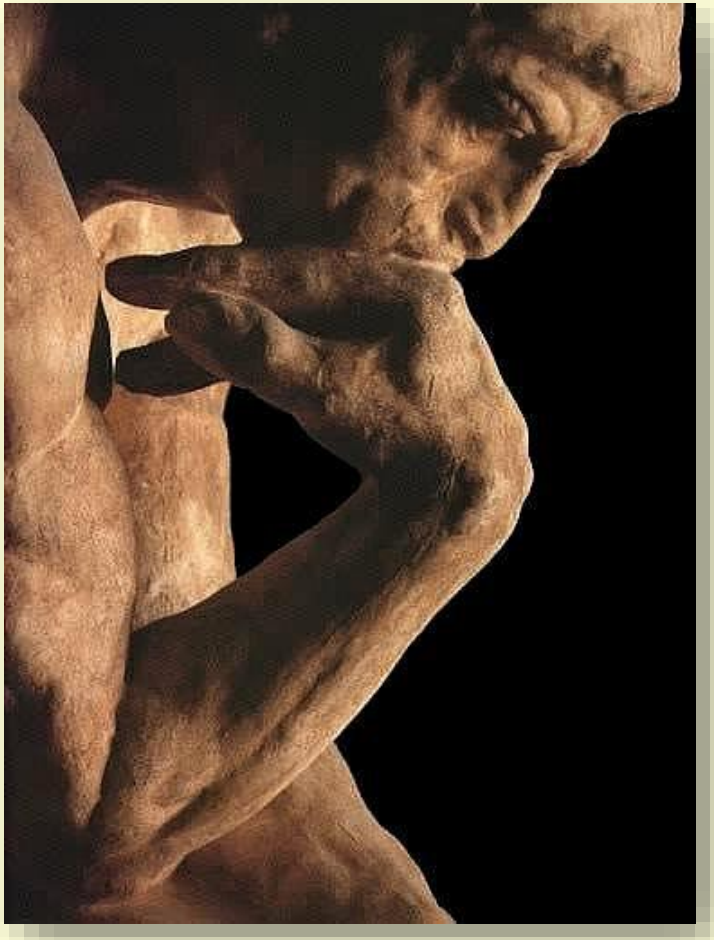
Using Neuroscience to Understand Decision Making

Scott Huettel

Duke University

Rational Choice Models

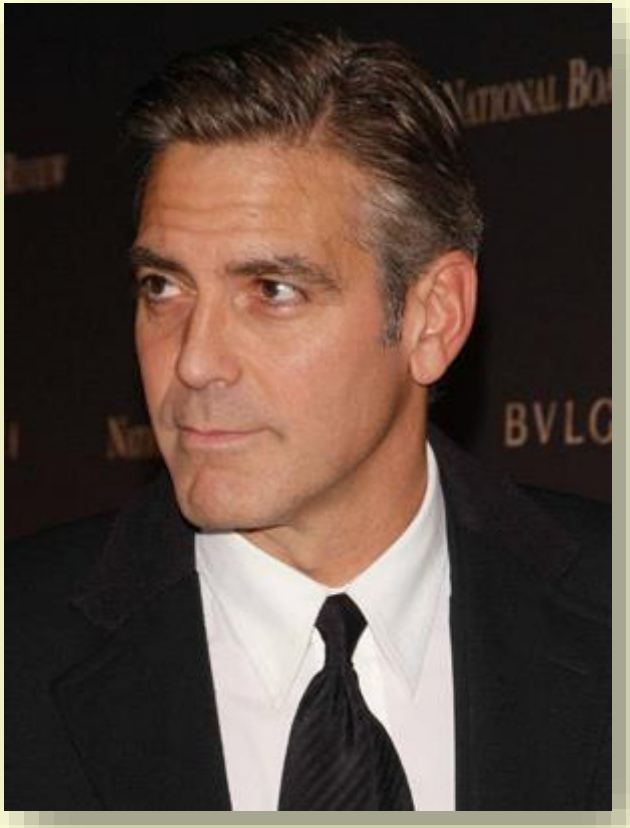


***Homo Economicus*.**

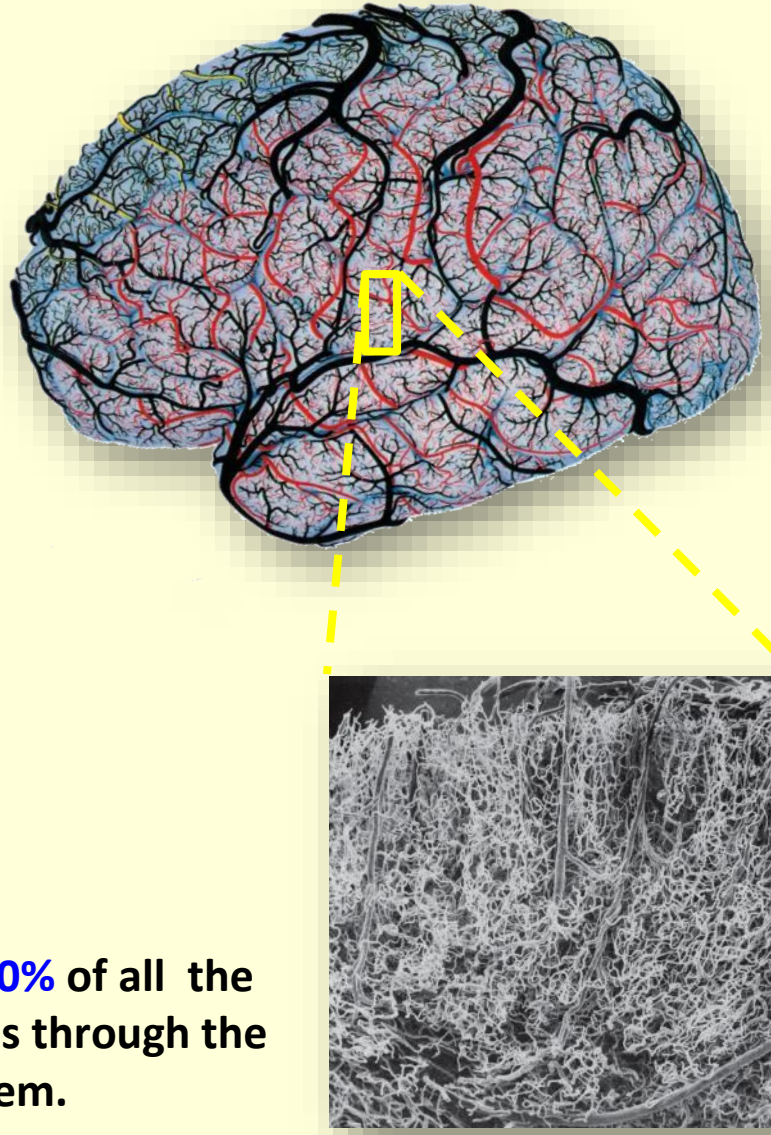
Decisions are rational, self-interested, foresighted, and emotionless.

Decisions involve tradeoffs between different *decision variables*, each exerting *weight* on the choice.

For a typical 5’11”, 200 lb male adult…



… the brain weighs only about 4 lbs (2% of body)…



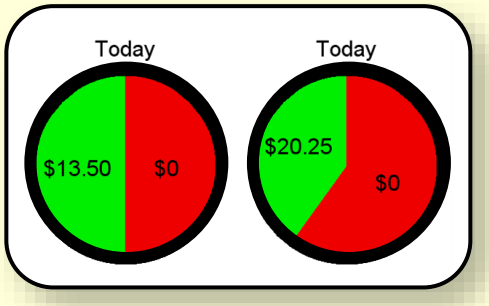
… but takes in about 20% of all the body’s energy resources through the vascular system.

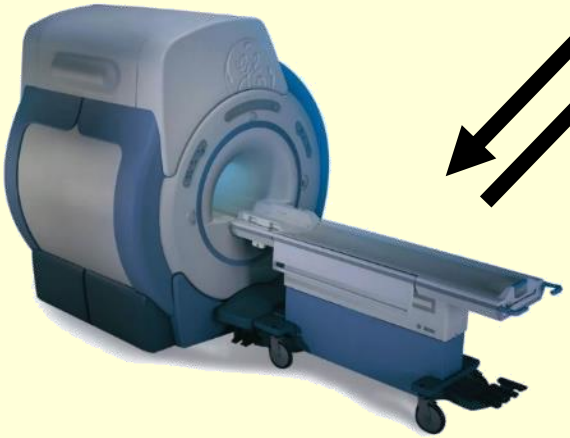
Our brains are not optimizers.

They are *simplifiers*…

… *predictors*…

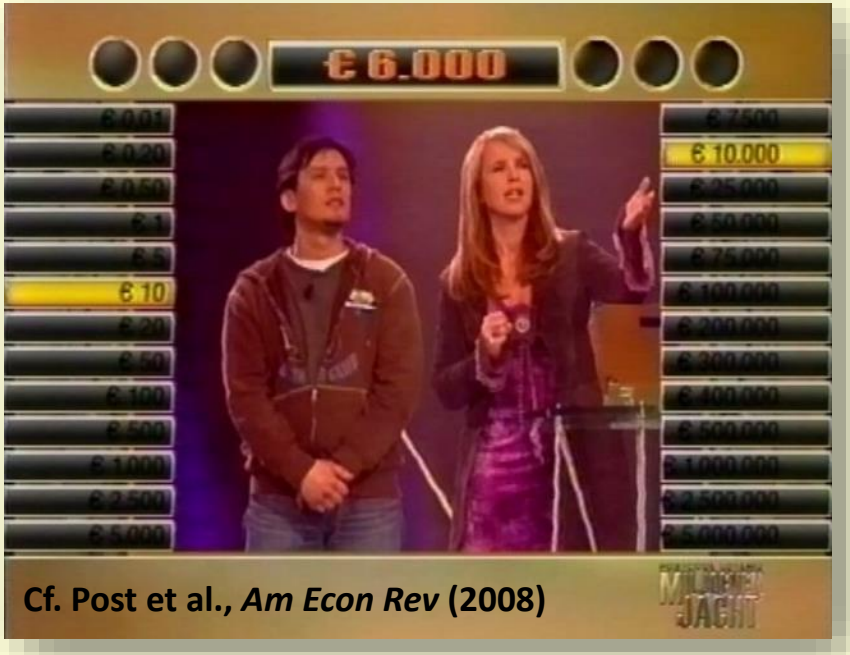
… and *strategists*.





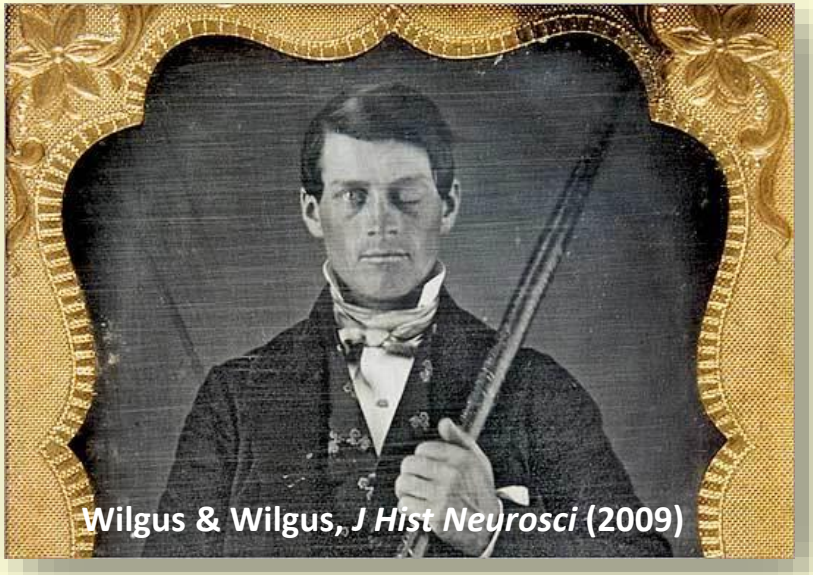
Modeling

Interventions



"Should I play it safe or gamble?"

"Should I risk my life to save him?"



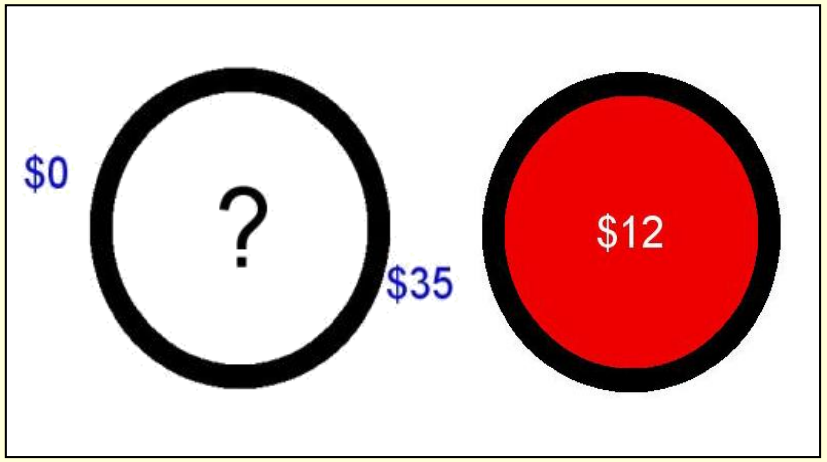
"How should I act if I want others to help me?"

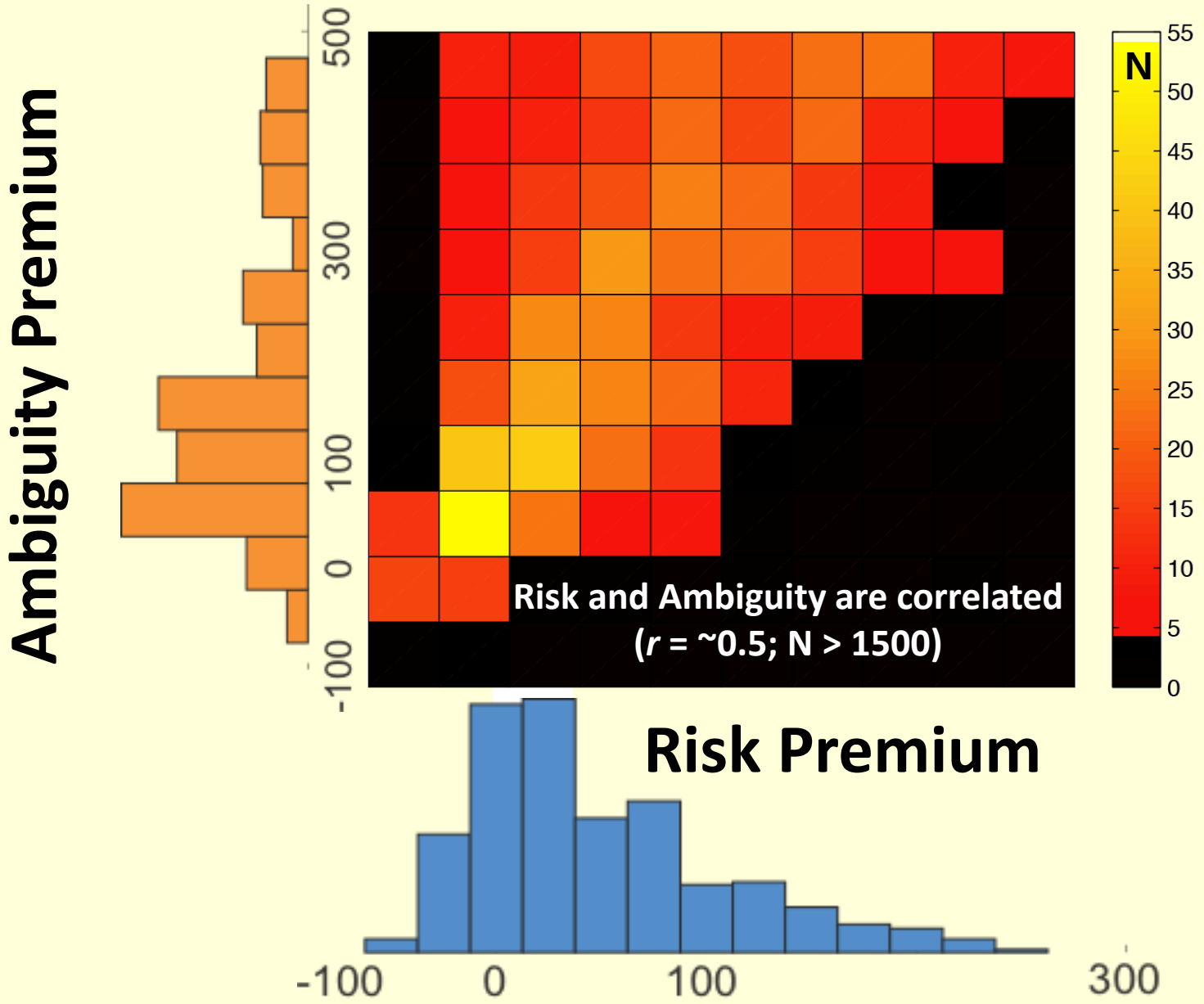
Risk and Ambiguity

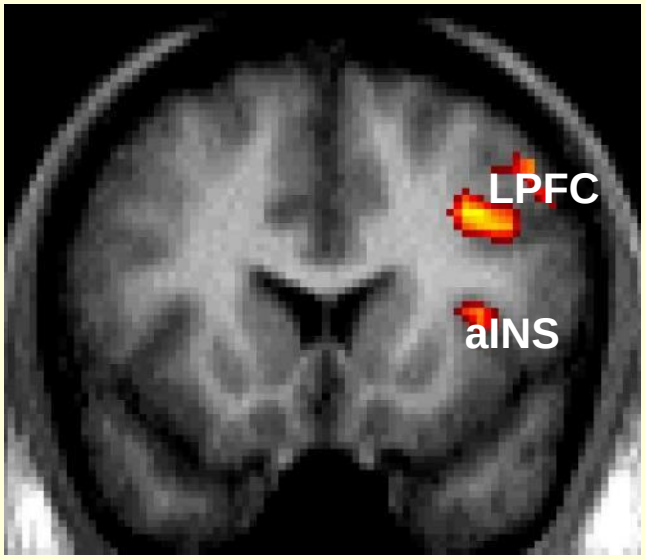
Scott Huettel, Duke University

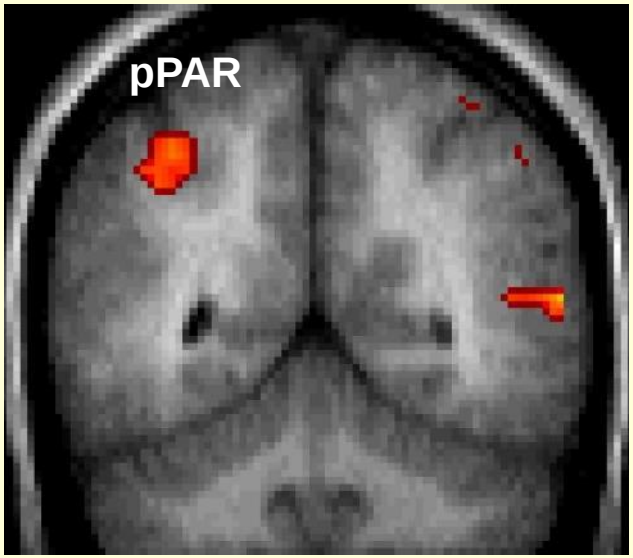
Risk:
Known Probabilities

Ambiguity:
Unknown Probabilities




Ambiguity Premium
500
300
100
0
-100
Risk and Ambiguity are correlated
(r = ~0.5; N > 1500)
N
55
50
45
40
35
30
25
20
15
10
5
0
Risk Premium
-100
0
100
300





Huettel et al. (2006, *Neuron*)

A specific set of brain regions are more engaged when decisions involve ambiguity as opposed to certainty or risk.

These include the lateral prefrontal cortex (LPFC), the anterior insula (aINS) and the posterior parietal cortex (pPAR)

What Shapes Risk Preferences?

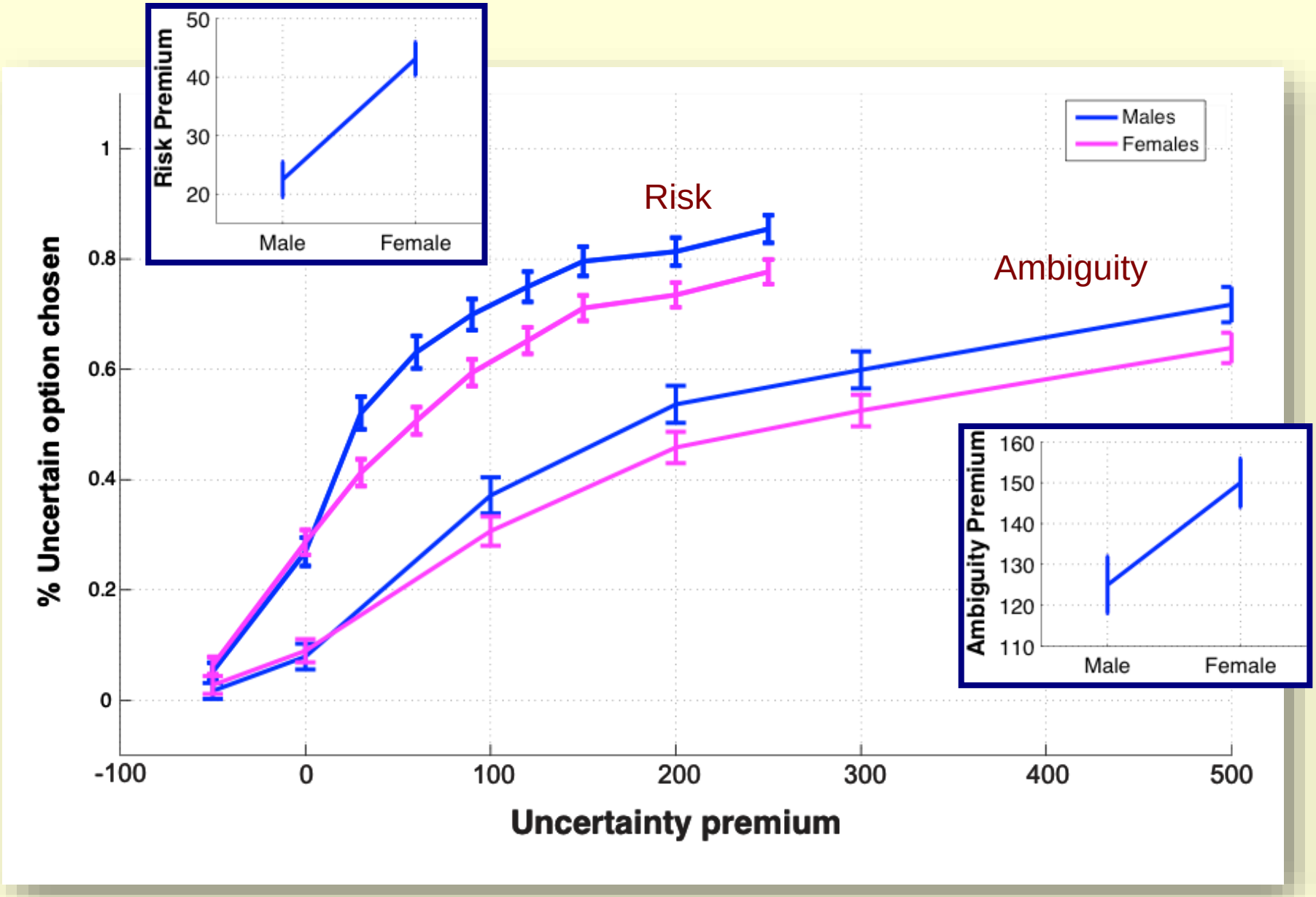
- Sex/Gender: Male vs. Female?
- Traits: General vs. Domain-Specific?
- Recent Sleep: Rest vs. Deprivation?
- Age: Younger vs. Older Adults?

Take-Home Message:
Risk preferences aren't fixed and immutable; people make different decisions in different contexts.

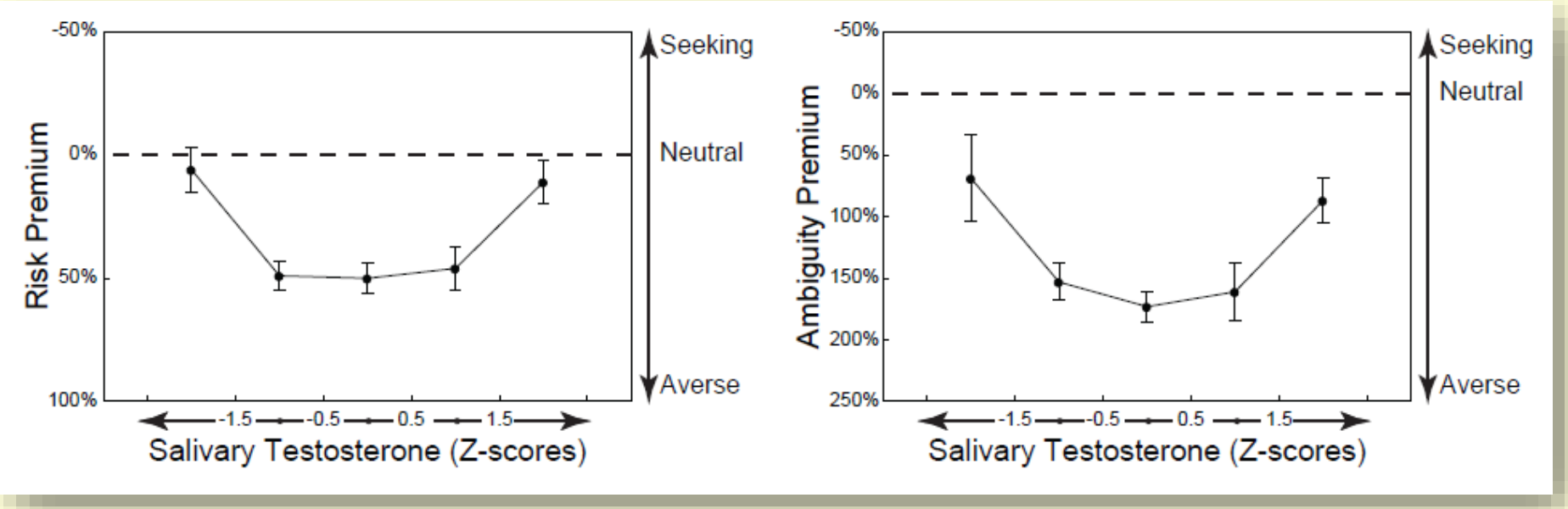
Stereotypically, men are risk seekers, possibly because of their high testosterone.

Stereotypically, women are risk avoiders.

What do the data say?


Risk Premium
50
40
30
20
Male
Female
Males
Females
Risk
Ambiguity
% Uncertain option chosen
1
0.8
0.6
0.4
0.2
0
-100
0
100
200
300
400
500
Uncertainty premium
Ambiguity Premium
160
150
140
130
120
110
Male
Female

We measured **salivary testosterone levels** in a sample of ~300 men and women.



Both high and **low** testosterone levels were associated with decreased uncertainty aversion.

Stanton et al. (2011, *Psychological Science*)

Some people are just “risk seekers” and others are just “risk avoiders”.

Right?

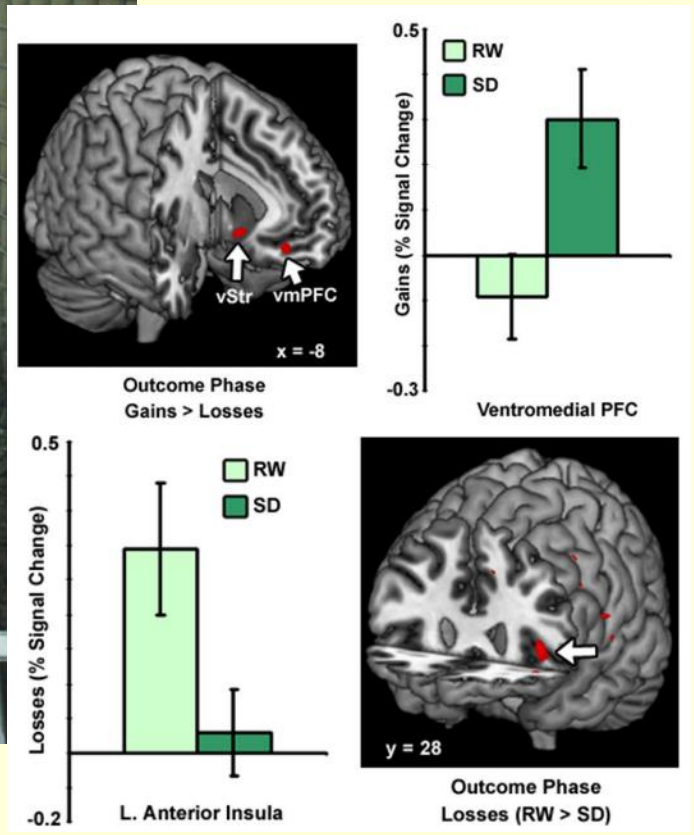
Different domains of risk preferences are largely uncorrelated.

Sleep deprivation is bad for decisions because it slows processing and diverts attention.

Right?

Sleep deprivation slows decision making. (1 night suffices)

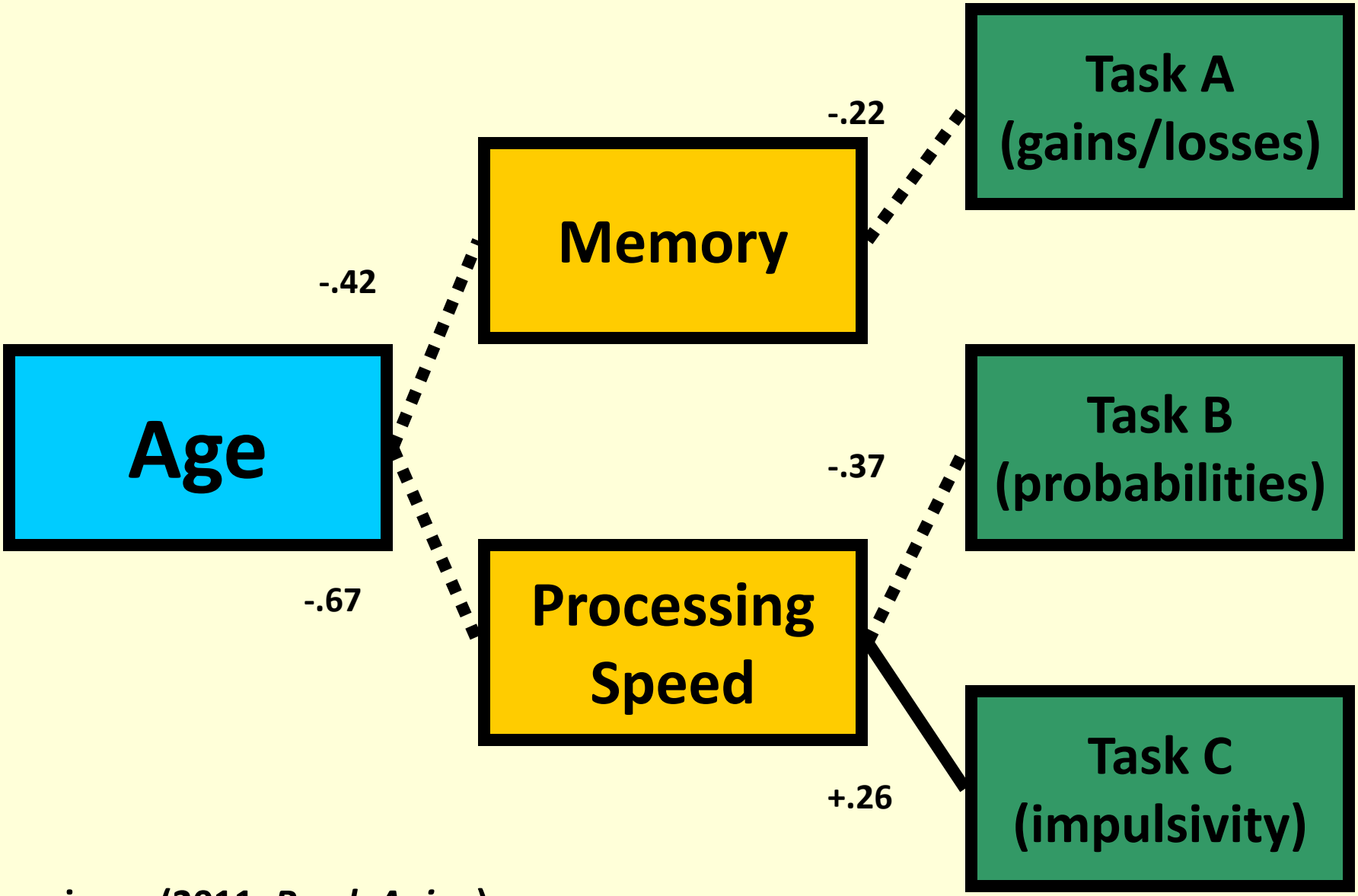
Sleep deprivation changes the processing of good/bad outcomes.



Venkatraman (2011, *J Neurosci*)

As people age, they move from being risk-seeking (in adolescence) to risk-neutral (in adulthood) to risk-averse (in older age).

Right?



Henninger (2011, *Psych Aging*)

What Shapes Risk Preferences?

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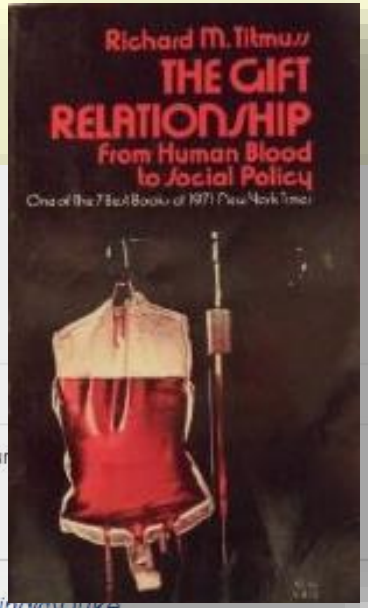
- Age: Younger vs. Older Adults?

Take-Home Message:
Risk preferences aren't fixed and immutable; people make different decisions in different contexts.

Social Decisions

Why should we care about *social* decisions?



Give Blood, Save Lives

Next Duke blood drive June 15

TOPICS FOR THIS STORY: NEWS RELEASES

June 9, 2010 | *Marsha Green*

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ARTICLE

Editor's Note: *This article originally appeared in Working@Duke.*

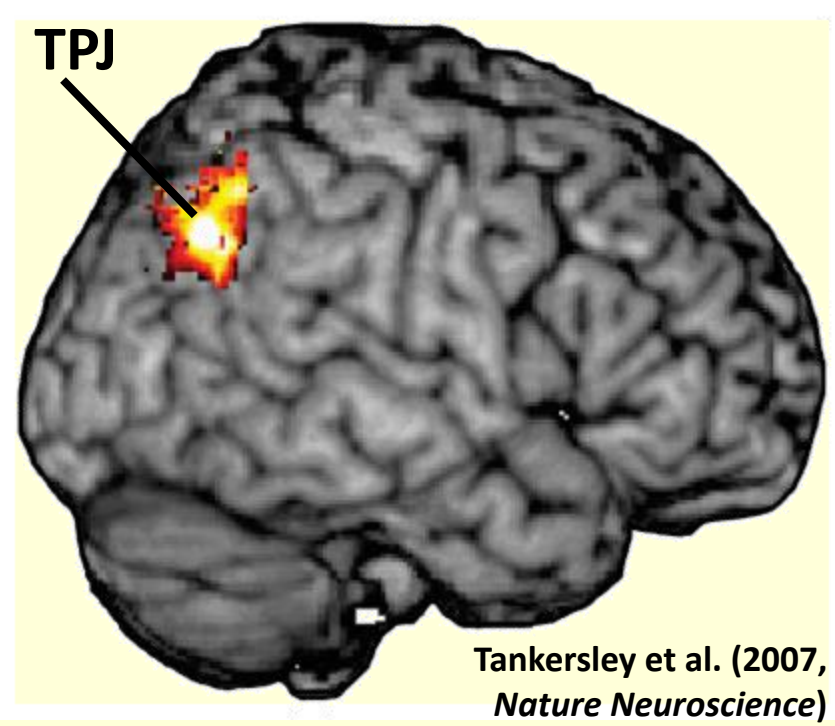
Durham Regional medical technologist David Clapp has a goal of donating blood 100 times.

David Clapp settled into a reclining chair with a crossword puzzle in his left hand and his sleeve rolled up to reveal veins in his right arm.

"I've given blood close to 90 times," said Clapp, a medical technologist II at Durham Regional Hospital.

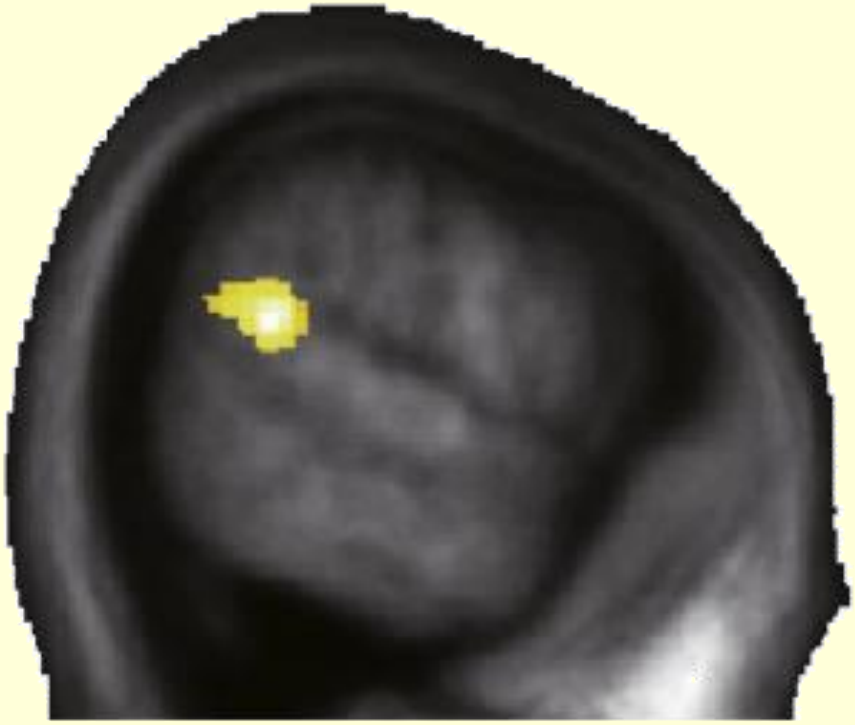
"It's easy."

Are social decisions *special*?



Tankersley et al. (2007, *Nature Neuroscience*)

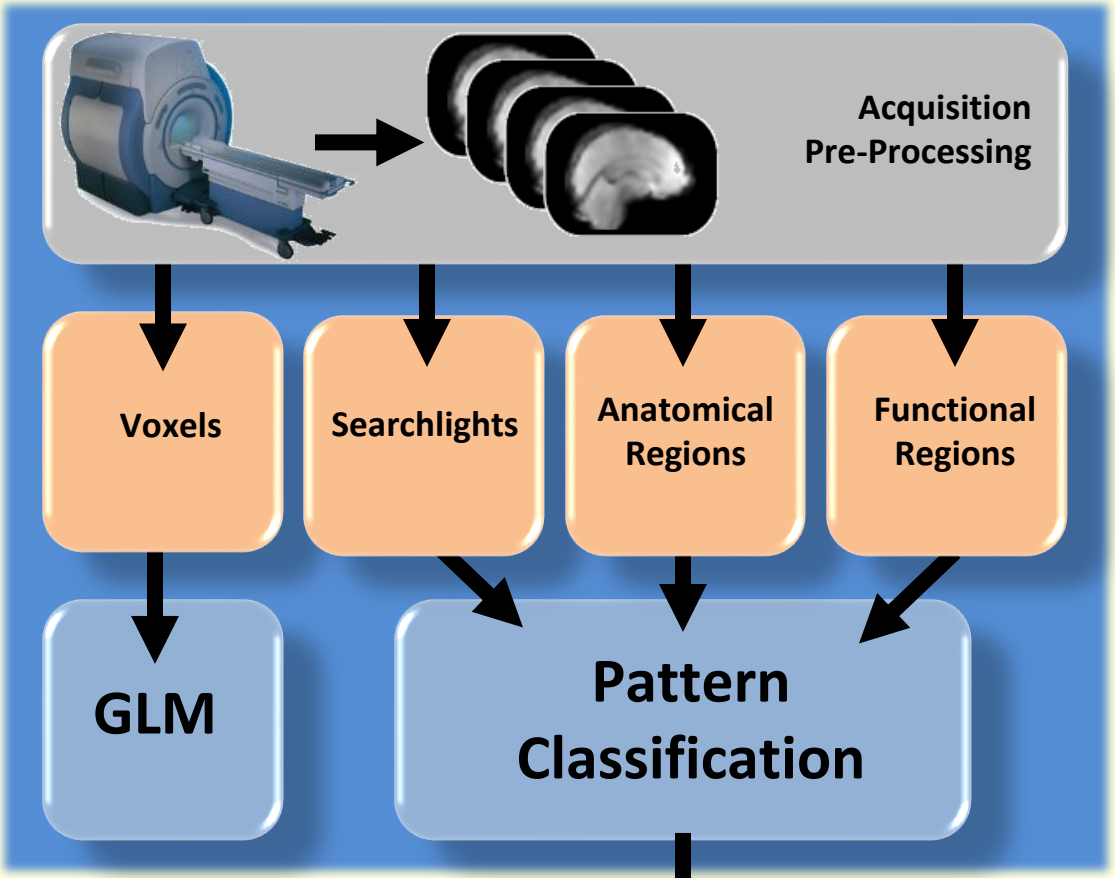
Activation in TPJ is associated with detecting another's actions predicts self-reported altruism.



Morishima et al. (2012, *Neuron*)

Gray matter volume in TPJ is associated with altruistic actions in economic games, when one faces advantageous inequality.

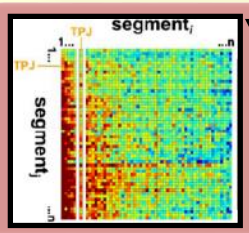
How can we identify brain processing that is *specific* to social decision making?



Data Collection

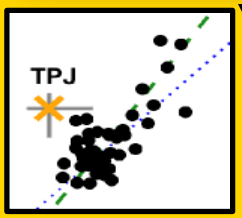
Feature Selection

Condition Contrasts



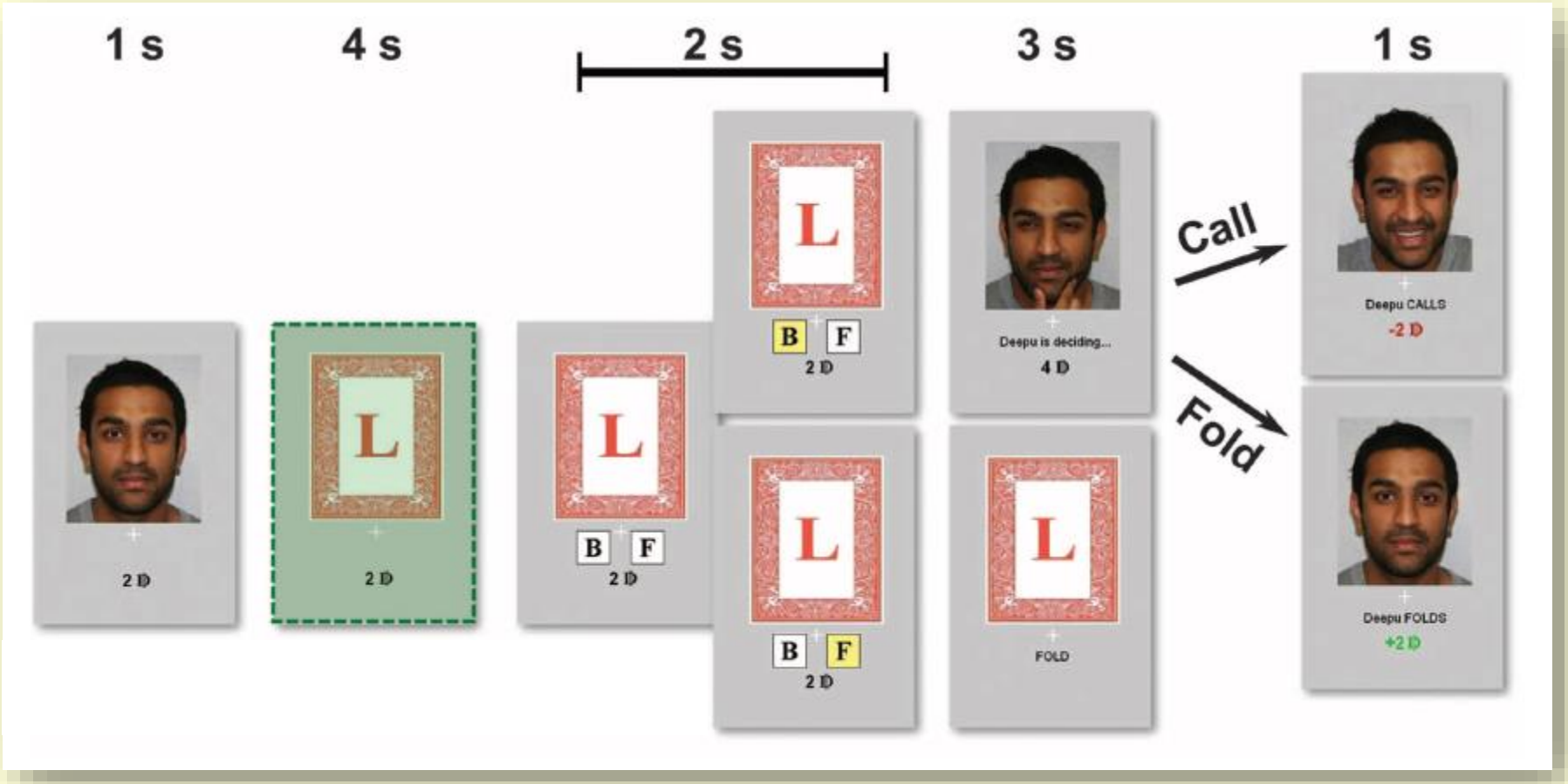
Combinatoric Analyses

Independent Information



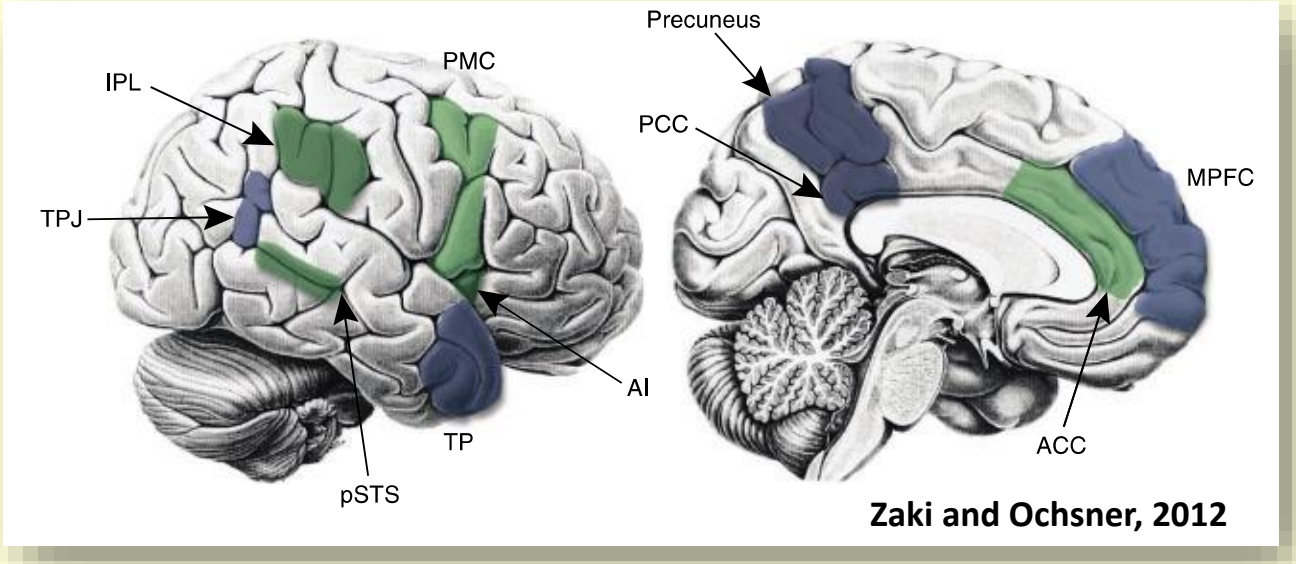
Distributional Analyses

Functional Specificity

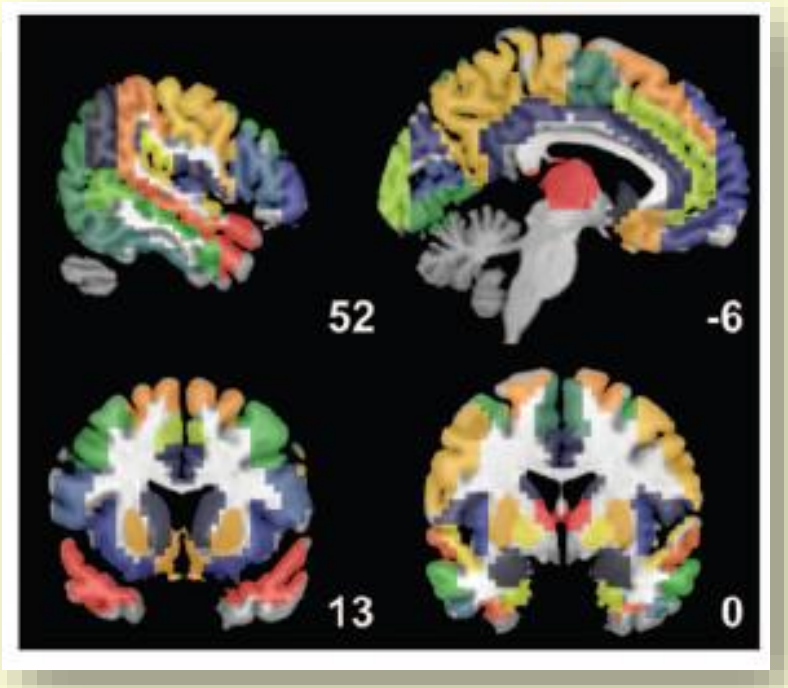


Carter et al. (2012, *Science*)

There are specific regions associated with the "social network"…



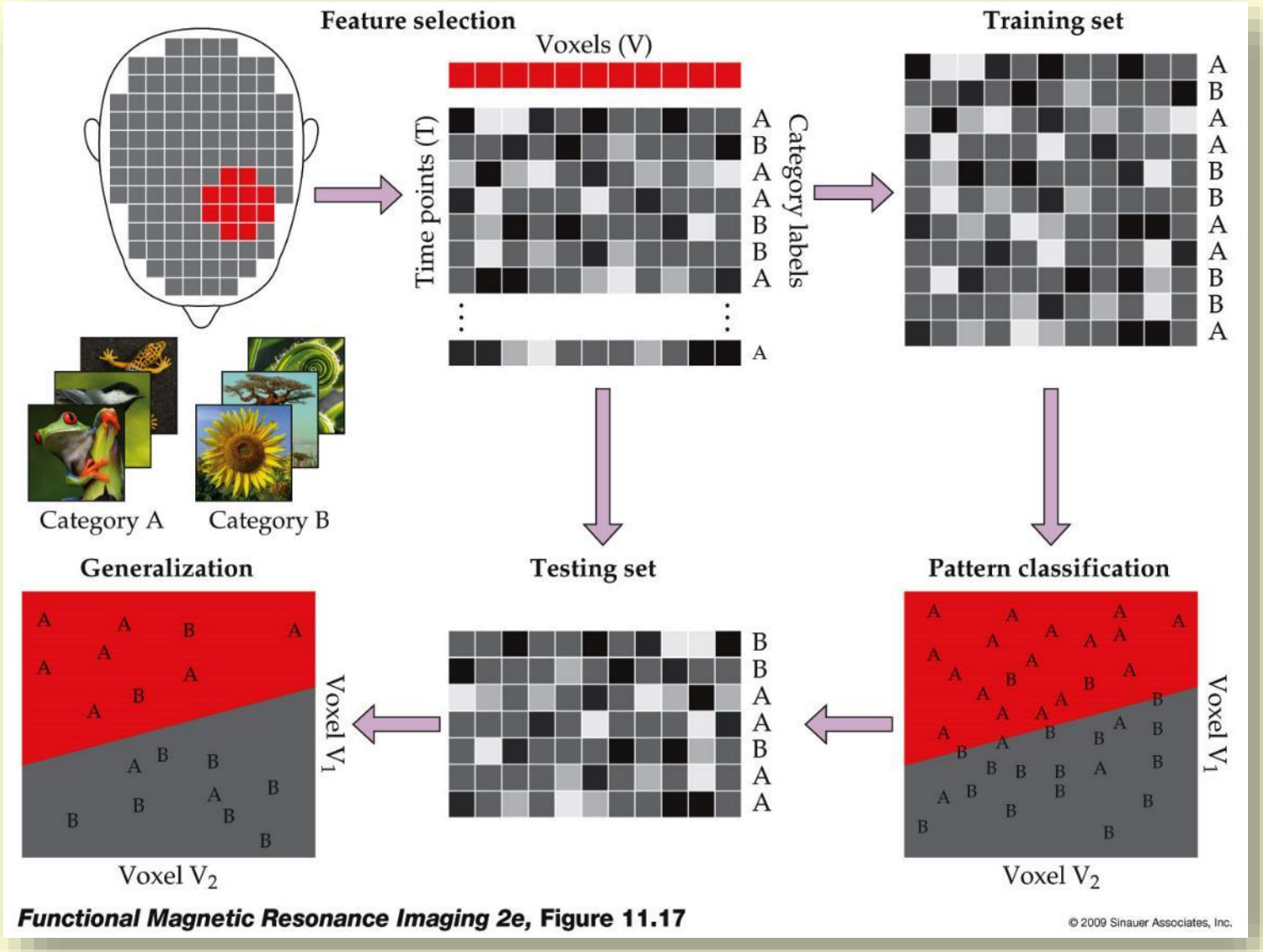
Zaki and Ochsner, 2012

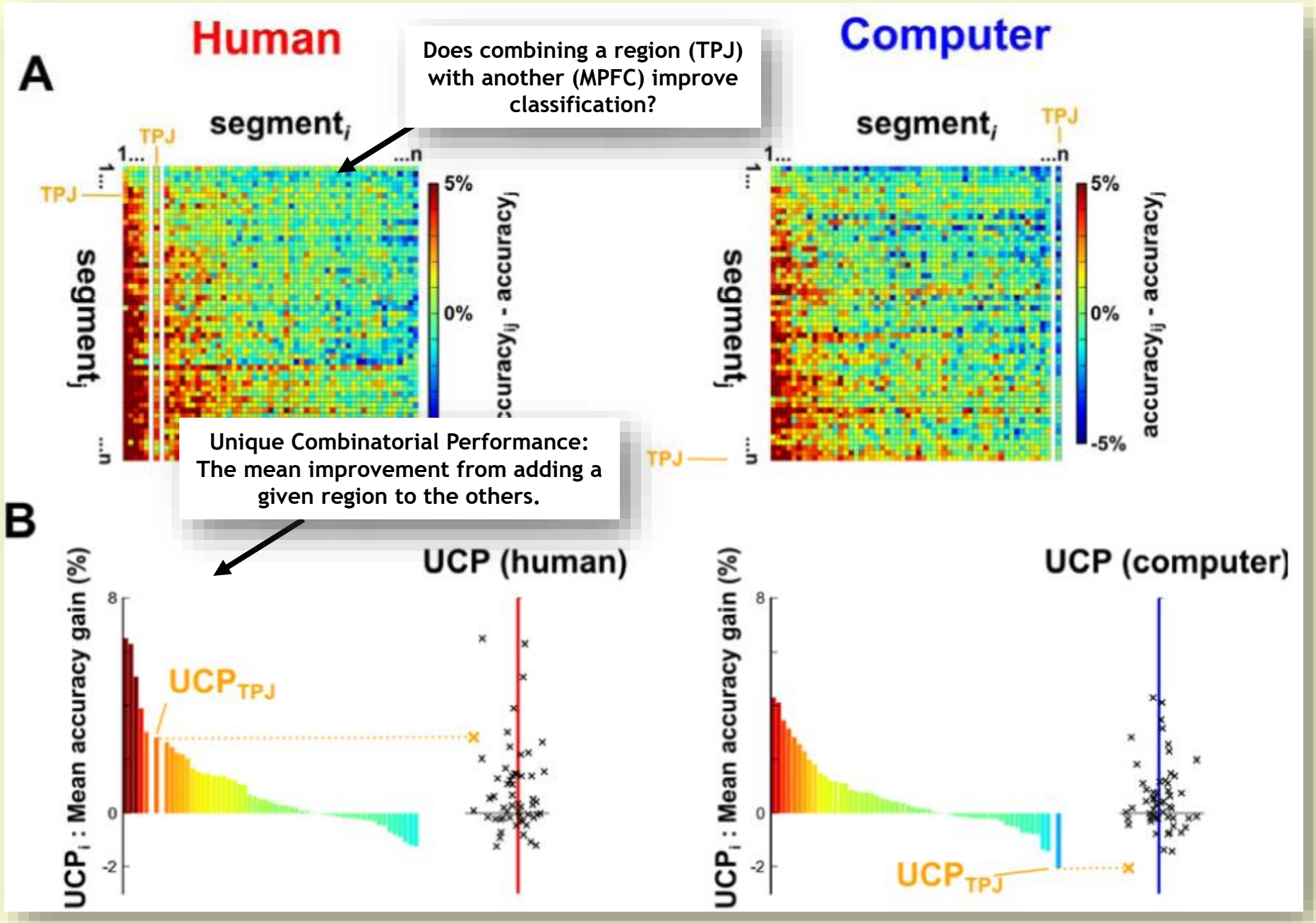


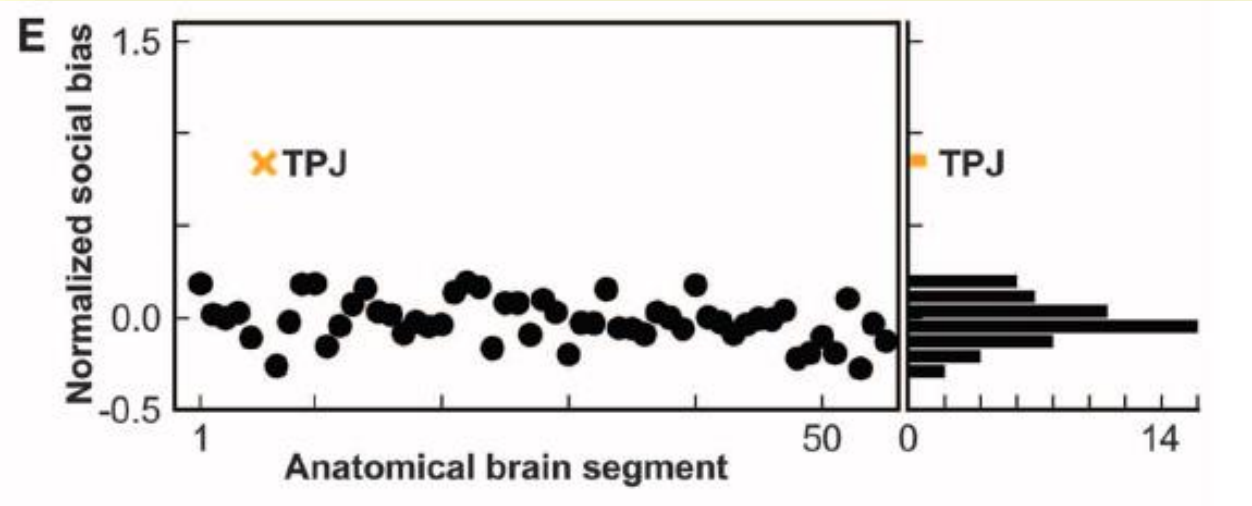
The brain was partitioned into separate regions, so that those regions' independent contributions could be identified.

See also Clithero et al. (2011A, 2011B, *NeuroImage*)

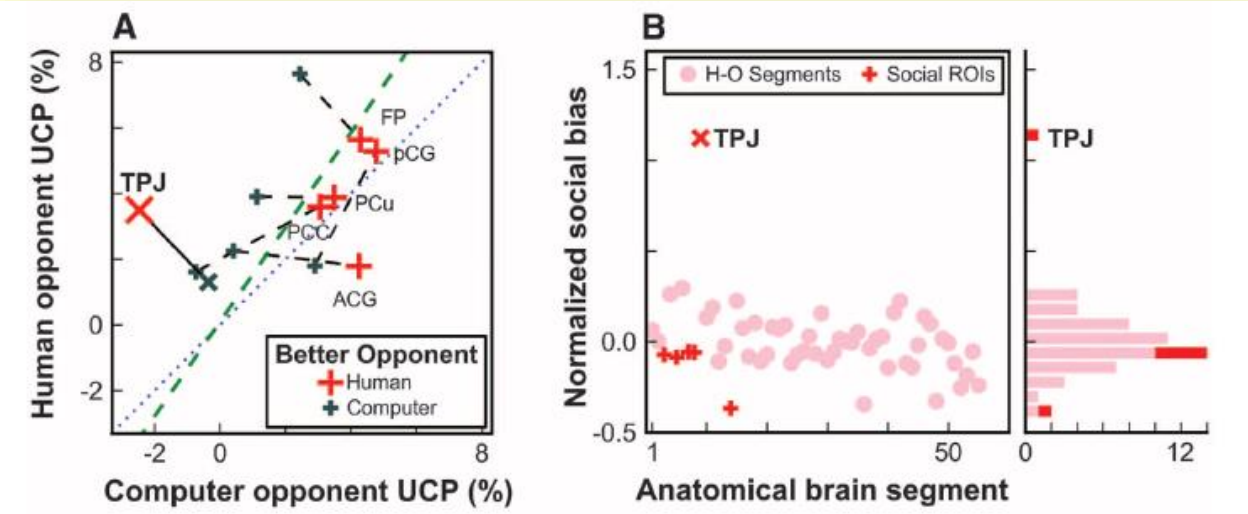
Multi-Voxel Pattern Analysis




A
Human
Computer
Does combining a region (TPJ) with another (MPFC) improve classification?
segment$_i$
segment$_j$
TPJ
1...
...n
5%
0%
-5%
accuracy$_{ij}$ - accuracy$_j$
Unique Combinatorial Performance: The mean improvement from adding a given region to the others.
B
UCP (human)
UCP (computer)
UCP$_i$: Mean accuracy gain (%)
UCP$_{TPJ}$
8
0
-2



Strong selectivity of the TPJ across the set of participants…



… but the effect was present selectively in those participants who thought that the human was a better opponent.

Take-Home Messages:

When people enter a *social* setting, the processes of decision making change.

People start tracking a different *currency*.

Two Currencies (to Track)

Rewards (Economic/Extrinsic)

Reputations (Social/Intrinsic)

@ SMA webinar

Scott Huettel, Duke

Neuroscience can inspire behavioral interventions.

Members of one social group helping someone outside their group.

Members of one social group harming someone outside their group.

(lovable lil' scamps!)

The Dictator Game

You*

Recipient

$20 → **$0**

*may not actually be you.

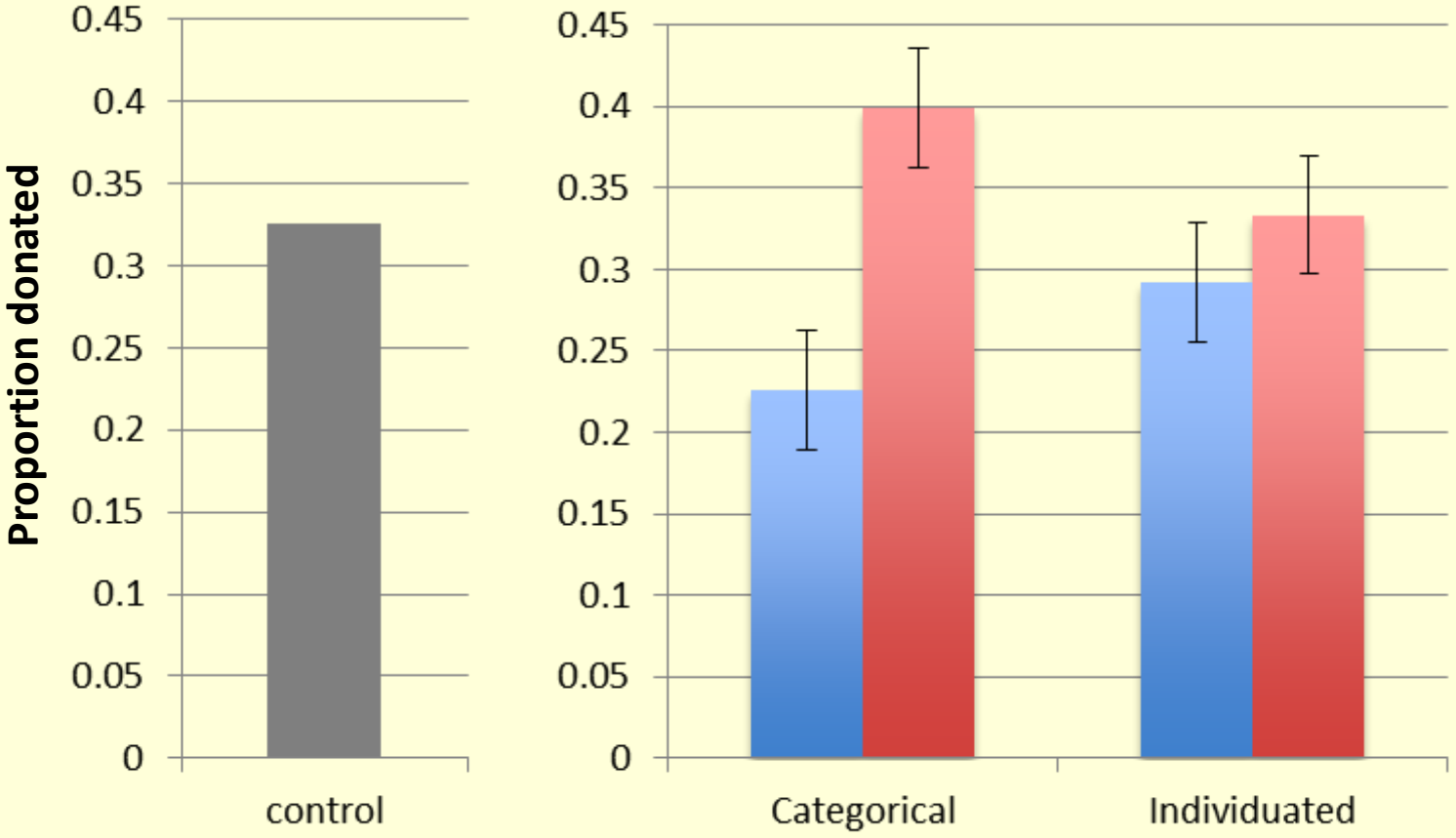
Lee, Kranton, Huettel (in prep)

	Ingroup	Outgroup
Categorical	You have 100 points Group: own I think gay marriage should be legally recognized	You have 100 points Group: other I think gay marriage should not be recognized
Individuated	You have 100 points Group: own When I was little I wanted to be a teacher	You have 100 points Group: other When I was little I wanted to be an astronaut

Political Group

within-subjects, order counterbalanced

Minimal Group



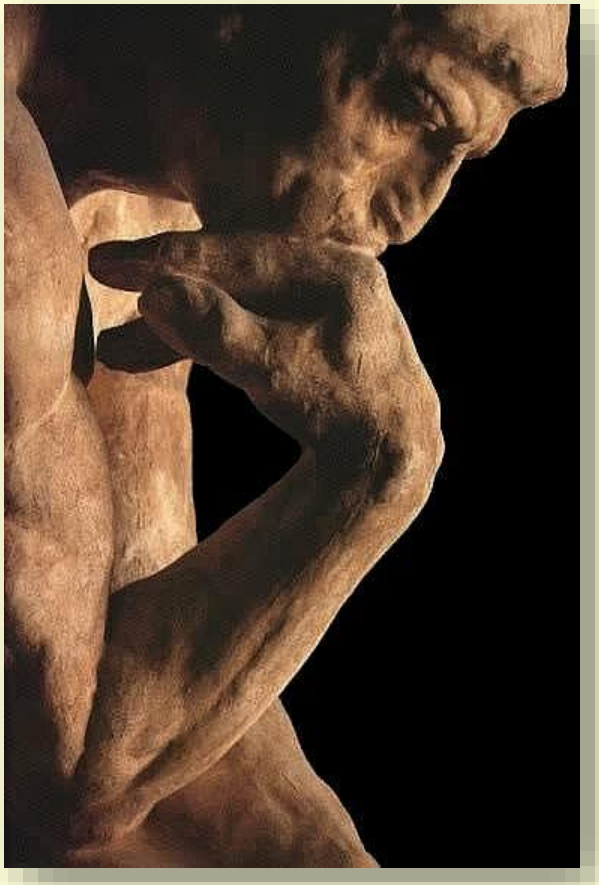
Interaction: $F(1, 75) = 35.63$, $p < 10^{-7}$

(N = 76; all results fully replicated in second experiment w/N=75)

(effect holds for minimal groups; $p < 10^{-5}$)

Individuation humanizes.
We see an individual.
We learn how they are like us.
Prosociality increases.

Individuation humanizes.
We see an individual.
We learn how they are not like us.
Prosociality decreases.



***Homo Economicus*. Decisions are rational, self-interested, foresighted, and emotionless.**

***Adaptive Flexibility*. Decisions result from interactions of a wide range of brain systems, each supporting a different sort of process.**