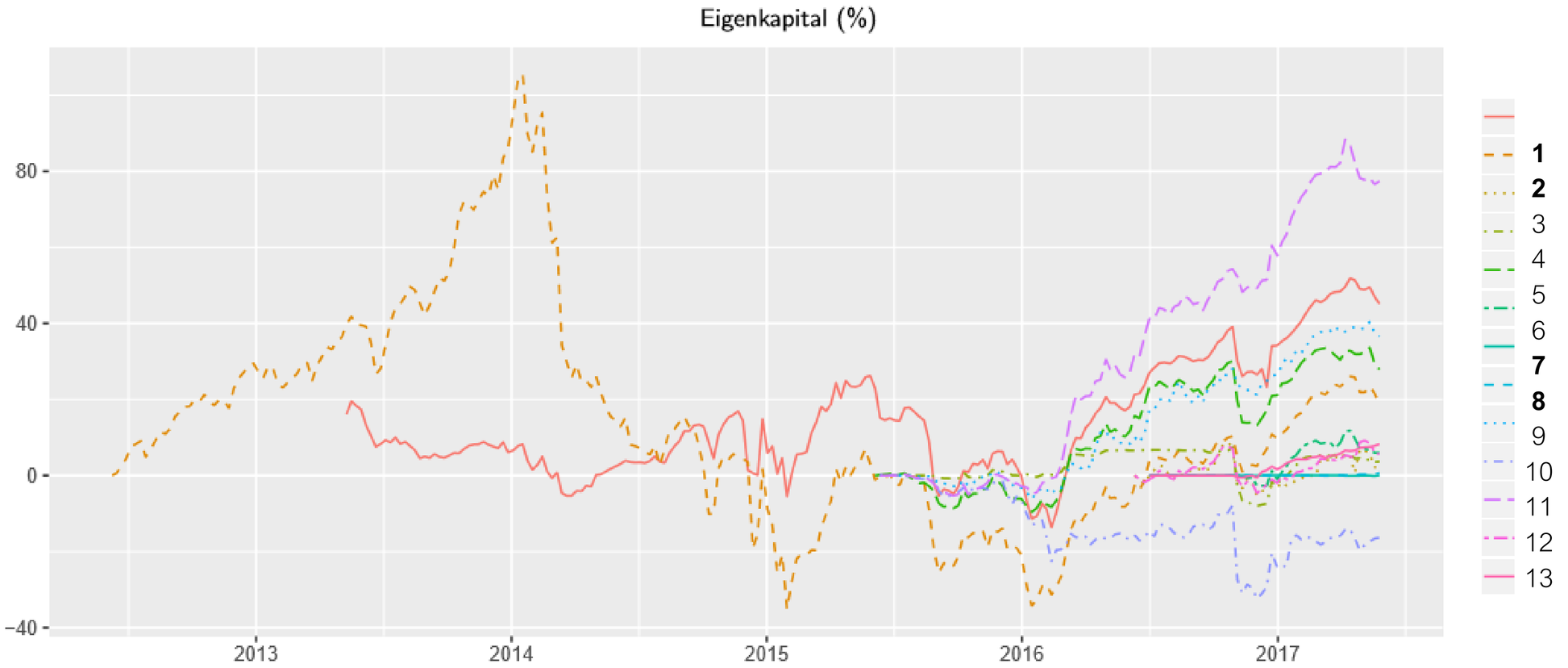


Figure 2. Regression line plotting score on the heartbeat counting task against the traders' rank ordered P&L, with 1 representing the most profitable trader, 17 the least.

Professional portfolio managers



seed capital (y=0): 200’000 (7,8), 400’000, 1’000’000 (1,2) CHF

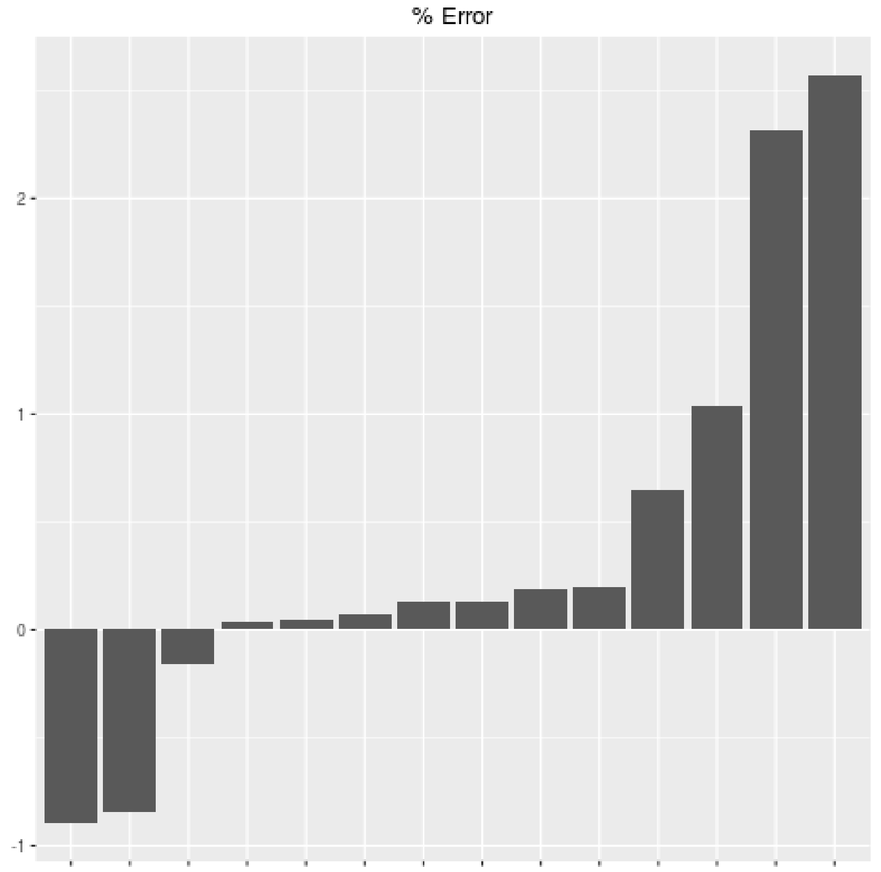
Risk proneness & loss tolerance based on investment behaviour

	Risk proneness
	2.14
11	2.00
10	1.75
4	1.58
6	0.82
2	0.78
3	0.74
5	0.69
13	0.59
12	0.48
9	0.32
1	0.09
7	0.09
8	

	Loss tolerance
	19.57
11	13.57
4	12.71
10	11.82
6	8.59
3	8.41
5	7.72
2	5.81
13	5.66
12	4.10
9	3.12
1	0.81
7	0.81
8	

Optimism / pessimism bias based on predictions and actual prices (1 month prediction)

Pessimism bias

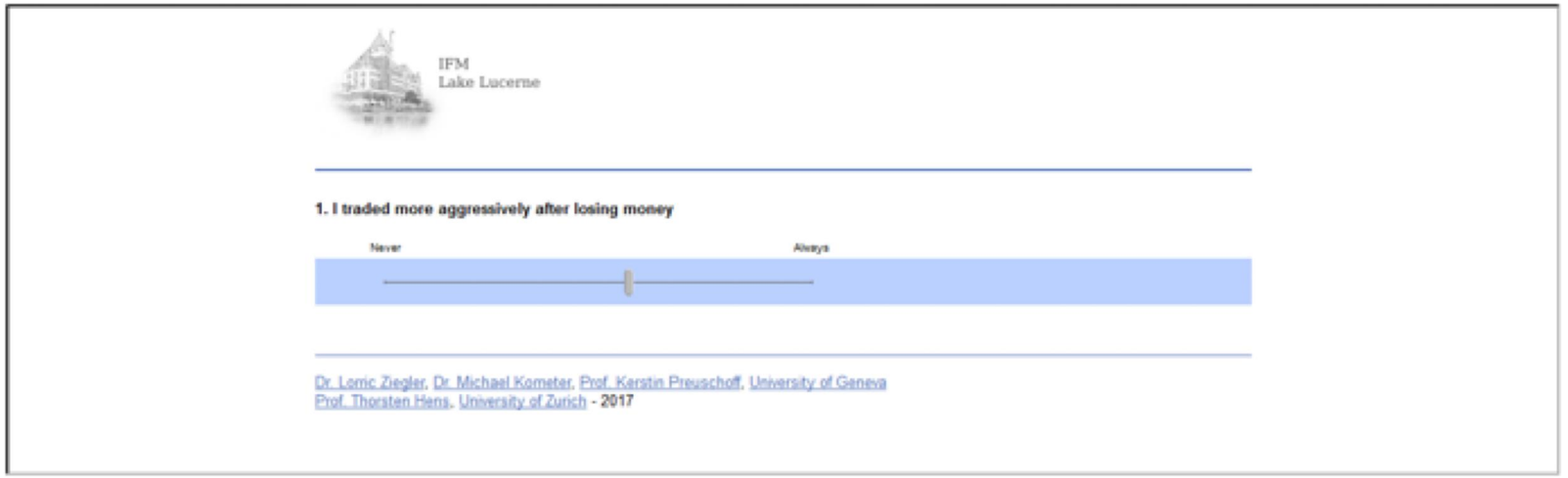


Optimism bias

Trader Insight Questionnaire (TRIQ)

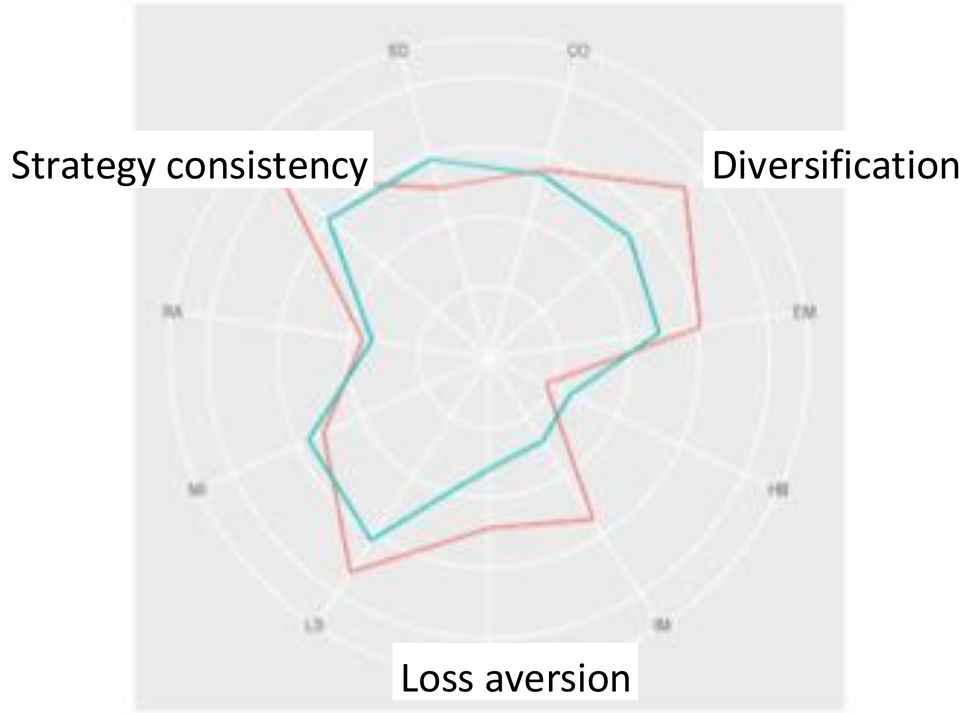
- 61 questions regarding trading behavior/psychology, 5 questions regarding strategy, 7 questions regarding demographics

- Investors on a social trading platform



Individual investor profiles

- Investment strategies.
- Psychological traits.
- Behavioral biases.
- Portfolio performance.



What we’ve learned

The evolutionary mismatch

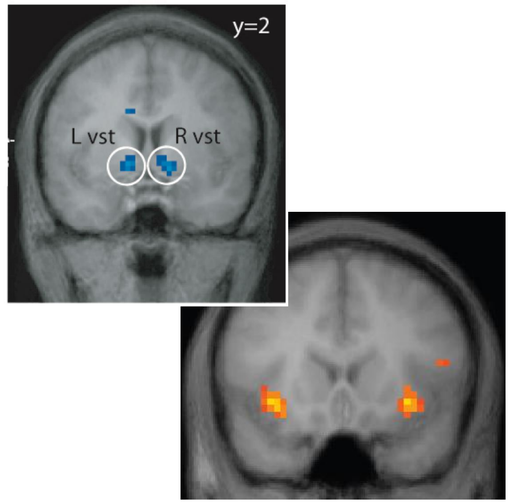
- Human brains evolved for survival in small groups, not for modern financial markets
- Our neural systems create systematic biases in risk perception and decision-making

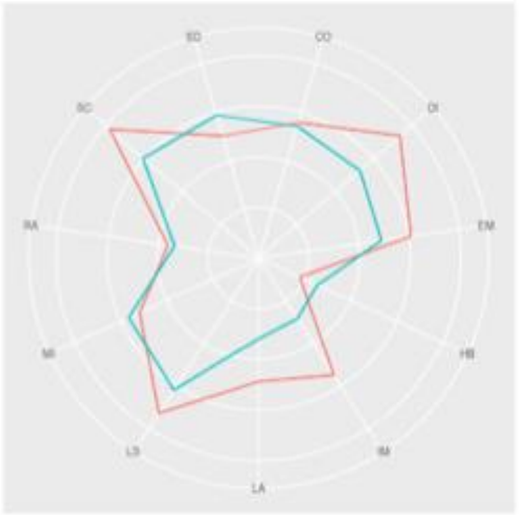
The Neural Foundations of Financial Decision-Making

- Expected reward and risk are processed in distinct brain regions
- Individual differences in neural responses predict trading behavior and performance
- Professional traders show enhanced interoceptive abilities but still exhibit cognitive biases fight-or-flight response poorly suited for complex financial decisions

From Lab to Markets: Real-World Validation

- Controlled experiments reveal how price information literally changes taste perception
- Professional portfolio managers display measurable behavioral/cognitive biases
- Social trading platforms enable large-scale behavioral profiling and personalization





Outlook: The Future of Neurofinance

Personalized Investment Solutions

- Neural and behavioral profiling to match investors with suitable strategies
- AI-driven portfolio optimization incorporating individual cognitive biases
- Real-time emotion and stress monitoring for trading decision support

Market-Level Applications

- Better models of market volatility incorporating collective psychological states
- Improved risk management through understanding of behavioral cascades
- Policy interventions informed by neuroscientific insights

Technological Integration

- Wearable devices tracking physiological responses during financial decisions
- Brain-computer interfaces for enhanced decision-making support
- Machine learning algorithms that adapt to individual neural patterns

Challenges Ahead

- Ethical considerations around neural privacy and manipulation
- Regulatory frameworks for neurotechnology in finance
- Bridging the gap between laboratory findings and market complexity

learning
prediction
risk
neural
brain
reward
value
different
information
decisions
perceptual
task
variance
action
expected
emotions
values
results
goods
show
visual
decision
uncertainty
performance
video
subjects
economic
game
markets
decision-making
individual
behaviors
new
activation
consumption
role
energy
theory
agents
behavior
training
evidence
playing
imaging
computations
repurchase
Bayesian
effect
volatility
error
also
mechanisms
encodes
choose
model
use
guide
system
VGP
outline
additional
improved
area
NVGP
rates
understanding
counterfactual
expectation
neuroeconomic
signal
cognitive
learn
human
finance
experience
energy-related
errors
high
probabilistic
encoding
Human
categories
computation
Action
stocks
previously
cortex
organisms
firing
hypothesis
reinforcement
less
biased
compared
noise
processes
stochastic
consistent
correlates
Risk
idiosyncratic
predicted
correlating
representations
gambling
stock
phase
predict
core
models
across
rate
improve
several
economy
sensory
underlying
appraisal
focus
sale
much
time
gone
response
TvC
standard
value-based
experiment
term
vmPFC
external
Neural
possibility
Using
blocks
NVGPs
functional
activations
may
investors
returns
research
correlated
previous
data
share