RISK

Using games to study human behavior

9:00 to 11:15

Who we are

Kelsey

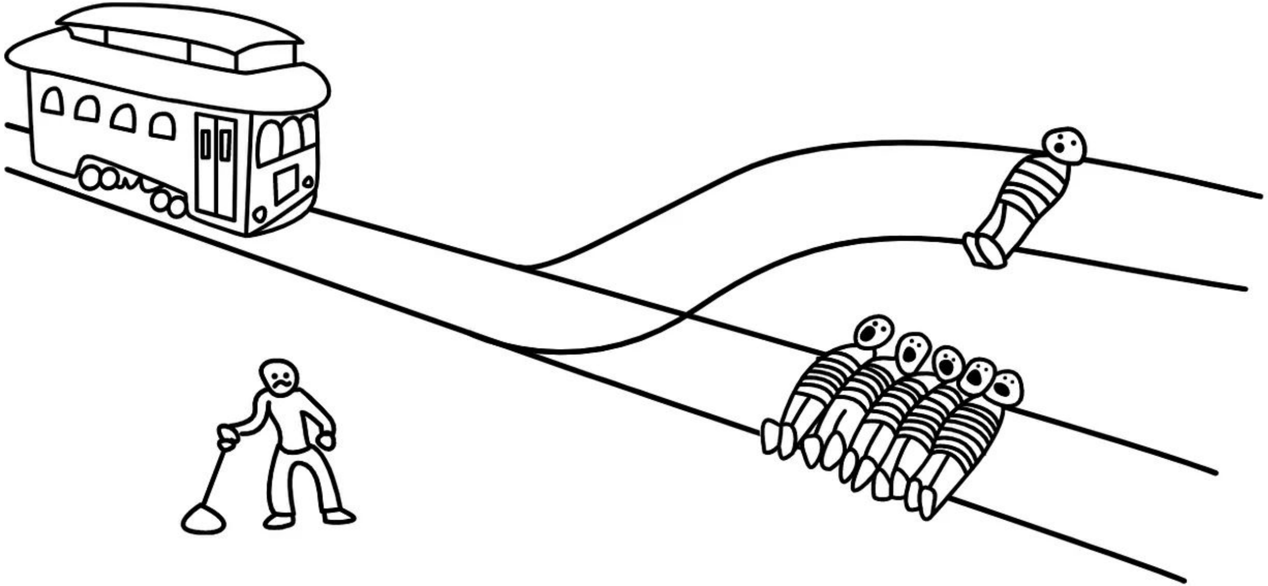
- Graduate student at Virginia Tech
- Studies PTSD and decision-making
- Likes game theory and computer science
- Good at the application side of things, not great at the theory behind it.

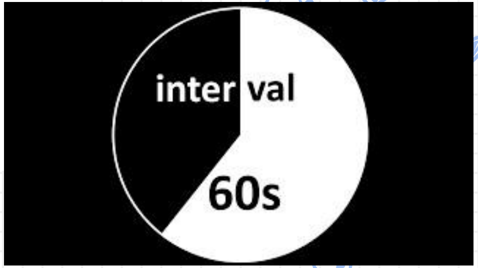
Zach

- Math professor at Smith College
- Does research in knot theory and topology
- Also likes game theory and computer science
- Good at the theory behind these things, not as familiar with the applications.

The trolley problem: What should you do?

Talk to the person next to you.





Why do people make certain decisions?

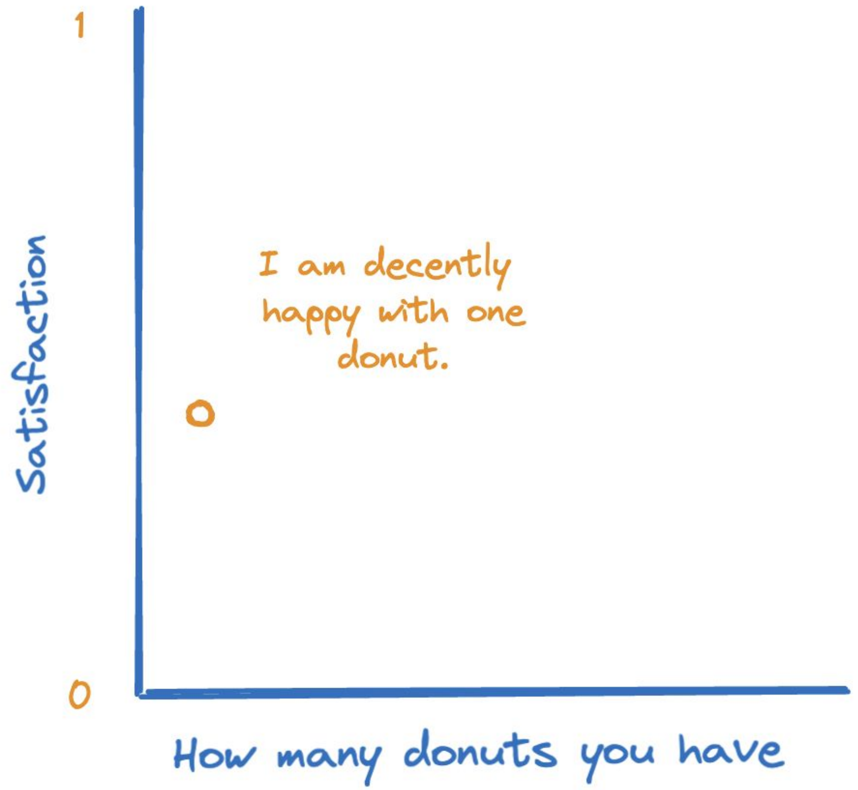
- The average person makes 35,000 decisions per day
- How do you know what choices someone is going to make?
- We can use games, math modeling, and brain imaging to learn about how people make decisions.

How can you use games and math to study decisions?

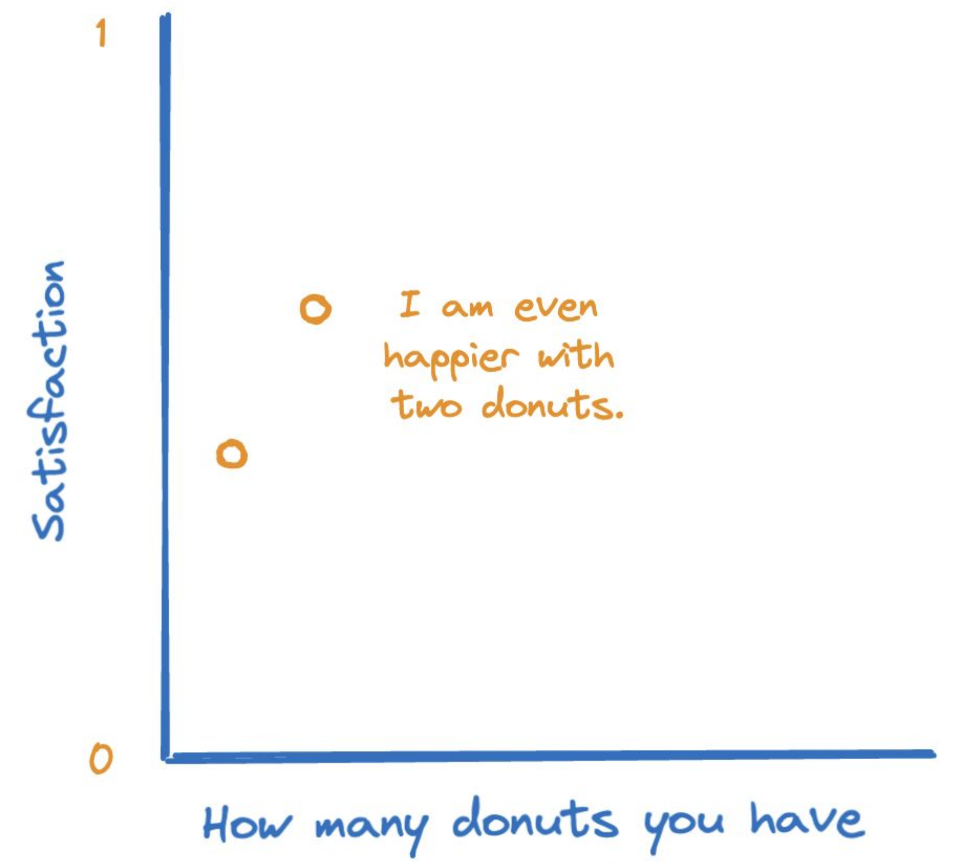
In economics, you can predict the decisions someone is going to make using information about the situation.

Ex: how much money would you pay for one donut?

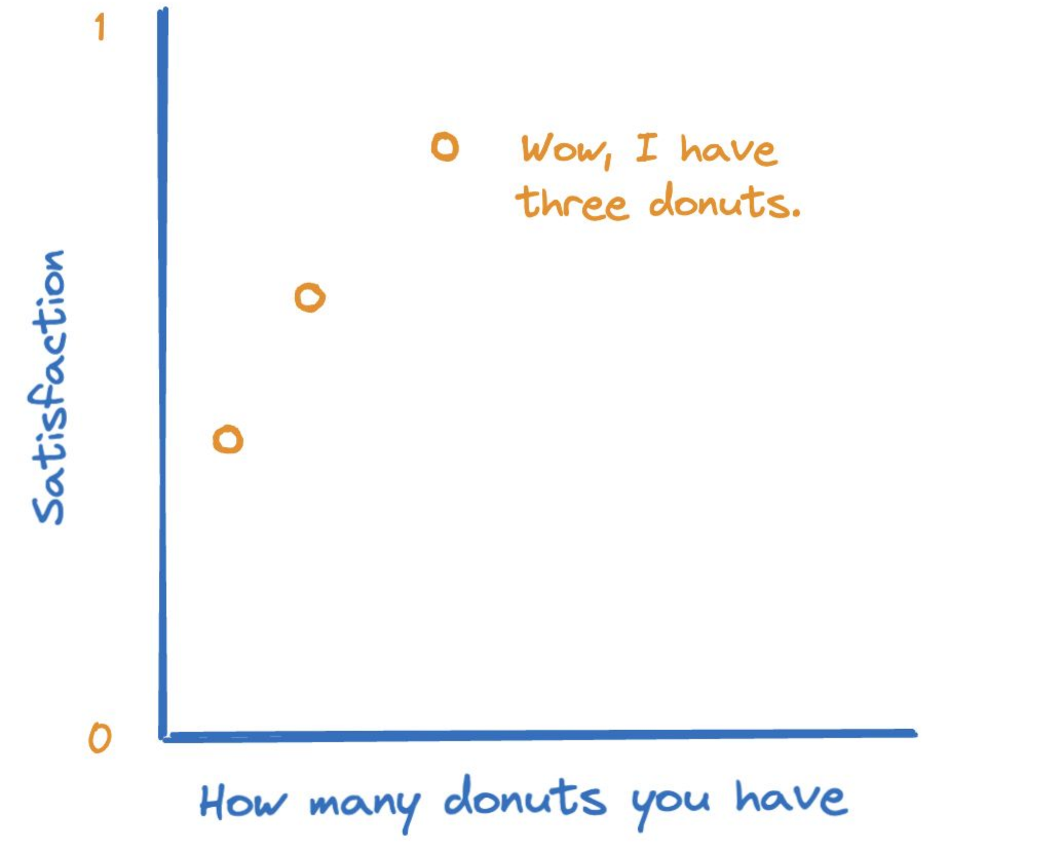
Utility: How much something is worth to *you.*



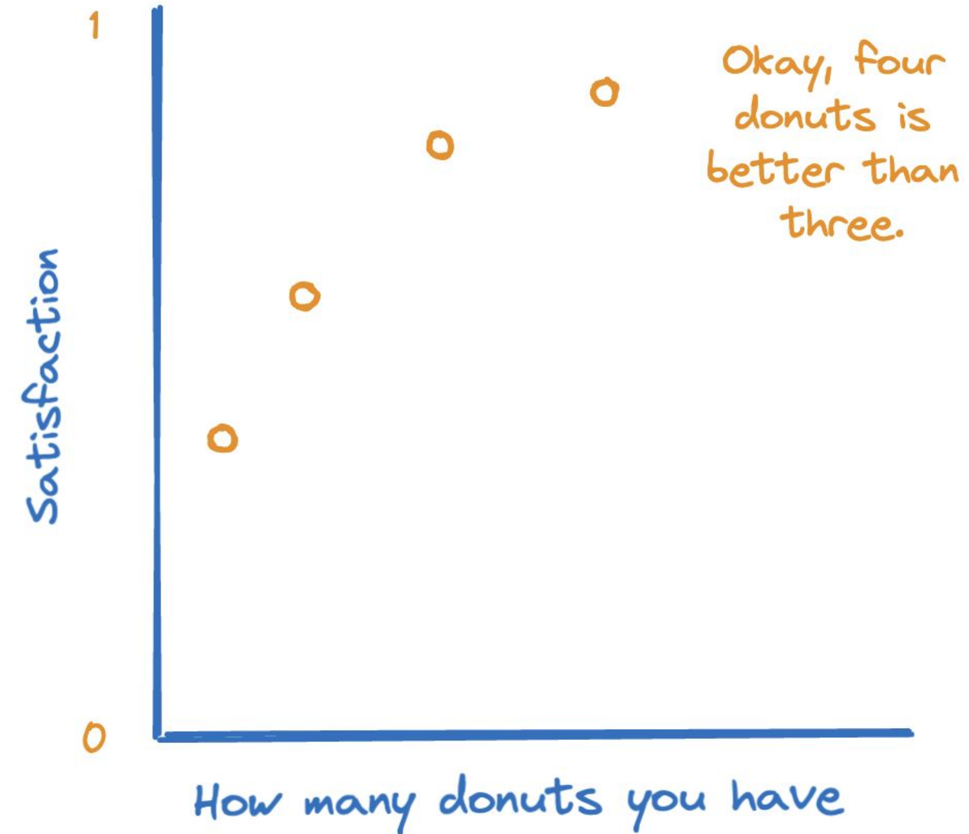
Utility: How much something is worth to *you.*



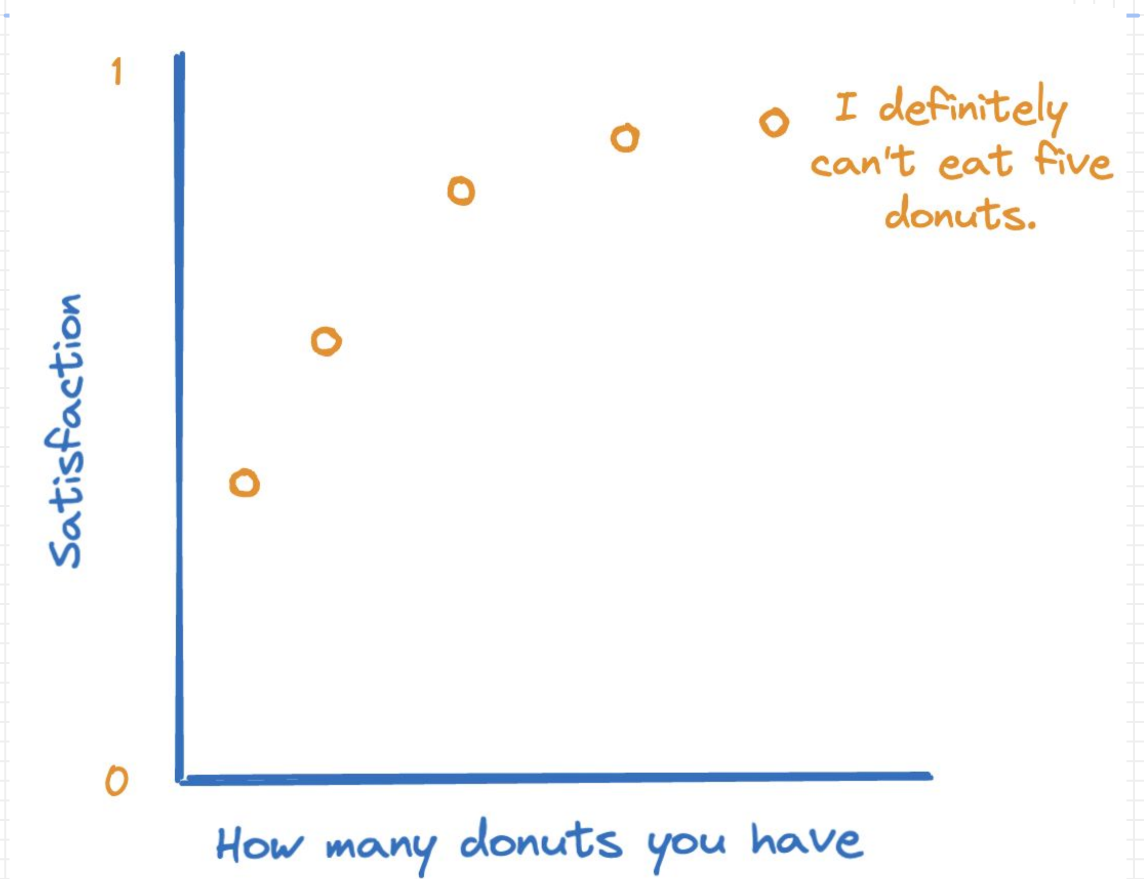
Utility: How much something is worth to *you.*



Utility: How much something is worth to *you*.

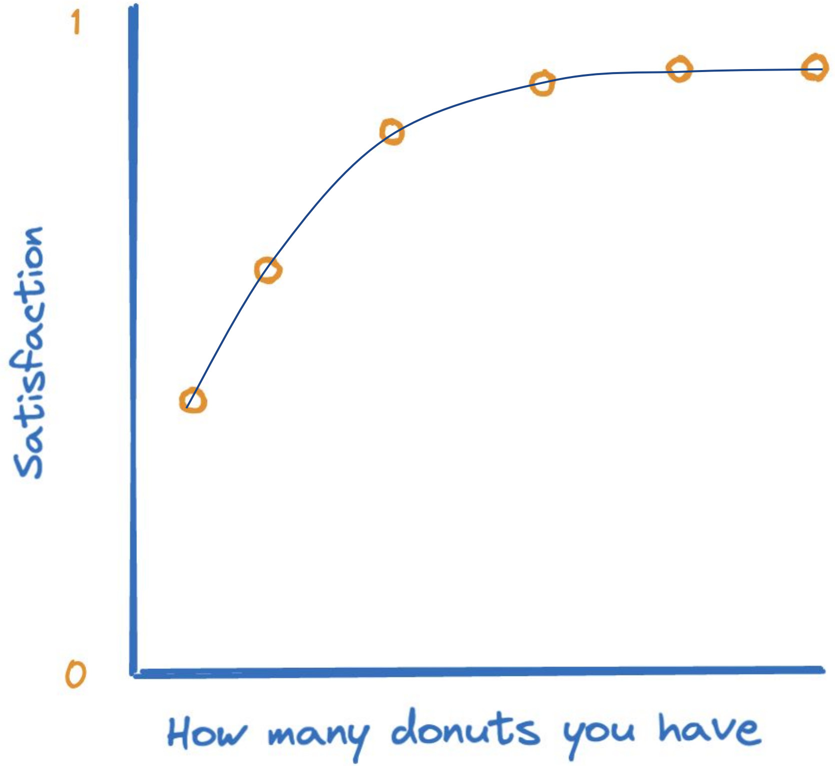


Utility: How much something is worth to *you.*



Utility: How much something is worth to *you.*

Utility function: An equation that approximates how much something is worth to *you.*



This curve is kinda like the square root function

$$y = x^{\frac{1}{2}}$$

The exact equation isn't really important. Some scientists use a sigmoid (S-shaped) function instead!

Next, we're going to play a game.

While you're playing, consider the relationship between your score and your willingness to "roll" again. How does the utility of "rolling" change? What affects your willingness to roll/not roll again?

How to play: Pass the Pigs

- Get into a group. Your group is on your card.

Your Group:

Name:	__________	___________	____________	____________
Round 1 Score				
Round 2 Score				
Round 3 Score				
Round 4 Score				
Round 5 Score				

How to play: Pass the pigs

- On your turn, roll the pigs.
- The way the pigs land determines your points.

Table 1 **Scoring Possibilities for Pass the Pigs**[a]

If you roll a...	You will get...	If you roll a...	You will get...
Razorback	5 points	Double Razorback	20 points
Trotter	5 points	Double Trotter	20 points
Snouter	10 points	Double Snouter	40 points
Leaning Jowler	15 points	Double Leaning Jowler	60 points
Pig Out	0 points	Sider Or	1 point
Oinker	Back to zero	Mixed Combo	Combined score

EX:

What did I get here?

"A Sider" = 1 point

Your Group:

Name:	Kelsey	Zach	__________	__________
Round 1 Score				
Round 2 Score				
Round 3 Score				
Round 4 Score				
Round 5 Score				

EX:

After I write down my points, I can choose to roll again, OR, I can choose to roll again.

I have 1 point.

Your Group:				

Name:	Kelsey	Zach	___________	___________
Round 1 Score	1			
Round 2 Score				
Round 3 Score				
Round 4 Score				
Round 5 Score				

EX:

What did I get here?

Two leaning jowlers! What luck! That's 60 points!
I have 61 points now.

Your Group:

Name:	Kelsey	Zach	___________	___________
Round 1 Score	61			
Round 2 Score				
Round 3 Score				
Round 4 Score				
Round 5 Score				

EX:

What did I get here?

Dang, this is a pig out. I lose all my points for this round and I pass the pigs to the next person (Zach).

Your Group:

Name:	Kelsey	Zach	__________	__________
Round 1 Score	~~61~~ 0			
Round 2 Score				
Round 3 Score				
Round 4 Score				
Round 5 Score				

How to play: Pass the Pigs

- ✘ On your turn, roll the pigs.
- ✘ Use the helper sheet to determine how many points you get.
- ✘ At any time, you can choose to bank your points and pass the pigs to the next person. Or, you can roll the pigs again and score more points.
- ✘ Each time you pass, you “bank” your points and can keep them between rounds.
- ✘ If you "pig out", you lose all your points for the round and are forced to pass the pigs!
- ✘ If you get an “oinker”, you lose ALL your points (including your banked points) and have to start over from 0.
- ✘ First person to get 75 points wins!

Table 1 Scoring Possibilities for Pass the Pigs[a]

If you roll a...	You will get...	If you roll a...	You will get...
Razorback	5 points	Double Razorback	20 points
Trotter	5 points	Double Trotter	20 points
Snouter	10 points	Double Snouter	40 points
Leaning Jowler	15 points	Double Leaning Jowler	60 points
Pig Out	0 points	Sider Or	1 point
Oinker	Back to zero	Mixed Combo	Combined score

05:00

Play Pass the Pigs with your group!

Debrief

Who was able to get 75 points and win?

Who got the highest score?

Who got a "pig-out" the most?

What influenced your decision to roll or pass the pigs?

Decision-making under uncertainty

When you're deciding to buy a donut or not, you know what the cost is, and what you'll get.

But what about when you **don't know** what the outcome will be, like in Pass the Pigs? How do you decide to pass the pigs, or keep rolling? (turn and talk to the person next to you)

Scientists have proposed you can model behavior using "expected utility".

Imagine you can either take \$5 now, or flip a coin. If the coin lands on heads, you get \$10. If the coin lands on tails, you get \$0.

Which option should you pick?
(Talk to the person next to you.)

Expected value *E(v)* is:
the probability of an event x the payout of the event

For example, taking the $5:

$$E(v) = 1 \cdot 5 = 5$$

So the expected value of taking the $5 is 5.

The expected value of taking the coin flip:

$$E(v) = .5 \cdot 10 + .5 \cdot 0 = 5$$

THEY'RE EQUAL????????

New problem:

Let's say I offer you either $10, or a coin flip.

If you pick the coin flip and get heads, you get $0.

If you get tails, you get $15.

Which option should you pick?

Talk to the person next to you.

Take the money:

$$E(v) = 1 \cdot 10 = \$10$$

Take the gamble:

$$E(v) = 0 \cdot 0.5 + 15 \cdot 0.5 = \$7.5$$

How could we use this approach to play pass the pigs... smarter?

Talk to the person next to you.

Don't worry, someone already did this for us.
You don't have to follow the next four slides, but I'll go through them for those who are interested

Michael had way too much time on his hands and we thank him for it.

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Analytics, Pedagogy and the Pass the Pigs Game

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The Pass the Pigs® game provides an opportunity to combine multiple analytical skills sets and problem-solving capabilities in an enjoyable and challenging application. In this paper, I describe how I structure a classroom exercise to help students work through developing, analyzing, and testing strategies for the game. The game utilizes multiple analytics and decision making tools, such as problem framing, data collection and preparation, probability, optimization, heuristics, expert systems, and simulation.

Key words: active learning; classroom games; teaching management; teaching modeling; statistics; optimization; heuristics; Monte Carlo simulation
History: Received November 2011; accepted February 2012.

If anyone would like to read the original paper, we will post it on Zach's website.

1. Michael rolled the pigs a bunch of times to figure out the probabilities of each result.

Table 2 Probability of Each Pig Roll

Pig position	Probability (%)
Side (no dot)	34.9
Side (dot)	30.2
Razorback	22.4
Trotter	8.8
Snouter	3.0
Leaning Jowler	0.6

2. Next, he made a table of the probabilities of each of the combinations.

Table 3 Joint Probabilities of Any Combination of Two Pigs

	Side (no dot) 34.90 (%)	Side (dot) 30.20 (%)	Razorback 22.40 (%)	Trotter 8.80 (%)	Snouter 3.00 (%)	Leaning Jowler 0.70 (%)
Side (no dot) 34.90 (%)	12.180	10.540	7.818	3.071	1.047	0.244
Side (dot) 30.20 (%)	10.540	9.120	6.765	2.658	0.906	0.211
Razorback 22.40 (%)	7.818	6.765	5.018	1.971	0.672	0.157
Trotter 8.80 (%)	3.071	2.658	1.971	0.774	0.264	0.062
Snouter 3.00 (%)	1.047	0.906	0.672	0.264	0.090	0.021
Leaning Jowler 0.70 (%)	0.244	0.211	0.157	0.062	0.021	0.005

3. Next, he made a table of the points, and reduced that table to the probabilities of scoring points

Table 4 Scoring Value of Any Pig Configuration

	Side (no dot) 34.90 (%)	Side (dot) 30.20 (%)	Razorback 22.40 (%)	Trotter 8.80 (%)	Snouter 3.00 (%)	Leaning Jowler 0.70 (%)
Side (no dot) 34.90 (%)	1	0	5	5	10	15
Side (dot) 30.20 (%)	0	1	5	5	10	15
Razorback 22.40 (%)	5	5	20	10	10	20
Trotter 8.80 (%)	5	5	10	20	15	20
Snouter 3.00 (%)	10	10	15	15	40	25
Leaning Jowler 0.70 (%)	15	15	20	20	25	60

Table 5 Numerical Outcomes and Their Probabilities

Score	Probability (%)
Pig out	21.080
1	21.301
5	40.622
10	8.520
15	2.111
20	6.229
25	0.042
40	0.090
60	0.005

NOW we can calculate expected value.

$$E(v) = currentPoints \cdot 1 + 1 \cdot 0.21301 + 5 \cdot 0.40622 + 10 \cdot 0.8520$$
$$+15 \cdot 0.2111 + 20 \cdot 0.06229 + 25 \cdot 0.00042$$
$$+40 \cdot 0.00090 + 60 \cdot 0.00005 - currentPoints \cdot 0.21080$$

Table 5 Numerical Outcomes and Their Probabilities

Score	Probability (%)
Pig out 0	21.080
1	21.301
5	40.622
10	8.520
15	2.111
20	6.229
25	0.042
40	0.090
60	0.005

(Michael argues that the "oinker" is more about skill than probability, doesn't happen often, and therefore doesn't matter.
Do you agree with him?)

$$E(v) = currentPoints \cdot 1 + 1 \cdot 0.21301 + 5 \cdot 0.40622 + 10 \cdot 0.8520$$
$$+15 \cdot 0.2111 + 20 \cdot 0.06229 + 25 \cdot 0.00042$$
$$+40 \cdot 0.00090 + 60 \cdot 0.00005 - currentPoints \cdot 0.21080$$

Let's make this simpler

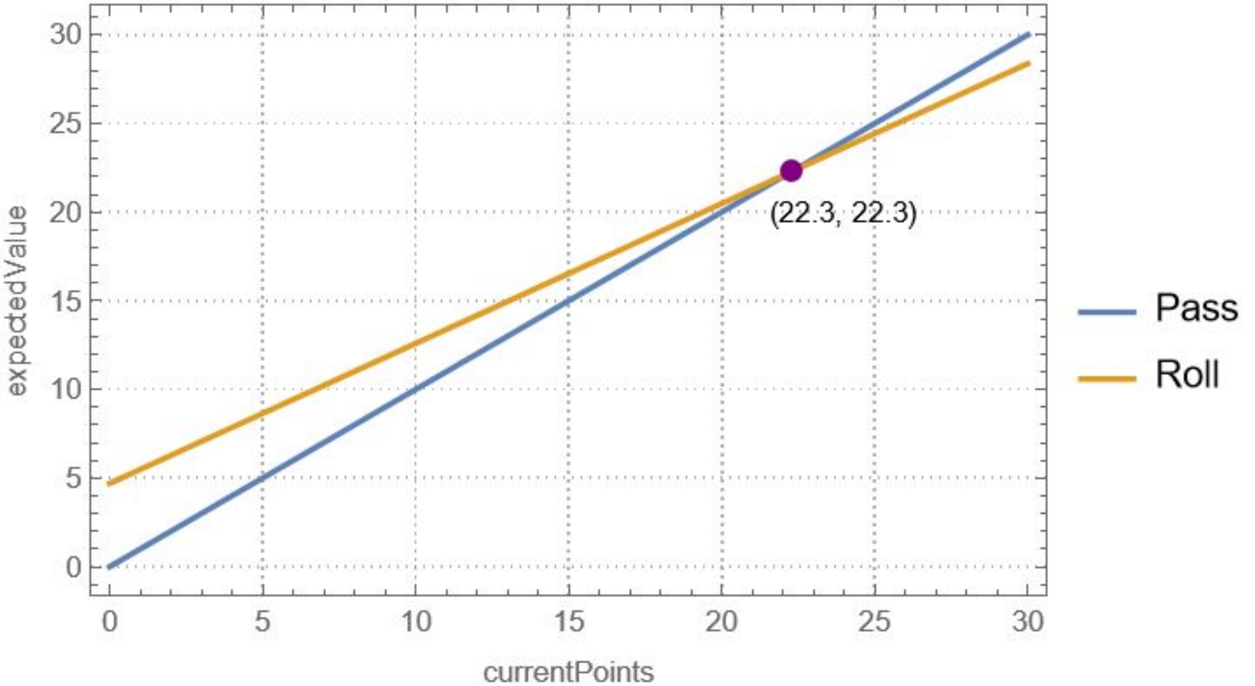
Roll: $E(v) = currentPoints \cdot 1 + 4.7 - currentPoints \cdot 0.2108$

Pass: $E(v) = currentPoints \cdot 1$

Roll: $E(v) = currentPoints \cdot 1 + 4.7 - currentPoints \cdot 0.2108$

Pass: $E(v) = currentPoints \cdot 1$

Here's a graph to help visualize what's going on.



If your score is 22 or less, rolling has the higher EV.
If your score is 23 or more, passing has the higher EV.

Play pass the pigs again, using this new information.

- Did you change your strategy the second time you played pass the pigs?

- What changed? Why?

The issue with using expected value for everything:

Imagine I give you the option to either take $500,000, or flip a coin. If you flip the coin and get heads, you get $1,500,000. If you flip the coin and get tails, you owe ME $500,000.

Let's calculate expected value here:

E(v) [take the money] = 500,000*1

=

500,000

E(v) [gamble] =

1,500,000*.5, -500,000*.5

750,000 - 250,000 =

500,000

These situations have equivalent expected values.

Expected Utility: how much you value the options, given the uncertainty, possible outcomes, and other factors.

It's really hard to figure out someone's actual expected utility, but we can add things to our expected value function to get closer to predicting how people will behave in different situations.

When we come back from break, we will discuss risk preference, and how that influences utility and behavior.

Break time!

Math warning:

The following slides will include some math. It doesn't really matter if you understand the math or not, just the concepts.

Risk Preference

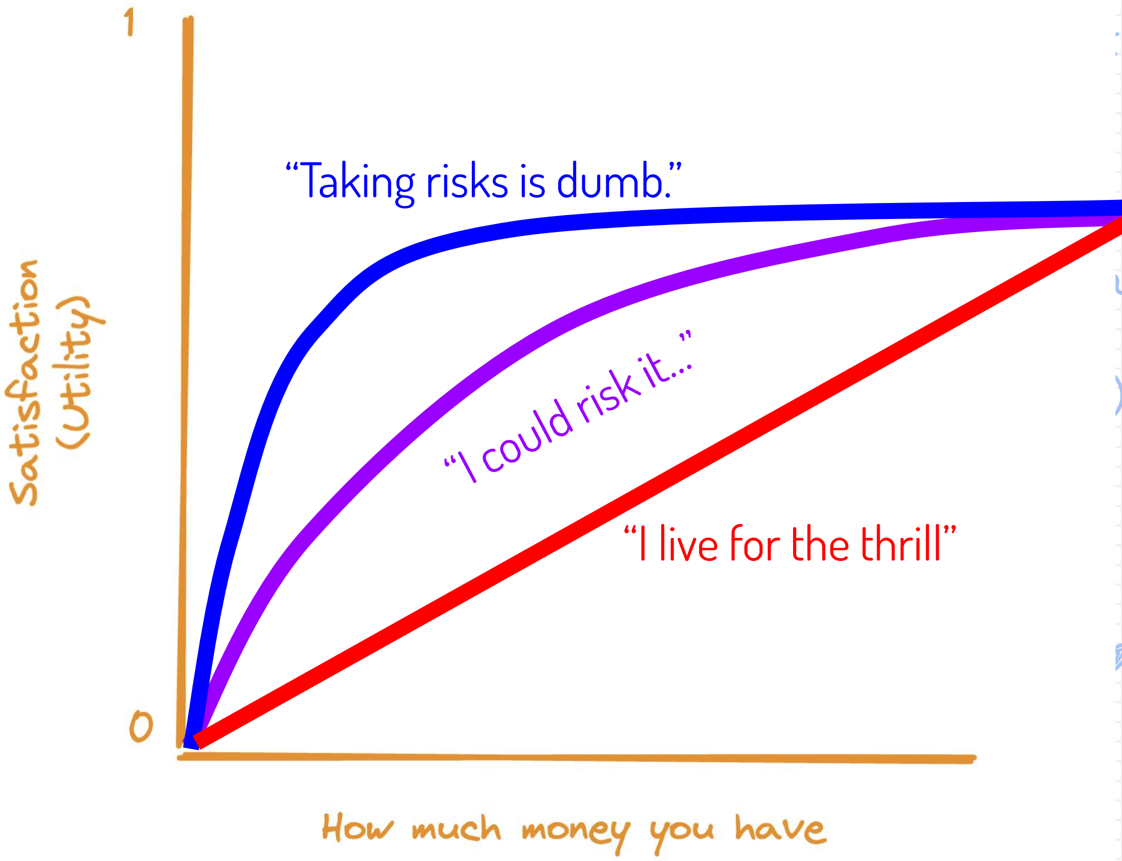
Remember this?

$$y = x^{\frac{1}{2}}$$

(AKA our utility function)

You can alter the equation to make the person more or less likely to take the risky bet with a "risk preference parameter", **a.**

$$y = x^{a}$$



Risk Avoidant

Let's say our person deciding to take the gamble does not like to take risks (like Zach. He's not a risky person.)

$$y = x^{0.1}$$

Risk Seeking

Let's say our person deciding to take the gamble is super risky (like Kelsey, she likes adventure).

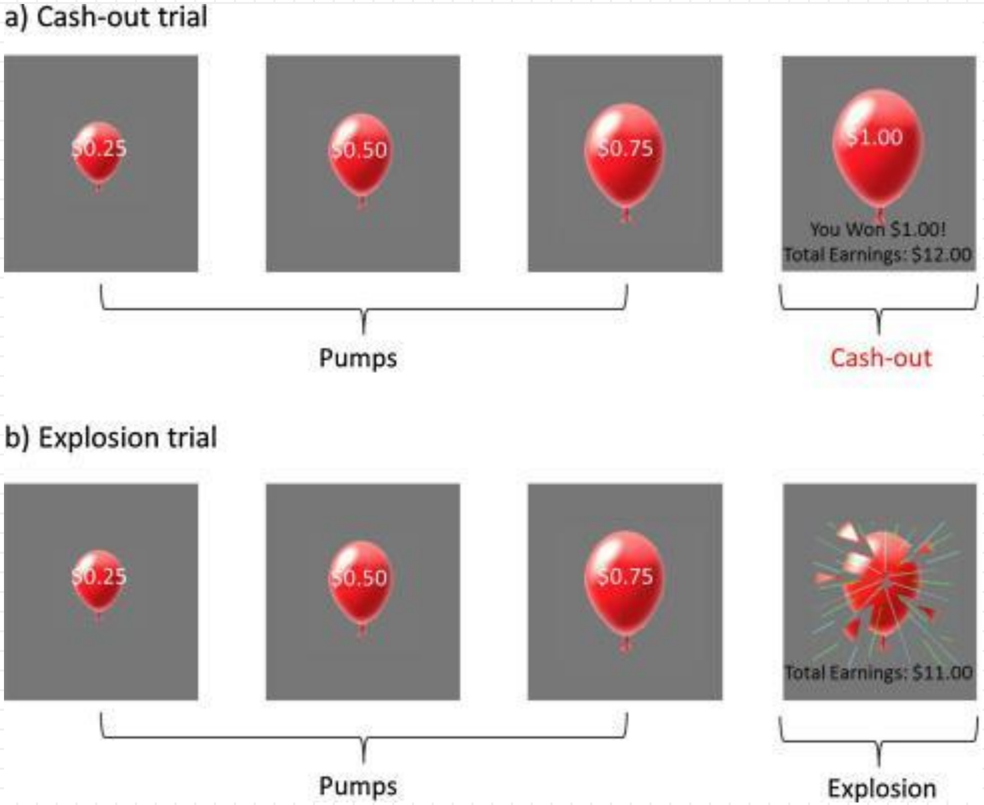
$$y = x^{0.9}$$

Why does this matter?

We can use risk preference to understand how people behave. You can imagine that if Zach and I are in the same situation but behave very differently, it could be that the choices one of us is making is bad for us– either by being too scared of making the wrong move, or by being too willing to take unnecessary risk. Next, we're going to look at a task that researchers use to measure risk preference in children and teenagers– the balloon analogue risk task.

zach-winkeler.github.io

BART (Balloon Analog Risk Task)



Play the BART!

Record:
How many times did you do the task?
Likelihood of balloon exploding
How many pumps did you do?
Did it explode or did you cash out?

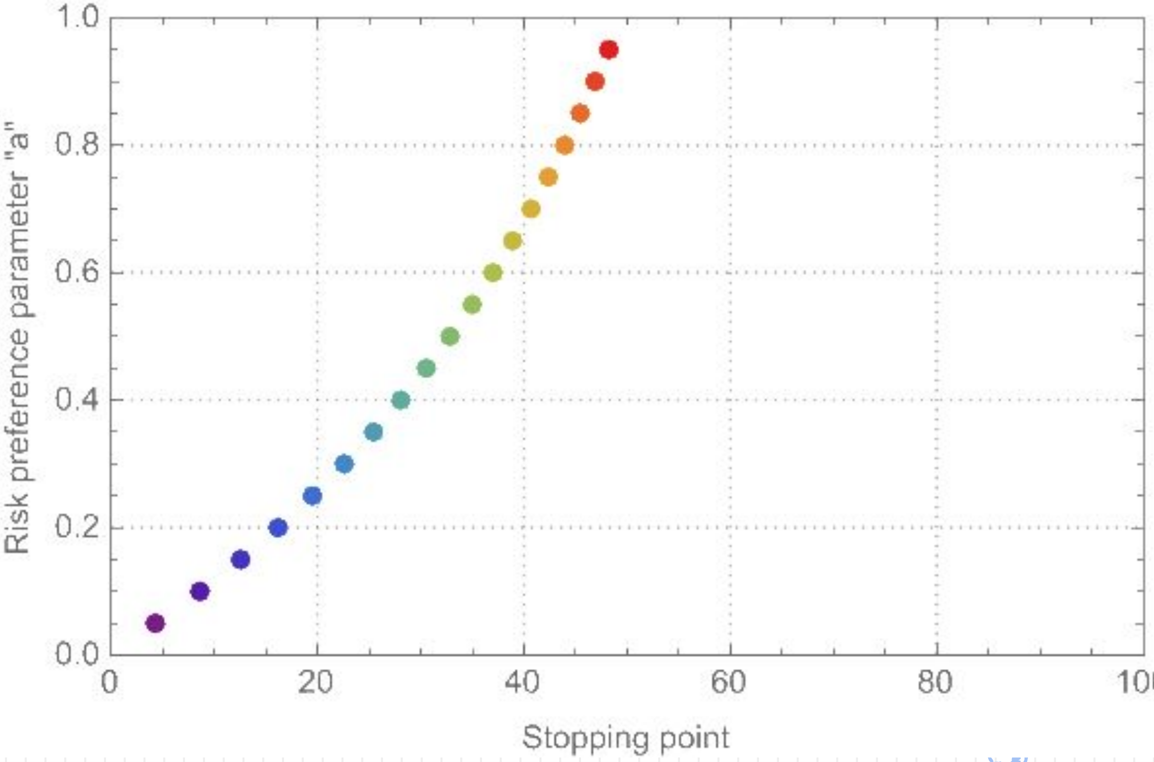
The BART and Risk Preference

What does the BART tell you about your risk preference?

Assuming your personal utility function looks like

$$y = x^a$$

we can calculate the value of *a* based on where you stop inflating!



Stopping point	a
1	0.01
2	0.03
3	0.04
4	0.05
5	0.06
6	0.07
7	0.08
8	0.09
9	0.1
10	0.12
11	0.13
12	0.14
13	0.16

Stopping point	a
14	0.17
15	0.18
16	0.2
17	0.21
18	0.23
19	0.24
20	0.26
21	0.27
22	0.29
23	0.31
24	0.32
25	0.34
26	0.36

Stopping point	a
27	0.38
28	0.4
29	0.42
30	0.44
31	0.46
32	0.48
33	0.5
34	0.53
35	0.55
36	0.57
37	0.6
38	0.63
39	0.65

Stopping point	a
40	0.68
41	0.71
42	0.74
43	0.77
44	0.8
45	0.83
46	0.87
47	0.9
48	0.94
49	0.98
50	1.02
51	1.06
52	1.11

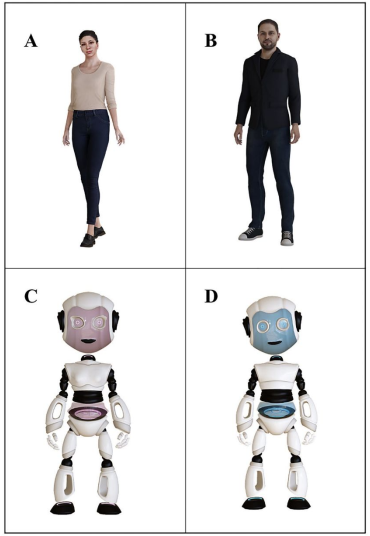
Using the BART in research

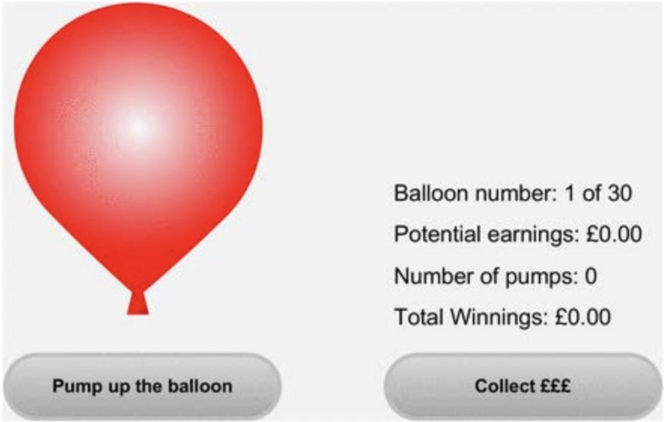
Article | Open access | Published: 11 July 2023

Virtual agents and risk-taking behavior in adolescence: the twofold nature of nudging

Cinzia Di Dio, Federico Manzi, Laura Miraglia, Michaela Gummerum, Simone Bigozzi, Davide Massaro & Antonella Marchetti

Scientific Reports 13, Article number: 11242 (2023) | Cite this article





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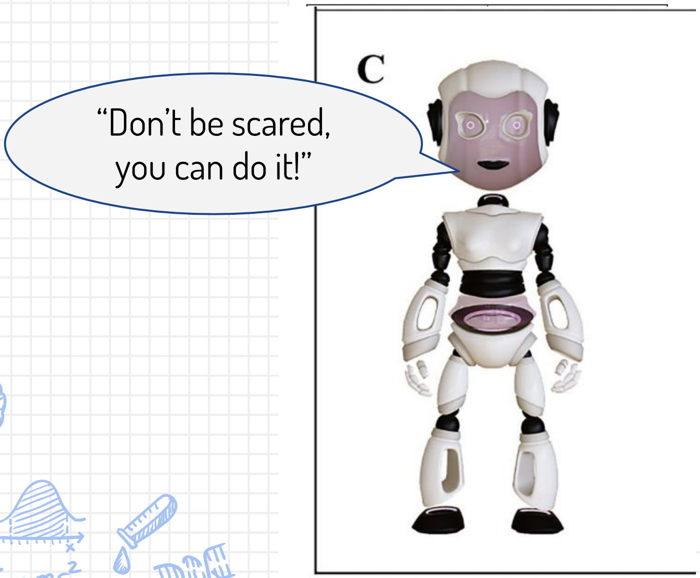

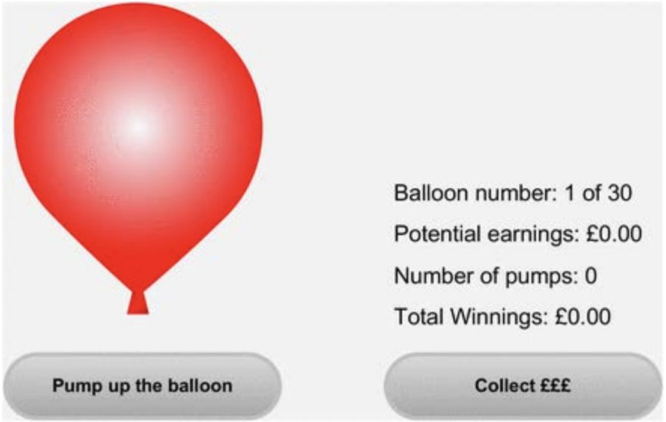

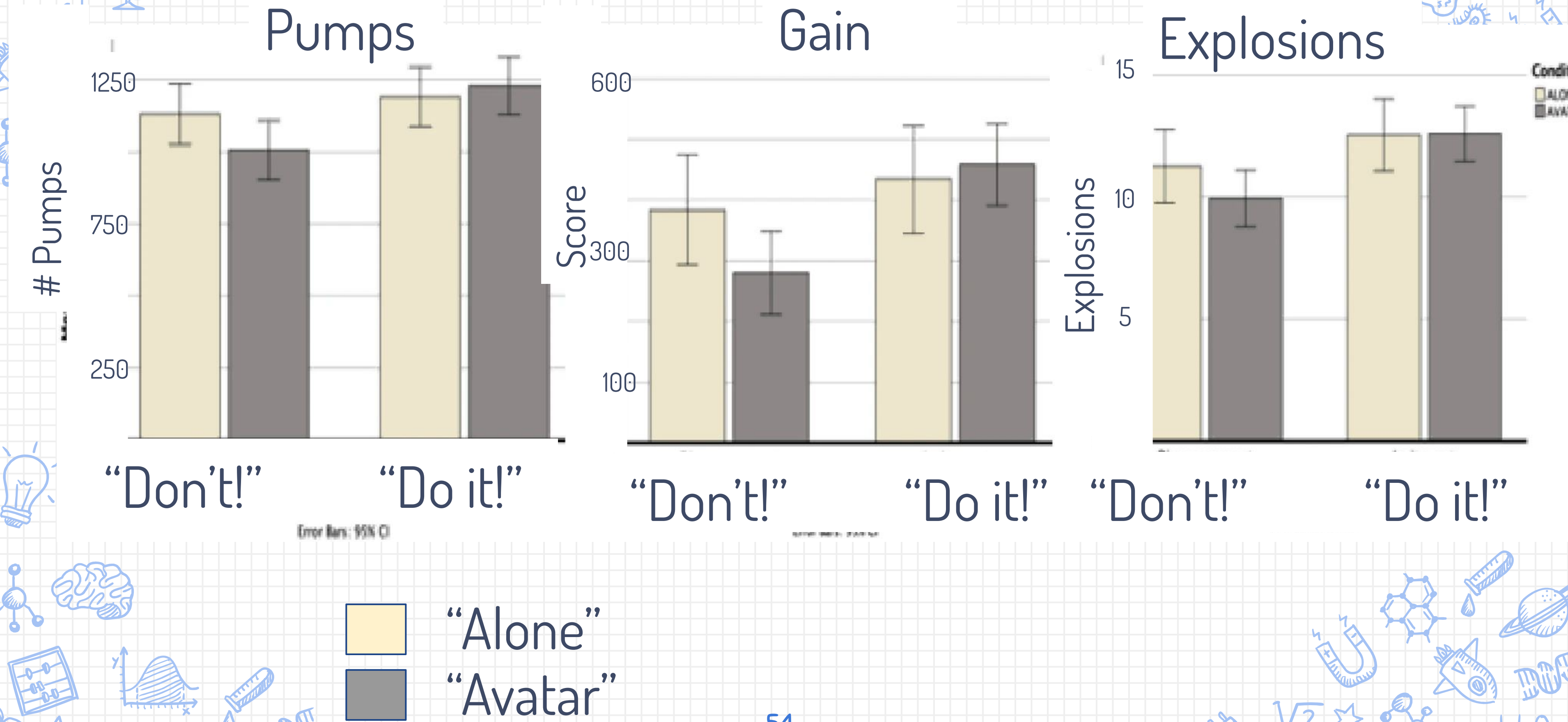
Pumps
Pumps
1250
750
250
"Don't!"
"Do it!"
Error Bars: 95% CI
Gain
Score
600
300
100
"Don't!"
"Do it!"
Explosions
Explosions
15
10
5
"Don't!"
"Do it!"
"Alone"
"Avatar"

Variable	Pumps			Gain			Explosions		
	B	SE(B)	β	B	SE(B)	β	B	SE(B)	β
Age range	− 40.93	32.06	−0.10	12.07	20.66	0.05	0.01	0.32	0.00
Gender	−25.14	63.68	−0.03	−50.43	41.37	−0.09	−0.00	0.65	0.00
BIS11-Att	0.43	11.06	0.00	−0.18	7.13	−0.00	−0.03	0.11	−0.02
BIS11-Mot	5.55	7.17	0.07	−1.58	4.68	−0.03	−0.08	0.07	−0.09
BIS11-NonPl	0.10	6.49	0.00	5.91	4.19	0.11	0.08	0.07	0.09
Playing-alone	0.57	0.08	0.56	0.46	0.06	0.58	0.53	0.06	0.66
Type of agent	−16.99	56.18	−0.02	10.47	36.31	0.02	0.52	0.57	0.06
Modality	141.46	57.16	0.19	105.22	37.04	0.22	1.43	0.59	0.18

To summarize the main results, here are reported data for Model 4 encompassing all the variables for each regression. The full model is in Supplementary Material Table 1.

RESEARCH ARTICLE | BIOLOGICAL SCIENCES

Valuation of peers' safe choices is associated with substance-naïveté in adolescents

Dongil Chung, Mark A. Orloff, Nina Lauharatanahirun, Pearl H. Chiu, and Brooks King-Casas -1 Authors Info & Affiliations

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November 30, 2020 | 117 (50) 31729-31737 | https://doi.org/10.1073/pnas.1919111117

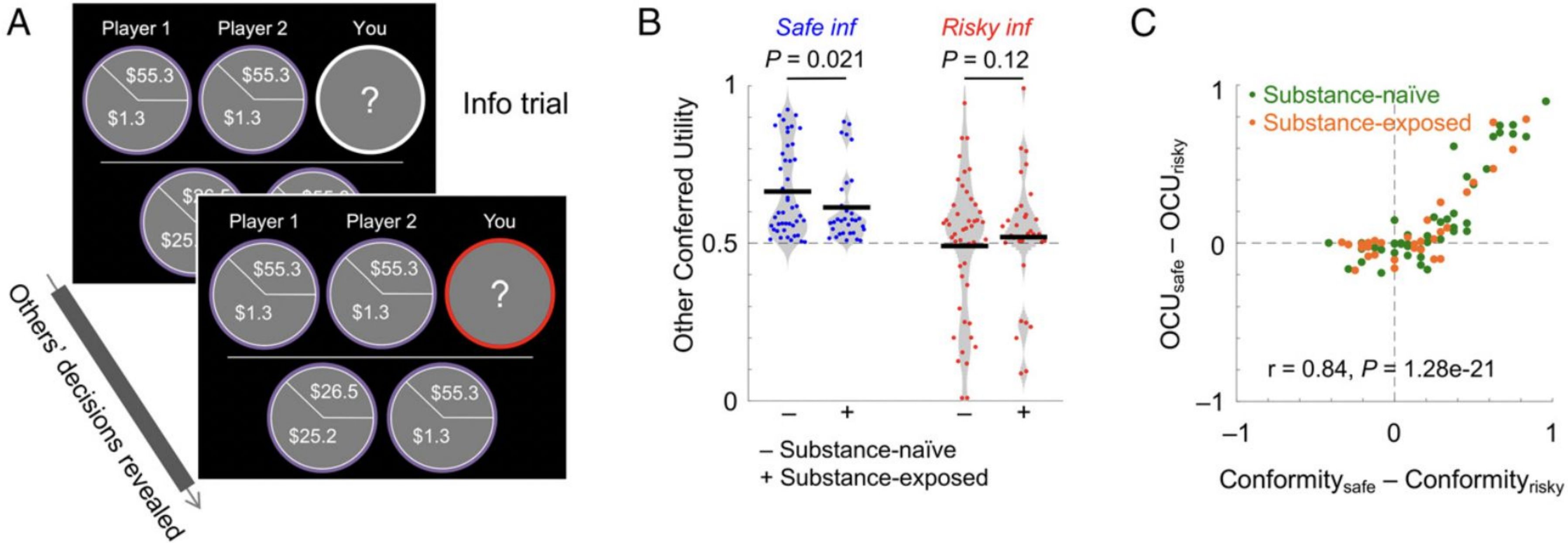


Fig. 1 Substance-naïveté is associated with greater valuation of peers' safe choices. (A) Adolescents made a series of choices between two gambles (one safe

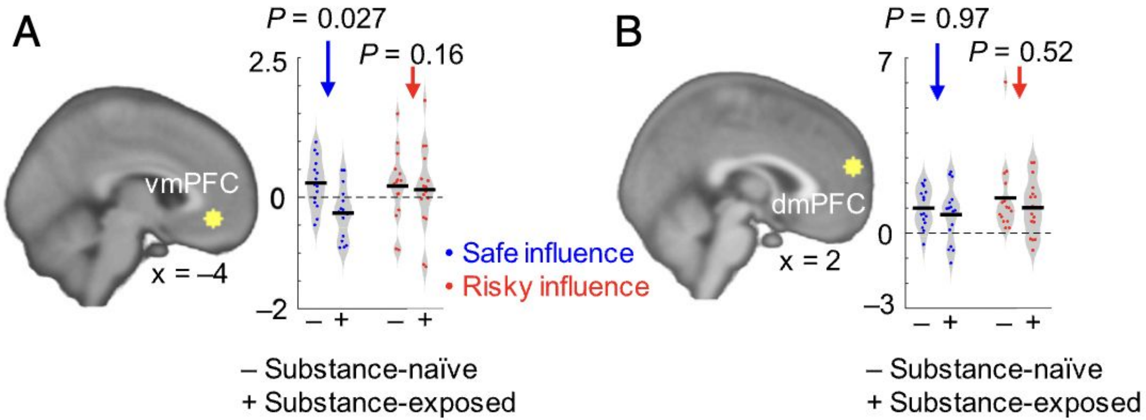


Fig. 2. Neural valuation of peers' safe choices (OCU_{safe}) is associated with substance-naïveté. (*A*) Social valuation: In vmPFC, responses to OCU_{safe}, but not to OCU_{risky} were significantly associated with substance exposure (OCU_{safe}, OR = 0.0086, 95% CI for OR: [3.0e-05, 0.21], $P = 0.027$; OCU_{risky}, OR = 0.13, 95% CI for OR: [0.0023, 1.28], $P = 0.16$). In addition, Bayesian comparison shows decisive evidence in favor of a logistic regression model that includes neural responses to OCU_{safe} over that including OCU_{risky} (BF = 278.66), indicating that neural valuation of others' safe choices is more strongly associated with substance exposure than is neural valuation of others' risky choices (see *Results* for model comparison details). (*B*) Nonvaluation social processing: In dmPFC, responses to social information were not associated with substance exposure (for Social versus Solo trials; safe info: OR = 0.97, 95% CI for OR: [0.17, 5.30], $P = 0.97$; risky info: OR = 0.61, 95% CI for OR: [0.11, 2.14], $P = 0.52$).

Last break!

How do you integrate neural imaging data?

- ✘ You can see what happens in people's brains when they're being more or less risky, making certain decisions, learning from prior decisions, etc.
- ✘ How do we collect and analyze this data?

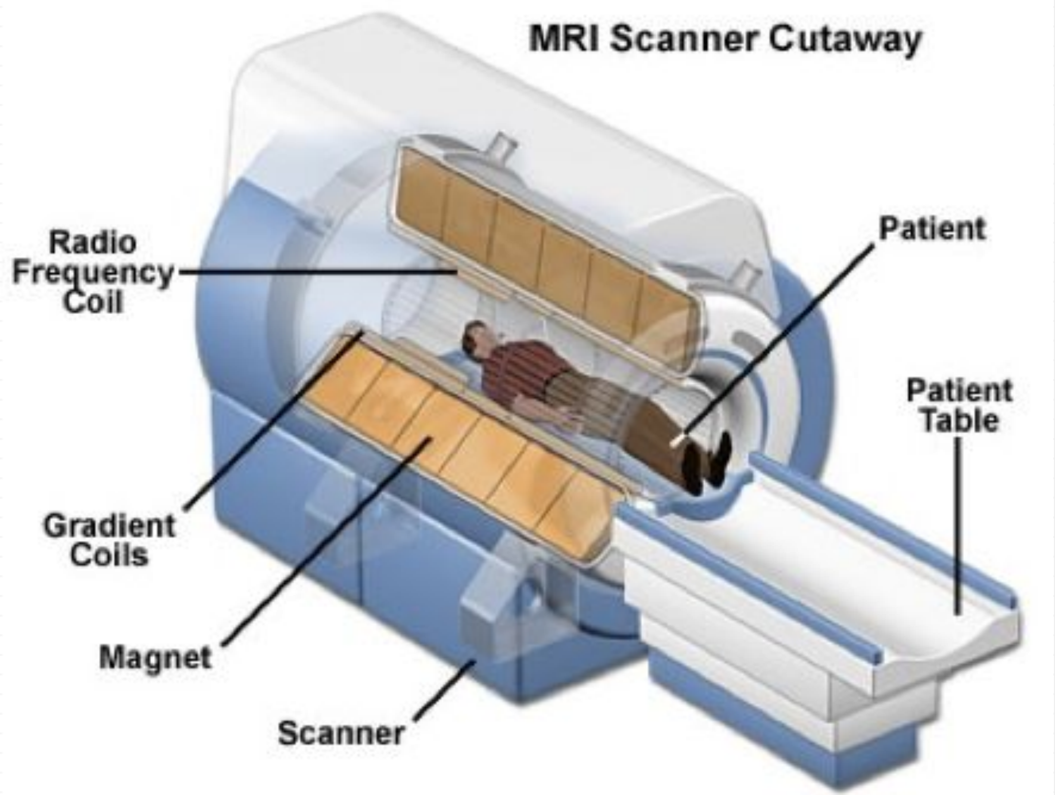
Unscramble the fMRI steps!

I could just tell you how to collect and analyze this data. But when you're a grad student, you just kind of have to figure it out! You have printed out a set of pictures of the analysis steps– try to put them into order.

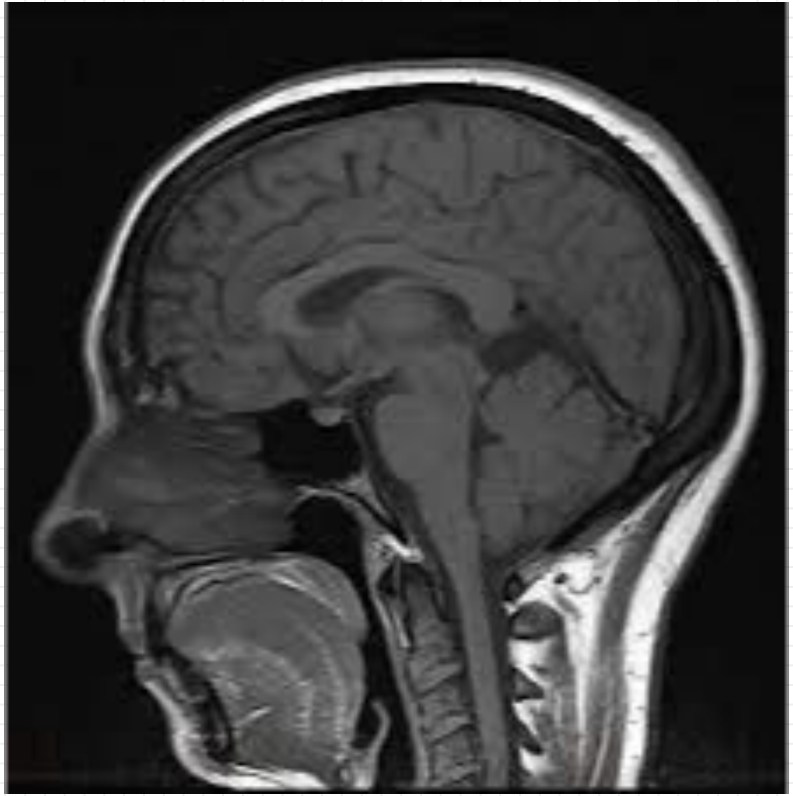
(It's okay if you don't do it correctly the first time. It took me about two years to figure it out.)

Answers

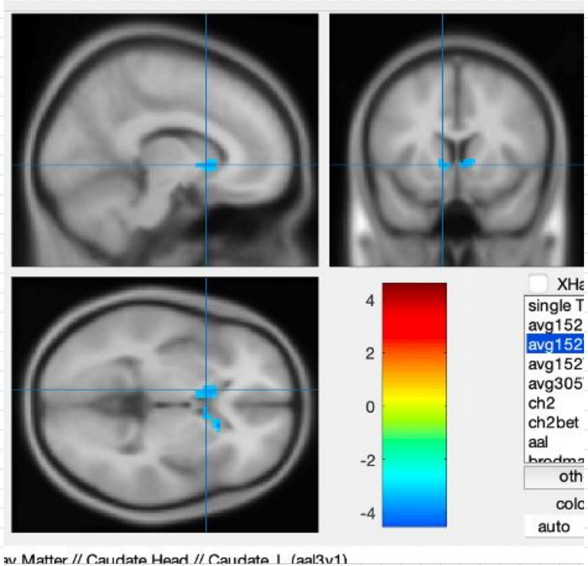
1. Put the person in the MRI!

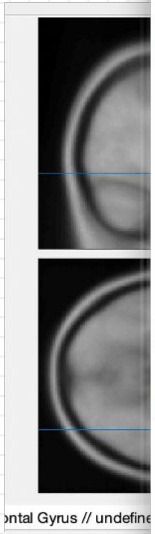


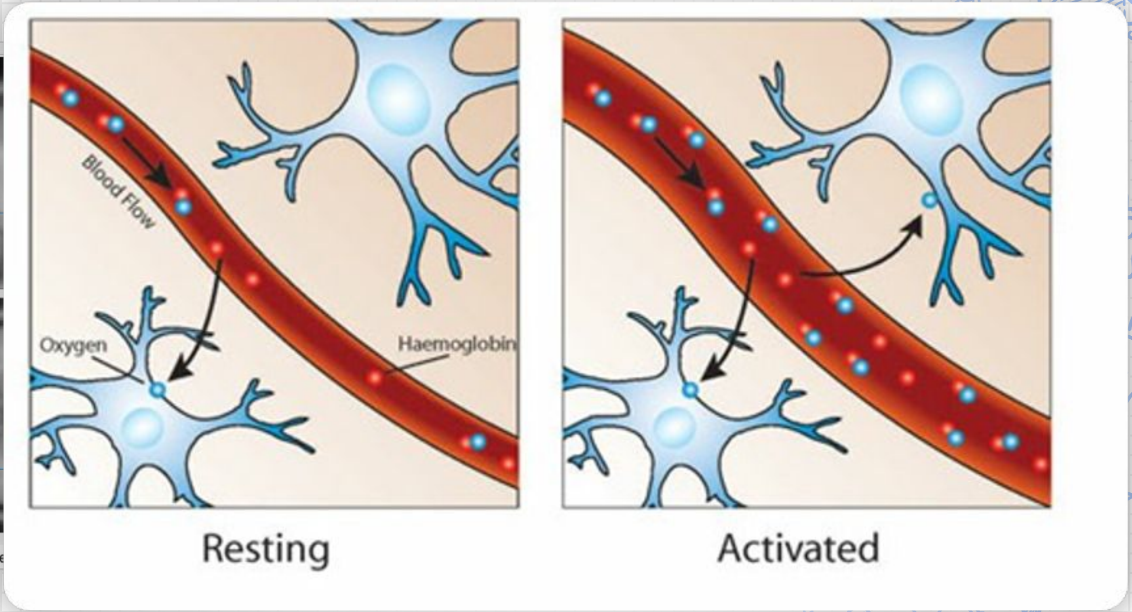
2. Take a structural scan



3. Take scan of the person's blood flow while playing the game



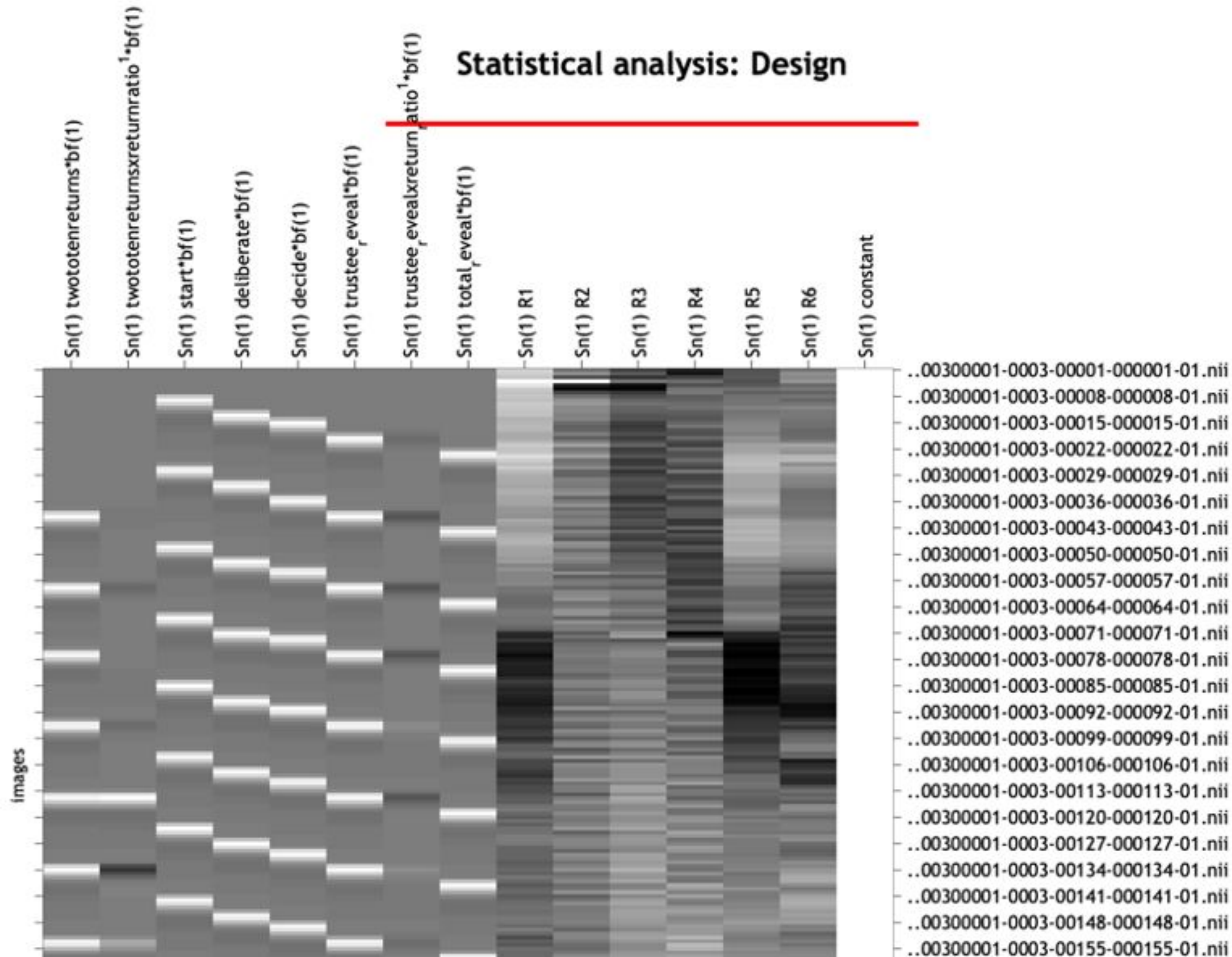




Different parts of the brain get more blood when they're being "activated" more.

4. Line up the structural and the functional scans
5. Line up the structural scan to a template brain
6. Warp the structural/functional scans to fit the template

Statistical analysis: Design



(bonus)

If you only want to look at, ex: explosions

atistical analysis: Design

Start

See problem

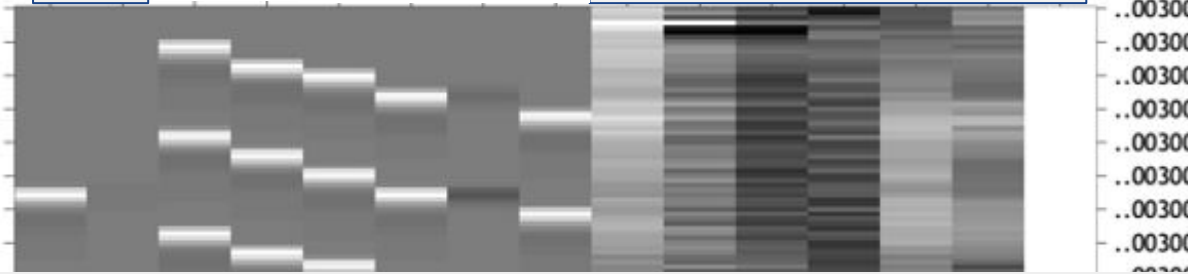
Make decision

Wait for results

See results

Wait for next round

If the person moved

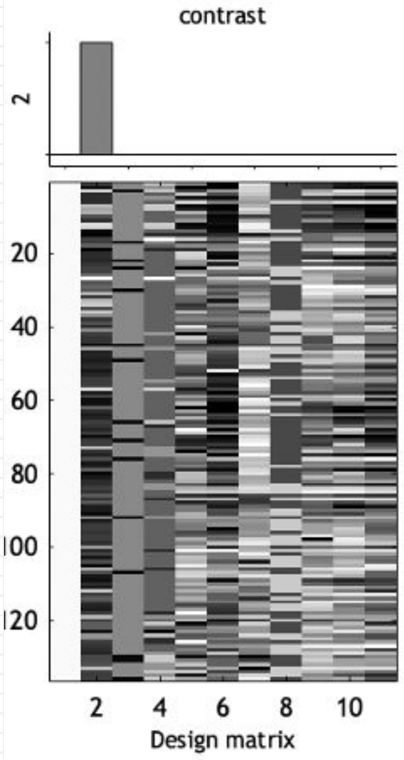


2 seconds
4 seconds
6 seconds
8 seconds
10 seconds
12 seconds
etc.

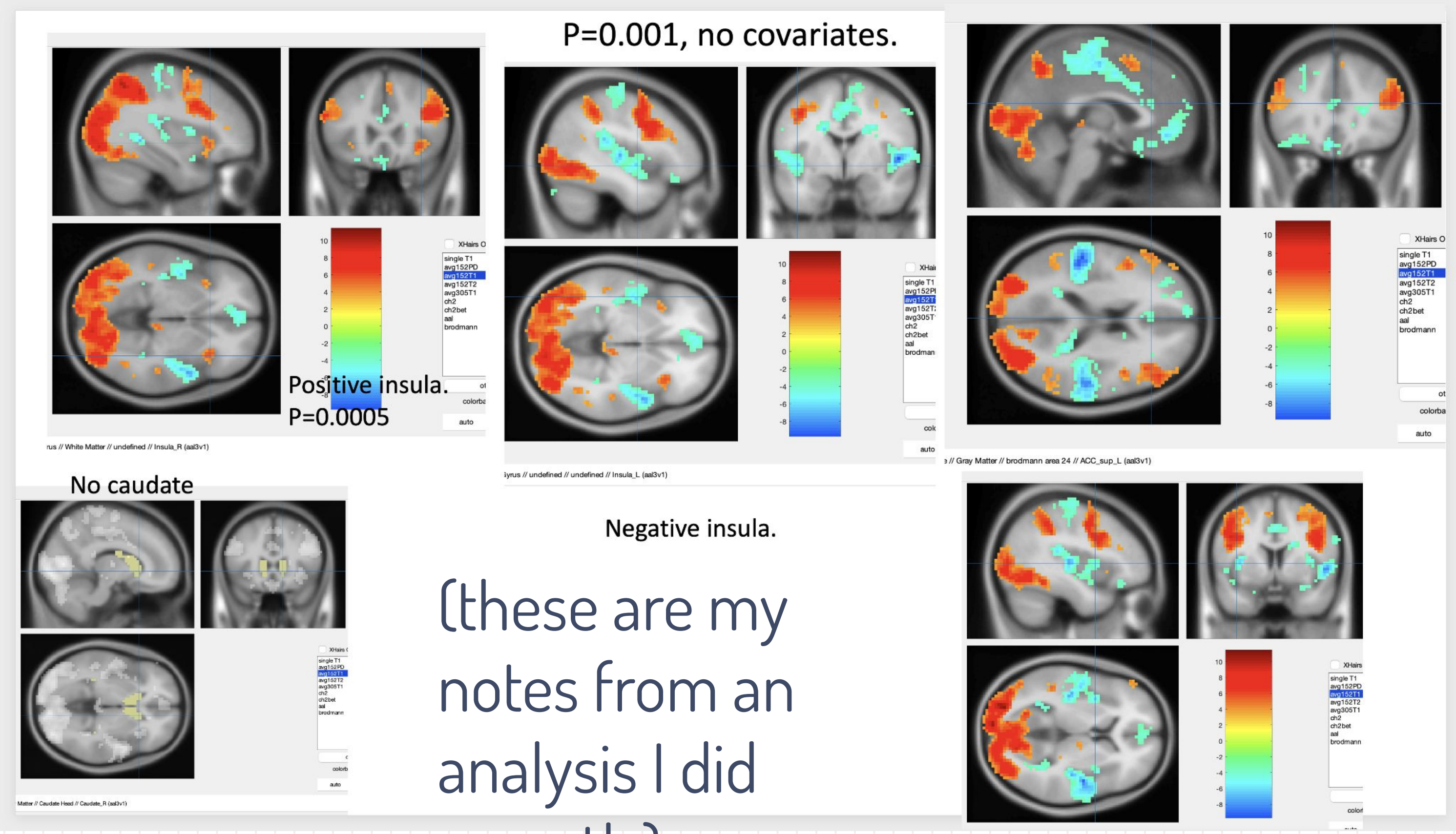
8. Take out only the brain activity that happened at the part of the game you care about for each person

“Just the event”

People



Do statistics on the images you took to figure out what all the people had in common during the part of the game you cared about



(these are my notes from an analysis I did recently)

Profit??????

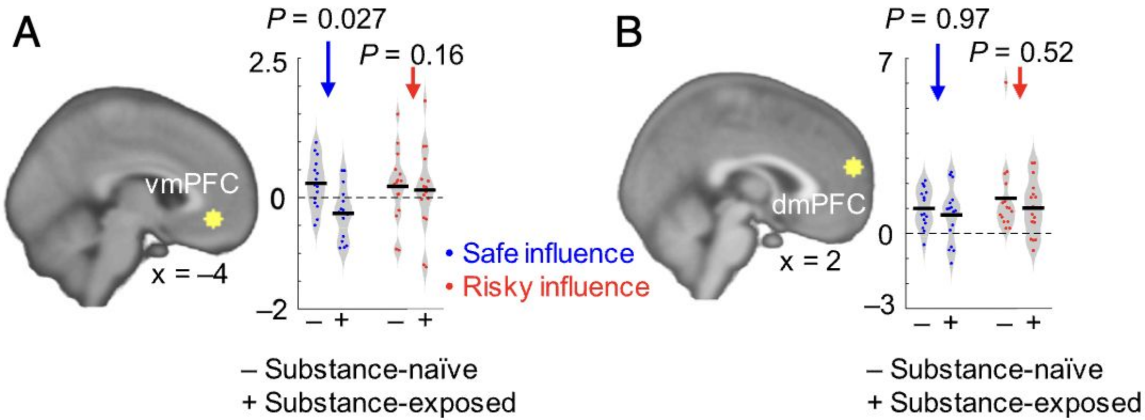


Fig. 2. Neural valuation of peers' safe choices (OCU_{safe}) is associated with substance-naïveté. (*A*) Social valuation: In vmPFC, responses to OCU_{safe}, but not to OCU_{risky} were significantly associated with substance exposure (OCU_{safe}, OR = 0.0086, 95% CI for OR: [3.0e-05, 0.21], $P = 0.027$; OCU_{risky}, OR = 0.13, 95% CI for OR: [0.0023, 1.28], $P = 0.16$). In addition, Bayesian comparison shows decisive evidence in favor of a logistic regression model that includes neural responses to OCU_{safe} over that including OCU_{risky} (BF = 278.66), indicating that neural valuation of others' safe choices is more strongly associated with substance exposure than is neural valuation of others' risky choices (see *Results* for model comparison details). (*B*) Nonvaluation social processing: In dmPFC, responses to social information were not associated with substance exposure (for Social versus Solo trials; safe info: OR = 0.97, 95% CI for OR: [0.17, 5.30], $P = 0.97$; risky info: OR = 0.61, 95% CI for OR: [0.11, 2.14], $P = 0.52$).