Econ 211

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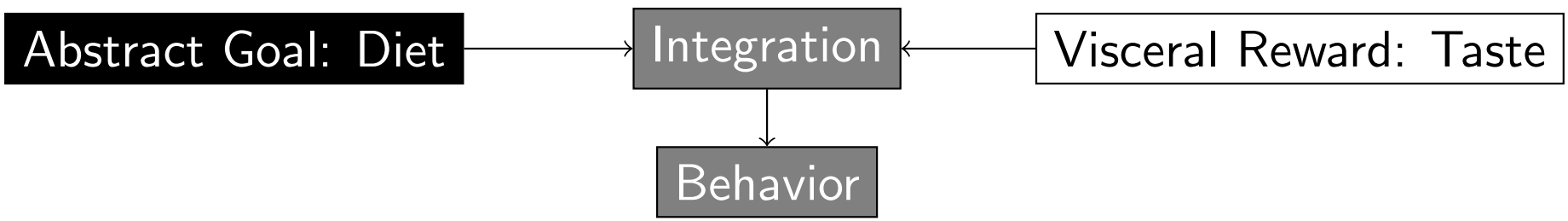
Neuroeconomics

Neuroeconomics

- *Neuroeconomics* is the study of economic decision-making through its biological foundations in the brain
- What are these biological foundations?
  - Neural mechanisms like neurons, chemical pathways, brain systems
  - Genetics
- How do we measure these foundations?
  - Scans like PET, CAT, MRI
  - Secondary reactions like skin conductance, pulse rate, eye tracking

Multiple Systems Hypothesis

- One possible neuroeconomic way to study behavior is the *multiple systems model*
- The model:
  - Brain is built up from many independent systems
  - Each system has a physical locus in the brain, and is specialized for a certain task or activity
  - Given a stimulus, each system produces a (potentially different) response
  - The brain integrate these multiple signals to decide on a final course of action
- Example: do you want a cookie right now?

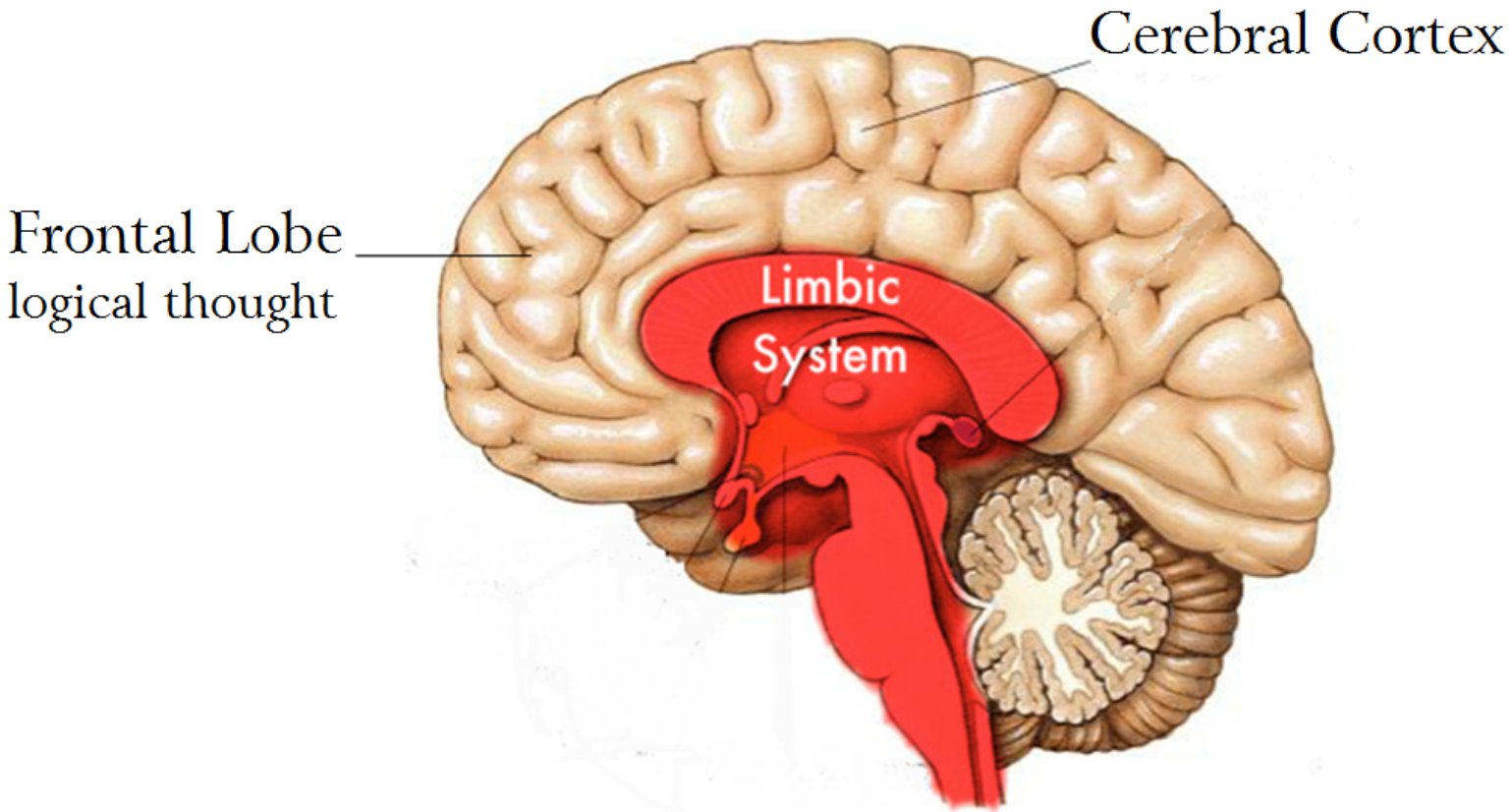


Connection to System 1 and 2

- The multiple systems model sounds a lot like Kahneman's System 1 and System 2
- However, system 1 and system 2 is just *one example* of a multiple systems hypothesis
- Other examples:
  - Frued's id, ego, and superego
  - Prefrontal cortex vs Mesolimbic dopamine system
  - Deliberative vs impulsive
  - Patient vs myopic
- Note that there can be more than two systems interacting in general

An Over-Simplified Model of the Brain

- Prefrontal cortex (PFC): the center higher reasoning, logic, self control
- Limbic system: releases dopamine in response to rewards like food and sex



Relation to Time Preferences and Self-Control

- Hypothesis: the PFC is patient but the limbic system is impatient
- Preferences are derived from adding up the outputs of the two systems
- For example, consider how the two systems evaluate the prospect of getting a small reward each period:

Period	1	2	3	4
PFC contribution	1	1	1	1
Limbic contribution	1	0	0	0
Average signal	1	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$

- What does average signal look like? Present-biased model with $\beta = \frac{1}{2}$ and $\delta = 1$

Testing the Hypothesis

- How might we test this hypothesis?
  - If we can vary the relative signal strength of the two systems, we should make individuals appear more or less patient
- How could we easily implement this?
  - If we tax or distract the PFC, people should look more impatient
  - Alternatively, we can directly look at the signal strength with brain scans

Cognitive Load

- Shiv and Fedorikhin (1999) ask people to remember a number
- While holding the number in their head, they are asked if they want cake or fruit
- Two treatments:
  - High cognitive load: 7 digit number
  - Low cognitive load: 2 digit number
- Results:
  - High cognitive load: 63% choose cake
  - Low cognitive load: 41% choose cake
- Two systems explanation?
  - PFC is distracted by cognitive load, so relative contribution to decision is smaller
- Any alternate explanations?
  - Could be that remembering longer numbers just makes you hungrier

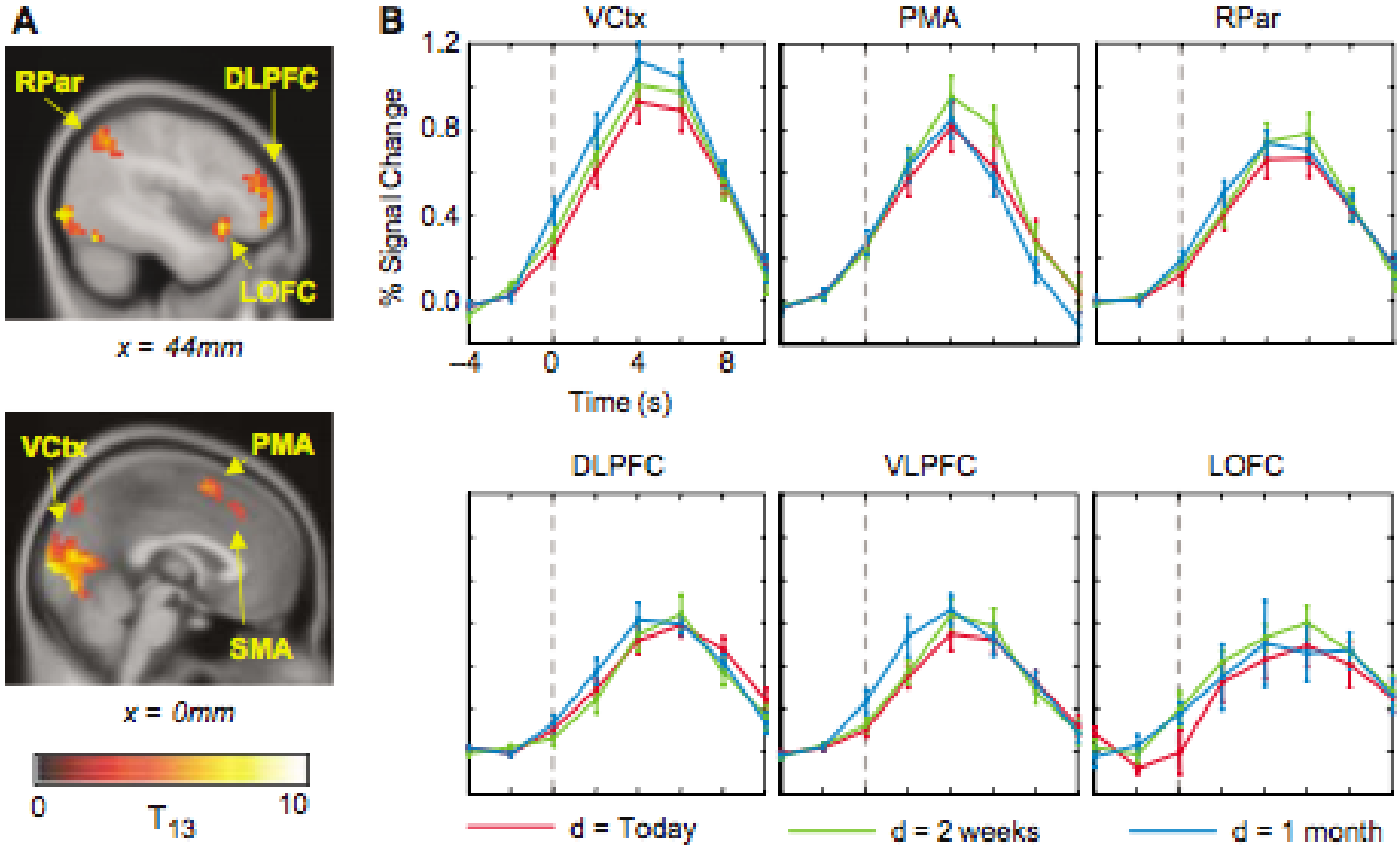
Discount Rates

- Hinson, Jameson, and Whitney (2003) seek to measure time preferences directly using price list methodology we saw earlier in course
- Subjects choose between smaller, sooner reward and later, larger reward
- Vary the cognitive load in a similar way:
  - Control: no cognitive load
  - Treatment: hold a 5-digit number in memory
- Estimated one-month discount rate:
  - Control: 26.3%
  - Treatment: 49.8%

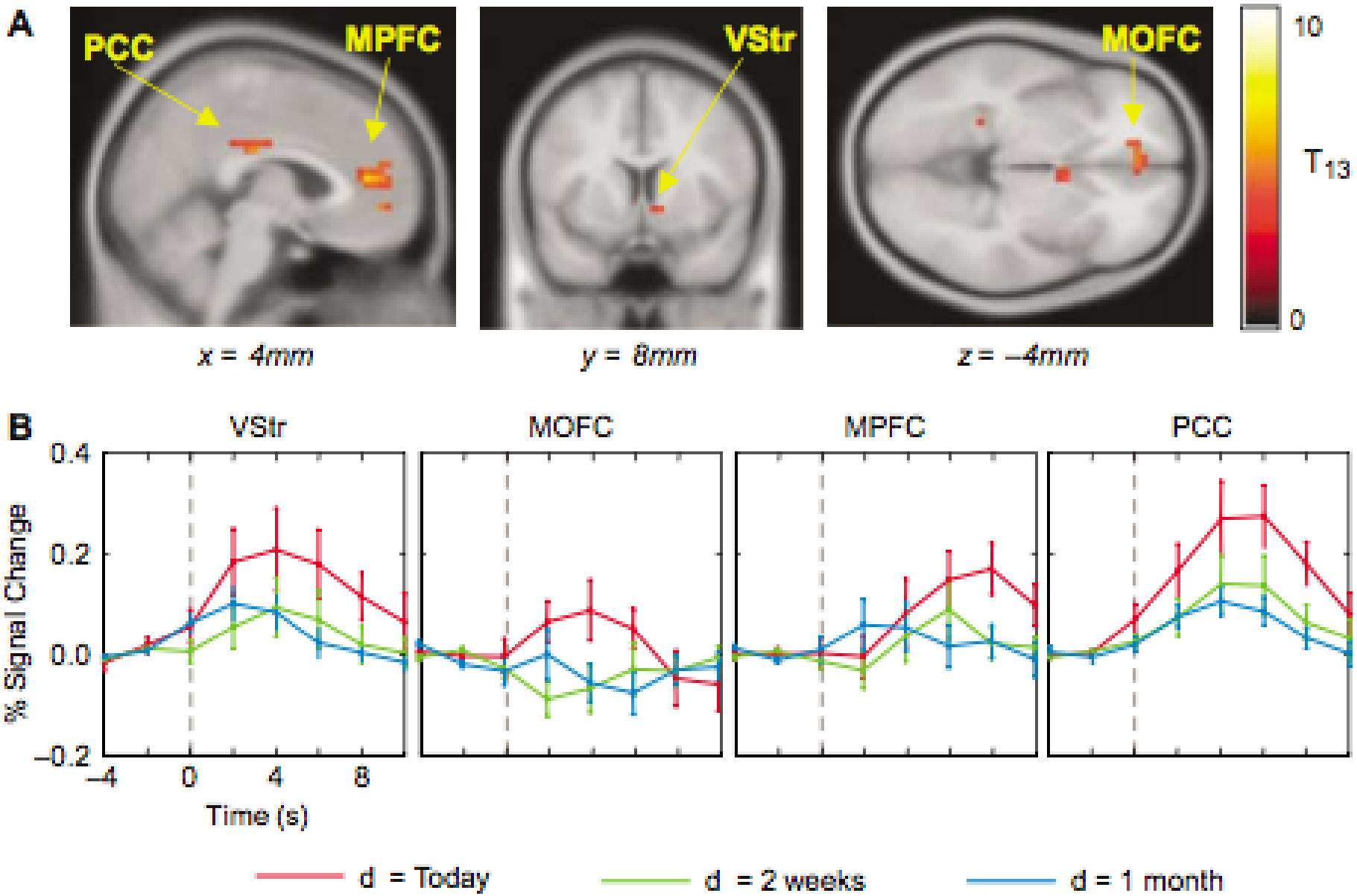
Measuring Brain Activity Directly

- McClure, Laibson, Loewenstein, and Cohen (2004) take a more direct approach
- Attempt to measure the signal coming from each of the two systems
- Task: Subjects make binary decisions between a smaller sooner reward and a larger later reward
  - Sooner period: delay $d = 0$, 2, or 4 weeks
  - Later period: 2 weeks later
- Predictions of which tasks brain areas will send signal?
  - PFC: Send signal for every task (the δ part of the $\beta - \delta$ model)
  - Limbic system: Send signal only for tasks with $d = 0$ (the β part)

δ Areas Activate for All Options



β Areas Activate Only for Options with Immediate Rewards



Behavioral Economics and The Internet

Motivation

- The internet (and technology more generally) has greatly expanded the options for empirical economics
- Much more data being collected for empirical studies
  - 6,000 tweets per second
  - 41,000 Facebook posts per second
  - Terabytes of publicly available financial data every day
- Also many more platforms for running experiments
  - Social media companies running experiments essentially constantly
  - Lower barrier to entry for researchers though Amazon Mechanical Turk

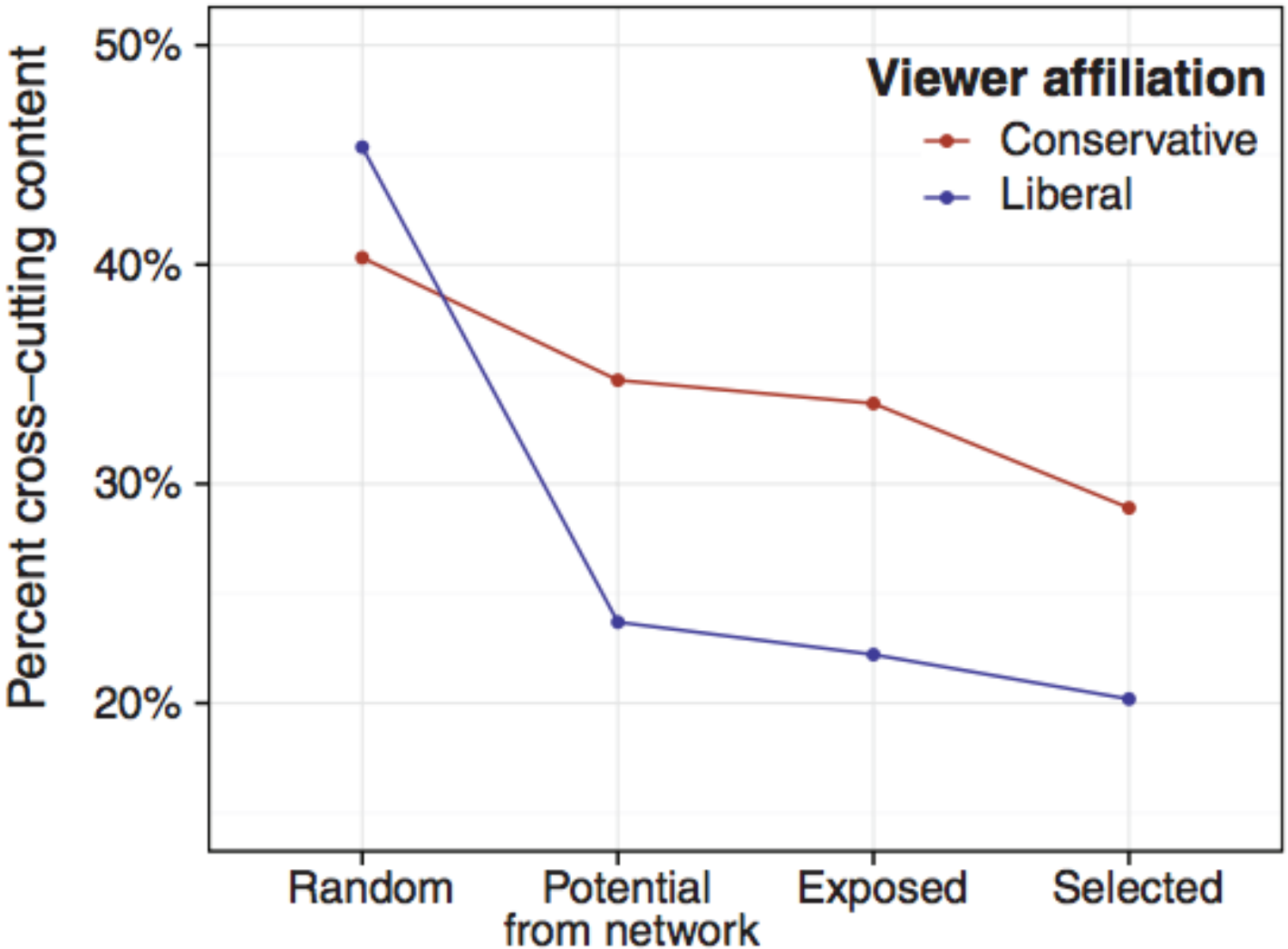
Is All This Useful?

- Question: does the internet make people better-informed?
  - Maybe yes:
    - Information is easier to obtain and verify
    - More likely to have conversations with people very different from yourself
  - Maybe not:
    - People may choose to surround themselves with connections and information sources that fit with their preferences
    - This is know as the *echo chamber effect*

Facebook Echo Chamber Study

- Bakshay, Messing, Adamic (2015) address this issue using data from Facebook posts
- Observed approx. 10 million people on Facebook (no experimental variation)
- Linked stories were classified either "cross-cutting" or "ideologically consistent" with each person's self-reported political affiliation
- What determines which content people read?
  1. Your network of friends
  2. How Facebook shows you your friends' content (Newsfeed)
  3. What content you choose to click on
- Baseline: how much cross-cutting content you would see if you were show random Facebook posts

Results from Adamic et al



Results from Adamic et al

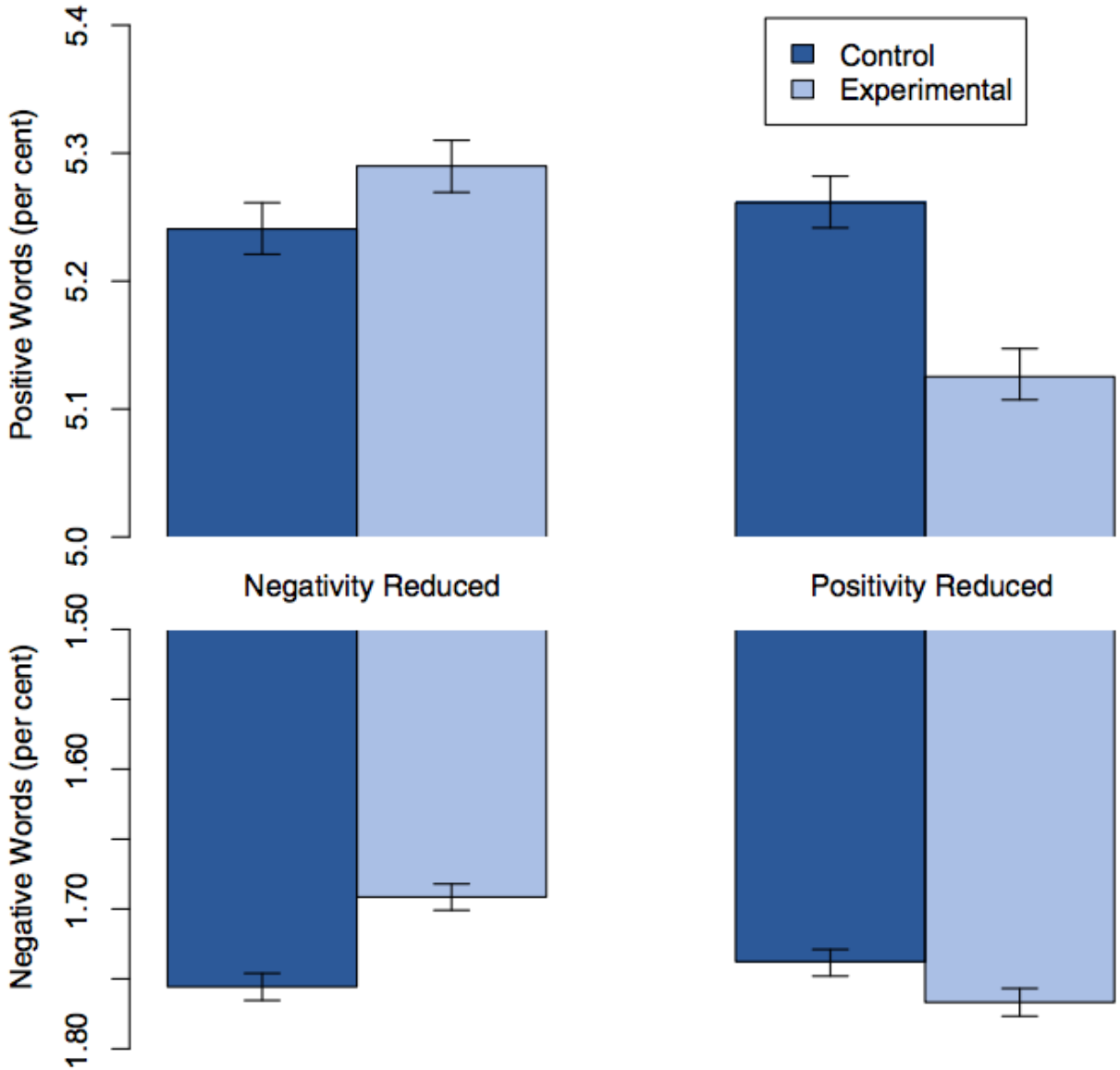
- Choice of friends is single biggest factor limiting exposure to cross-cutting content
  - This is the drop from "Random" to "Potential from Network"
- News feed algorithm has little effect on available content
  - This is the drop from "Potential from Network" to "Exposed"
- Selection from available content accounts for larger relative effect than algorithm
  - This is the drop from "Exposed" to "Selected" (ie clicked on)

Viewer affiliation	Random → Potential	Potential → Exposed	Exposed → Selected
Liberal	-0.626	-0.080	-0.063
Conservative	-0.212	-0.046	-0.172

News Feed Experiment

- The previous study used Facebook data but did not experimentally vary the user's experience
- Kramer, Guillory, and Hancock (2014) run experiment to determine how much of an effect news feed content has on user's emotions
- Experimental design:
  - Facebook posts categorized as either positive or negative
    - 22.4% negative, 46.8% positive
  - Treatment 1: Omit a percentage of all positive posts by friends that would otherwise show up on Newsfeed
  - Treatment 2: Omit a percentage of all negative posts by friends that would otherwise show up on Newsfeed
  - Controls: Omit a percentage of all posts
- Outcome variable: Positive/negative content of subjects' posts
- $N = 689,003$ people

Kramer et al Results



Kramer et al Results

- Results show emotional "contagion"
  - Omitting positive posts in feed lead to a 0.1% decrease in positive posts by subjects and a 0.04% increase in negative posts
  - Omitting negative posts in feed lead to a 0.07% decrease in negative posts by subjects and a 0.06% increase in positive posts
  - Results are statistically significant (due to large sample) but effect size is small
- Some public reaction to the paper was very negative, however:
  - One user on Twitter: "I wonder if Facebook KILLED anyone with their emotion manipulation stunt"
- Responses to these objections?
  - Note that Facebook gathered consent through terms of use agreement
  - No claim that the baseline algorithm is good or bad for mental health
  - One could argue that Facebook has an obligation to test their algorithm

Methodology: Amazon Mechanical Turk

- Most researchers do not have access to Facebook data (and certainly not able to manipulate their software)
- However, other tools do exist to reach lots of people online
- One such tool: Amazon Mechanical Turk
  - Online labor platform of English-speaking workers
  - Employers posts small tasks with an associated wage rate
  - Tasks can include experiments (either explicitly or implicitly)
  - Much cheaper and faster than running lab or field experiment
- Another tool: Harvard Digital Lab for the Social Sciences