The Role of Control Processes in the Dynamics of Episodic Memory Search

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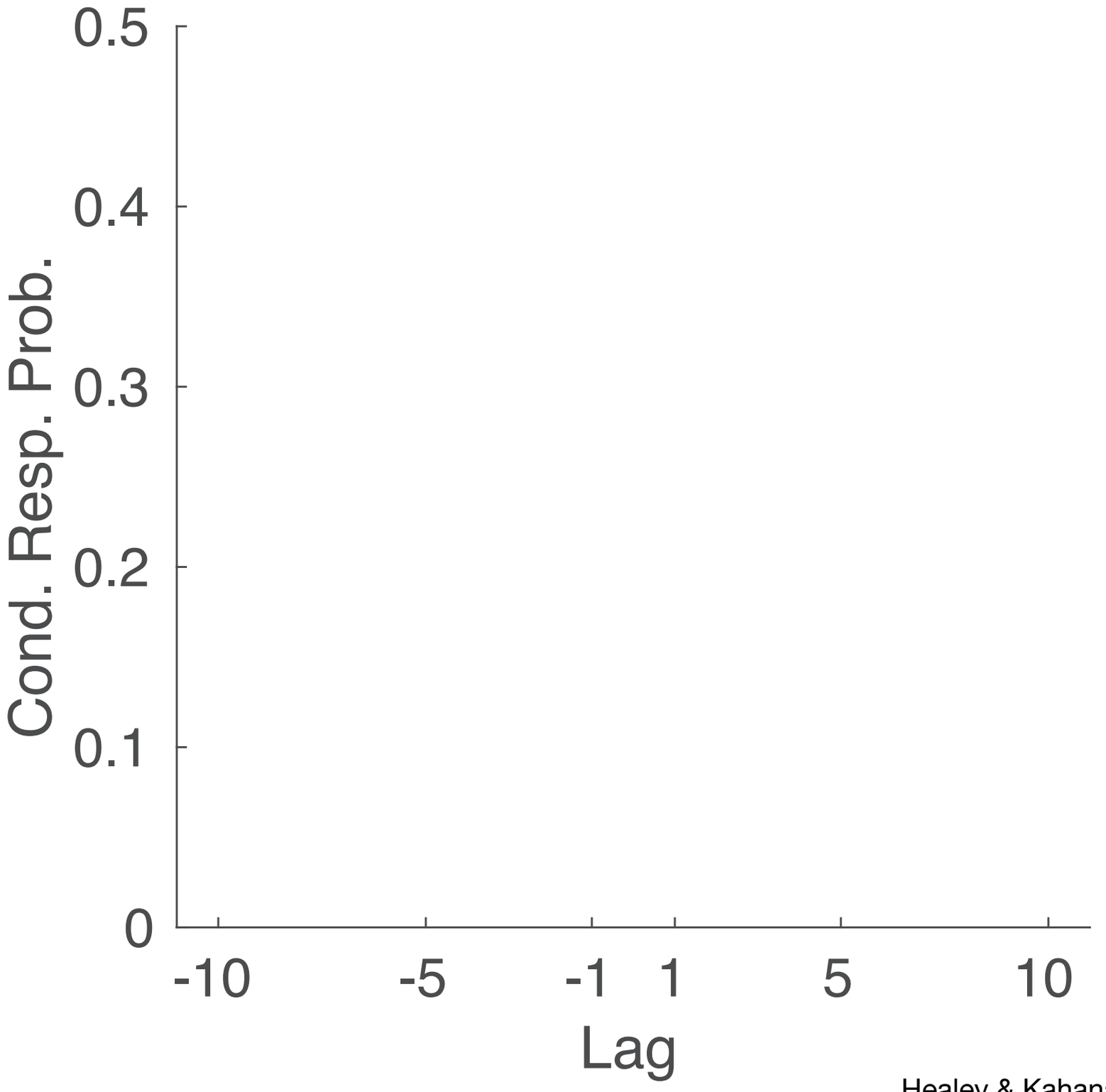
CBCC LAB

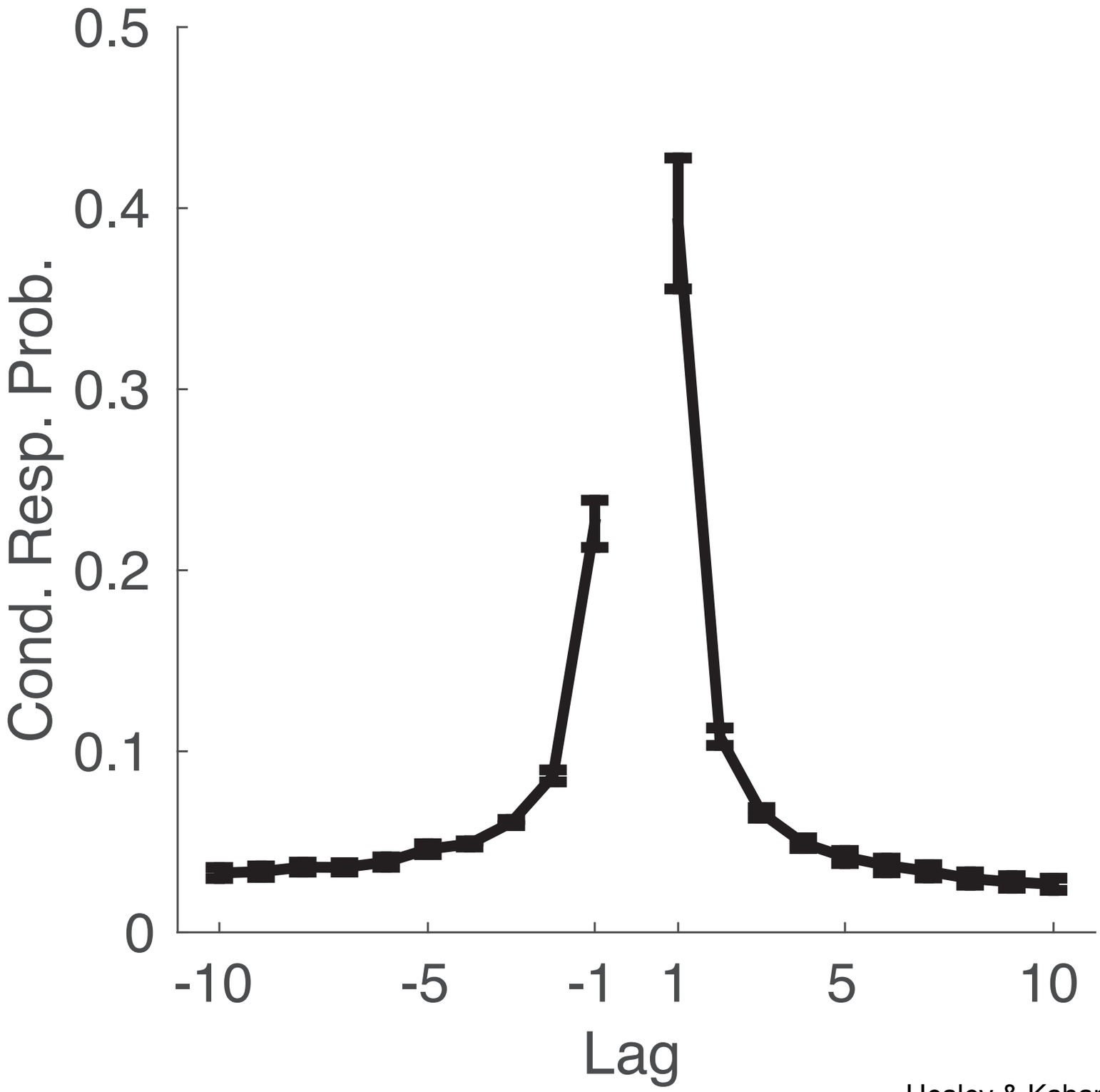
MICHIGAN STATE UNIVERSITY

Temporal Contiguity



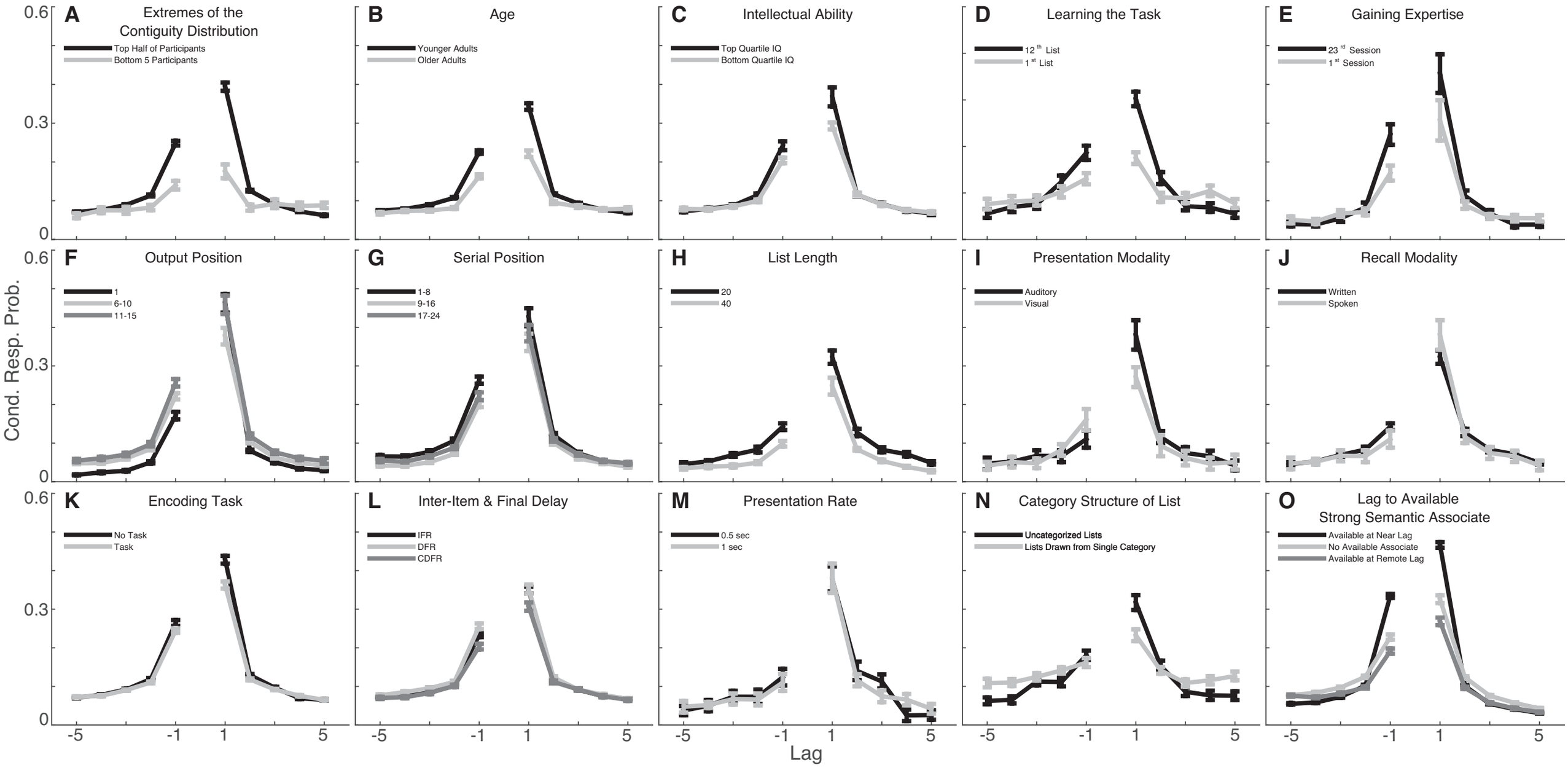
Healey & Kahana (2019), *PB&R*; Kahana, 1996

Temporal Contiguity



Healey & Kahana (2019), *PB&R*; Kahana, 1996

Temporal contiguity is extremely robust in free recall



Healey & Kahana (2019), *PB&R*

Temporal contiguity in other lab tasks

- Final Free Recall (Howard et al. 2008; Unsworth, 2008)

- Recognition (Schwartz et al., 2005; Sadeh et al.; 2015; Averell et al. 2016)

- Paired Associates (Davis et al.,2008; Caplan, Glaholt, & McIntosh, 2006)

Contiguity predicts group and individual differences

- Age (Kahana et al. 2002; Wahlheim & Huff, 2015)
- ADHD (Gibson, Healey, & Gondoli, in press)
- Schizophrenia (Polyn et al., 2015; Sahakyan and Kwapil, 2018; Murty et al., 2018)
- Worry and anxiety (Pajkossy et al., 2017)
- Memory Ability (Sederberg et al., 2010)
- IQ (Healey, Crutchley, & Kahana, 2014)

Perhaps contiguity is a general principle of memory

- “Indeed, the contiguity and proximity effects were so consistent across individuals that one is tempted to rename them contiguity and proximity laws.” Healey & Kahana, 2014

- “…this pattern of results suggests that the memory system automatically encodes information about temporal proximity … moreover, the memory system tends to use this information to guide memory search, even when other associative dimensions (like semantic similarity or presentation modality) are available to support recall.” Healey, Long, & Kahana, 2019

Is contiguity *really* a general principle of memory?

- Wherever we've looked for it, we've found it
  - Almost without exception
- But perhaps we haven't looked in enough places

Many studies show it, but most studies share features like:

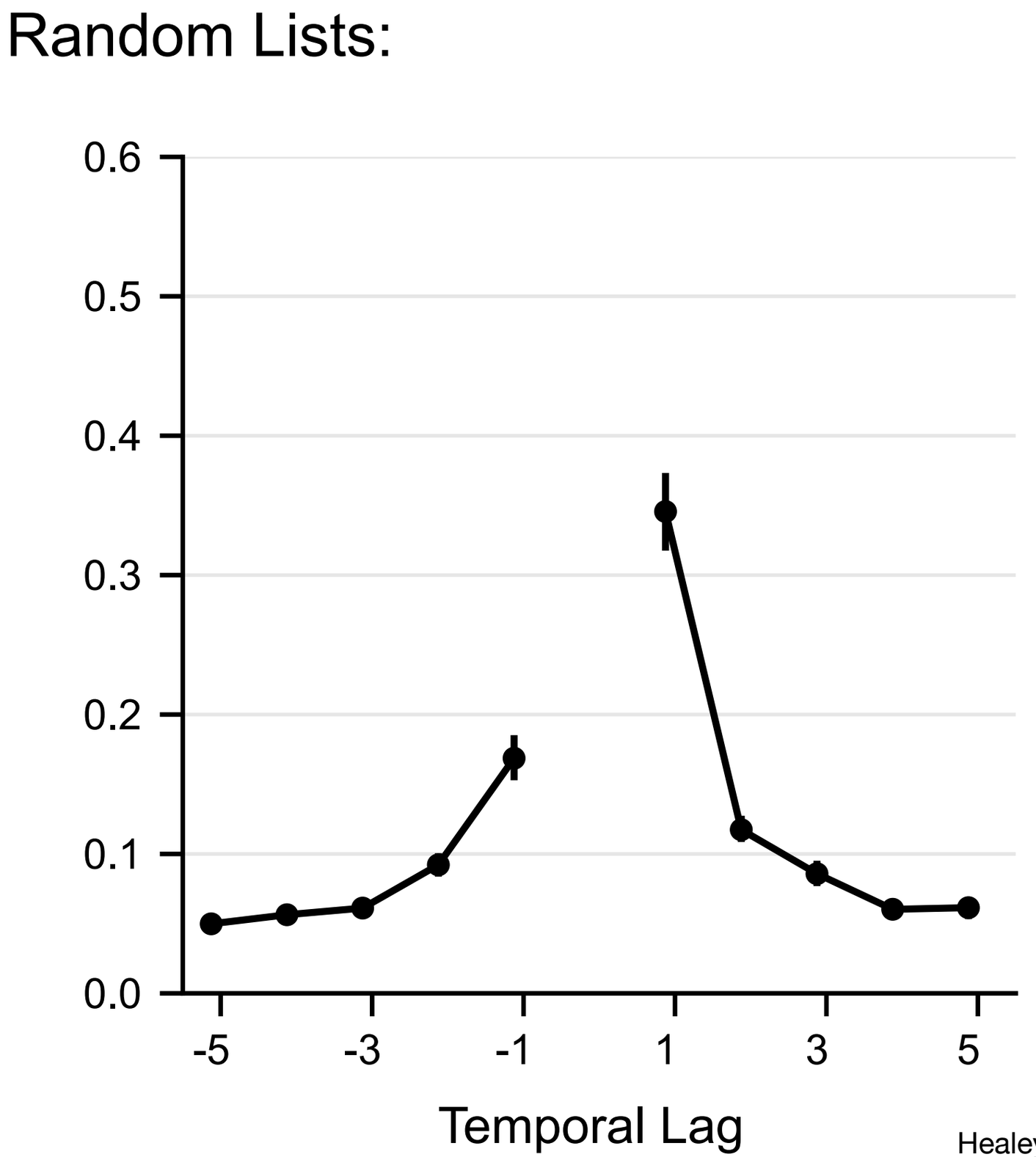
- Lists of randomly selected words:
  - Does contiguity occur when there are rich semantic associations?
- Free recall or serial instructions:
  - Does contiguity occur when instructions emphasize non-temporal information?
- Deliberate study:
  - Does contiguity occur when we are not studying?
- Lab tasks:
  - Does contiguity occur outside the lab?

Study 1: Adding Cognitive Control

- Varying recall instructions
  - Free-Recall: “Type in whatever word comes to mind first.”
  - Order-Focus: “Allow the order in which you saw the words to guide your memory search.”
  - Meaning-Focus: “Allow the semantic associations to guide your memory search.”
- 18 lists, 16-items per list

Healey & Uitvlugt (2019), *Mem & Cog*

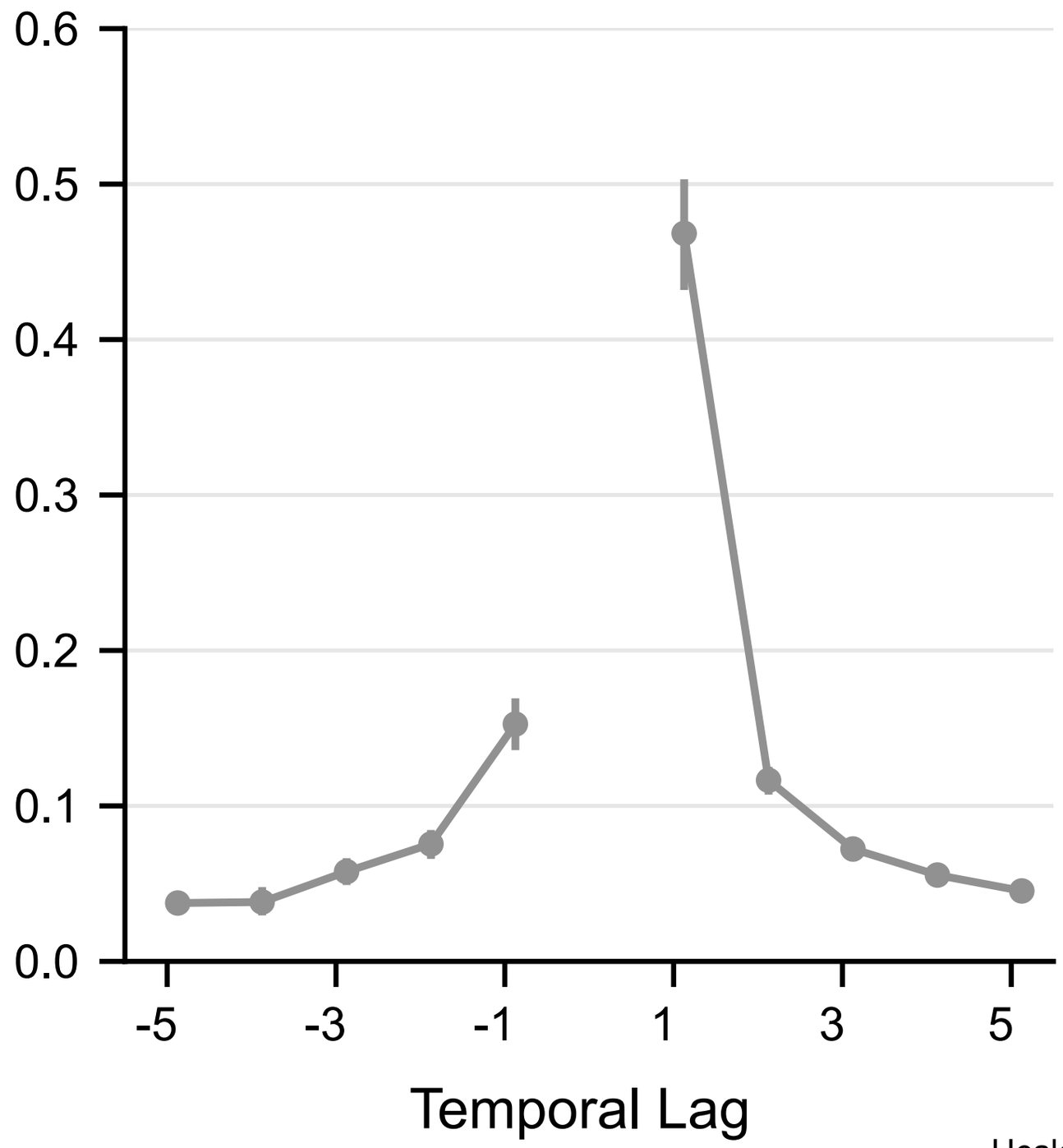
“Normal” contiguity effect with free recall instructions



Healey & Uitvlugt (2019), *Mem & Cog*

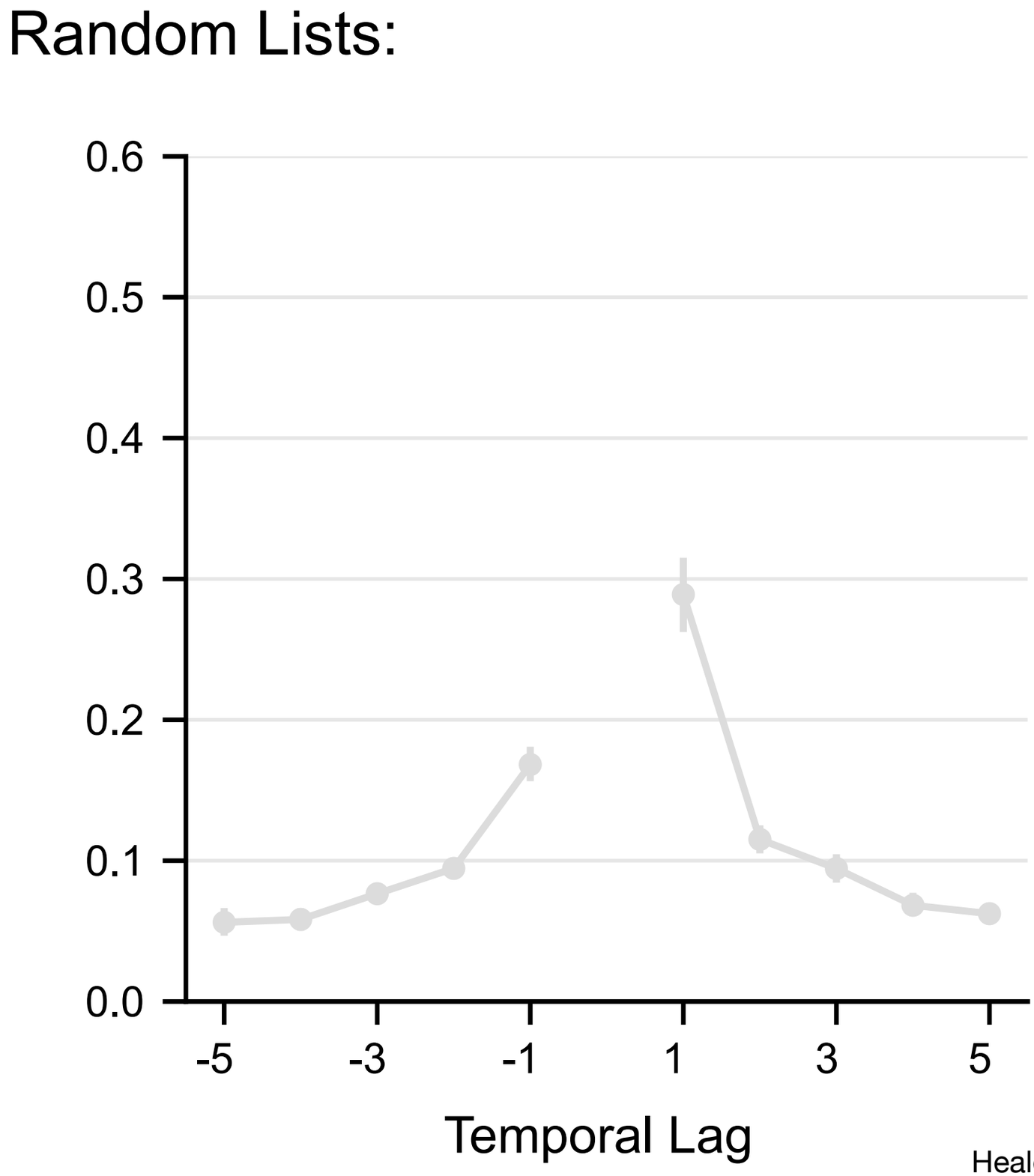
Order-focus instructions increase contiguity (not surprising)

Random Lists:



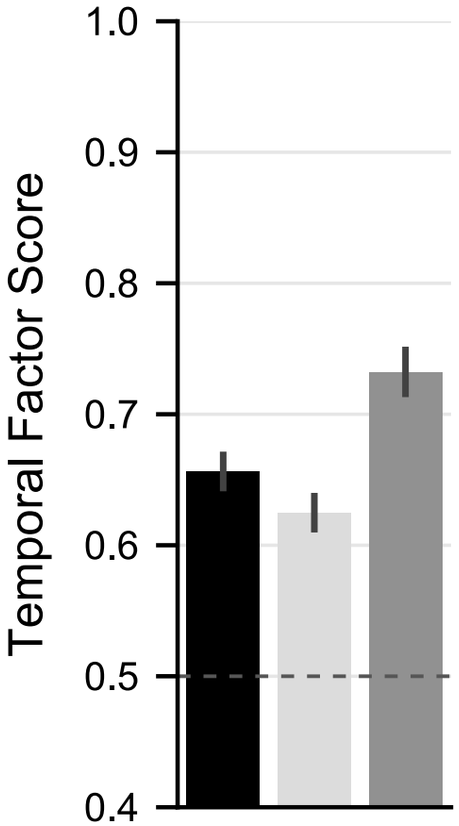
Healey & Uitvlugt (2019), *Mem & Cog*

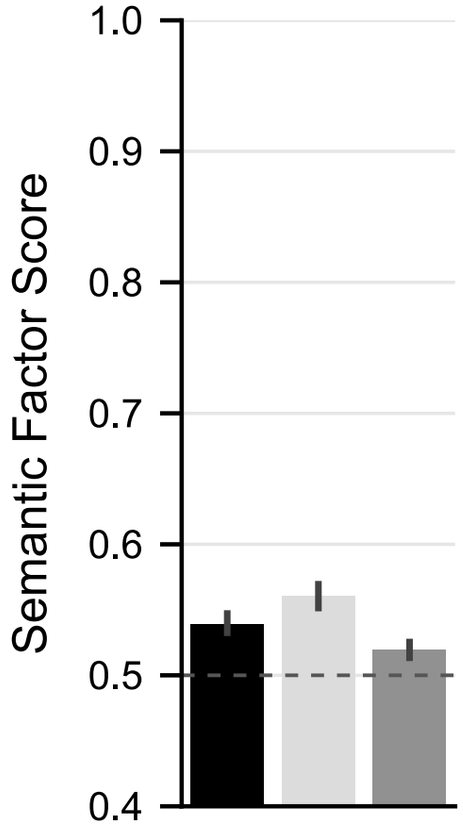
Contiguity is decreased by meaning-focus instructions



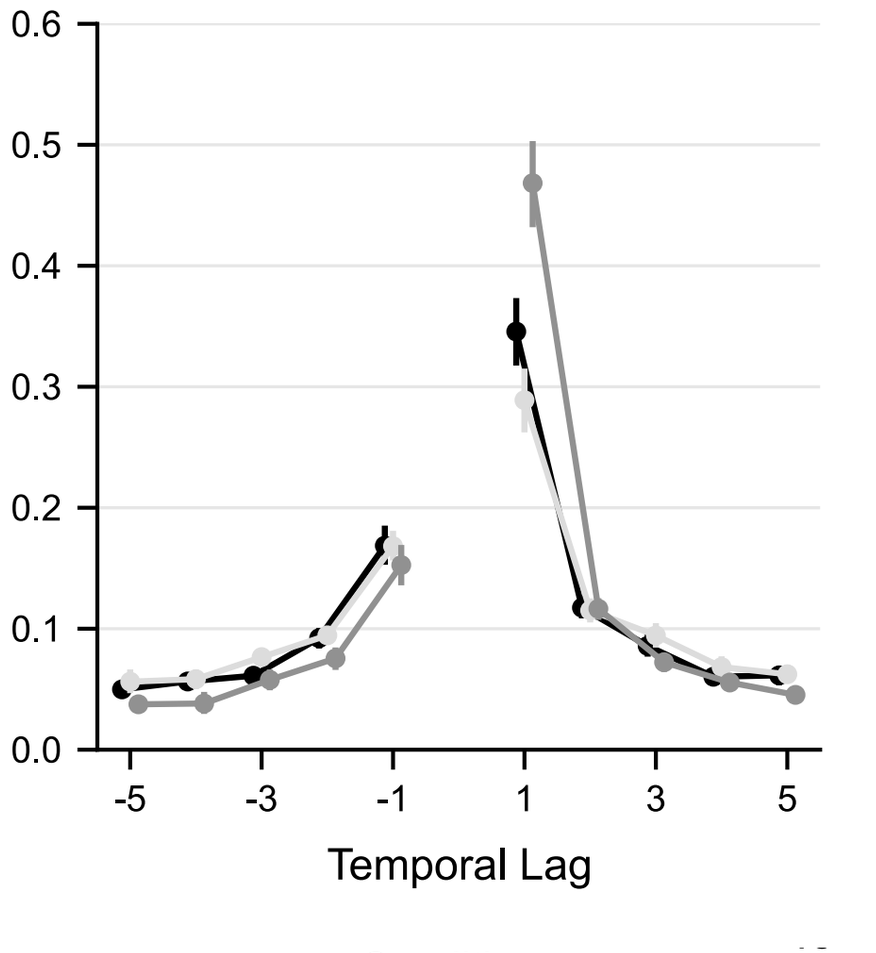
Healey & Uitvlugt (2019), *Mem & Cog*

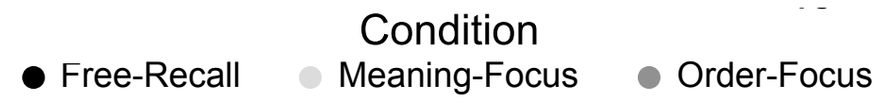
Cognitive control modulates the contiguity effect





Random Lists:





Healey & Uitvlugt (2019), *Mem & Cog*

Study 1: Adding Semantic Structure

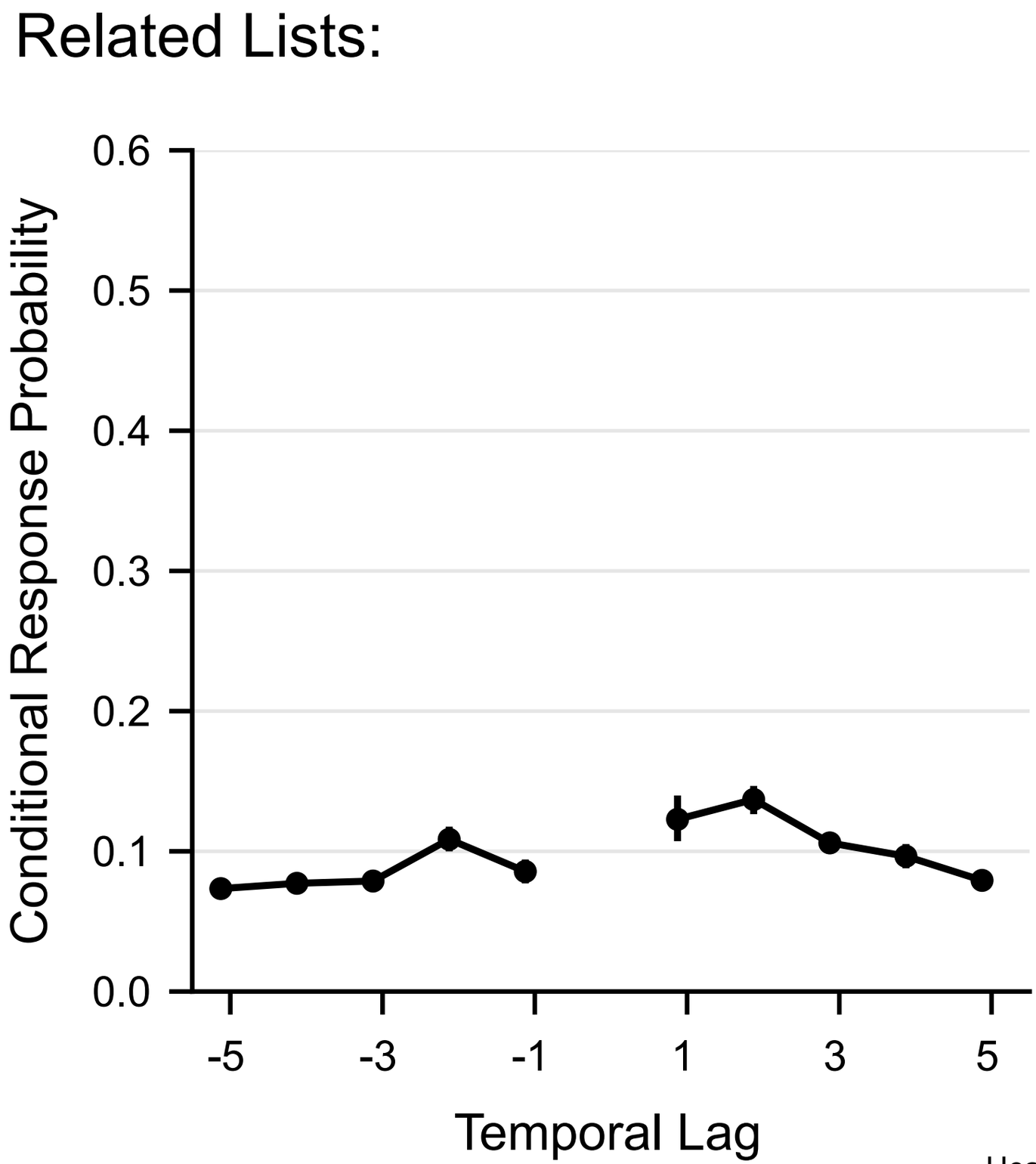
- Adding Semantic Structure to Lists
  - Conceptual replication of Polyn, Erlikhman, & Kahana (2011)
  - Two different list structures:
    - Words randomly selected, ignoring semantics
    - Four groups of semantically related words - ordered randomly

Example Lists

- Group A: *DANDRUFF, SHAMPOO, SKIN, SOAP*
- Group B: *WHEEL, LEVER, MACHINE, TOOL*
- Group C: *ANCHOR, CREW, DOCK, PORT*
- Group D: *SCULPTURE, ARTIST, PAINTING, MUSEUM*
- But random presentation order:
  - B_1 A_1 B_2 D_1 C_1 A_2 B_3 D_2 B_4 D_3 A_3 C_2 A_4 C_3 D_4 C_4

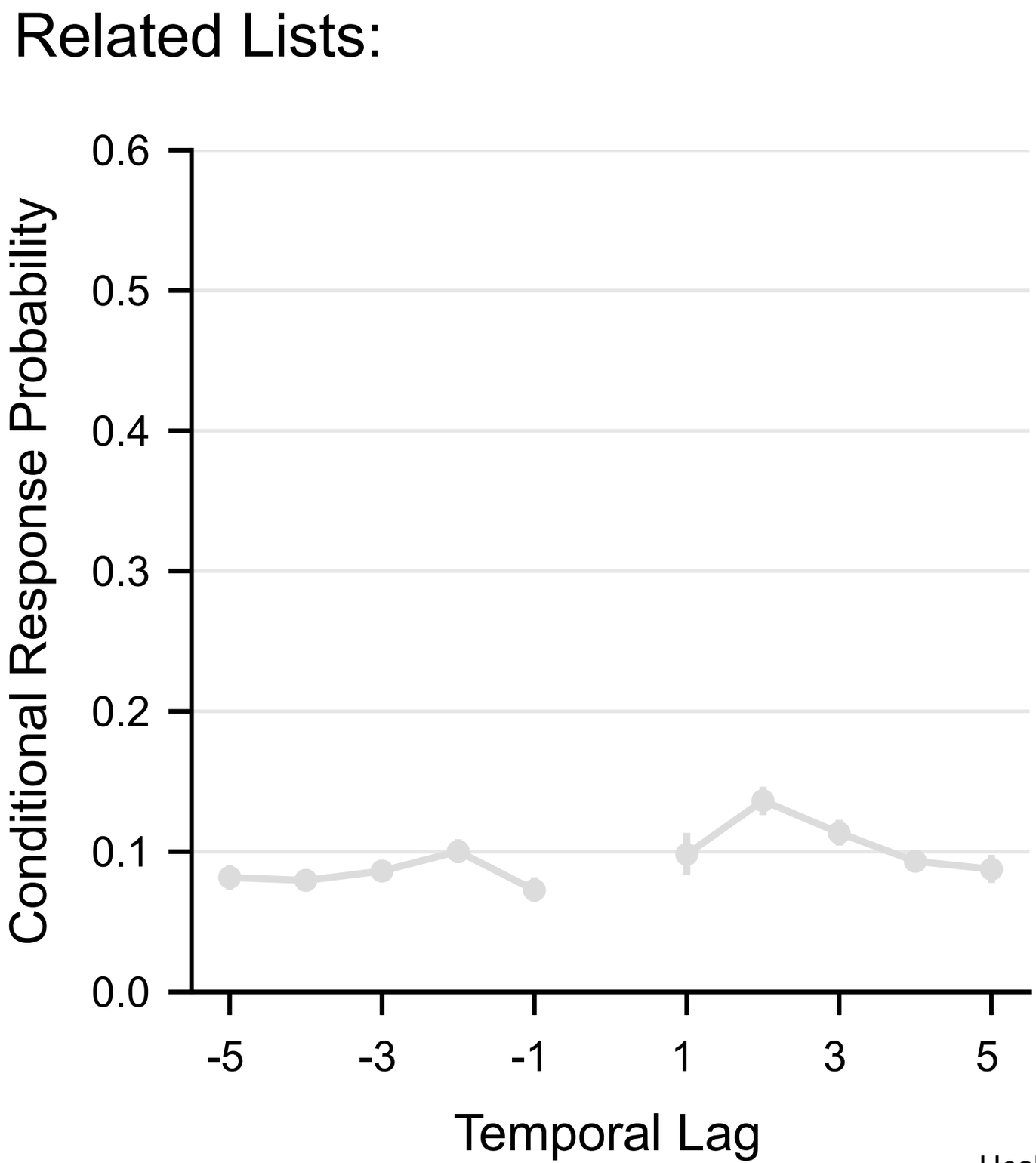
Healey & Uitvlugt (2019), *Mem & Cog*

Contiguity is almost gone even with free recall instructions (replicates Polyn et al., 2011)



Healey & Uitvlugt (2019), *Mem & Cog*

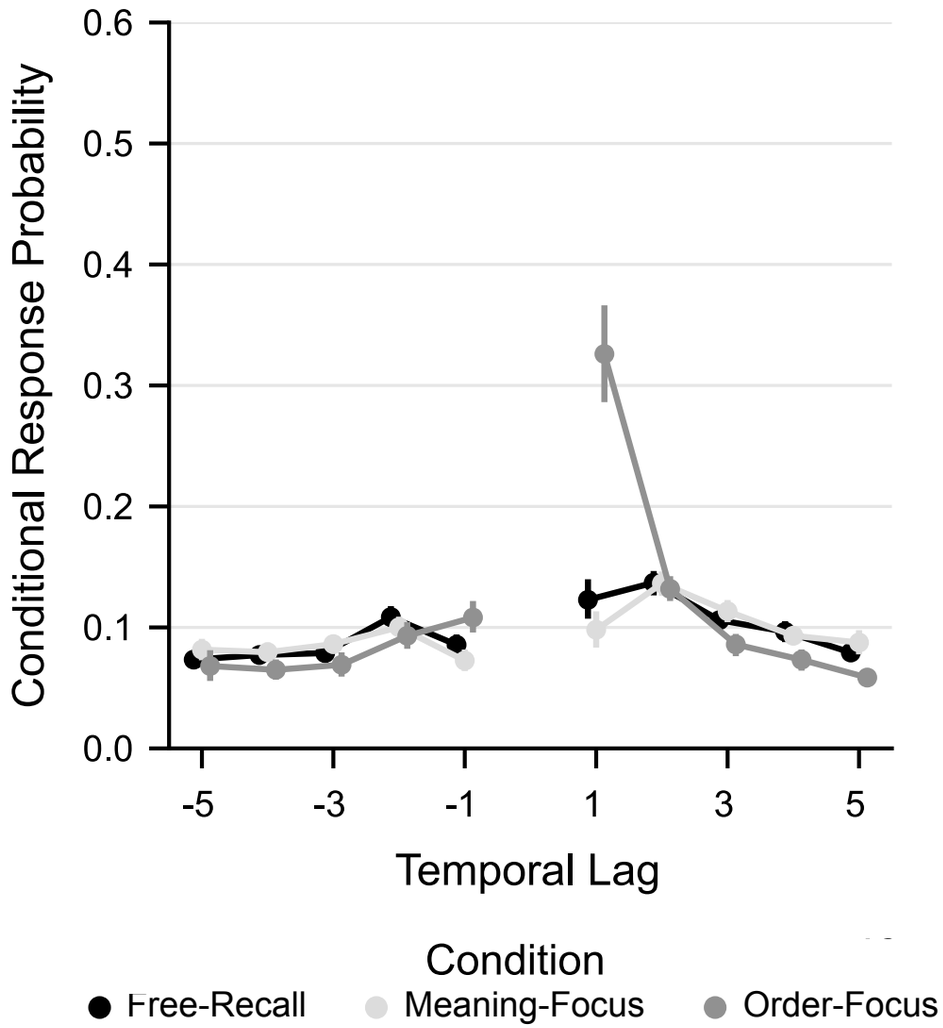
Contiguity also almost gone with meaning-focus instructions

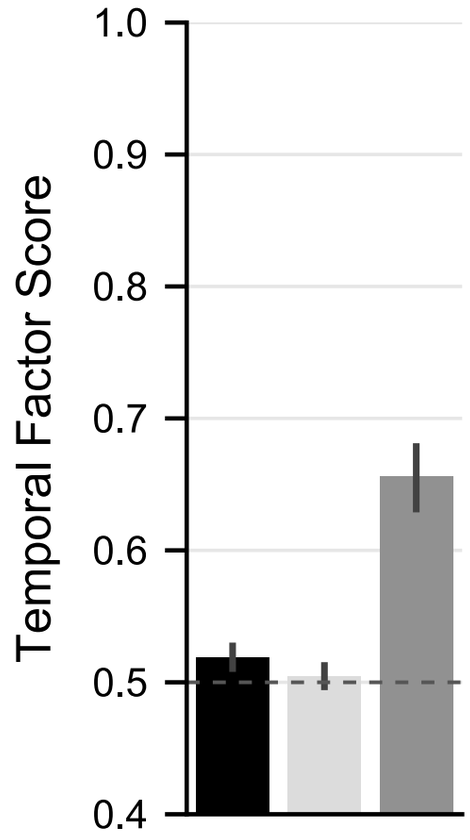


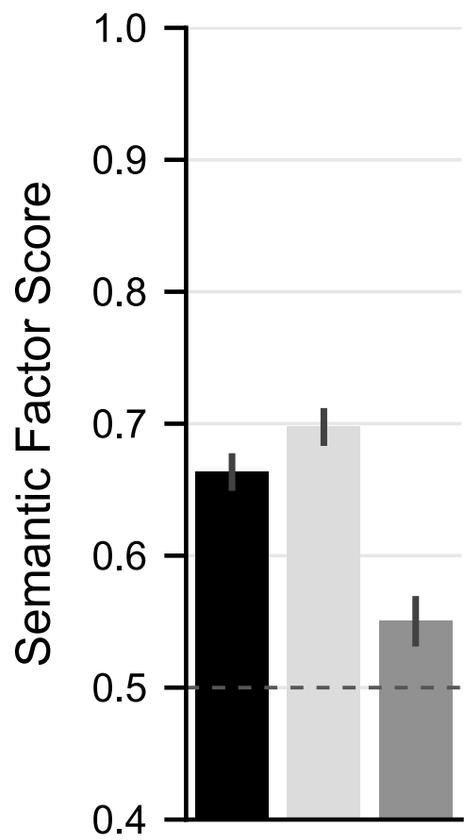
Healey & Uitvlugt (2019), *Mem & Cog*

But contiguity is restored under order-focus instructions

Related Lists:







Healey & Uitvlugt (2019), *Mem & Cog*

Study 1: Conclusions

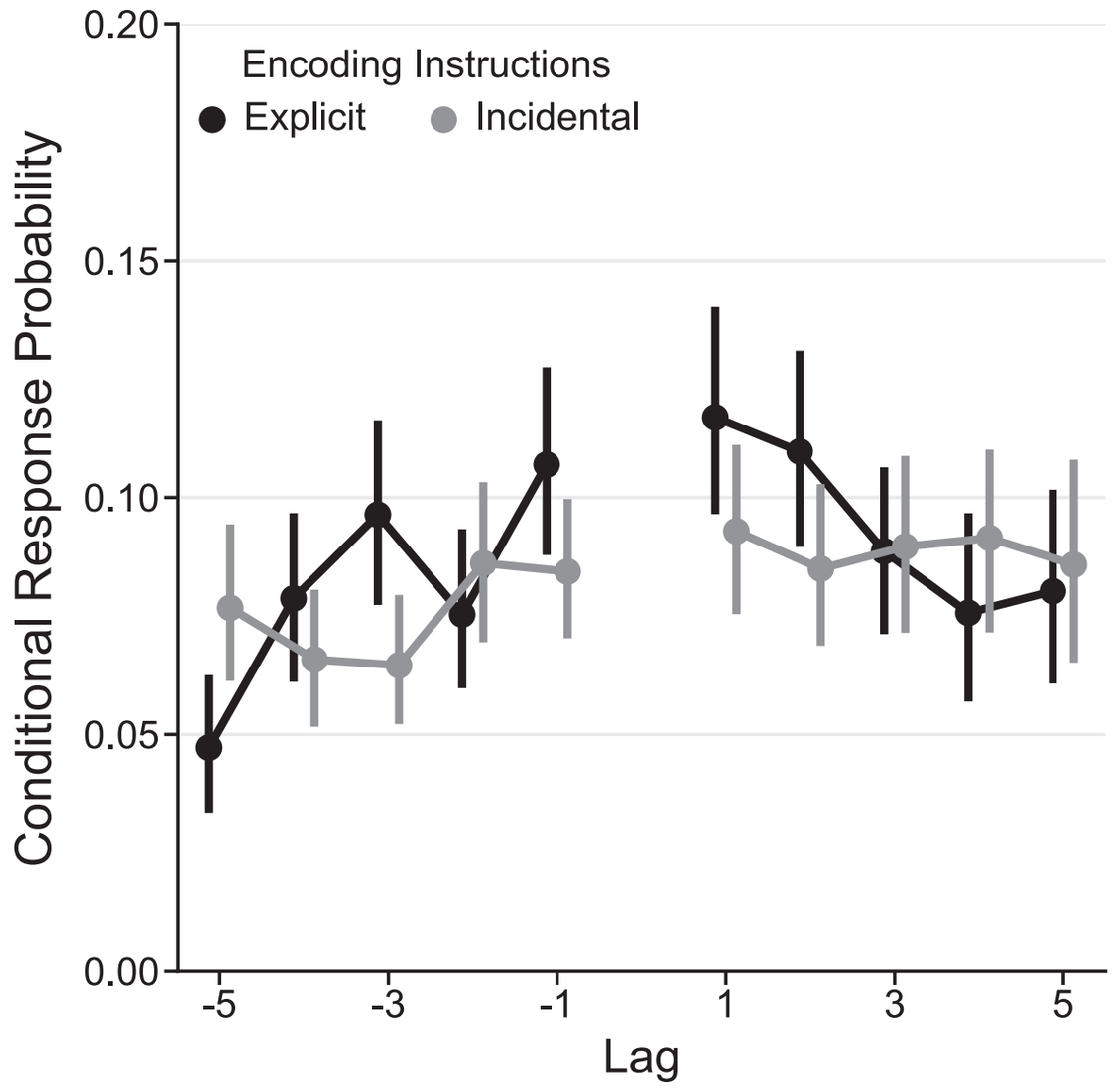
- Cognitive control modulates the use of temporal information
- Raises questions:
  - Can models explain how this modulation occurs?
  - Does the effect ***require*** control processes to encode temporal information?

Study 2: Does removing intent to encode eliminate contiguity?

- Some evidence that it does (Nairne, Cogdill, & Lehman, 2017)
- We presented:
  - A single 16-item list
  - *N* = 629 (MTurk)
  - Incidental encoding judgment task: Would it fit in a shoebox?

Does removing intent to encode eliminate contiguity?

- It reduces it dramatically



Healey (2018), *JML*

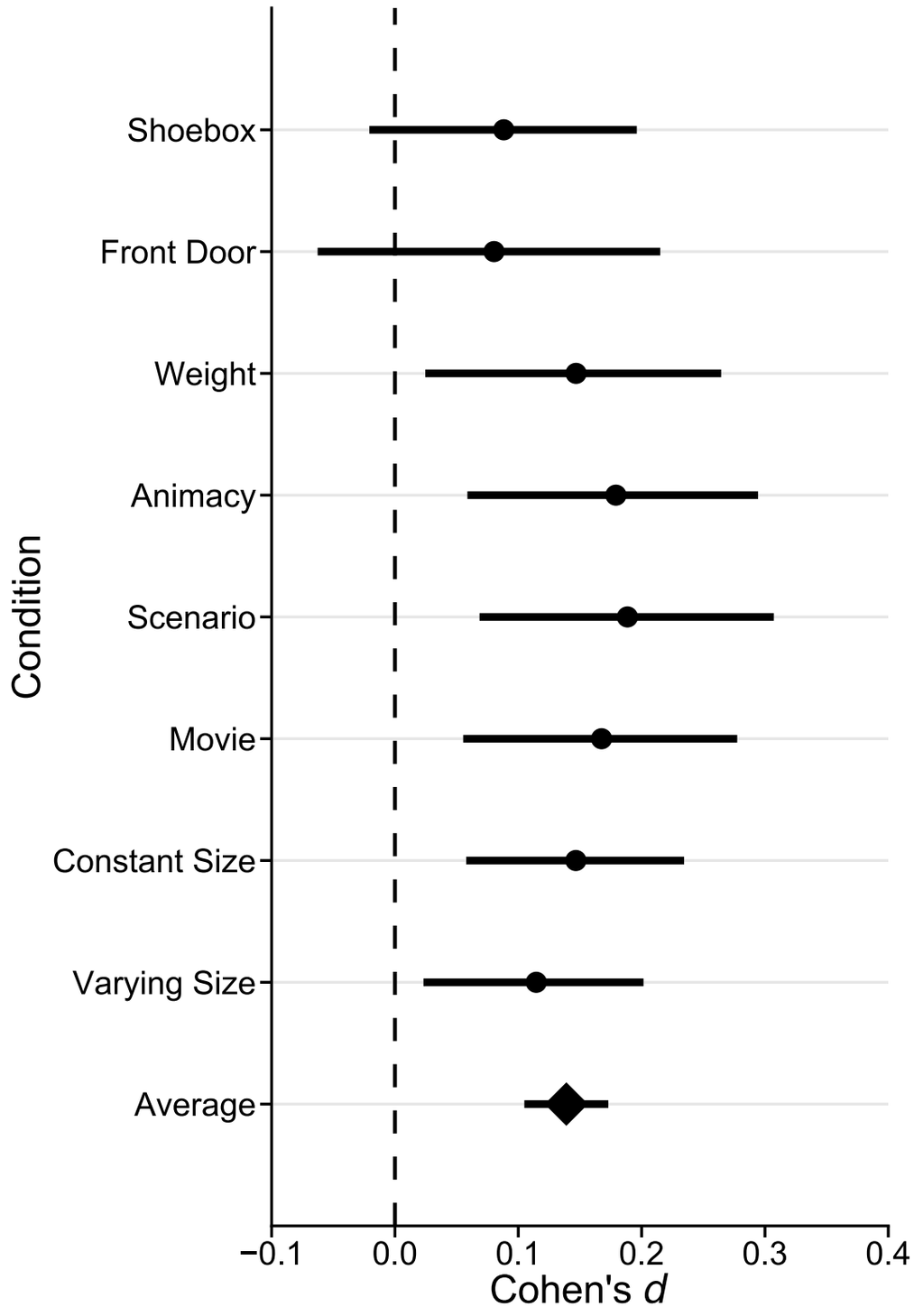
Study 2: Does removing intent to encode *eliminate* contiguity?

- Seven different incidental encoding judgment tasks:
  - Heavier than a bottle of water?
  - Living or non-living?
  - Relevant for moving to a foreign land?
- *N* = 2,812 (MTurk)

Healey (2018), *JML*

Does removing intent to encode *eliminate* contiguity?

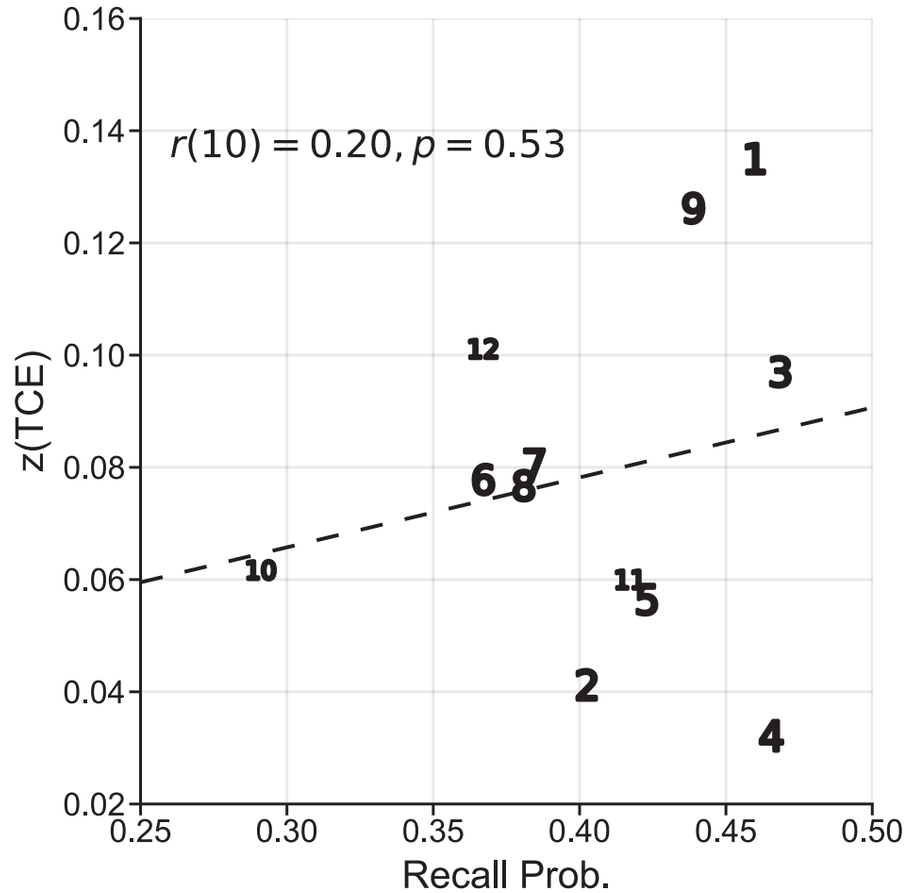
- No



Healey (2018), *JML*

Study 2: Conclusions

- Incidental encoding reduces temporal contiguity
- But a robust but small residual effect remains
- Open Question:
  - Recall is high but contiguity is low:
    - Is this a problem for models?
    - Want the answer?
    - Go see Abby Dester's poster!
- If the effect is so small, is it important outside the lab?



Healey (2018), *JML*

Study 3: Looking Outside the Lab

- If contiguity is a general principle of memory, it should guide search for memories formed outside the lab
- Some evidence suggests this does happen
  - Moreton and Ward (2010)
  - Cortis Mack, Cinel, Davies, Harding, & Ward (2017)
- But it is very hard to control both semantic relatedness and encoding intentionality

Uitvlugt & Healey (2019), *Psych Science*

Looking for temporal contiguity outside the lab

- Right after the election, we asked people to recall details of the election campaign.
- Subjects from Amazon Mechanical Turk
- 7,931 headlines (M = 7.55, SD = 4.82)
- 5,776 transitions (M = 5.50, SD = 4.36)

Uitvlugt & Healey (2019), *Psych Science*

Calculating Transition Lags

“Trump’s Access Hollywood hot mic”

- October 7, 2016

“FBI re-opens Clinton email investigation”

- October 28, 2016

$$\text{Lag} = 599 - 578 = +21$$

Uitvlugt & Healey (2019), *Psych Science*

Calculating Transition Lags

“Trump won’t accept the results of election”

- October 9, 2016

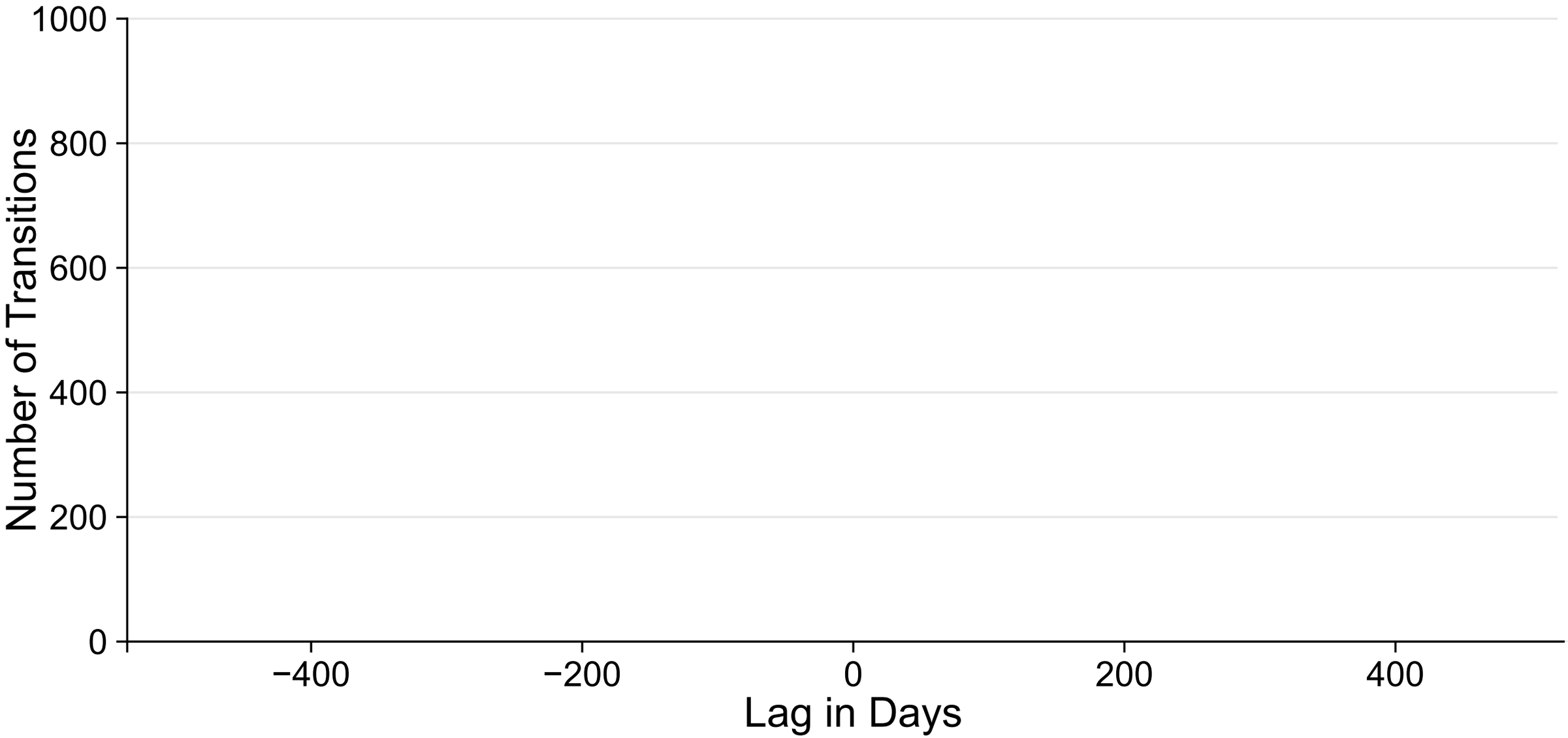
“Trump invites Obama’s half-brother to third debate”

- October 9, 2016

Lag = 0

Uitvlugt & Healey (2019), *Psych Science*

transition lags peak at zero days



Uitvlugt & Healey (2019), *Psych Science*

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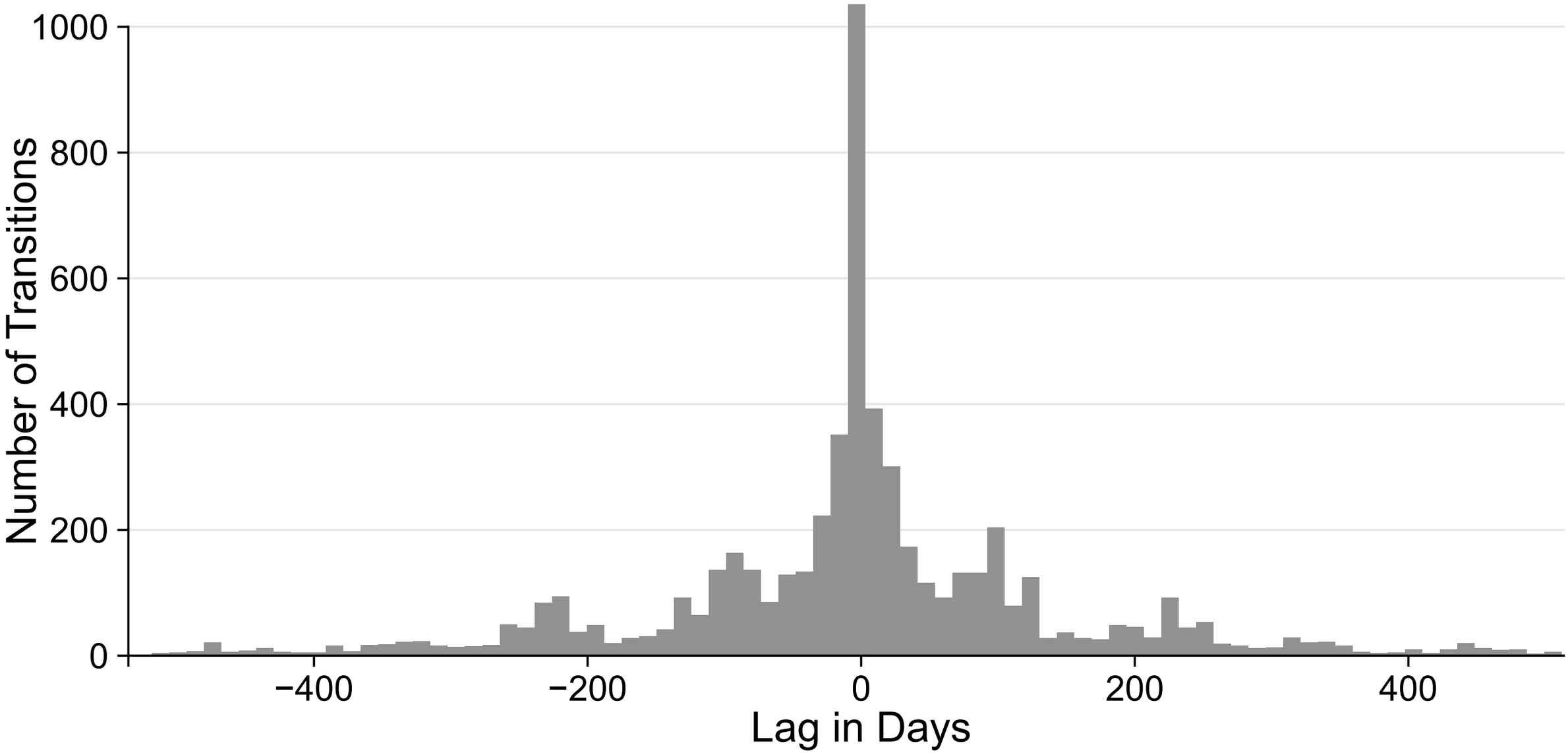
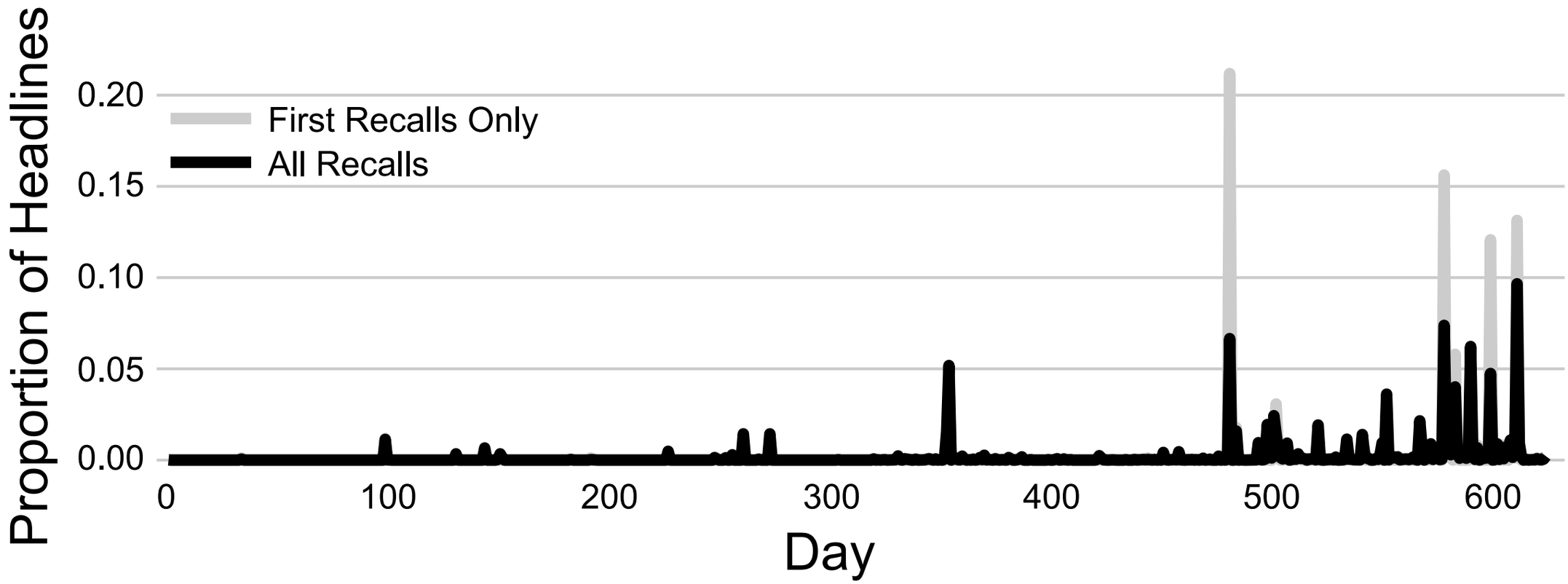


Uitvlugt & Healey (2019), *Psych Science*

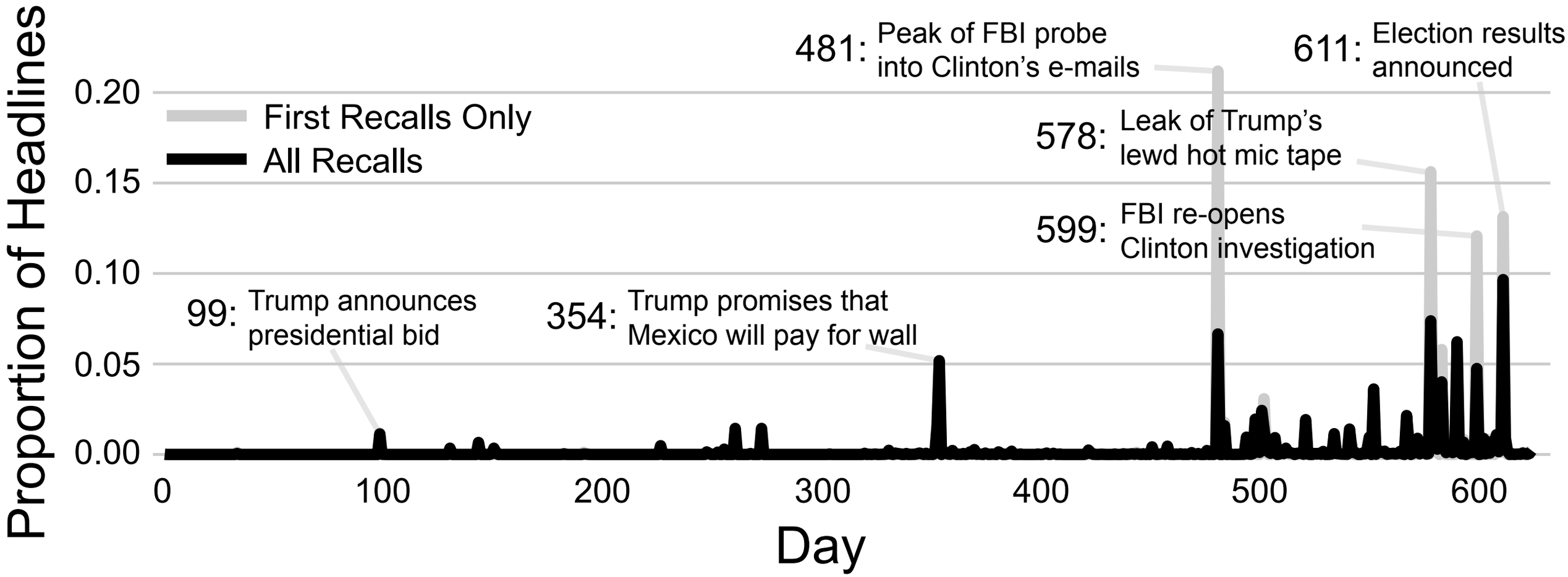
A Confound

- Imagine if 9 out of every 10 stories came from a particular day
- There would be many ways to make lag-zero transitions, and few ways to make longer transitions
- We'd expect an artificial contiguity effect
- We do see this sort of "story clustering":



Uitvlugt & Healey (2019), *Psych Science*

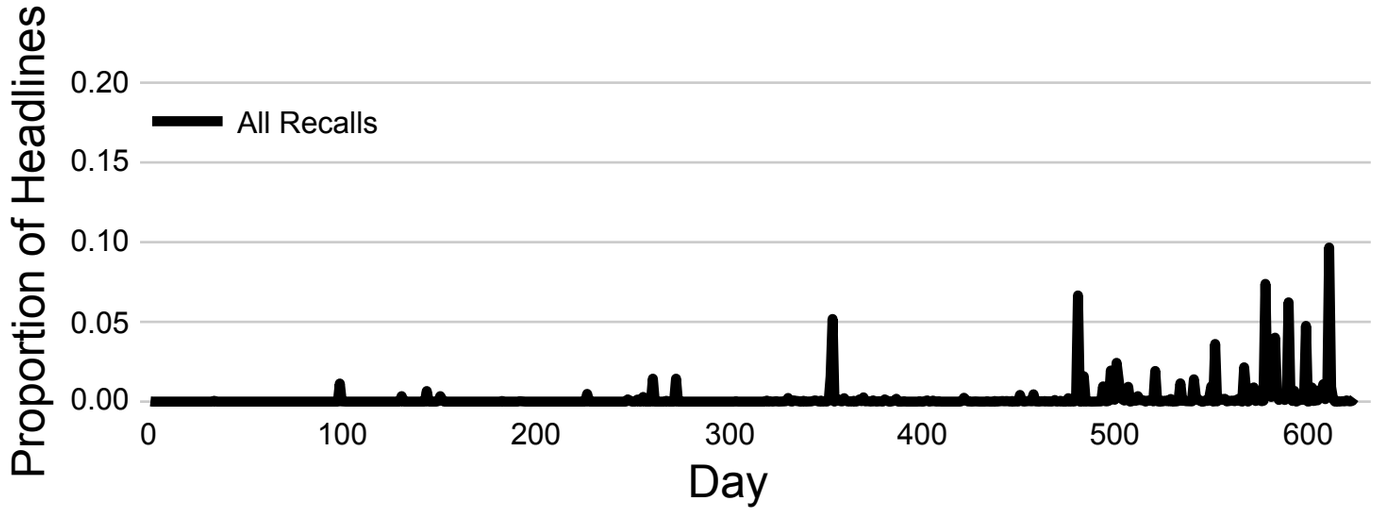
A Confound



Uitvlugt & Healey (2019), *Psych Science*

Removing the Confound

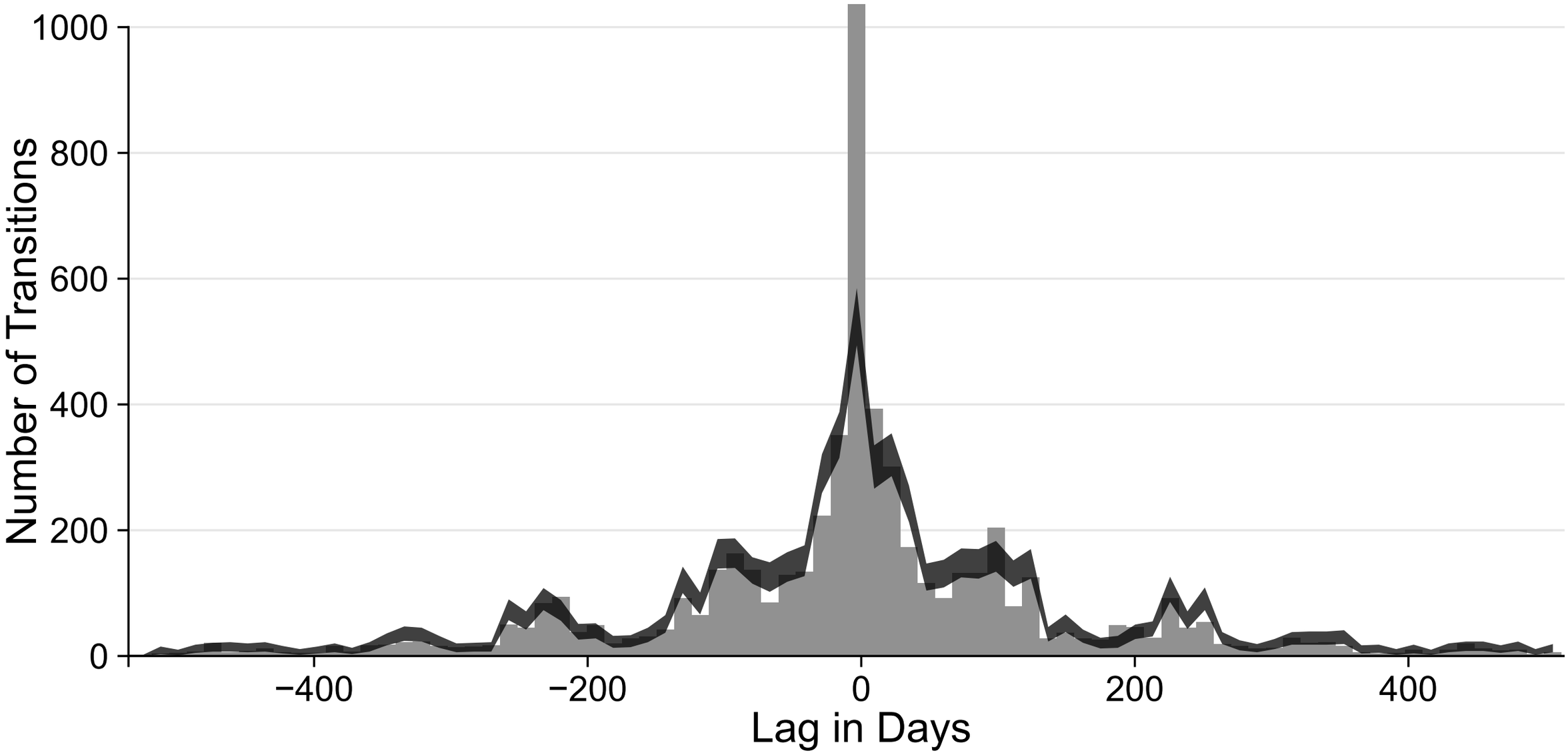
- Simulation in which temporal order could not influence recall order
- Simulated subjects recalled *k* headlines by randomly sampling from:



- Because each draw from the distribution is independent, all links between successive recalls are broken and transition lags depend only on headline-clustering

Uitvlugt & Healey (2019), *Psych Science*

Near-lag transitions more frequent than chance



Uitvlugt & Healey (2019), *Psych Science*

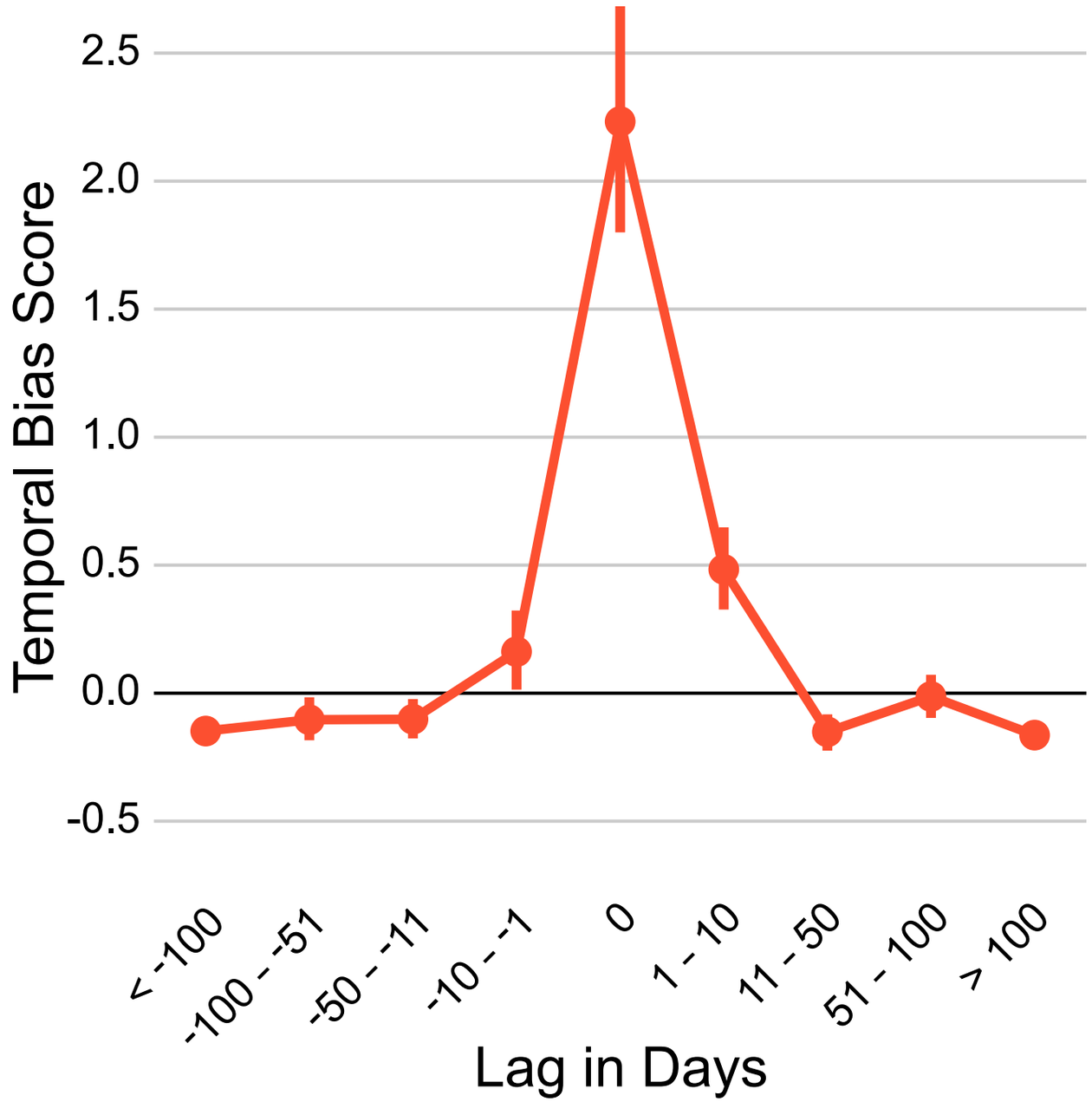
Lets zoom in on short-lags

- The difference between the actual and null distributions is largest at short lags.
- Zoomed in on these short lags by grouping lags into bins, using wider bins for longer lags
- For each bin, used the actual and null distributions to calculate a temporal bias score:

$$Temporal\ bias\ score = \frac{actual\ count}{}$$

Uitvlugt & Healey (2019), *Psych Science*

A Bias Toward Near-Lags



Uitvlugt & Healey (2019), *Psych Science*

Another Confound

- Items that are semantically related tend to be recalled together (Bousfield, 1953)
- Could produce a peak at near-lags if news stories that occur near in time to one another tend to be semantically related

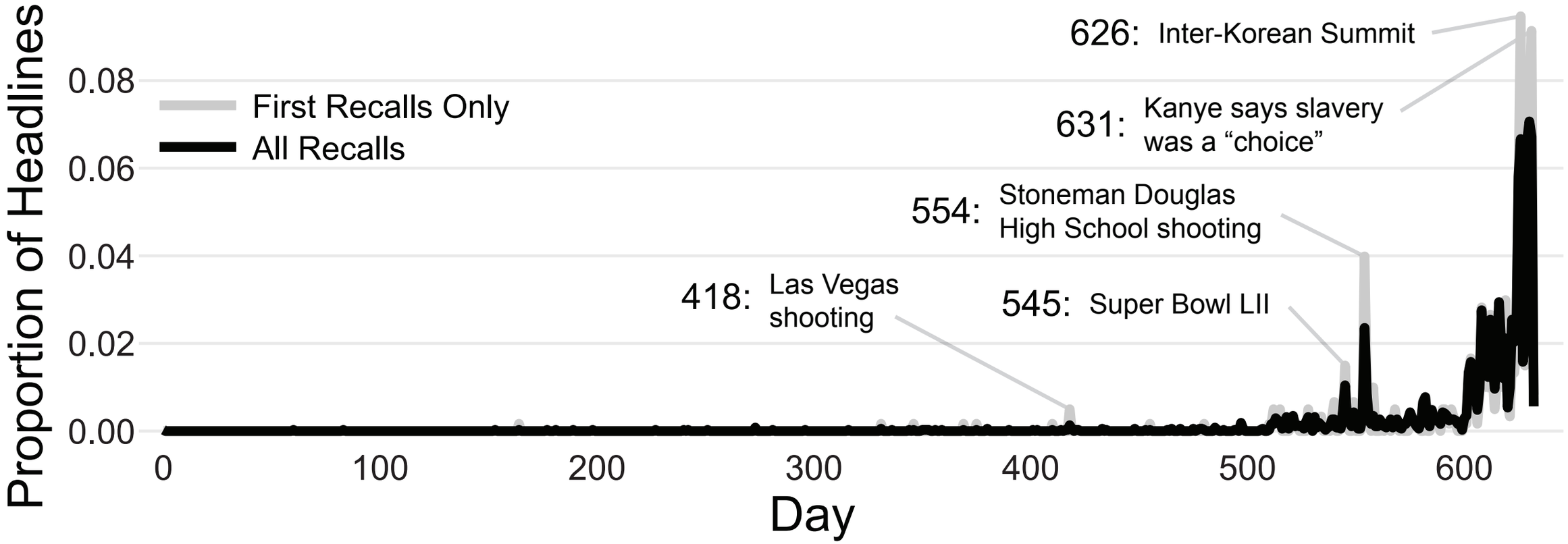
Uitvlugt & Healey (2019), *Psych Science*

A Second Experiment

- This time asking people to recall any news stories that came to mind

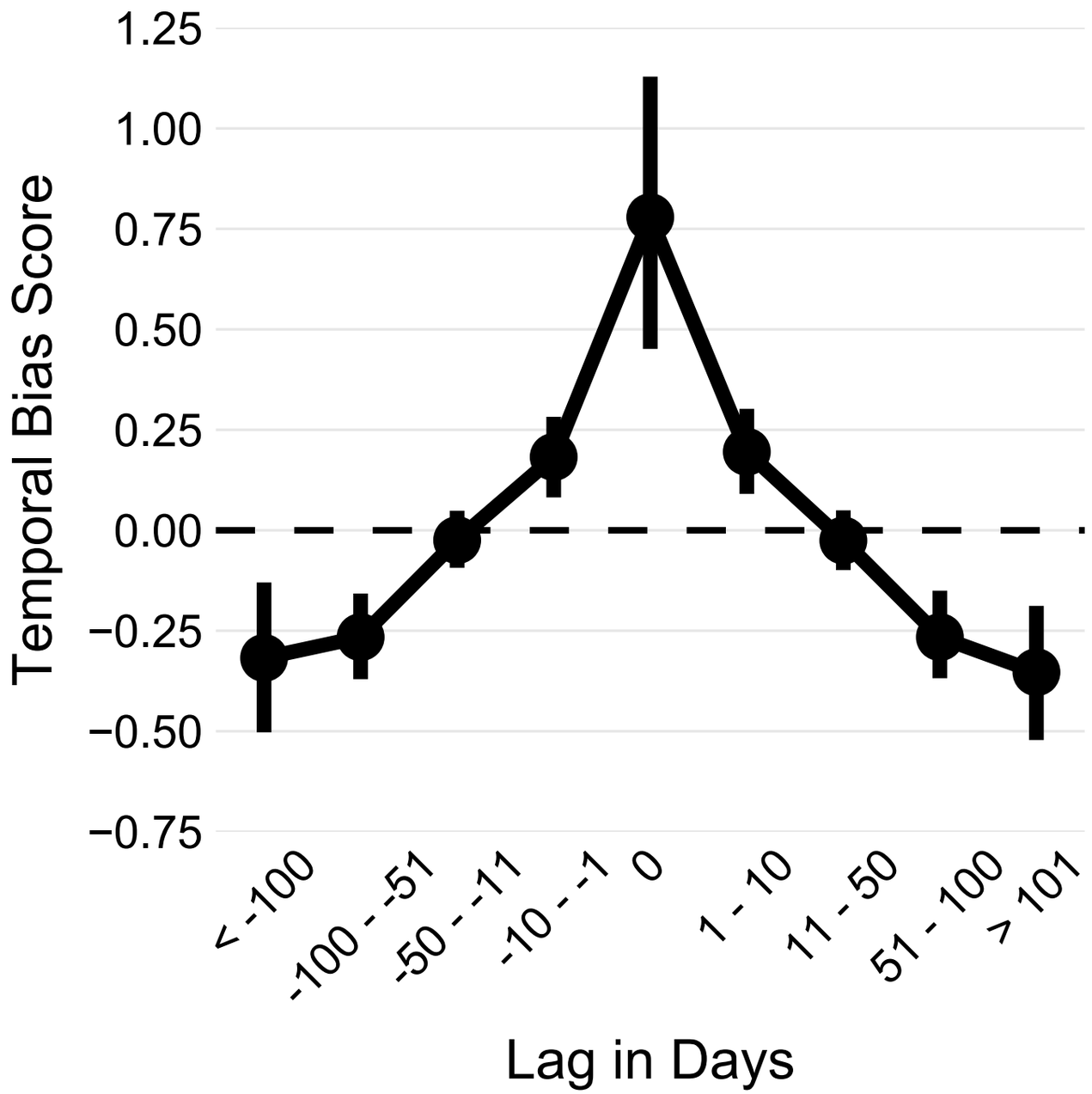
Uitvlugt & Healey (2019), *Psych Science*

The Events



Uitvlugt & Healey (2019), *Psych Science*

A Bias Toward Near-Lags



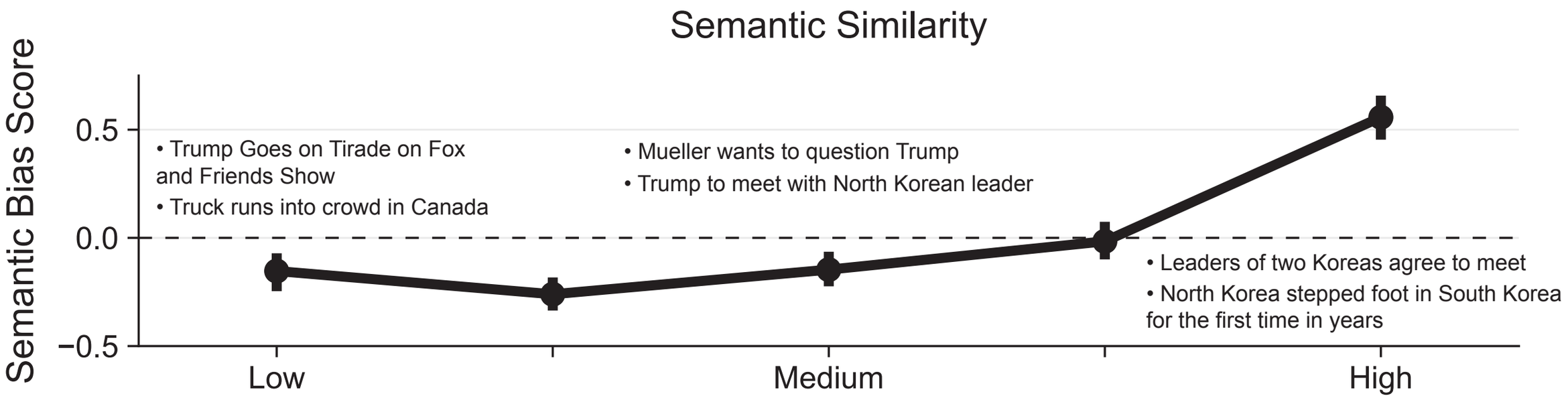
Uitvlugt & Healey (2019), *Psych Science*

Controlling for Semantic Similarity

- Had subjects provide a URL for the story
  - Downloaded all 3,595 web pages
  - Ran Latent Semantic Analysis
  - Measured the similarity between stories as the cosine of the angle between their LSA representations

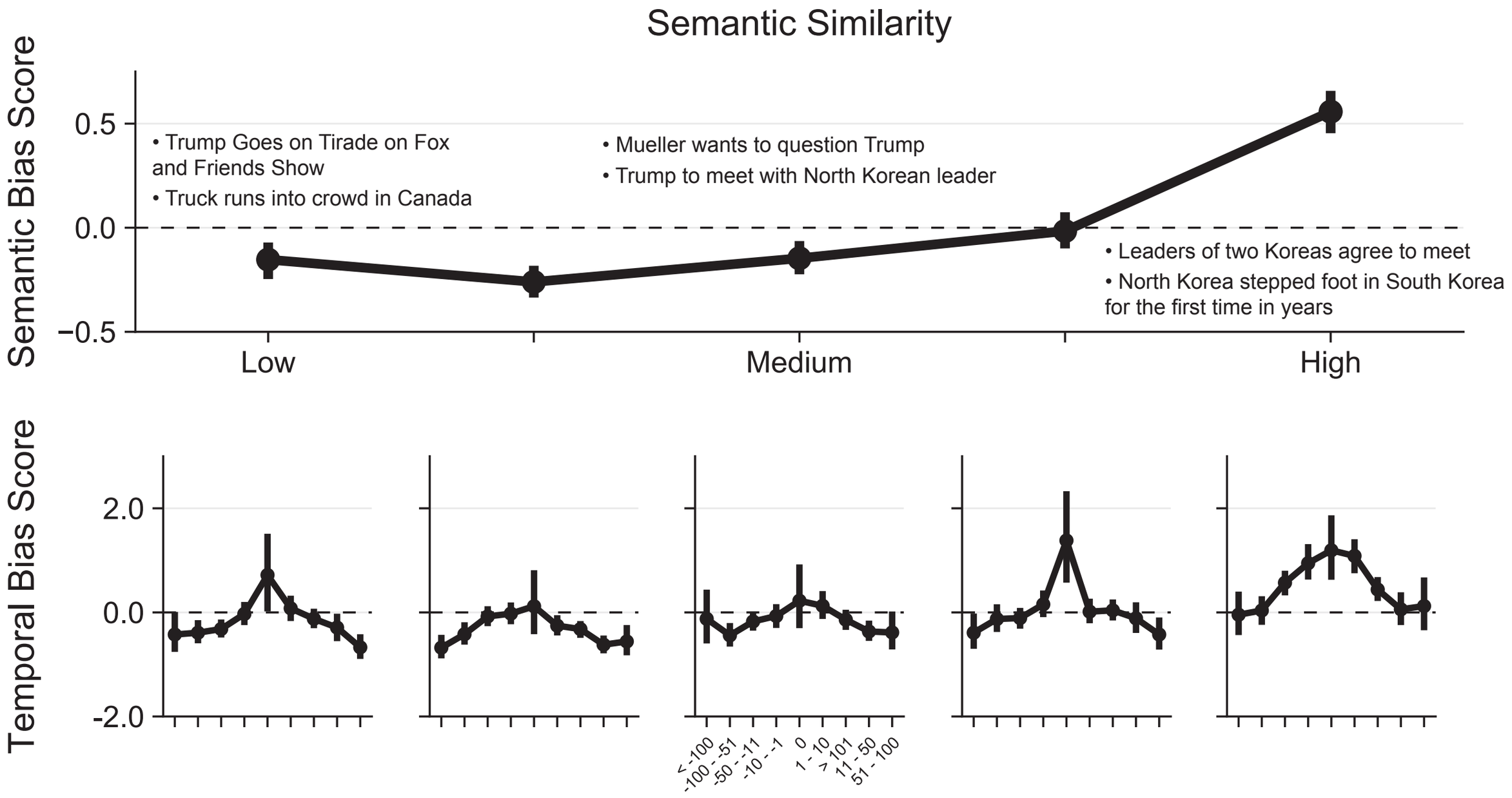
Uitvlugt & Healey (2019), *Psych Science*

There is a semantic contiguity effect



Uitvlugt & Healey (2019), *Psych Science*

But the temporal contiguity effect remains



Uitvlugt & Healey (2019), *Psych Science*

Study 3: Conclusions

- Temporal contiguity occurs in recall of “real world” memories
- Open Question:
  - Can existing theories simultaneously account for this real world effect and the lab effects?

Time Scale Invariance?

Take Home Messages

- Temporal Contiguity is a real effect
  - Found even when lists are semantically rich
  - Does not require deliberate encoding
  - Found in real-world memories
- But our models of the effect are not “finished”
  - They account for contiguity, but not the variables that modulate it
  - See our posters for first steps in this direction!

Thanks!

All the papers are on our website: **cbcc.psy.msu.edu**

Healey, M. K. and Uitvlugt M. G. (in press). The role of control processes in temporal and semantic contiguity. Memory & Cognition.
Healey, M. K. (2018). Temporal contiguity in incidentally encoded memories. Journal of Memory and Language, 102, 28-40.
Uitvlugt, M. G. and Healey, M. K. (2019). Temporal proximity links unrelated news events in memory. Psychological Science, 30, 92-104.

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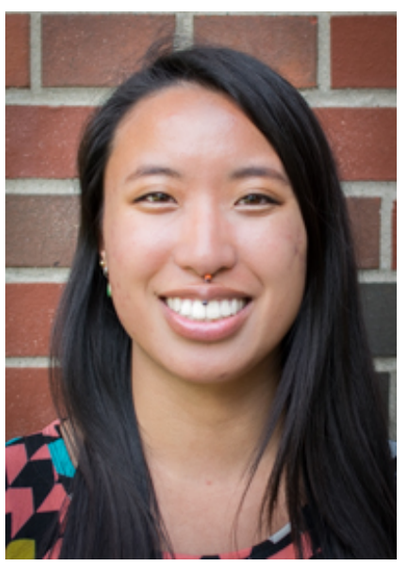
Abigail Dester



Linh Lazarus

Mitchell Uitvlugt