

# Are scientists *attending* to the right things?

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*for the University of Texas Austin – thanks to Jarrod Lewis-Peacock!*



THE UNIVERSITY OF  
CHICAGO

# I'm a visual **attention** researcher!

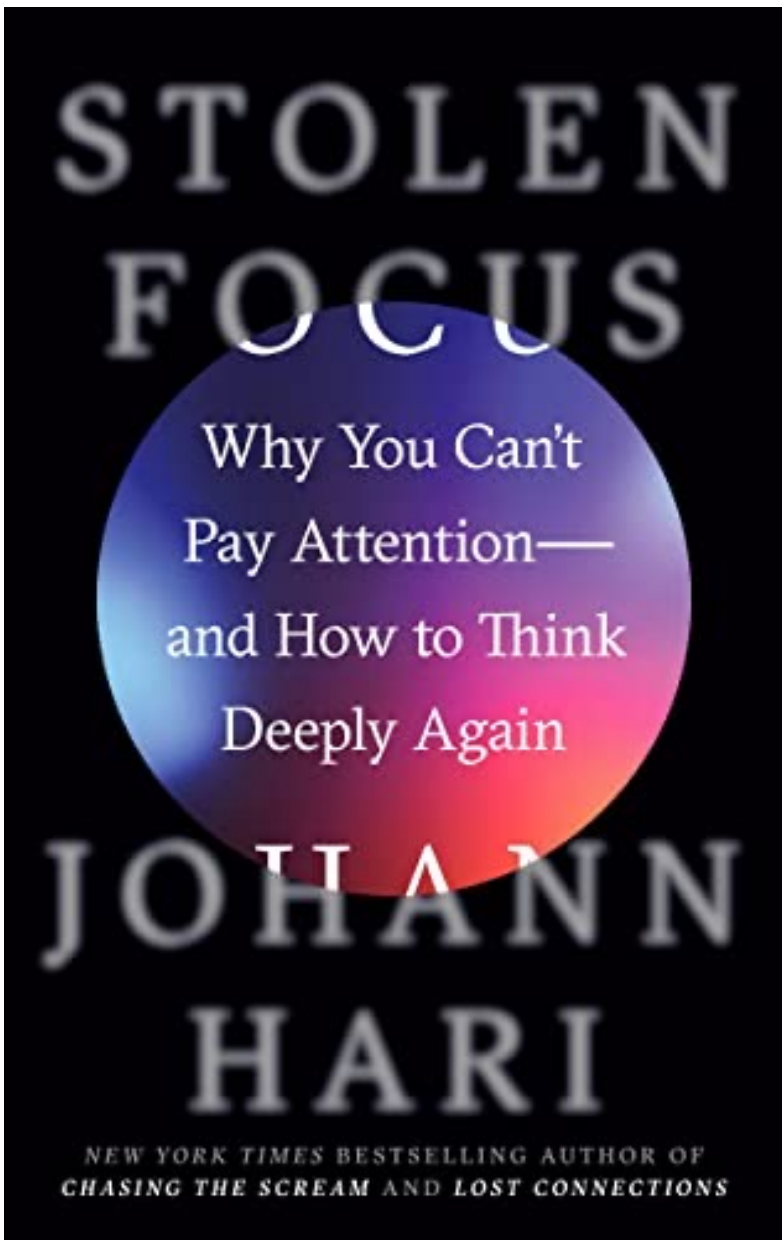


A demo – look for the change!

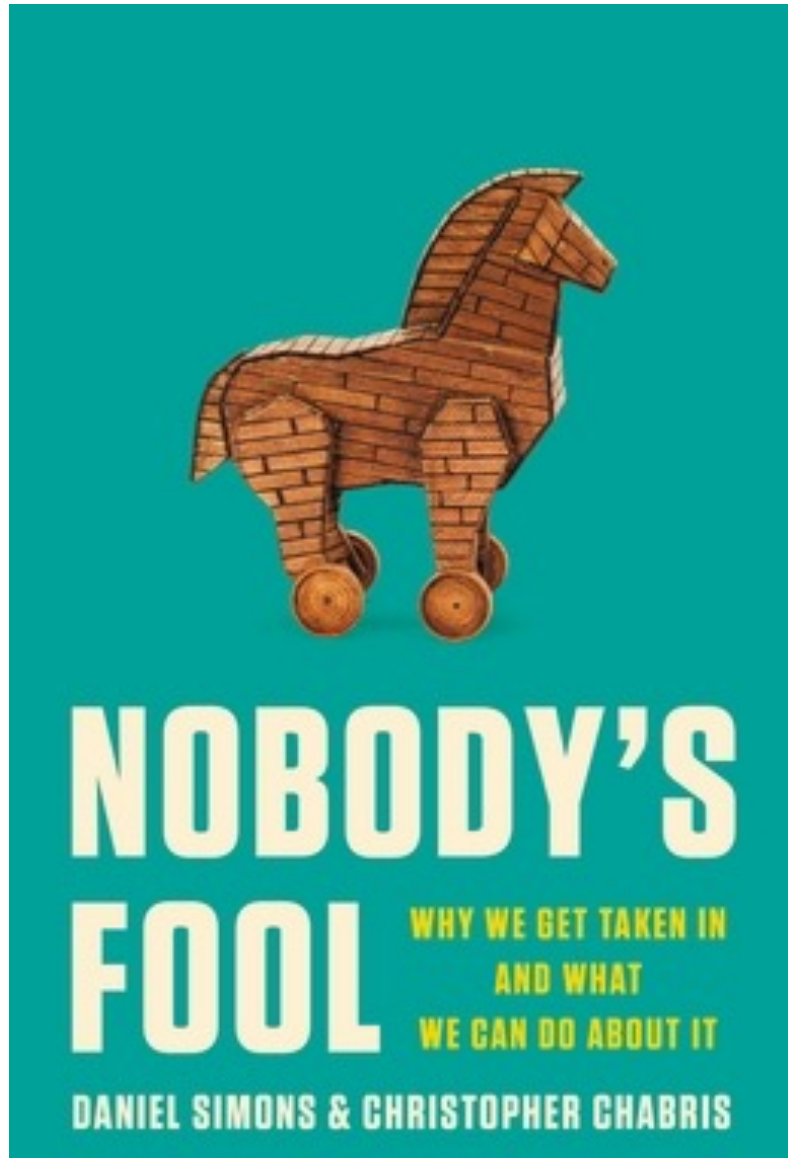
Our attention is very limited

Our attention is precious

We want the right things to take  
up our attention!



It feels like we are losing our ability to *focus*



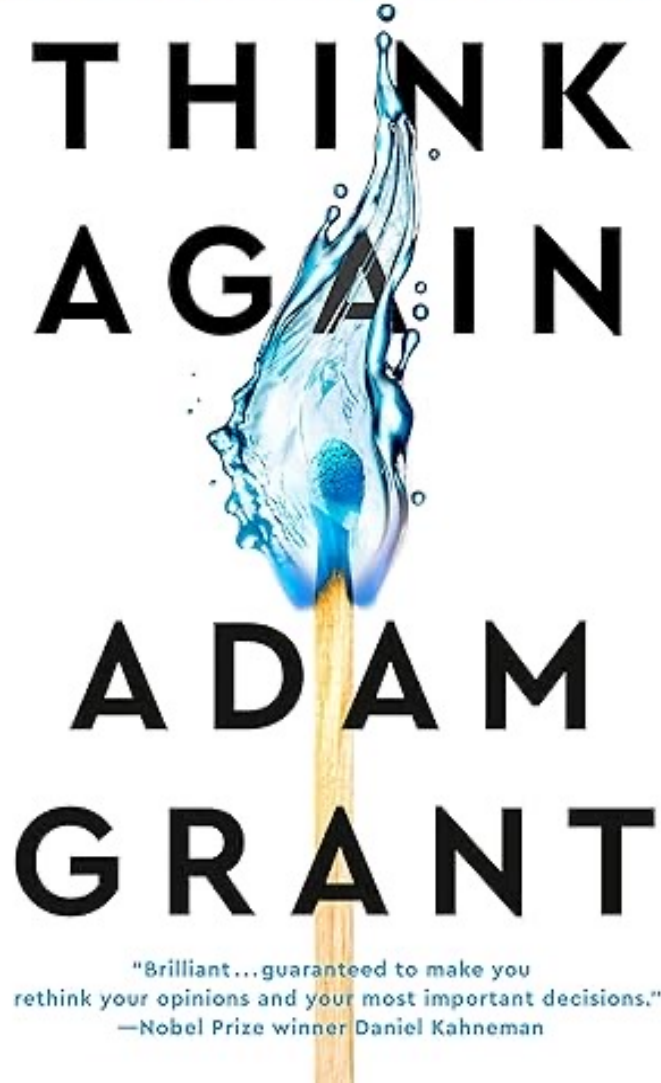
We can be deceived by being made to attend to the wrong things.

Do these slide transitions feel a bit too familiar?

The authors of the "invisible gorilla" study!

#1 *New York Times* Bestseller

The Power of Knowing What You Don't Know

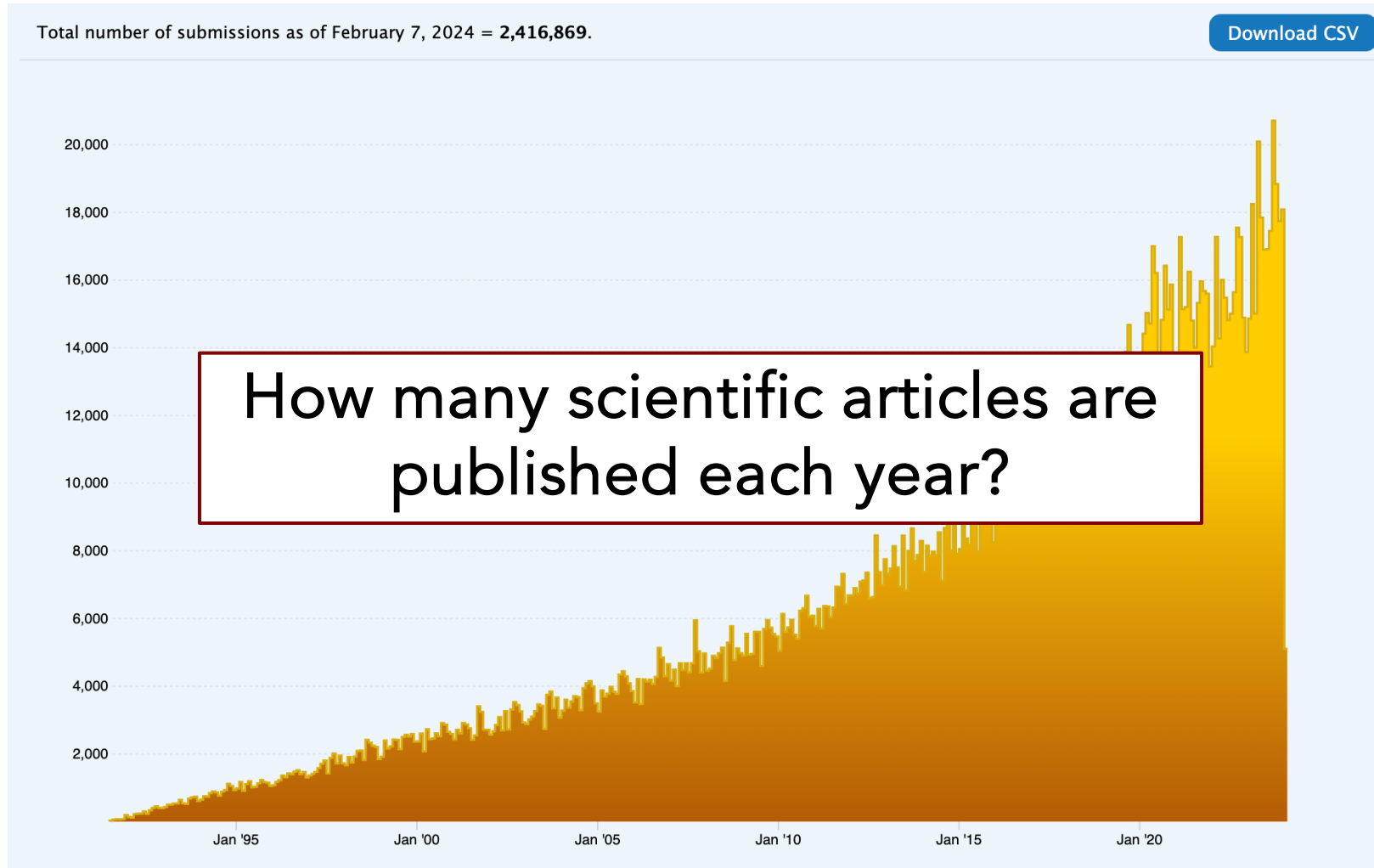


"We need to think (again) like scientists"

1. What has got scientists' attention?
2. Are attention researchers getting it right?
3. How do we rethink attention?

What has got scientists' attention?

# Exponential growth of scientific publications



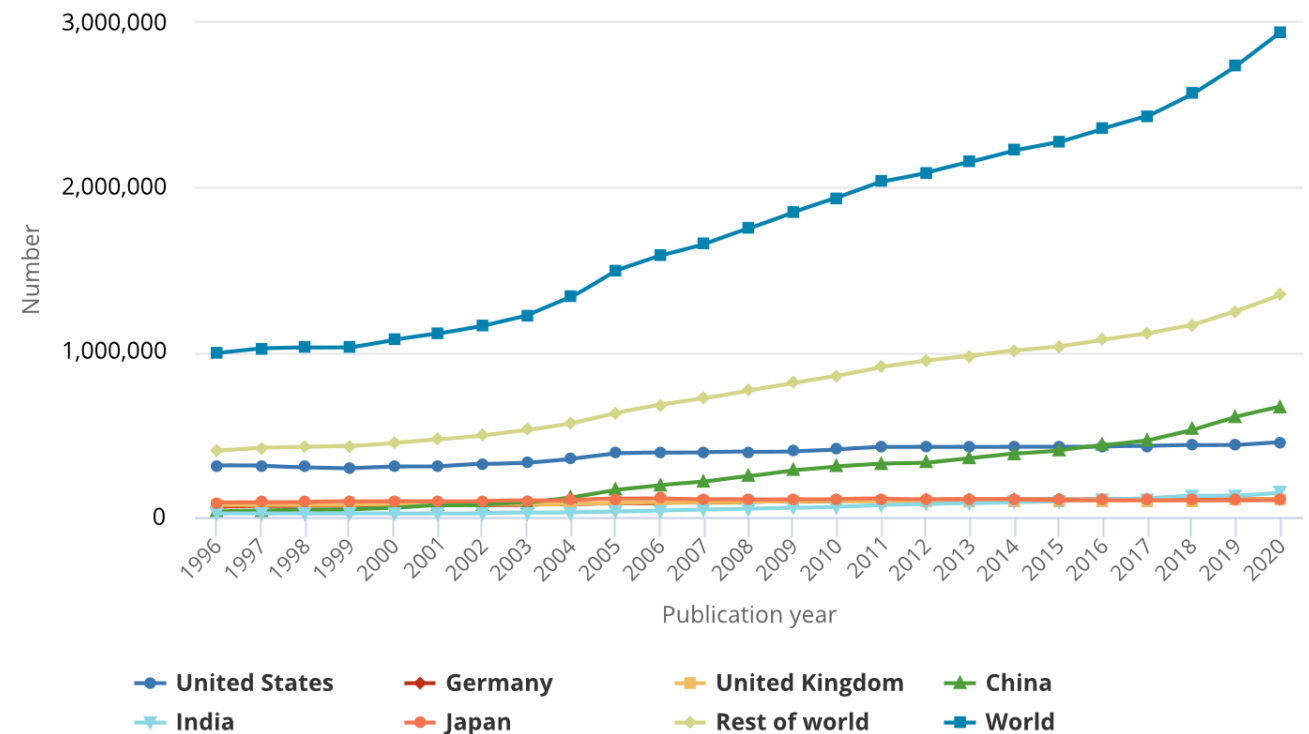


# Exponential growth of scientific publications

- Estimated to have reached **2.9 million articles** in 2020 (National Science Board, National Science Foundation)
- Increasing by approximately **4% each year** (Pan, Petersen, Pammolli and Fortunato, 2016)

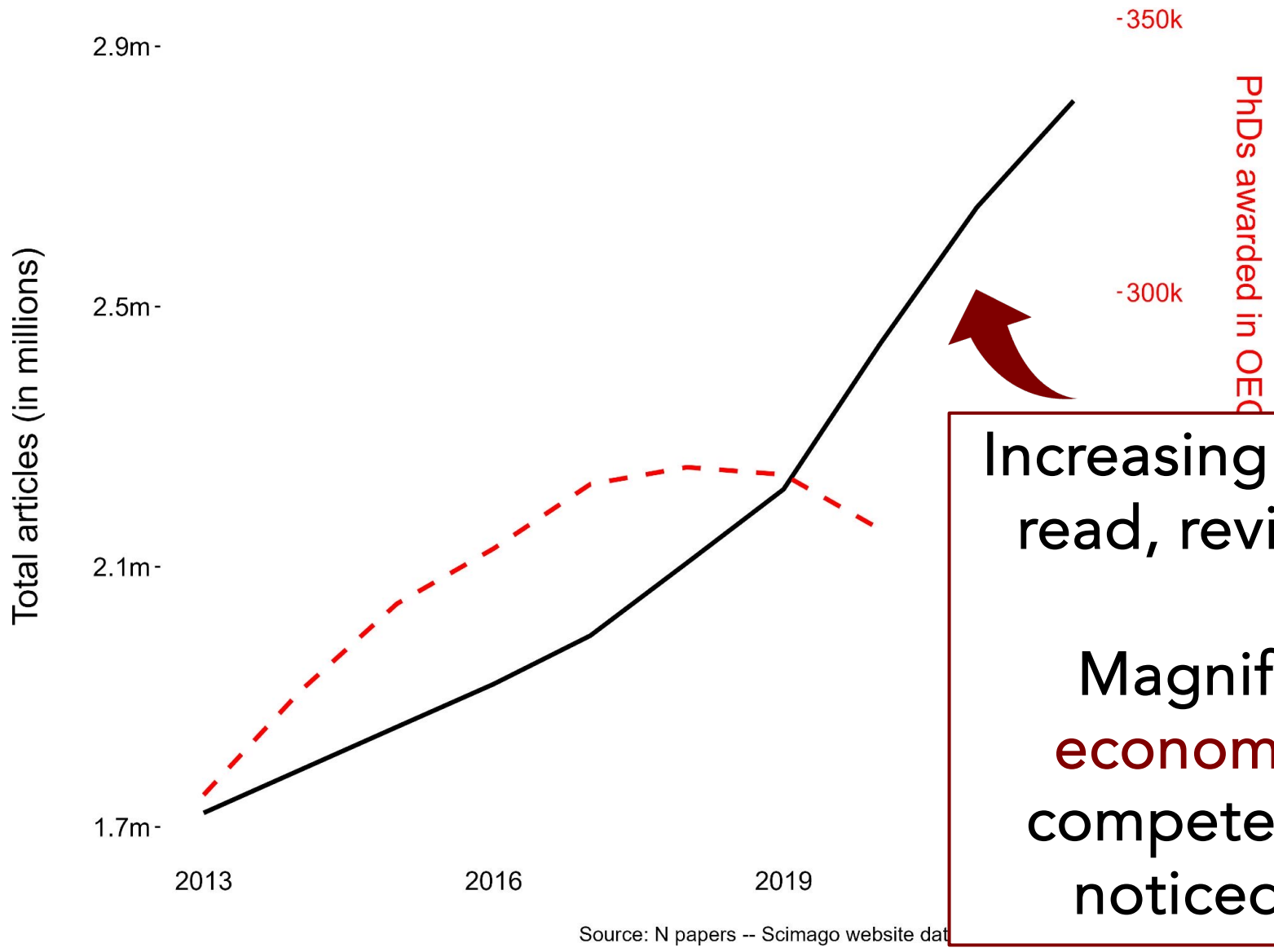
National Center for Science and Engineering Statistics | NSB-2021-4

Figure PBS-2  
S&E articles, by selected region, country, or economy and rest of world: 1996–2020



Review by National Center for Science and Engineering Statistics. <https://nces.nsf.gov/pubs/nsb20214/publication-output-by-country-region-or-economy-and-scientific-field>

Pan, R. K., Petersen, A. M., Pammolli, F., & Fortunato, S. (2018). The memory of science: Inflation, myopia, and the knowledge network. *Journal of Informetrics*, 12(3), 656-678. <https://arxiv.org/abs/1607.05606>



Increasing strain on scientists to read, review and co-ordinate.

Magnifying an “**attention economy**” where scientists compete for their work to be noticed and have impact.

Source: N papers -- Scimago website data

Figure copied from <https://bsky.app/profile/hansonmark.bsky.social/post/3kajeqzv3nt2b>  
 Hanson, Barreiro, Crosetto and Brockington (2023). The strain on scientific publishing. *ArXiv*. <https://arxiv.org/abs/2309.15884>

# The **decline** of negative results

- The proportion of papers reporting a positive result has been **increasing**

Does more papers (mostly with positive findings) mean faster scientific progress?

I say **not really.**

- In the recent psychology literature, this proportion is estimated to be **~95%** (Scheel, Schijen and Lakens, 2021)

Figure from Fanelli, D. (2012). Negative results are disappearing from most disciplines and countries. *Scientometrics*, 90(3), 891-904.

Scheel, A. M., Schijen, M. R., & Lakens, D. (2021). An excess of positive results: Comparing the standard Psychology literature with Registered Reports. *Advances in Methods and Practices in Psychological Science*, 4(2), 25152459211007467.

# A *theory crisis* in psychological science

- An understated precursor to the *reproducibility crisis* may be the **lack of coordinated theoretical development**
  - An over-reliance on the hypothetico-deductive method (e.g. null hypothesis significance testing) for inferences
    - Questionable research practices (QRPs): *p*-hacking, HARKing, data manipulation, etc.

Borsboom D. (2013, November 20). Theoretical amnesia. *Center for Open Science*

Borsboom, D., van der Maas, H. L., Dalege, J., Kievit, R. A., & Haig, B. D. (2021). Theory construction methodology: A practical framework for building theories in psychology. *Perspectives on Psychological Science*, 16(4), 756-766.

Oberauer K., Lewandowsky S. (2019). Addressing the theory crisis in psychology. *Psychonomic Bulletin & Review*, 26, 1596–1618.

Maatman, F. O. (2021). Psychology's theory crisis, and why formal modelling cannot solve it. *PsyArXiv*

Meehl P. E. (1978). Theoretical risks and tabular asterisks: Sir Karl, Sir Ronald, and the slow progress of soft psychology. *Journal of Consulting and Clinical Psychology*, 46, 806–834.

# Playing *20 questions* with nature

- It is often assumed that...

Theory A



Result A

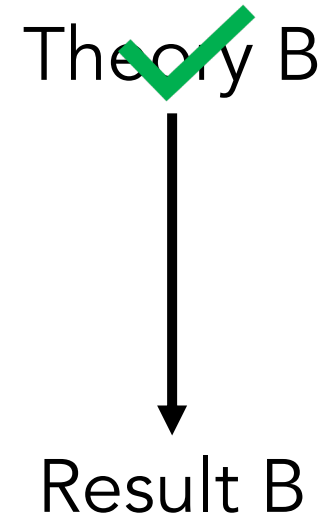
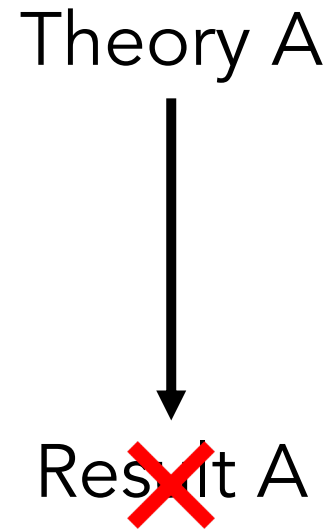
Theory B



Result B

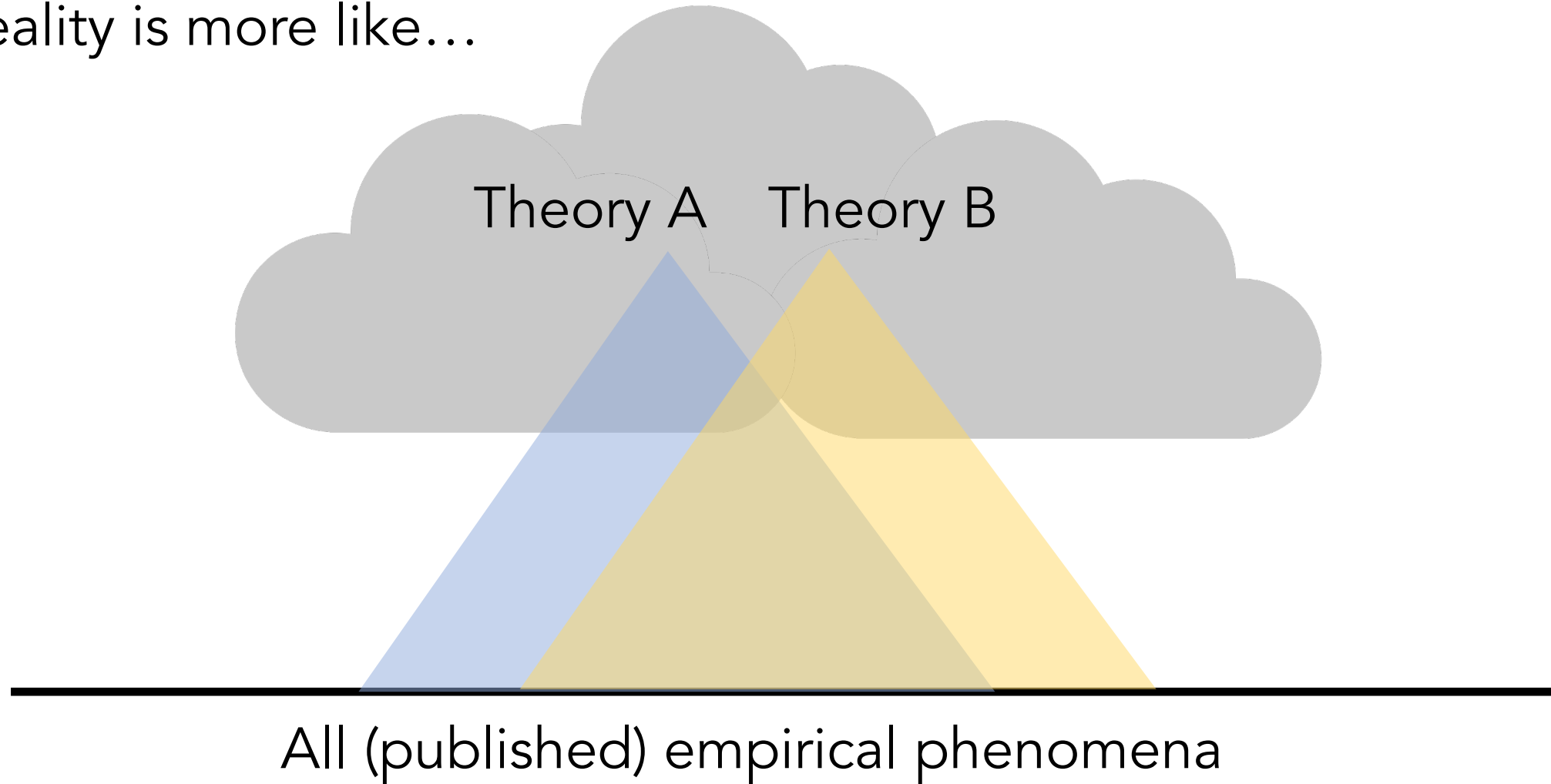
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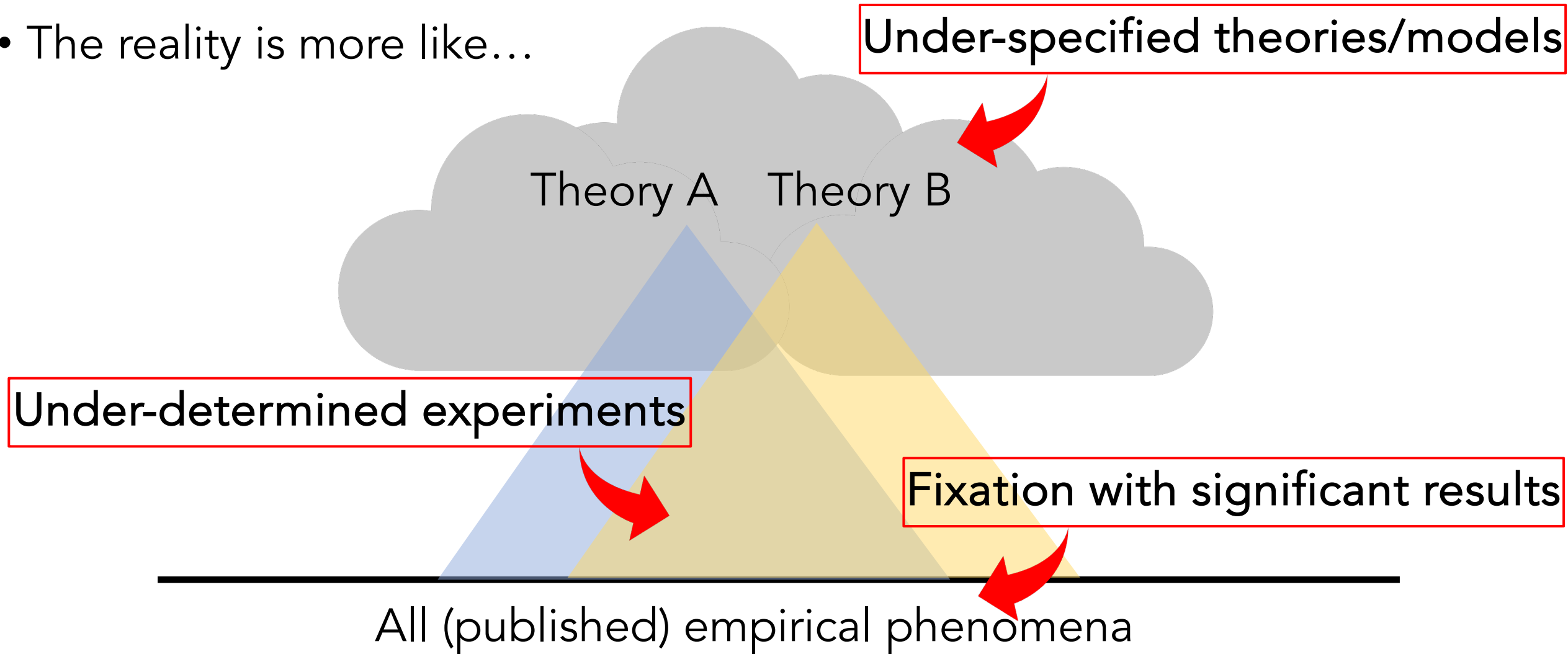
# Playing *20 questions* with nature

- The reality is more like...



# Playing *20 questions* with nature

- The reality is more like...





# A *theory crisis* in psychological science

- An understated precursor to the *reproducibility crisis* may be the **lack of coordinated theoretical development**
  - An over-reliance on the hypothetico-deductive method (e.g. null hypothesis significance testing) for inferences
    - Questionable research practices (QRPs): *p*-hacking, HARKing, data manipulation, etc.
  - Under-specified theories with under-determined experimental designs
    - *Ad hoc* changes in models, straw-man of competing models, blunt instruments of measurement
  - Overgeneralization of a theory or model to all related phenomena or empirical conditions
    - A lack of intellectual humility...

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Are attention researchers getting it right?

# What *is* visual working memory?

- “The system responsible for **maintaining visual information in a state of heightened accessibility** for ongoing perception and cognition.”

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- **Let's say working memory is basically attention for now.**

- What details a state of *heightened accessibility*?

# What *is* visual working memory?

- Many subtly different definitions:

## The many faces of working memory and short-term storage

[Nelson Cowan](#) 

[Psychonomic Bulletin & Review](#) **24**, 1158–1170 (2017) | [Cite this article](#)

**28k** Accesses | **231** Citations | **39** Altmetric | [Metrics](#)

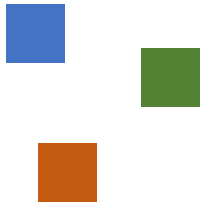
It has become clearer to me that a major source of confusion is that researchers use different definitions of the malleable and useful concept of WM. We do not seem to be converging on a common definition of the term. Others also have

# What *is* visual working memory?

## Object-based theory

*"slot models"*

(Luck and Vogel, 1997;  
Zhang and Luck, 2008)



## Feature-based theory

*"resource models"*

(Alvarez and Cavanagh, 2004;  
Wilken and Ma, 2004)



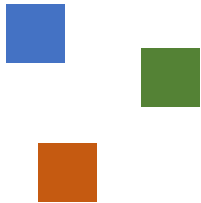
# What *is* visual working memory?

- An enduring theoretical framework has been

## Object-based theory

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versus

## Feature-based theory

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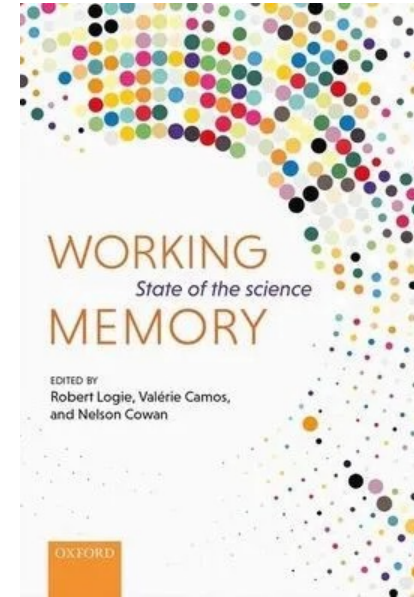


# What is visual working memory?

14

## Integrating Theories of Working Memory

*Robert H. Logie, Clément Belletier, and Jason M. Doherty*



First published  
in late 2020

- “We argue that many of these differences reflect different research questions, different levels of explanation, differences in how participants perform their assigned tasks in different laboratories, **rather than fundamental theoretical adversity**”



# How do we make progress if:

- There exist **subtly different definitions**
  - Due to different research questions, different methods, different measures, different contexts, etc.
- Theories (or models) attempt to explain all empirical phenomena related to ill-defined construct (**overgeneralization**)
- Models are **underspecified** such that empirical tests cannot be definitive
  - And these models may not reflect **fundamental theoretical adversity**

# A case study: conjunction whole-report

*Ngiam, Loetscher and Awh (2023) JEP:G*



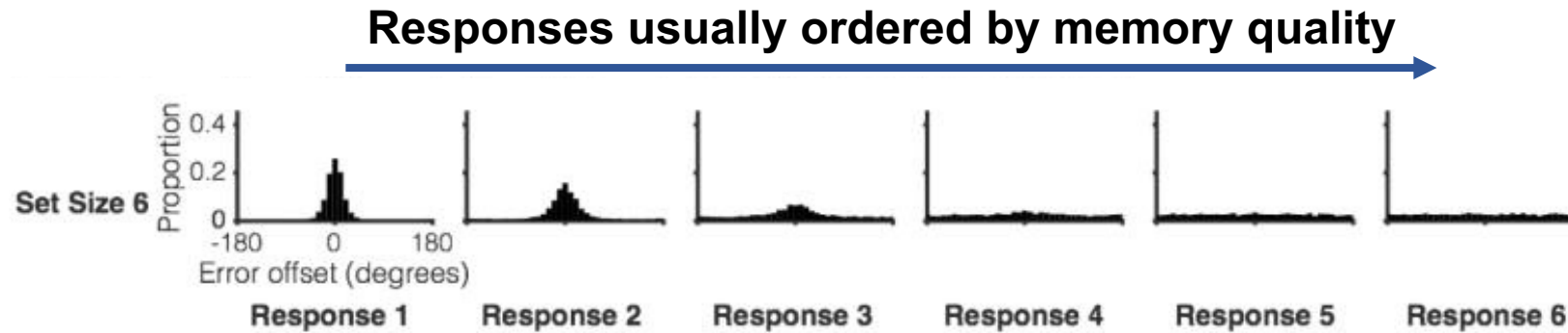
Krystian Loetscher



Edward Awh

# Introducing the conjunction whole-report paradigm

- Test recall for **all** items rather than just the one item (Adam et al., 2017)



- The first whole-report experiments with **conjunction stimuli**
- Response interface that collects **both features with one click** (Sone et al., 2021)

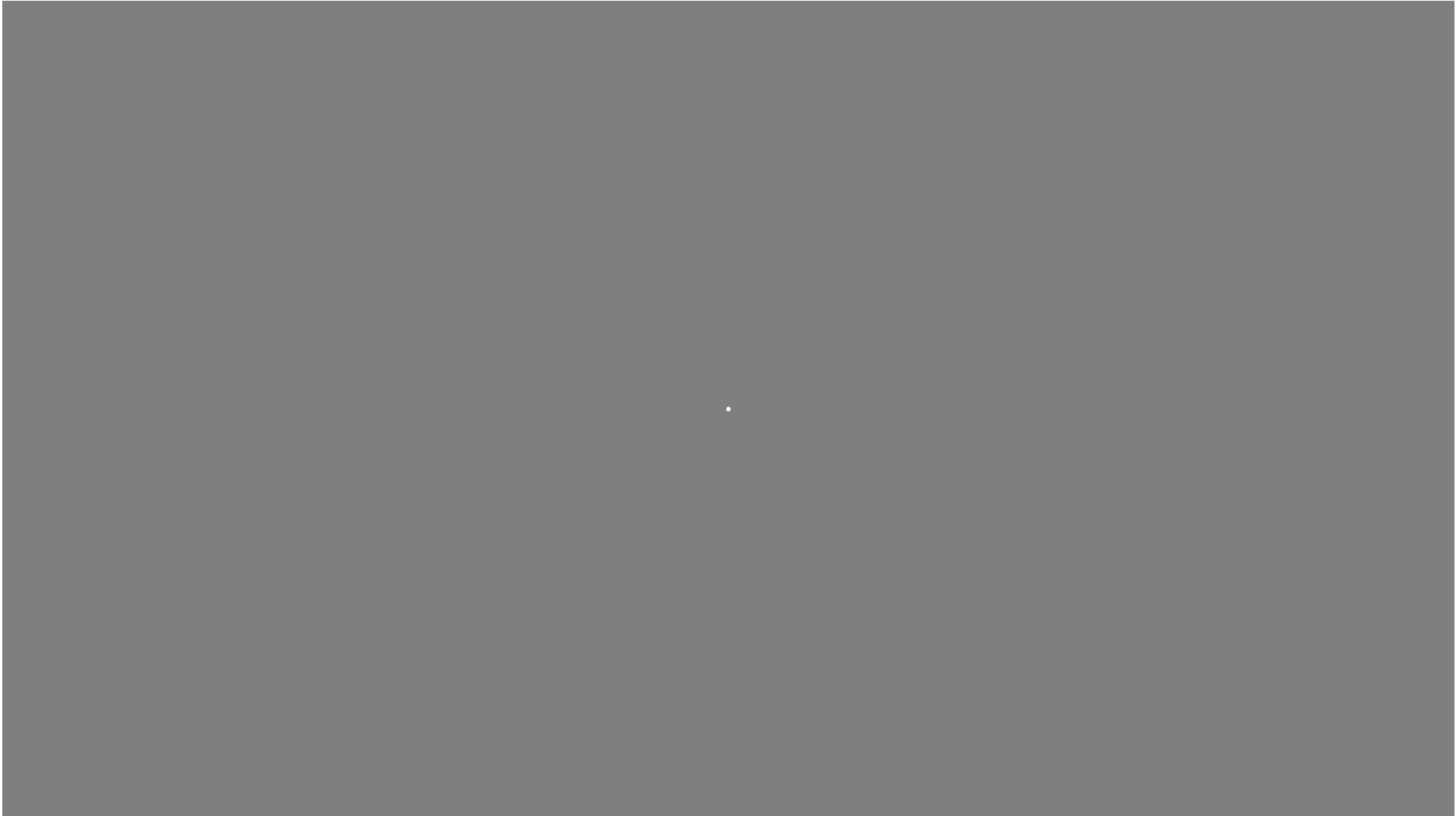
# Orientation whole-report



# Color whole-report



# Conjunction whole-report

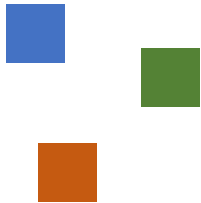


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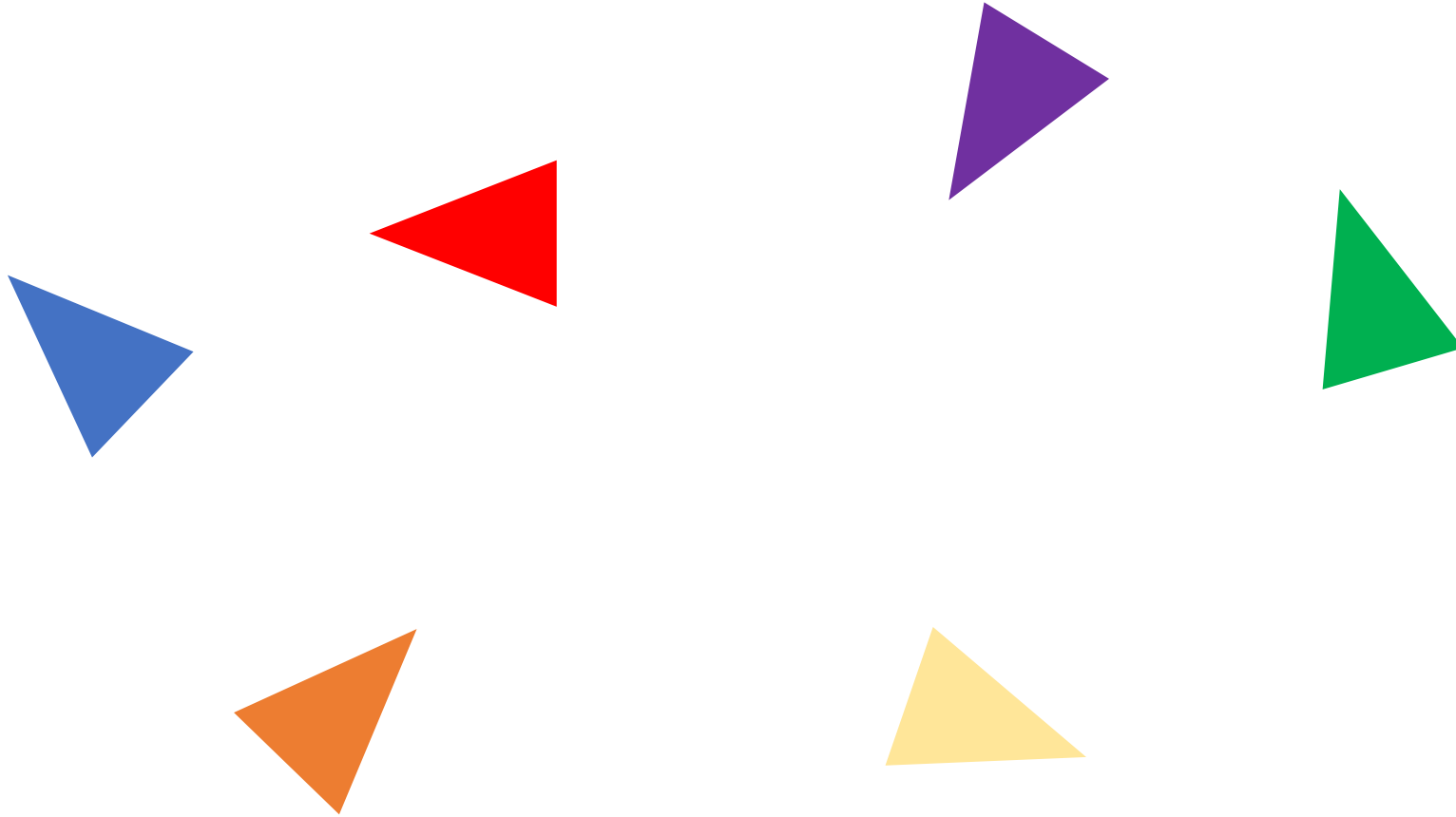
## Feature-based theory

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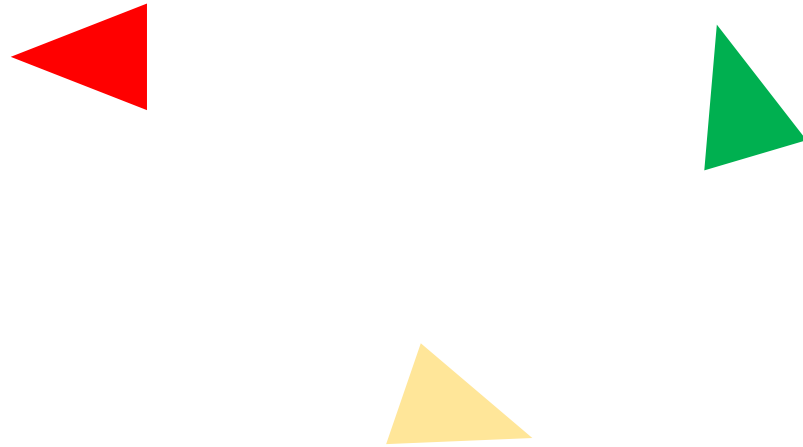
What is the unit of working memory?



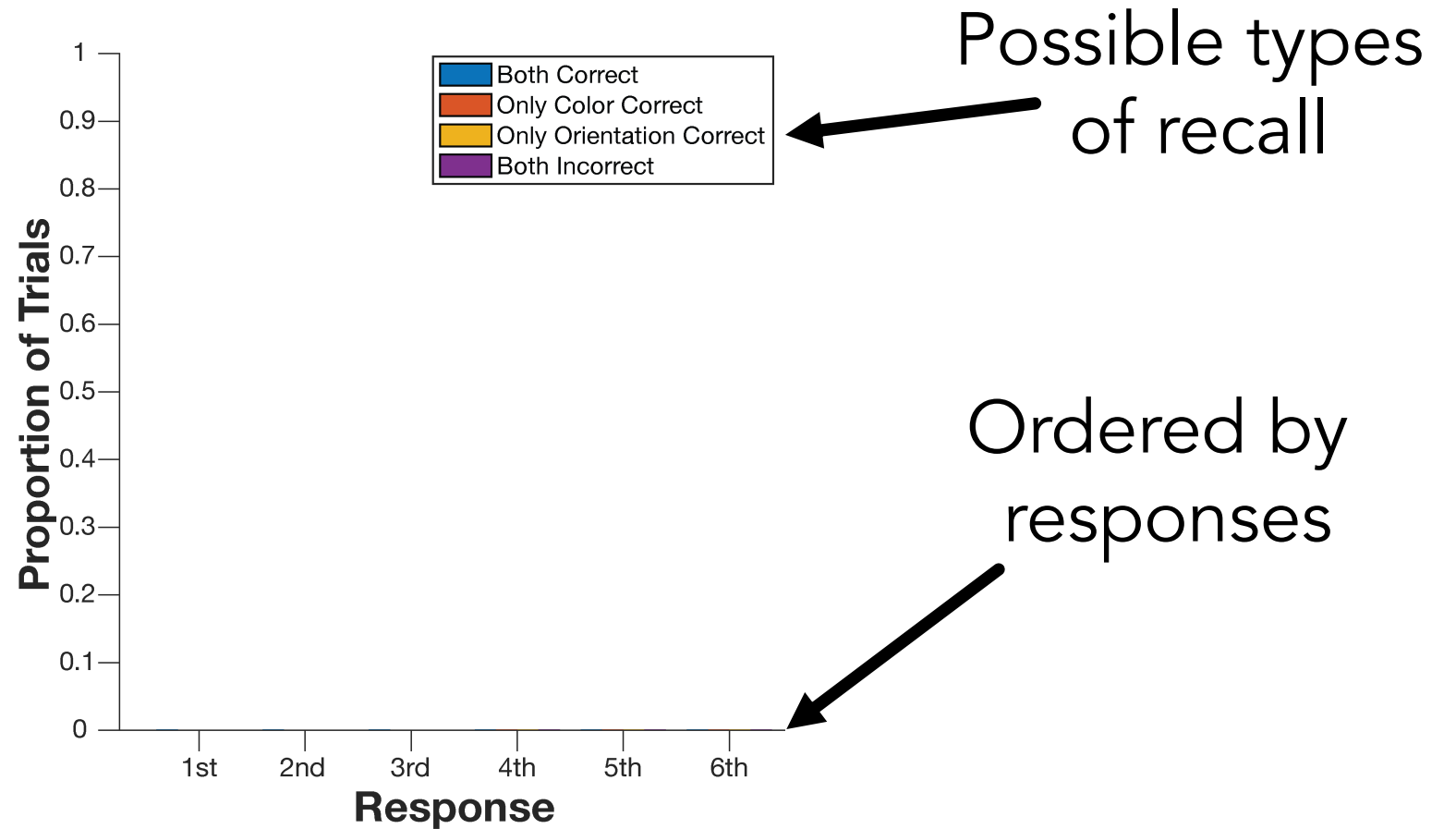


# A *specific* object-based model – strong objects

- Fixed object capacity limit
- Lossless representations (“all-or-none”)
- No impact of complexity (additional features)

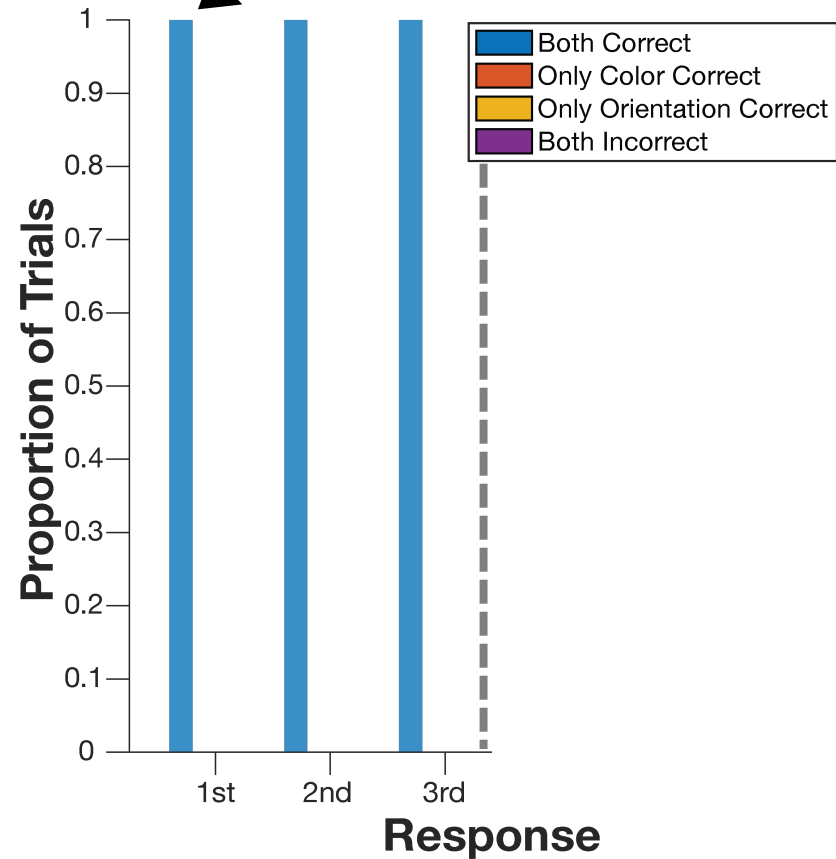


# Conjunction whole-report



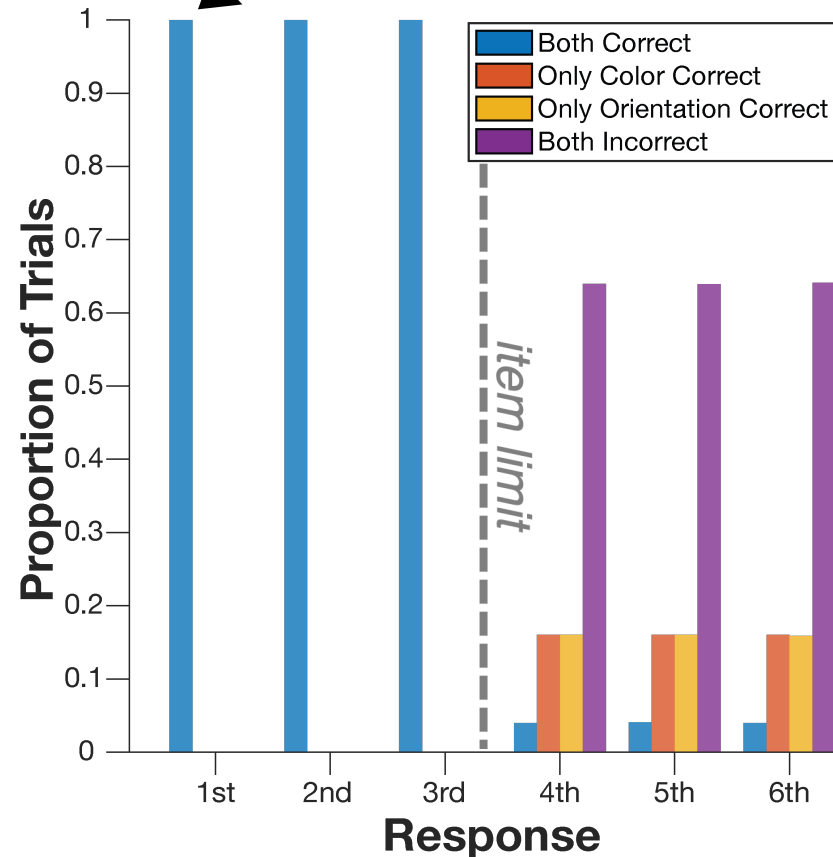
# A *specific* slot model – strong objects

Perfect recall  
within item limit



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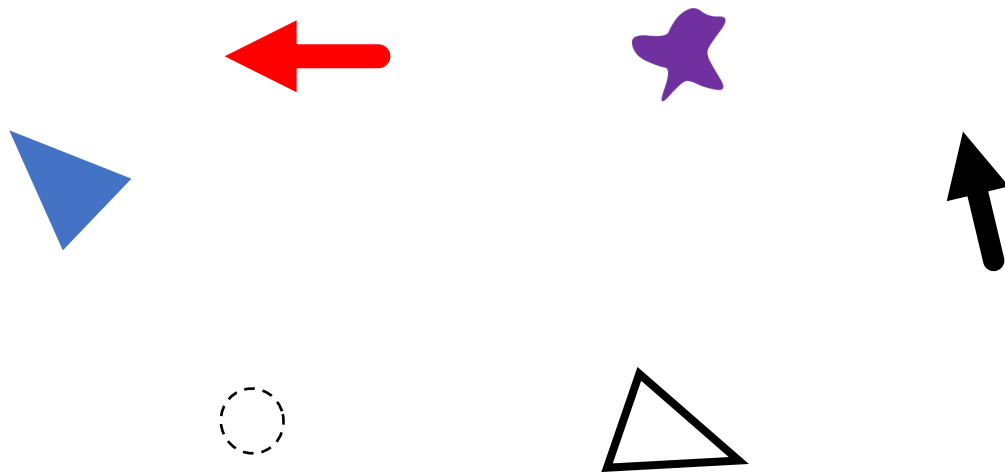
Perfect recall  
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Guessing for  
remaining responses

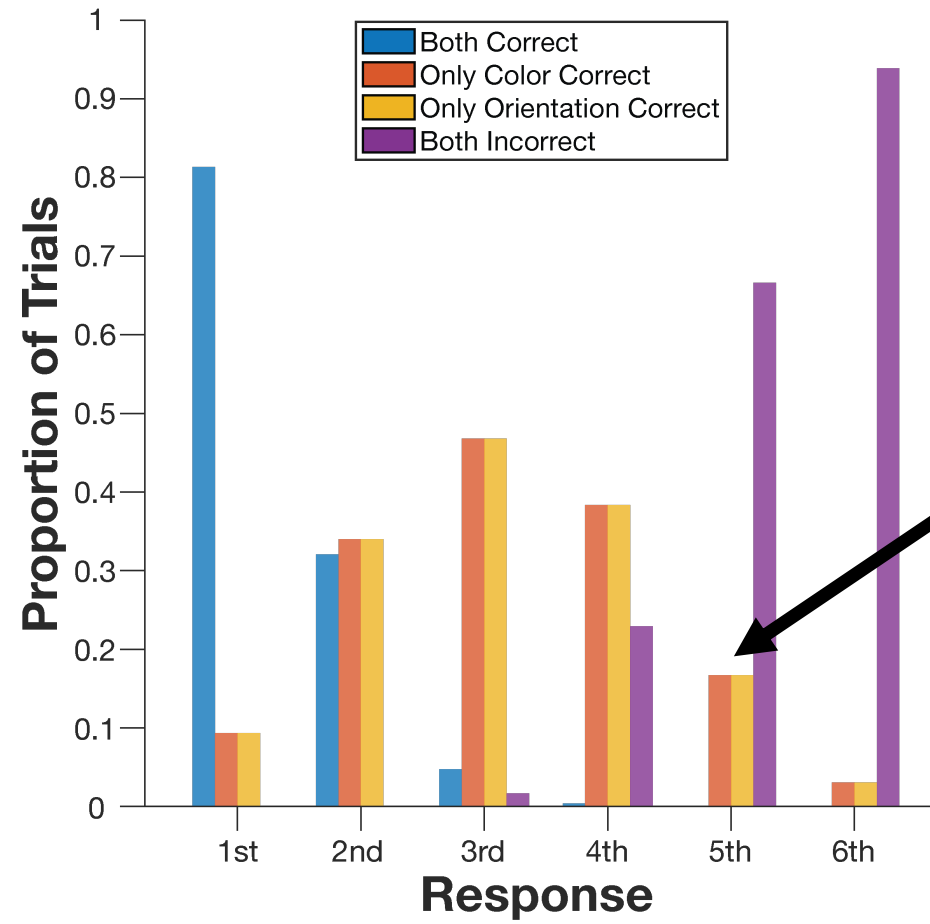
# A *specific* resource model – independent features

- Working memory resources are distributed to all items in the array
- Feature storage is not constrained by which objects contain the features
  - Probability of successful feature storage is independent of objecthood



# A specific resource model – independent features

Feature storage  
independent  
of objecthood



Accurate recall  
distributed across  
*all* responses

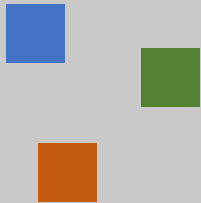
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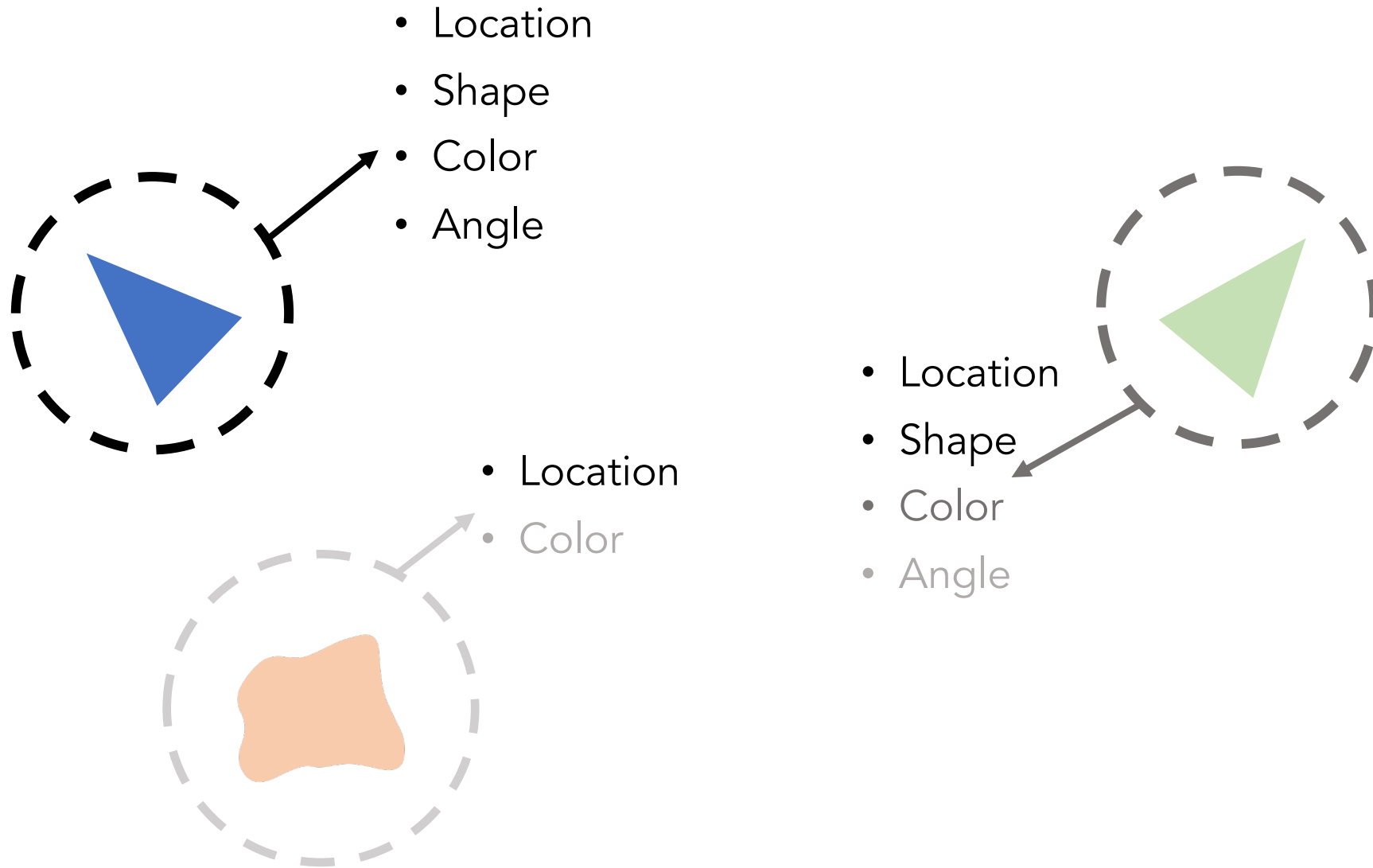
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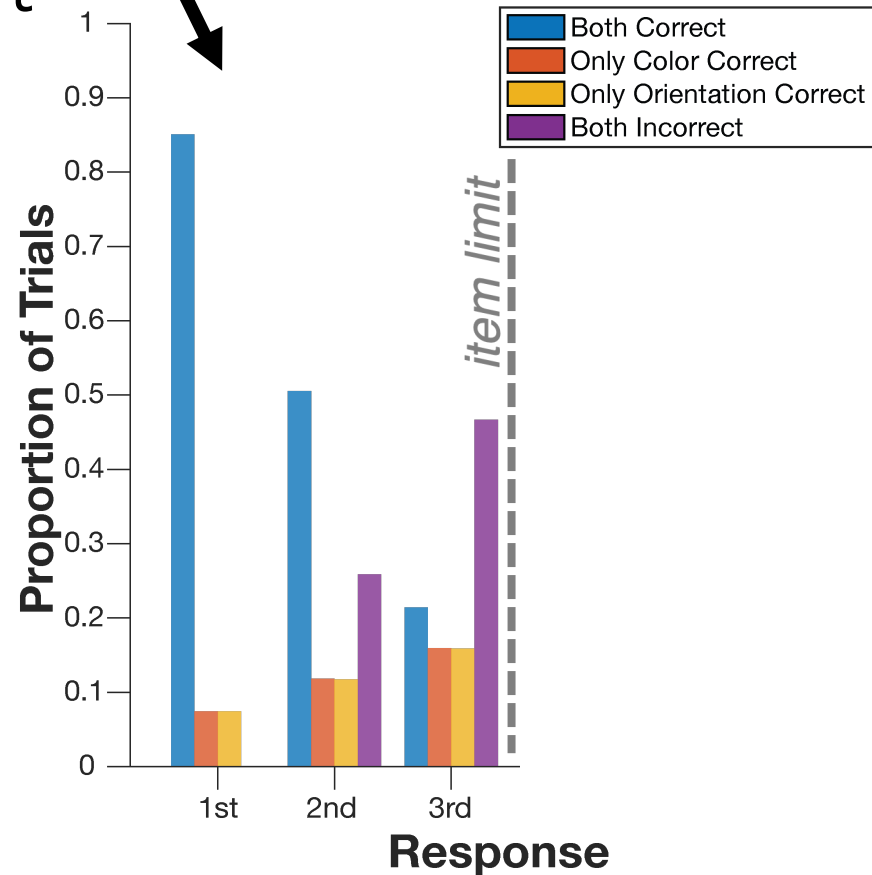
# A new model characterization – pointers





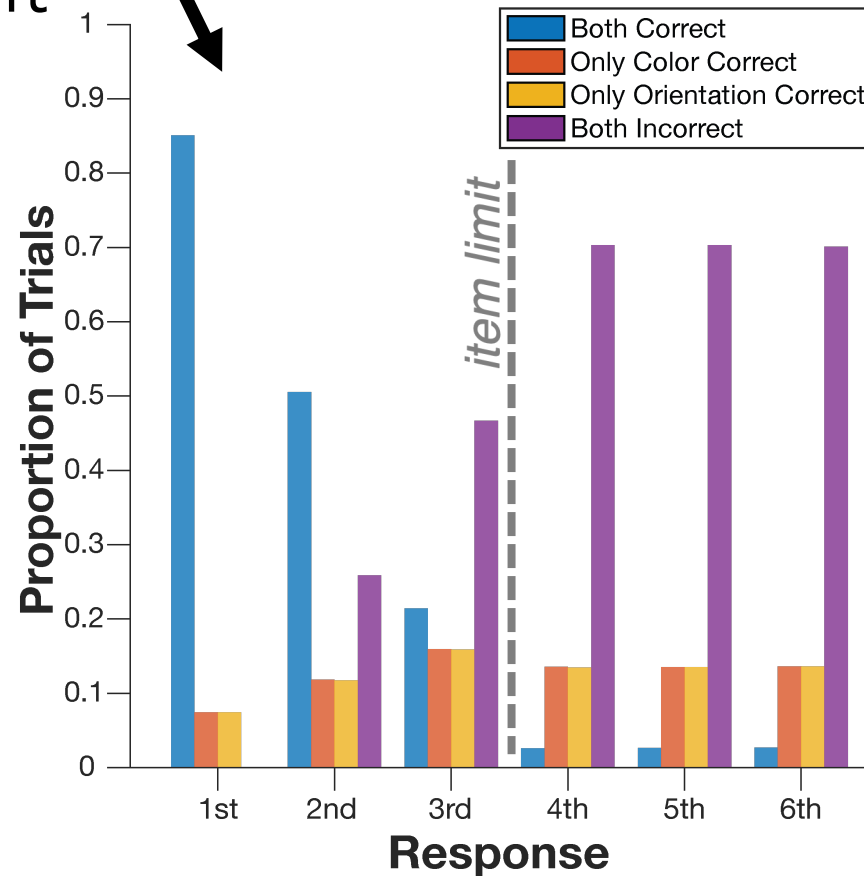
# A new model characterization – pointers

Accurate recall constrained  
within an item limit



# A new model characterization – pointers

Accurate recall constrained within the item limit



Guessing beyond the item limit

# Our conjunction whole-report experiments

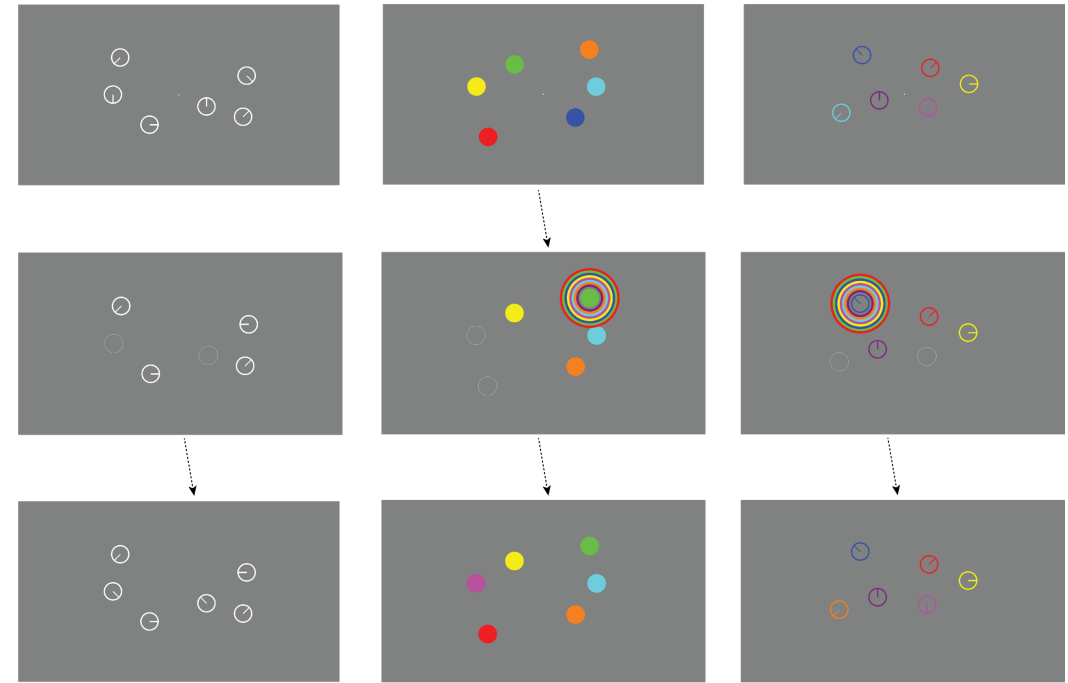
- Four experiments (30 subjects each)
  - E1: Colored clock faces
  - E2: Colored clock faces but rapid
  - E3: Colored triangles
  - E4: Colored shapes
- Three conditions (300 trials each)
  - Color only
  - Orientation only or Shape only
  - Conjunction
- Eight **discrete** colors, orientations, and shapes.

Fixation – 1000 msec

Memory – 500 msec  
(E2: 150 msec)

Retention – 1000 msec

Recall – Until response  
made to all items



# Recall accuracy

Mean Recall	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Colors	3.21 ± 0.74	2.94 ± 0.64		3.61 ± 0.75
Orientations/Shapes	2.79 ± 0.44	2.45 ± 0.45		3.39 ± 0.64
Conjunctions	<b>1.62</b> ± 0.38	<b>1.38</b> ± 0.42	<b>1.47</b> ± 0.44	<b>1.92</b> ± 0.43


- Memory for conjunction stimuli is **not lossless**
  - Fewer conjunctions are fully recalled overall



**“It’s not objects, it’s features!”**

# Recall accuracy

Mean Recall	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Colors	3.21 ± 0.74	2.94 ± 0.64		3.61 ± 0.75
Orientations/Shapes	2.79 ± 0.44	2.45 ± 0.45		3.39 ± 0.64
Conjunctions	1.62 ± 0.38	1.38 ± 0.42	1.47 ± 0.44	1.92 ± 0.43
Features	4.94 ± 0.68	4.52 ± 0.83	5.11 ± 0.65	5.34 ± 0.85

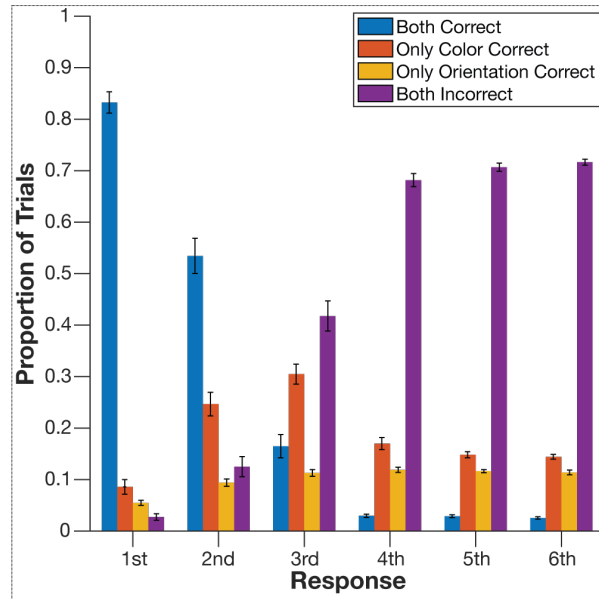
- Memory for conjunction stimuli is **not lossless**
  - Less conjunctions are fully recalled overall
- But we observe an **object-based benefit** 

"It's objects, not features!"

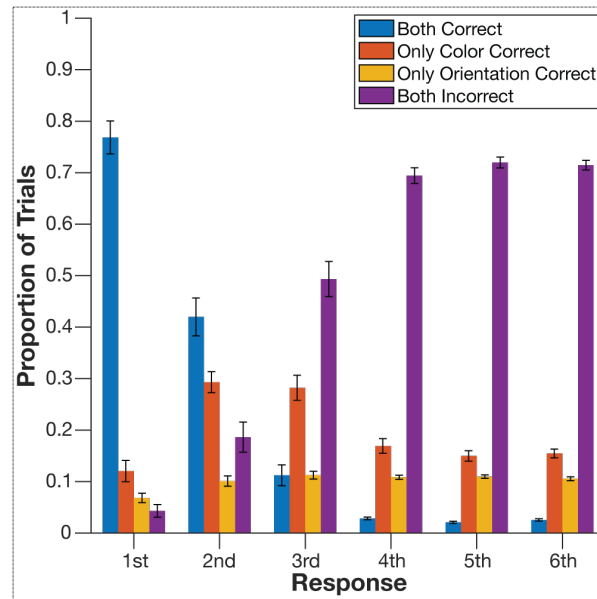
  - More features are recalled overall in the conjunction condition compared to the single-feature conditions (~5 features versus ~3 features)

# Accuracy across responses

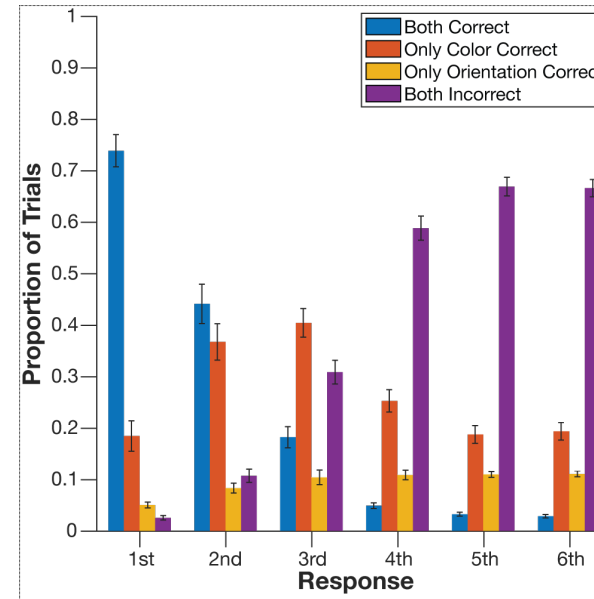
Experiment 1



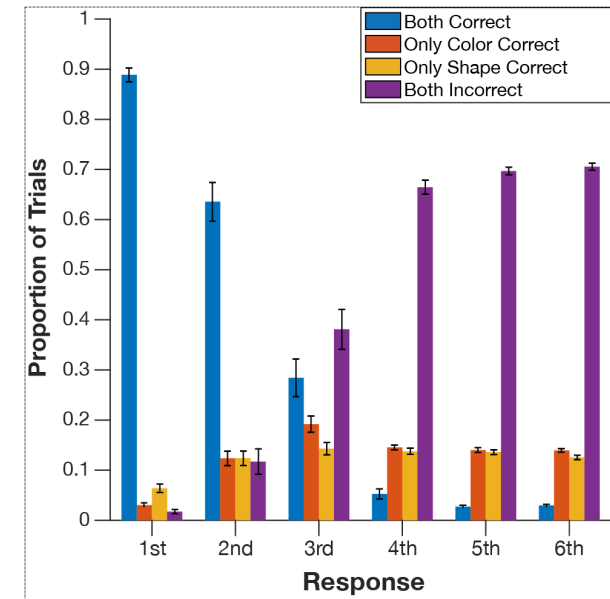
Experiment 2



Experiment 3



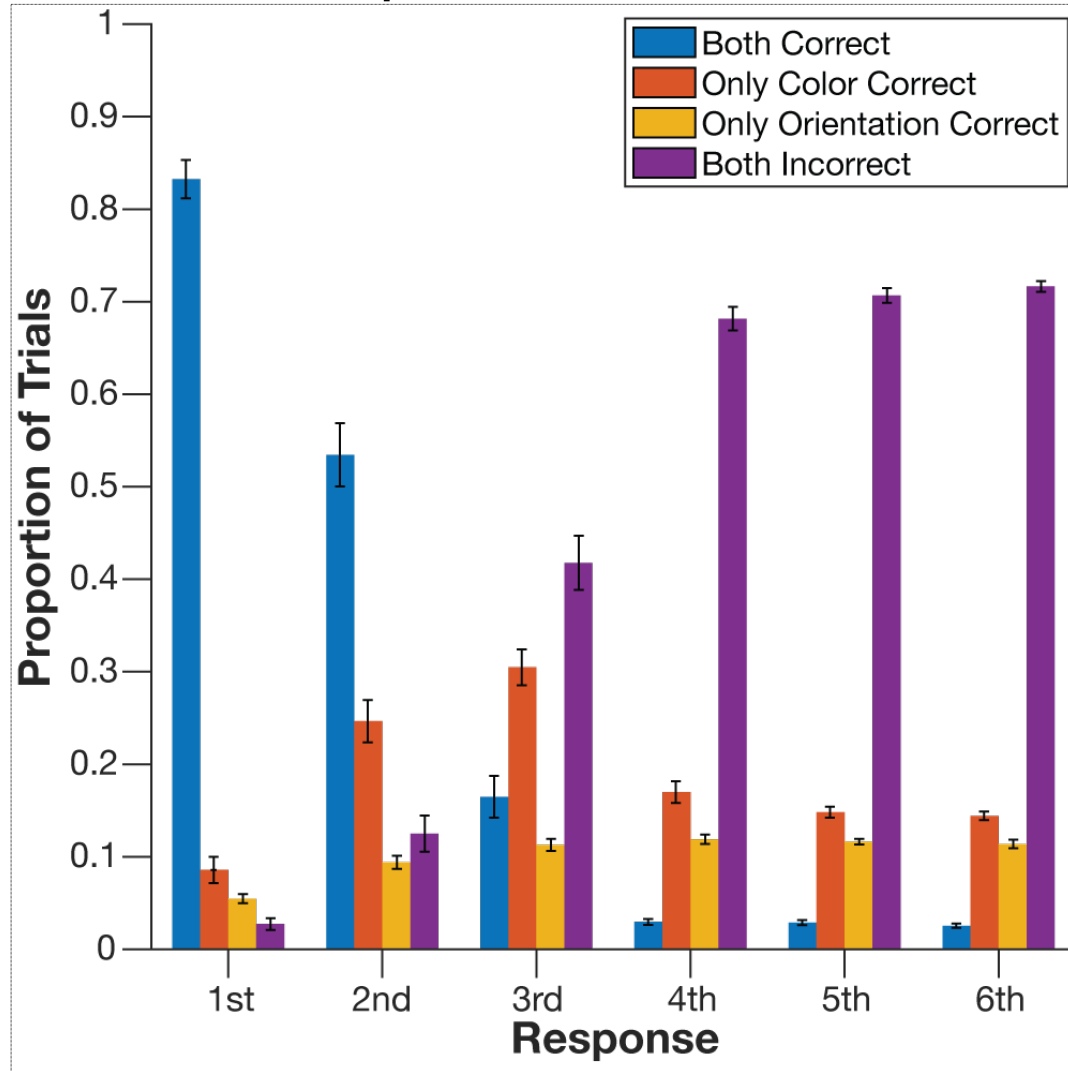
Experiment 4



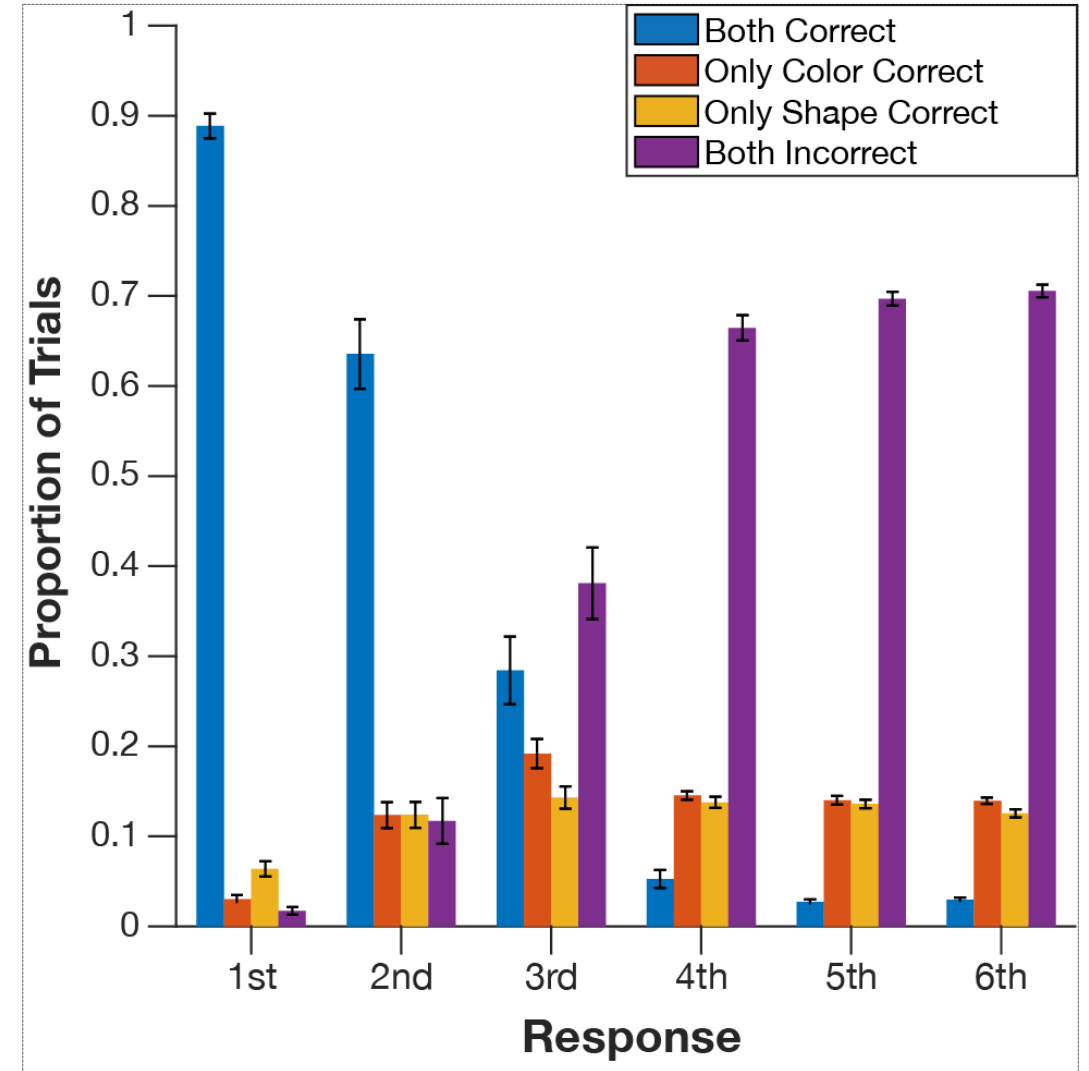
- The same empirical pattern was replicated across four experiments

# Accuracy across responses

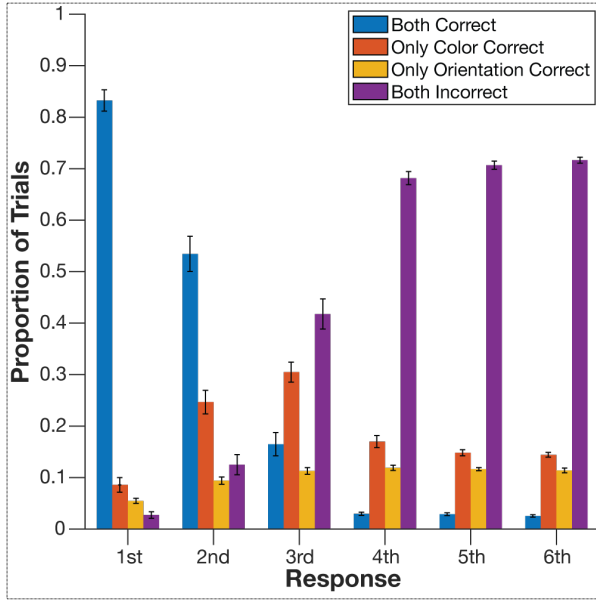
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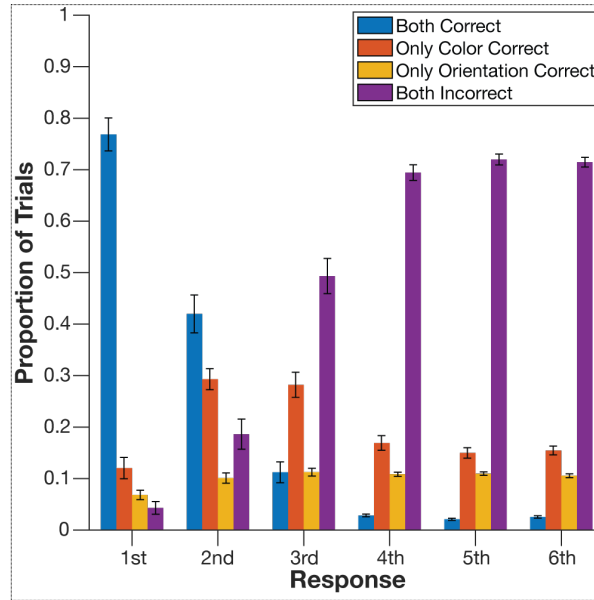
## Experiment 4



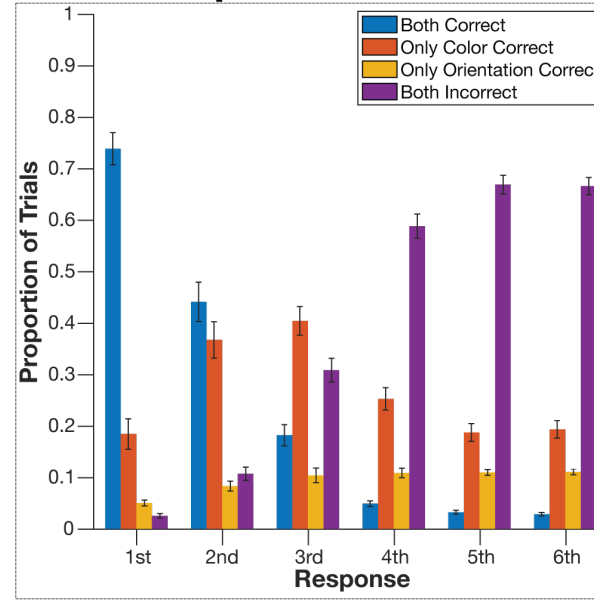
# Experiment 1



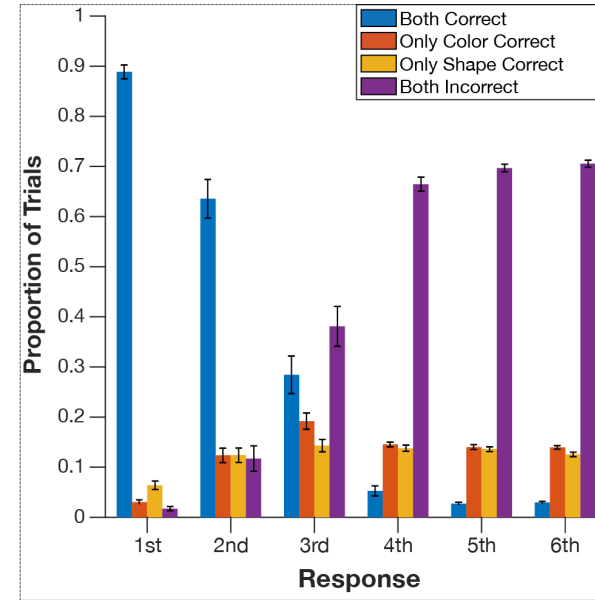
# Experiment 2



# Experiment 3

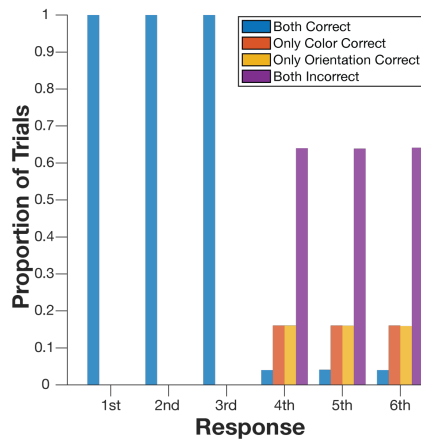


# Experiment 4



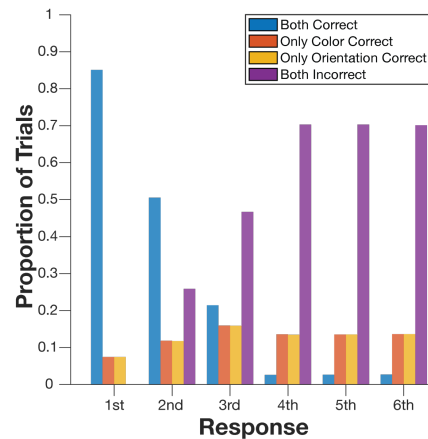
## Strong Object Model

*Accurate storage of three objects*



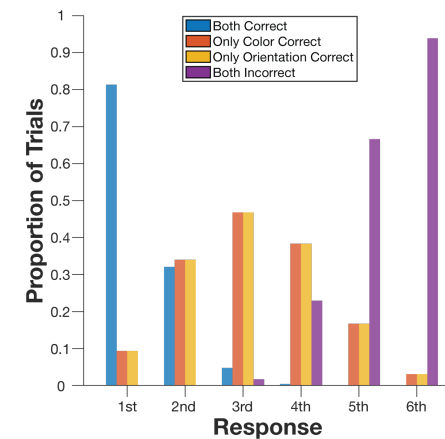
## Pointer Model

*Item-based storage with feature loss*



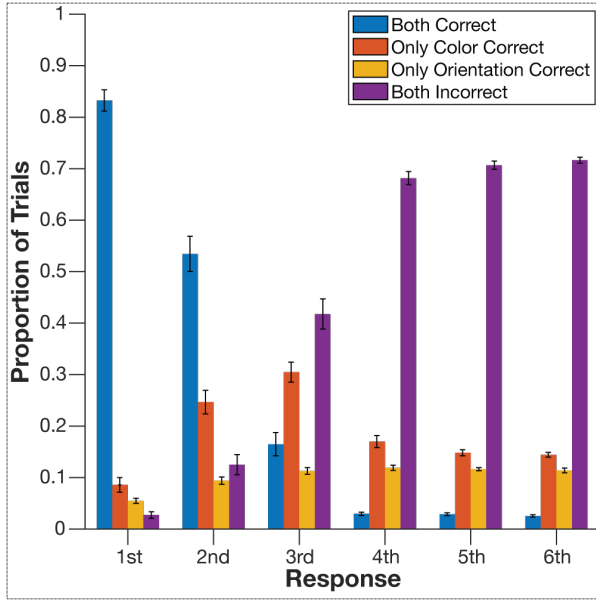
## Independent Feature Model

*Feature storage independent of objecthood*

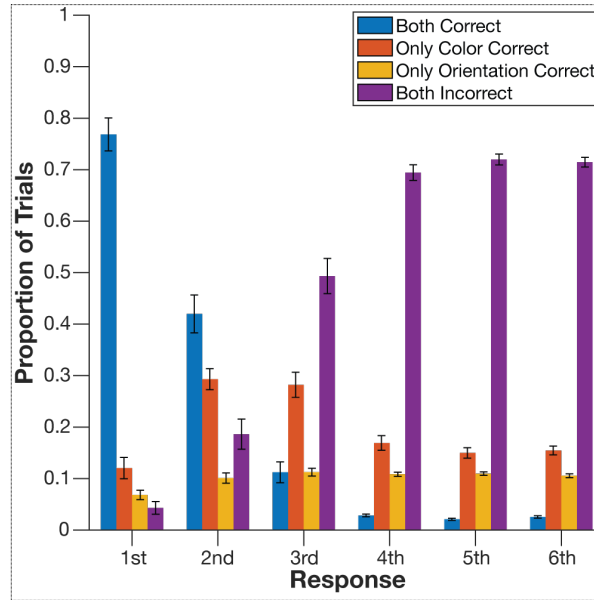




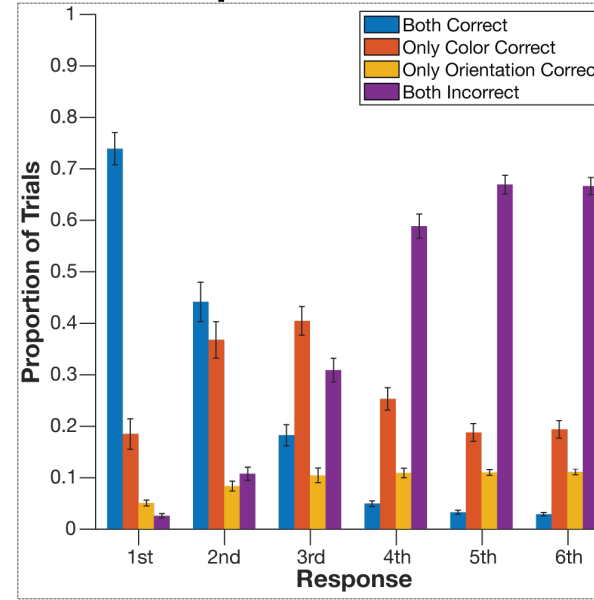
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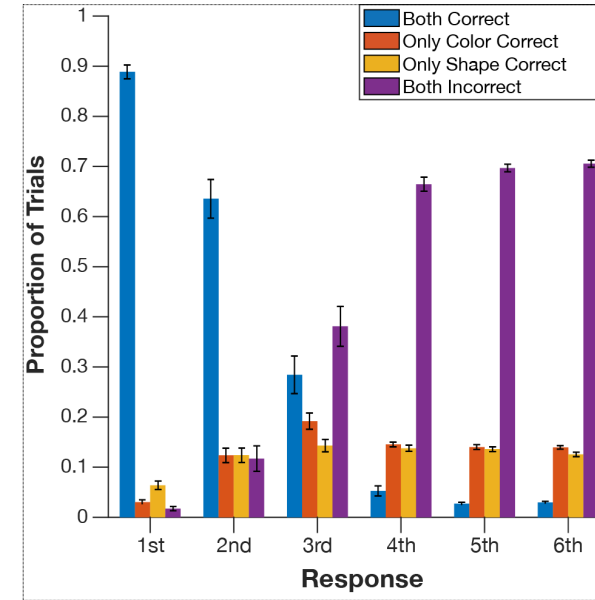
# Experiment 2



# Experiment 3

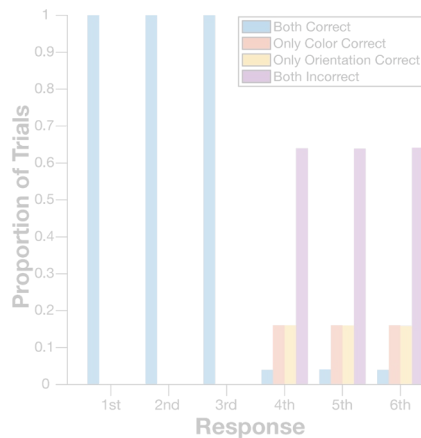


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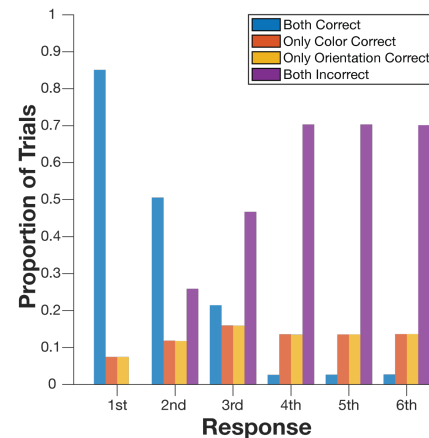
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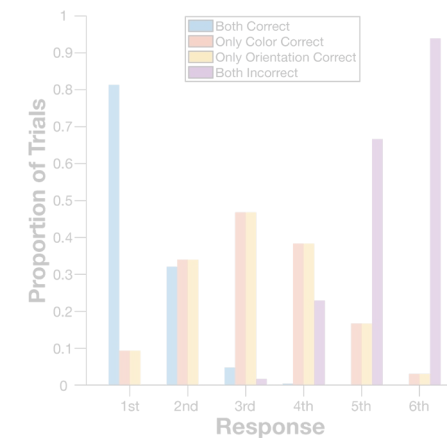
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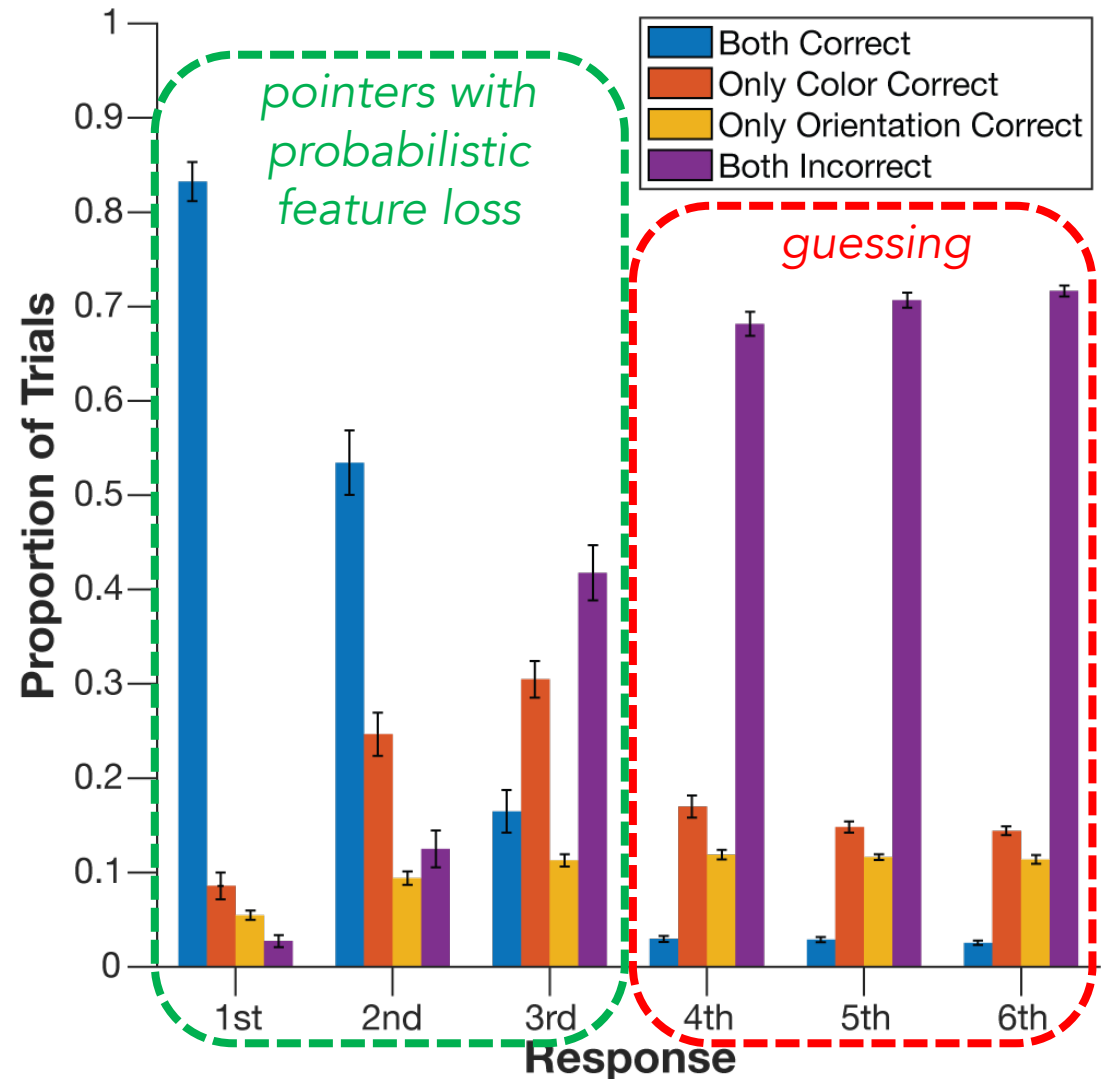
## Independent Feature Model

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# A pointer model

- **Pointers** are a mechanism to maintain representations of objects through changes in its features
  - *FINSTs* (Pylyshyn, 1989)
  - *Object Files* (Kahneman et al., 1992)
- Not simply objects *or* features
  - We see object-based and feature-based phenomena **in concert**



Pylyshyn, Z. (1989). [https://doi.org/10.1016/0010-0277\(89\)90014-0](https://doi.org/10.1016/0010-0277(89)90014-0)

Kahneman, D., Treisman, A., & Gibbs, B. J. (1992). [https://doi.org/10.1016/0010-0285\(92\)90007-O](https://doi.org/10.1016/0010-0285(92)90007-O)

Thyer, W. et al. (2022). <https://doi.org/10.1177/09567976221090923>

# What *is* visual working memory?

## Object-based theory

No one truly believed in a pure 'strong object' slot model!

A convenient straw-man.

versus

## Feature-based theory

*"resource models"*

The flexible notion of a 'resource' which can explain a wide range of empirical observations.



An academically productive debate, maybe no longer a scientifically productive one.

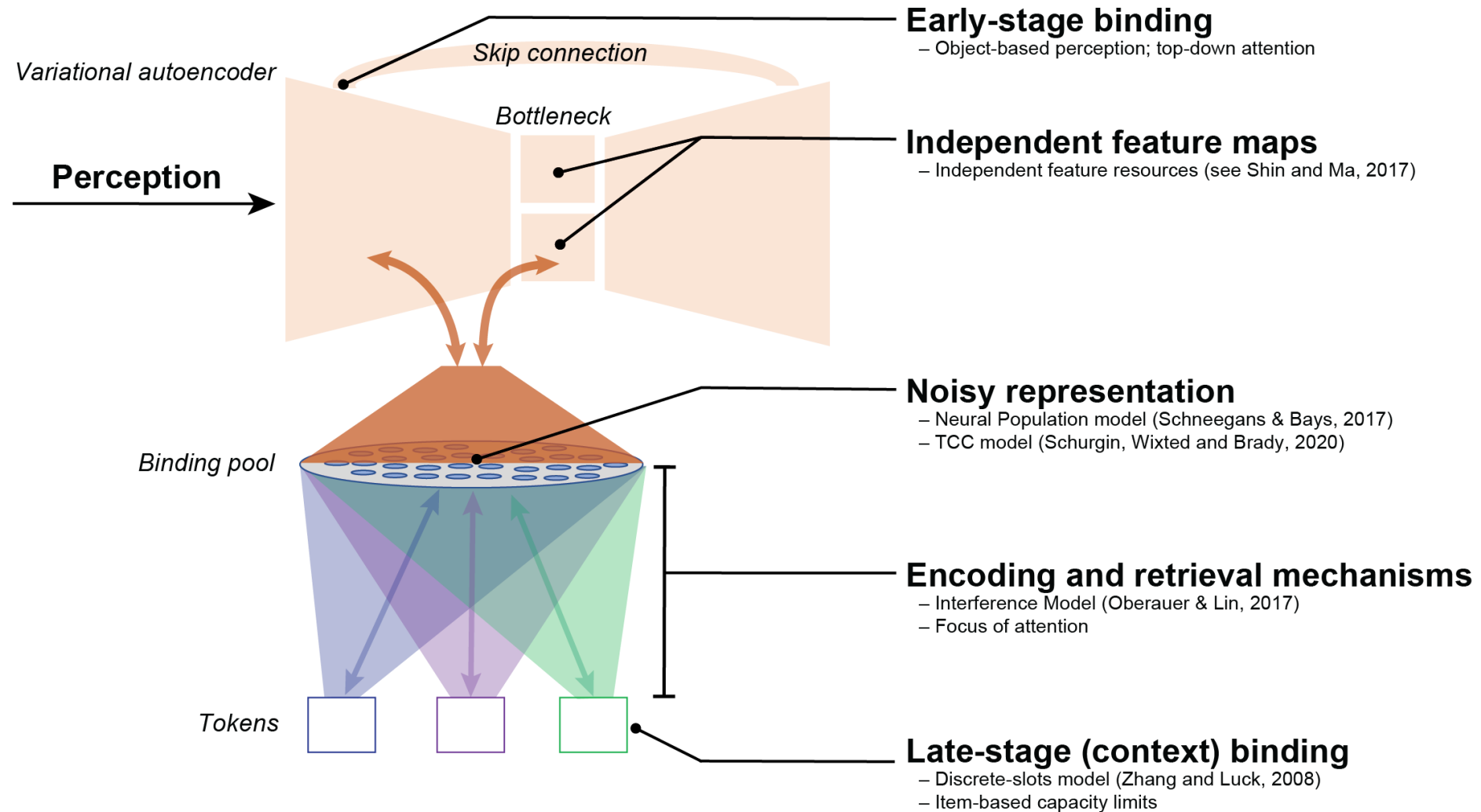
How do we right attention researchers'  
attention?

*Ngiam (2023) PB&R*

# Towards a model-centric science

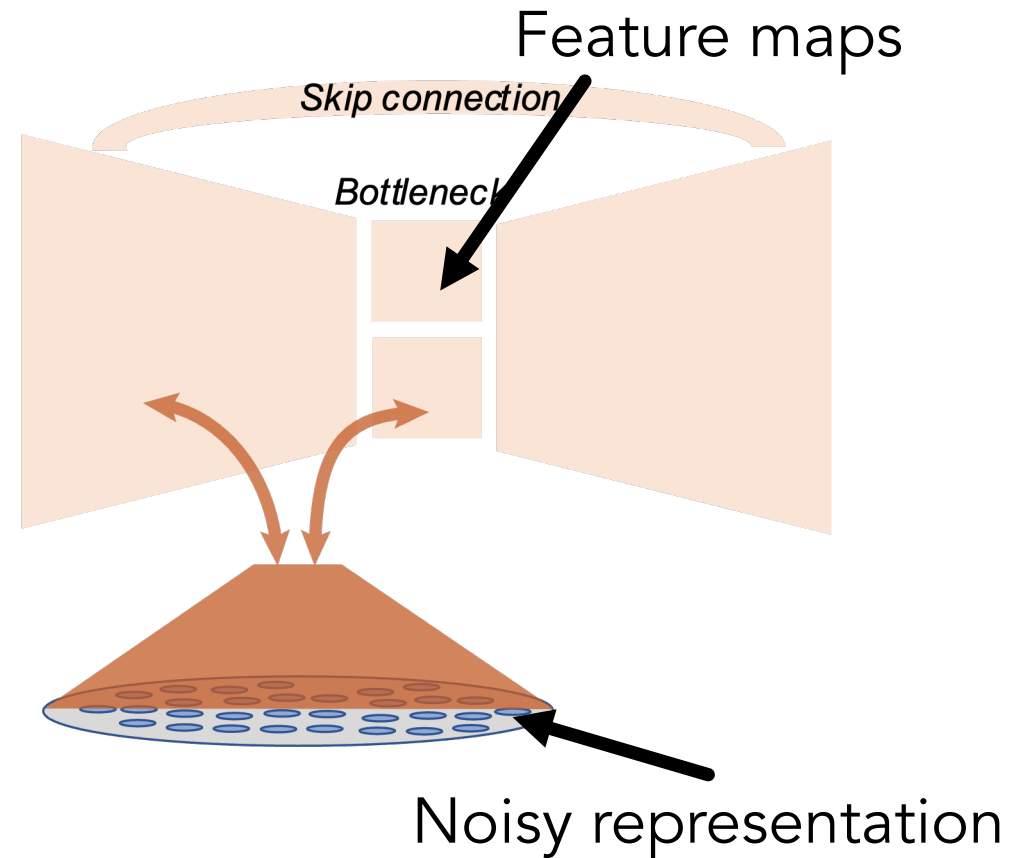
- We need to move away from dualistic experiments and a results-oriented science towards a model-centric science
- We need more theory development
  - Repeating and detailing the phenomena that we hope to explain
  - Integrating various empirical results and models
  - Clear specification of theories and models and how they relate to the phenomena
  - Careful generalization of current models (i.e. practicing intellectual humility)
  - Better thought-out methods and measures
  - Rigorous design of experiments to truly test hypotheses

# Presenting a **theory map** for visual working memory



# Binding pool as a locus for feature-based ideas

- Independent feature layers project into the binding pool (Shin and Ma, 2017)
  - But early-stage object-based attention may also be in play
- **Noisy representations** in VWM are well-captured by neural population and signal detection accounts (Bays, 2014; Schurgin et al., 2020)

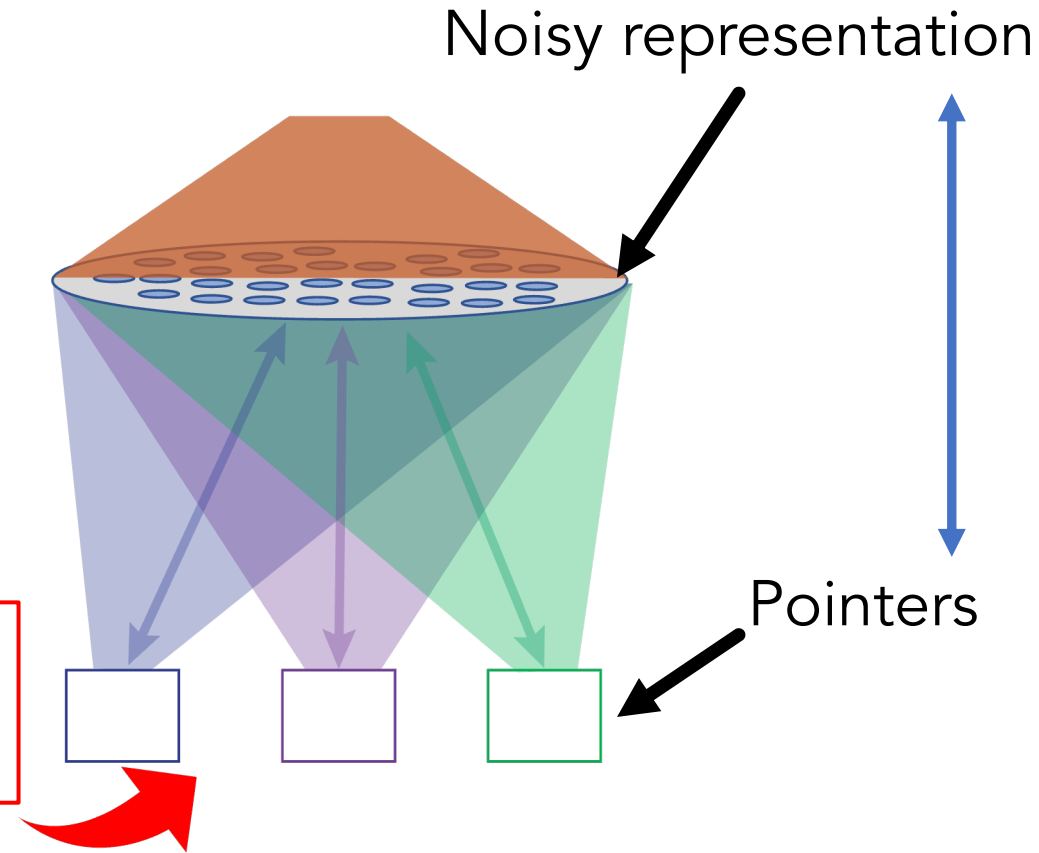


Bays, P. M. (2014). Noise in neural populations accounts for errors in working memory. *Journal of Neuroscience*, 34(10), 3632-3645.  
Schurgin, M. W., Wixted, J. T., & Brady, T. F. (2020). Psychophysical scaling reveals a unified theory of visual memory strength. *Nature human behaviour*, 4(11), 1156-1172.  
Shin, H., & Ma, W. J. (2017). Visual short-term memory for oriented, colored objects. *Journal of Vision*, 17(9), 12-12.

# Tokens as a locus for object-based ideas

- Content-independent pointers
  - Like *FINSTs* or *Object Files* (Pylyshyn, 1989; Kahneman et al., 1992)
- Evidence for a neural signature that indexes VWM load and generalizes across feature content (Thyer et al., 2022; Balaban et al., 2019)

**New conception of working memory as a very late-stage of encoding and selection**



Pylyshyn, Z. (1989). The role of location indexes in spatial perception: A sketch of the FINST spatial-index model. *Cognition*, 32(1), 65-97.

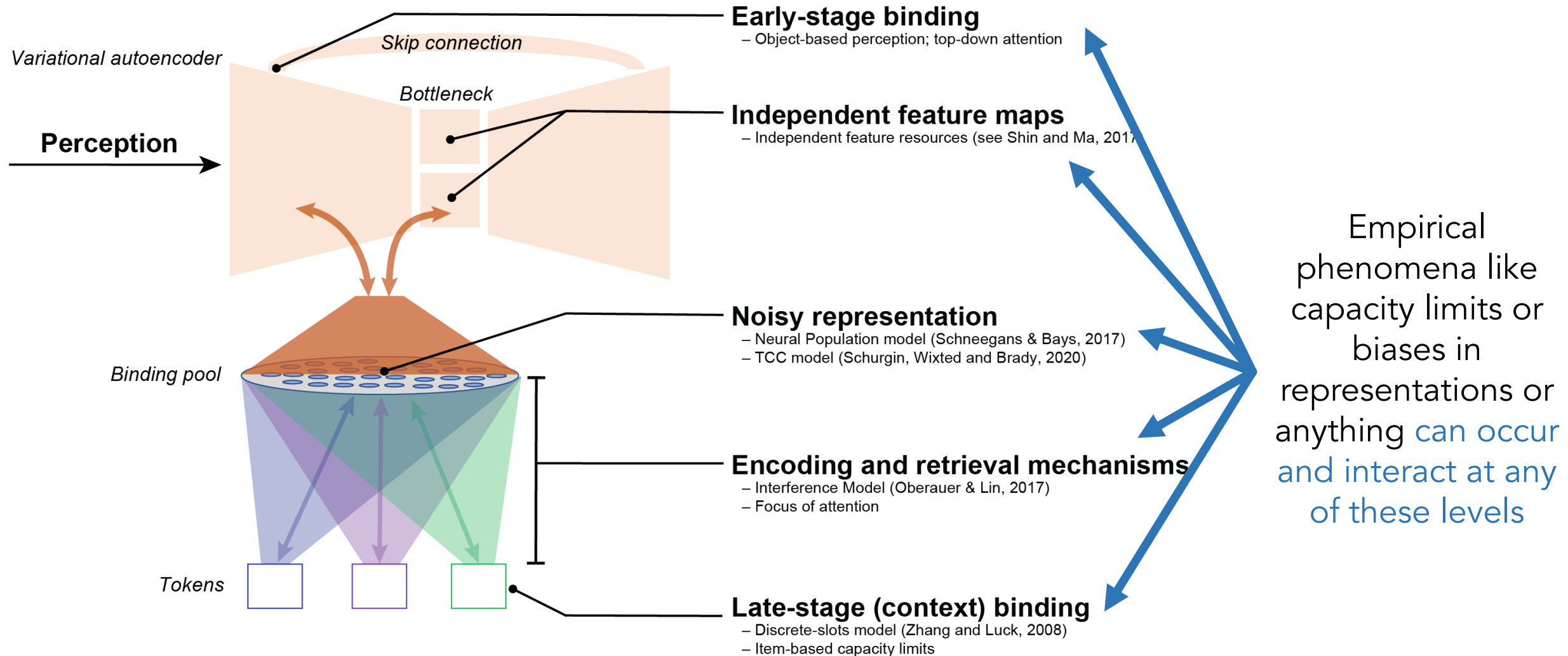
Kahneman, D., Treisman, A., & Gibbs, B. J. (1992). The reviewing of object files: Object-specific integration of information. *Cognitive psychology*, 24(2), 175-219.

Thyer, W., Adam, K. C., Diaz, G. K., Velazquez Sanchez, I. N., Vogel, E. K., & Awh, E. (2022). Storage in visual working memory recruits a content-independent pointer system. *Psychological Science*, 33(10), 1680-1694.

Balaban, H., Drew, T., & Luria, R. (2019). Neural evidence for an object-based pointer system underlying working memory. *cortex*, 119, 362-372.



# Presenting a **theory map** for visual working memory



# How does a theory map help?

- Provides a **common core language and framework** to discuss theories, models, and phenomena
  - Reveals hidden intuitions
  - Prevents misunderstandings from varying definitions
  - Better specifies connection between models and phenomena
  - Reduces straw-man of various positions
  - Discourages a dualistic framework for experimental design
  - Initiates better determined model comparisons and definitive empirical tests
- Inspires **theory development**
  - Promotes **counterinduction** (the use and development of others' models)
  - Encourages **slow science** from better thought-out studies

How do we right scientists' collective  
attention?

Research rigor and reproducibility  
is not at the forefront of scientists'  
minds.

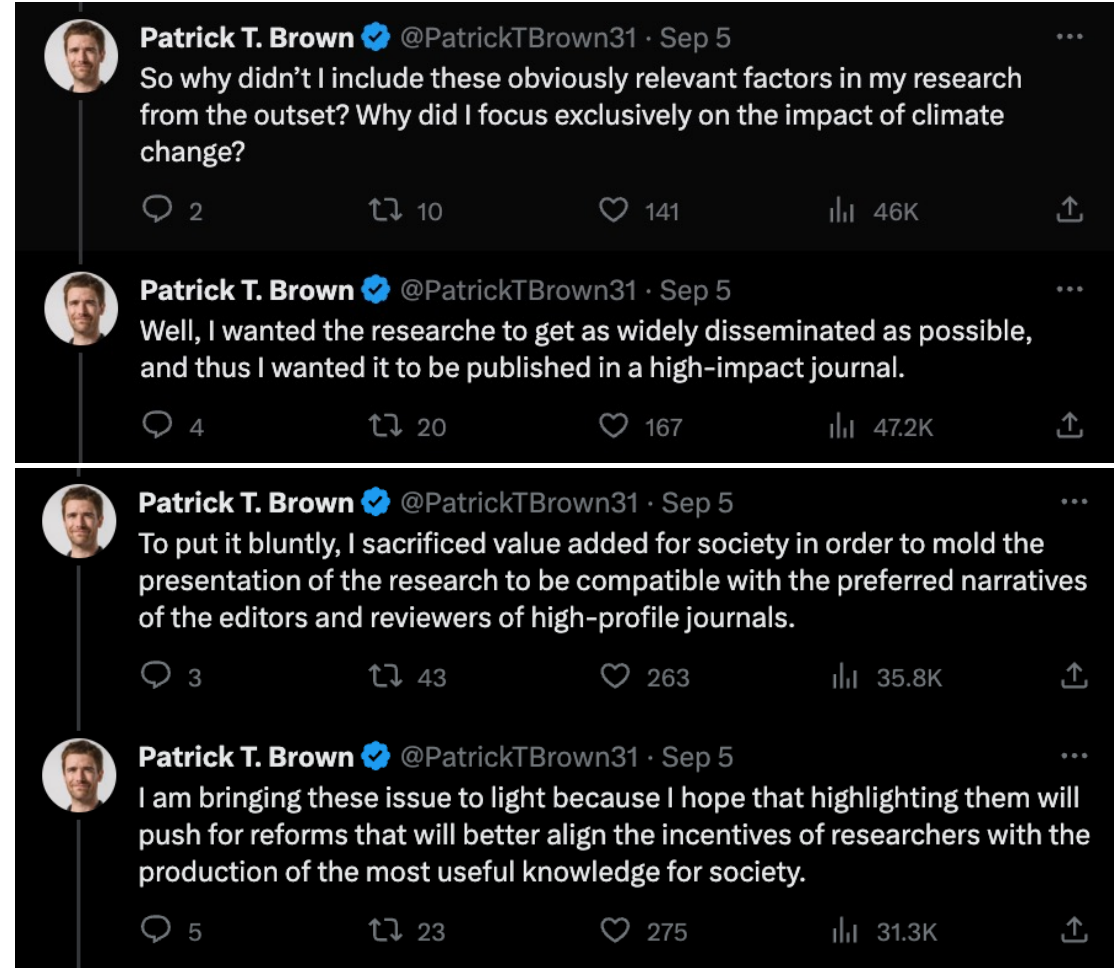
# What comes at the cost of scientific rigor

## Climate warming increases extreme daily wildfire growth risk in California


[Patrick T. Brown](#) , [Holt Hanley](#), [Ankur Mahesh](#), [Colorado Reed](#), [Scott J. Strenfel](#), [Steven J. Davis](#), [Adam K. Kochanski](#) & [Craig B. Clements](#)


[Nature](#) 621, 760–766 (2023) | [Cite this article](#)


12k Accesses | 1508 Altmetric | [Metrics](#)




Three screenshots of tweets by Patrick T. Brown (@PatrickTBrown31) from September 5, 2023. The tweets discuss his research on climate change and wildfire risk, and the challenges of publishing in high-impact journals.

**Patrick T. Brown**  @PatrickTBrown31 · Sep 5  
So why didn't I include these obviously relevant factors in my research from the outset? Why did I focus exclusively on the impact of climate change?  
2 replies · 10 retweets · 141 likes · 46K views

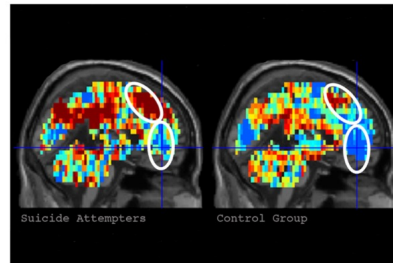
**Patrick T. Brown**  @PatrickTBrown31 · Sep 5  
Well, I wanted the research to get as widely disseminated as possible, and thus I wanted it to be published in a high-impact journal.  
4 replies · 20 retweets · 167 likes · 47.2K views

**Patrick T. Brown**  @PatrickTBrown31 · Sep 5  
To put it bluntly, I sacrificed value added for society in order to mold the presentation of the research to be compatible with the preferred narratives of the editors and reviewers of high-profile journals.  
3 replies · 43 retweets · 263 likes · 35.8K views

**Patrick T. Brown**  @PatrickTBrown31 · Sep 5  
I am bringing these issue to light because I hope that highlighting them will push for reforms that will better align the incentives of researchers with the production of the most useful knowledge for society.  
5 replies · 23 retweets · 275 likes · 31.3K views

# How a now-retracted study got published in the first place, leading to a \$3.8 million NIH grant

The scientific paper inspired international headlines with its bold claim that the combination of brain scans and machine learning algorithms could identify people at risk for suicide with 91% accuracy.



August 29, 2018  
Carnegie Mellon, Pitt Receive \$3.8M NIMH Grant To Diagnose Suicidal Thinking Using Brain Imaging

The promise of the work garnered lead author Marcel Adam Just of Carnegie Mellon University in Pittsburgh and co-author David Brent of the University of Pittsburgh a five-year, \$3.8 million grant from the National Institute of Mental Health to conduct a larger follow-up study.

## Retraction Watch

Tracking retractions as a window into the scientific process

One of the reviewers was not impressed, because the main analysis still focused on 34 participants “cherry-picked” from an original pool of 79, the reviewer wrote.

The authors retracted the paper this year after Timothy Verstynen of Carnegie Mellon University and Konrad Paul Kording of the University of Pennsylvania submitted a Matters Arising, a paper detailing their unsuccessful attempts to replicate the 2017 work with the code and data the authors had made available and their concerns about bias in the model.



This was received by Nature in September 2020, and published on 6<sup>th</sup> April, 2023 with retraction of the original article 6 years later.



**James Heathers**

@jamesheathers

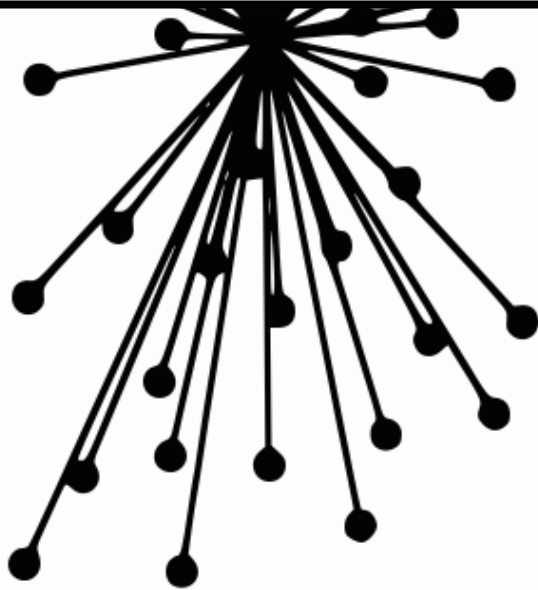


"Science is self-correcting" - sure, \*when we correct it\*, not because of Magical Progress (tm).

12:57 PM · Mar 25, 2017 · Twitter Web Client

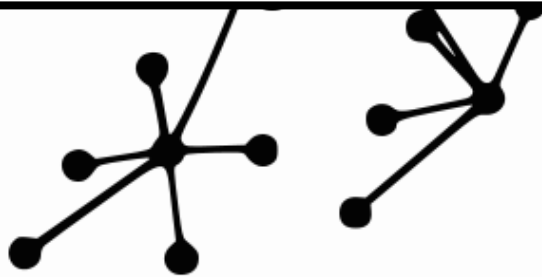
Not doing anything **adds resistance** to changes and reforms. It calcifies existing structures.

This hasn't worked.  
e.g. I've seen little support from my department in the past 4 years.

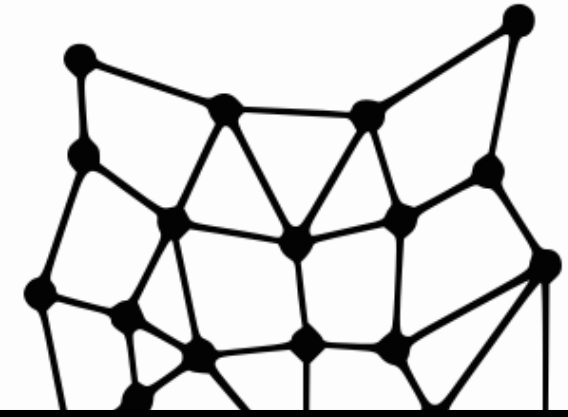


Centralized

This could work...  
But reform is siloed, and would not spread across the network.



Decentralized



This is the goal.  
We need reform at many levels, and changes to spread through the network.

Distributed



# Early-career researchers leading with



- An initiative founded by early-career researchers in 2018 that now spans almost 100 institutions across 25 countries
- Creating **open scholarship communities** at research institutions, especially empowering **early-career researchers**



Check out <https://reproducibilitea.org/>

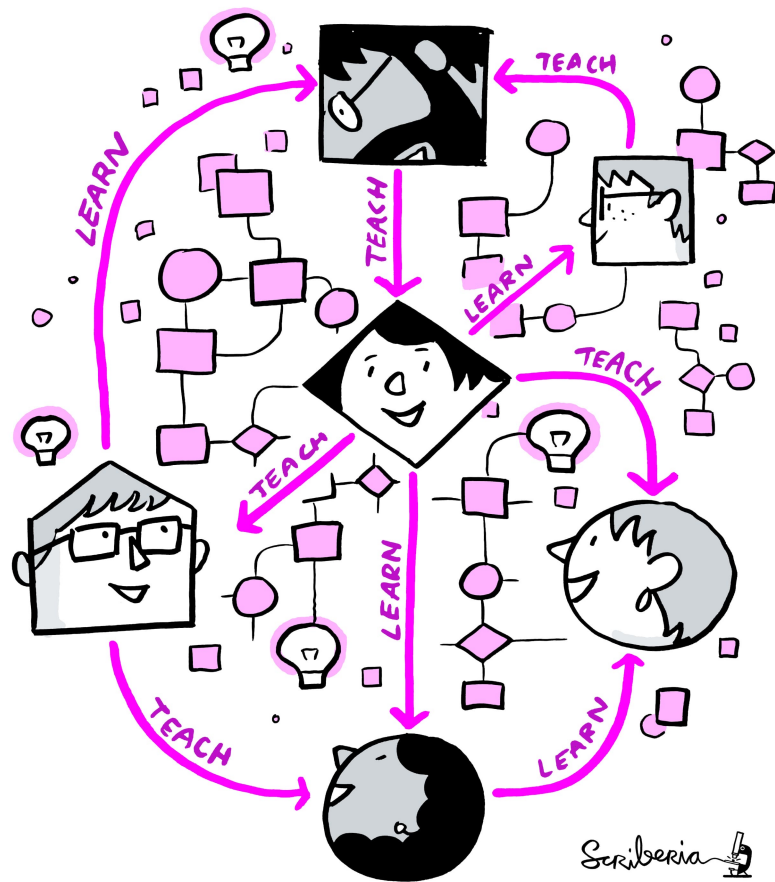


Fig. 1 Modes of change towards scientific credibility. This figure presents an overview of the three modes of change proposed in this article: structural change is often evoked at the institutional level and expressed by new norms and rules; procedural change refers to behaviours and sets of commonly used practices in the research process; community change encompasses how work and collaboration within the scientific community evolves.

Korbmacher, M., Azevedo, F., Pennington, C., Hartmann, H., Pownall, M., Schmidt, K., ... & Evans, T. (2023). The replication crisis has led to positive structural, procedural, and community changes. *Communications Psychology*. Communication network for sharing, learning and teaching. *The Turing Way* project illustration by Scriberia. Used under a CC-BY 4.0 licence. DOI: [10.5281/zenodo.3332807](https://doi.org/10.5281/zenodo.3332807).

# You don't have to do this on your own

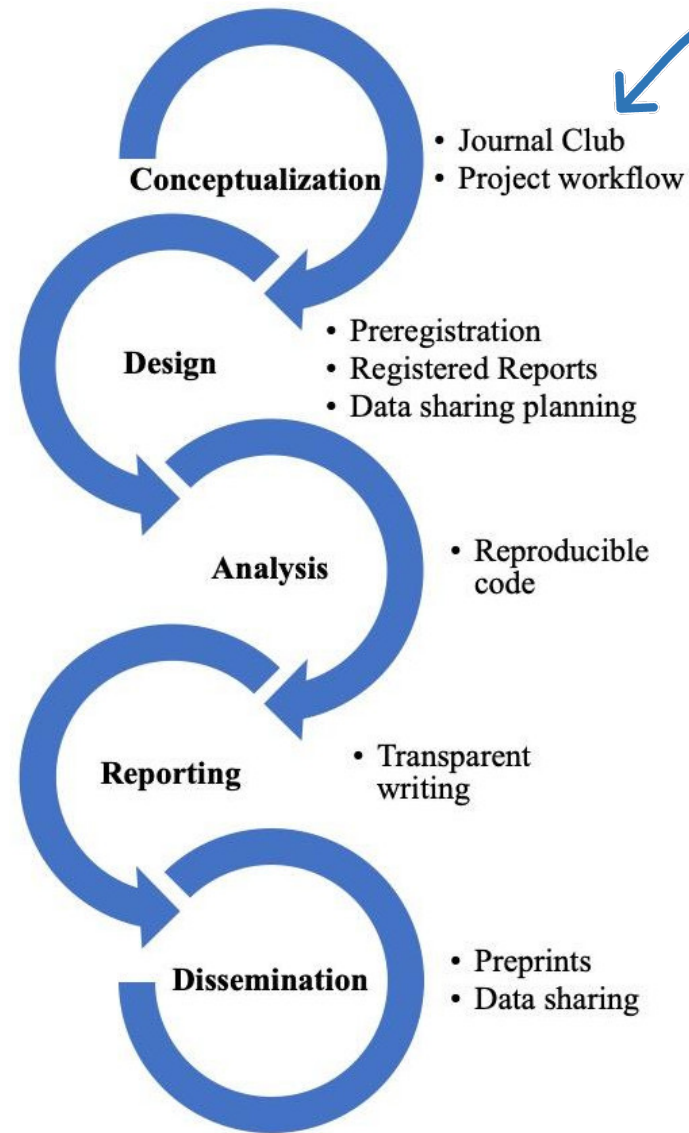
- Only **one hour** or so out of your week
- **Form community** with your fellow junior scientists from otherwise siloed areas in the department
- **Develop and get advice** on your research and science
- Have the hidden curriculum of academia and science revealed





# Where do I start?

- Open Science is not “all or nothing”
  - These are research skills that take time to develop!
- Some easy Open Science practices to adopt:
  - Post free copies of published articles / deposit preprints of all manuscripts
  - Publish in open access venues
  - Publicly share data and materials
  - Preregister studies



Kathawalla, U. K., Silverstein, P., & Syed, M. (2021). Easing into open science: A guide for graduate students and their advisors. *Collabra: Psychology*, 7(1).

McKiernan, E. C., Bourne, P. E., Brown, C. T., Buck, S., Kenall, A., Lin, J., ... & Yarkoni, T. (2016). Point of view: How open science helps researchers succeed. *eLife*, 5, e16800.



## ReproducibiliTea Reading List on Theory in Psychological Science

One precursor to the reproducibility crisis in psychology has been the haste to conduct empirical research, rather than rigorously develop theory and its connection to the research. These ten papers were selected to provide an introduction to theoretical psychology. They are separated by themes that your journal club may choose to explore in further detail in following meetings! We have also provided a brief summary, keywords and additional online resources to help inform your discussions.

### ReproducibiliTea Introductory Reading List

These are our recommendations for the papers to cover in the first term of your new ReproducibiliTea journal club! These ten papers were selected to provide an overview of the reproducibility crisis and introduction to the many aspects of Open Science. They are separated by themes that your journal club may choose to explore in further detail in following meetings! We have also provided a summary, keywords and online resources to help inform your discussions.



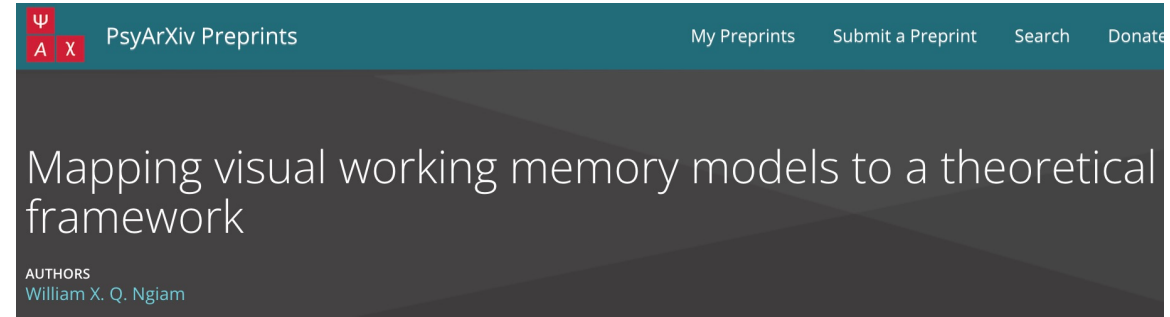
Order	Block	Paper	Summary	Keywords	Resources
1	The 'issues' that lead to the reproducibility crisis	Ioannidis JPA (2005). Why most published research findings are false. <i>PLoS Med</i> 2(8): e124. <a href="https://doi.org/10.1371/journal.pmed.0020124">https://doi.org/10.1371/journal.pmed.0020124</a>	<b>Defining the issue.</b> By simulating at various levels of statistical power, across different pre-study odds, the accumulation of significant results is shown to be potentially false positives predominantly. The paper introduces concepts like the positive predictive value and how it is related to the p-value, and how important having high statistical power is for the rigor of research.	p-values, positive predictive values, false positives, statistical power	Summary video (by William Ngiam): <a href="https://www.youtube.com/watch?v=C7N_-XangTI">https://www.youtube.com/watch?v=C7N_-XangTI</a>
2		Smaldino, P. E., & McElreath, R. (2016). The natural selection of bad science. <i>Royal Society open science</i> , 3(9), 160384. <a href="https://doi.org/10.1098/rsos.160384">https://doi.org/10.1098/rsos.160384</a>	<b>The myth of self-correction.</b> Estimates of statistical power historically in science appears to be extremely low. In addition to that, due to publication bias (the view that positive results are more likely to be published) and the incentives to publish, simulations suggest that a high false-discovery rate is 'naturally selected' for and that replications are ineffective at correcting that rate.	statistical power, replication	Summary video (by William Ngiam): <a href="https://www.youtube.com/watch?v=EdLDE2Y4eM">https://www.youtube.com/watch?v=EdLDE2Y4eM</a>
3		Simmons, J. P., Nelson, L. D., & Simonsohn, U. (2011). False-Positive Psychology: Undisclosed Flexibility in Data Collection and Analysis Allows Presenting Anything as Significant. <i>Psychological Science</i> , 22(11), 1359–1366. <a href="https://doi.org/10.1177/0956797611417632">https://doi.org/10.1177/0956797611417632</a>	<b>The problem of analytic flexibility.</b> A demonstration of how decisions made by researchers in statistical analysis, such as dropping conditions or adding observations after a non-significant test, can easily produce a false positive result.	analytic flexibility, researcher degrees of freedom, questionable research practices	Summary video (by William Ngiam): <a href="https://www.youtube.com/watch?v=b3G9ay8RqzY">https://www.youtube.com/watch?v=b3G9ay8RqzY</a>
4	The extent of the 'issues'	John, L. K., Loewenstein, G., & Prelec, D.	<b>The prevalence of questionable research practices.</b> With an	questionable research practices	
5					
6	Perspectives on the reproducibility crisis	Vazire, S. (2018). Implications of the credibility revolution for productivity, creativity, and progress. <i>Perspectives on Psychological Science</i> , 13(4), 411–417. <a href="https://doi.org/10.1177/1745691617751884">https://doi.org/10.1177/1745691617751884</a>	<b>The credibility revolution.</b> A reframing of the 'reproducibility crisis' that highlights the scientific reforms that have occurred with the Open Science movement, and their potential impacts on the productivity, creativity and progress of scientists.	credibility revolution, commentary, summary	Presentation by Simine Vazire at OSC 2019: <a href="https://www.youtube.com/watch?v=Y1Ovx-OixE">https://www.youtube.com/watch?v=Y1Ovx-OixE</a>
7		Yarkoni, T. (2018). Not its not The Incentives - it's you. Yarkoni Blog - [citation needed]: <a href="https://www.talyarkoni.org/blog/2018/10/02/ho-its-not-the-incentives-its-you/">https://www.talyarkoni.org/blog/2018/10/02/ho-its-not-the-incentives-its-you/</a>	<b>Dealing with the Incentives.</b> A blogpost arguing that the responsibility for reproducible science rests with the individual, and that the Incentives are not a good reason to be absolved of that responsibility	incentives, commentary	
8	Getting started with Open Science	Kathawalla, U. K., Silverstein, P., & Syed, M. (2021). Easing into open science: A guide for graduate students and their advisors. <i>Collabra: Psychology</i> , 7(1). <a href="https://doi.org/10.1525/collabra.18884">https://doi.org/10.1525/collabra.18884</a>	<b>Easing into Open Science.</b> A very accessible guide for graduate students (and their advisors) on some of the different ways to engage with the reproducibility movement. They are given difficulty ratings (easy, medium or difficult) and potential worries are also addressed.	early-career researchers, guide, introductory, pre-registration	Presentation by Priya Silverstein at RIOT Science Club: <a href="https://www.youtube.com/watch?v=owJaD3UiseQ">https://www.youtube.com/watch?v=owJaD3UiseQ</a>
9		Munafo, M. R., Nosek, B. A., Bishop, D. V. M., Button, K. S., Chambers, C. D., Percie Du Sert, N., Simonsohn, U., Wagenmakers, E. J., Ware, J. J., & Ioannidis, J. P. A. (2017). A manifesto for reproducible science. <i>Nature Human Behaviour</i> , 1(1), 1–9. <a href="https://doi.org/10.1038/s41562-016-0021">https://doi.org/10.1038/s41562-016-0021</a>	<b>A manifesto for reproducible science.</b> A general overview of the goals of various reproducibility measures and how they can be implemented.	guide, reproducibility	
10		Crüwell, S., van Doorn, J., Eltz, A., Makel, M. C., Moshontz, H., Niebaum, J. C., ... & Schulte-Mecklenbeck, M. (2019). Seven easy steps to open science. <i>Zeitschrift für Psychologie</i> . <a href="http://dx.doi.org/10.1027/2151-2804/a000387">http://dx.doi.org/10.1027/2151-2804/a000387</a>	<b>Where to next?</b> An annotated reading list of papers from seven topics: open access, open data, preregistration, reproducible analyses, replications and teaching open science in an attempt to make those practices more understandable and actionable for readers	transparency, meta-science	

On my website, under "reading lists"

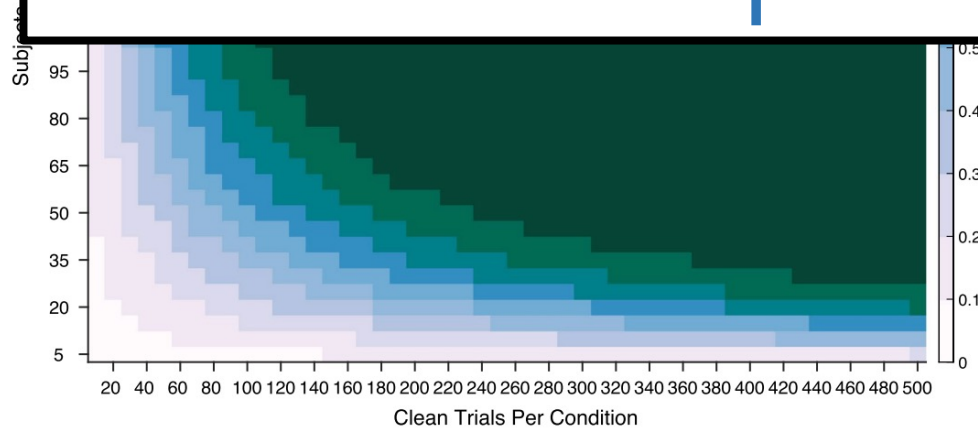
Order	Block	Paper	Summary	Keywords	Resources
1	What is a theory?	Fried, E. I. (2020). Theories and models: What they are, what they are for, and what they are about. <i>Psychological Inquiry</i> , 31(4), 336–344. <a href="https://doi.org/10.1080/1047840X.2020.1854011">https://doi.org/10.1080/1047840X.2020.1854011</a>	<b>What is a theory?</b> An overview on the role of theories and models in science, including a brief commentary on the weakness of theories in the psychological sciences and how to make them better.	introductory, theory development	Eiko Fried on "Theory building and testing in psychological research" for the RIOT Science Club: <a href="https://youtu.be/vB1HK3c-IZY">https://youtu.be/vB1HK3c-IZY</a>
2	Does psychology have a theory problem?	Meehl, P. E. (1978). Theoretical Risks and Tabular Asterisks: Sir Karl, Sir Ronald, and the Slow Progress of Soft Psychology. <i>Journal of Consulting and Clinical Psychology</i> 1978, Vol. 46, 806–834. <a href="https://www3.nd.edu/~ghaefel/Meehl(1978).pdf">https://www3.nd.edu/~ghaefel/Meehl(1978).pdf</a>	<b>The lack of theory development in psychology.</b> An astute criticism of the excessive use of null hypothesis significance testing in 'soft psychology' that left psychological theories lacking "the cumulative character of scientific knowledge because they tend to be neither refuted nor corroborated, but instead merely fade away as people lose interest."	NHST, statistical testing, scientific inference	A video recording of the first lecture by Paul Meehl in his course on philosophical psychology from 1989, where he contrasts the role of theory in the 'hard sciences' like physics and the 'soft science' of psychology. <a href="https://youtu.be/AEPbzCTneDs">https://youtu.be/AEPbzCTneDs</a>
3		Klein, S. B. (2014). What can recent replication failures tell us about the theoretical commitments of psychology?. <i>Theory &amp; Psychology</i> , 24(3), 326–338. <a href="https://doi.org/10.1177/0959354314529616">https://doi.org/10.1177/0959354314529616</a>	<b>A crisis in replication or beyond?</b> Determining success or failures of replications necessitates that theories be well-specified – clearly defining the relation between theory and prediction by linking rigorously established constructs to physical observations and detailing the essential conditions of experiments.	reproducibility crisis, replications, theory development	A personal commentary by Daniel Nettle on the pretense of having a theory in psychology: "Theories and models are not the only fruit" <a href="https://leonidtkohin.medium.com/theories-and-models-are-not-the-only-fruit-a05c7c1f1886">https://leonidtkohin.medium.com/theories-and-models-are-not-the-only-fruit-a05c7c1f1886</a>
4		Scheel, A. M., Tiohkin, L., Isager, P. M., & Lakens, D. (2021). Why hypothesis testers should spend less time testing hypotheses. <i>Perspectives on Psychological Science</i> , 16(4), 744–755. <a href="https://doi.org/10.1177/1745691620966795">https://doi.org/10.1177/1745691620966795</a>	<b>Are we ready to test?</b> Psychologists have been trained with a recipe: the hypothetico-deductive method – formulate a hypothesis from theory, devise a study to test the hypothesis, collect and analyze data, and finally evaluate whether there is support for or against the theory. However, without the groundwork strengthening the 'derivation chain that links theory to hypothesis test, the confirmatory testing that is prized by the recent reform movement may be premature.	exploratory versus confirmatory, derivation chain	Anne Scheel on "Equivalence testing for psychological research" for the RIOT Science Club <a href="https://youtu.be/T9pZORPTXFU">https://youtu.be/T9pZORPTXFU</a>
6	Improve psychological theory	Psychological Science, 16(4), 789–802. <a href="https://doi.org/10.1177/1745691620970585">https://doi.org/10.1177/1745691620970585</a>	theories as abstract constructs are formalized, and underlying intuitions and predictions are made open and transparent.		note presentation by Olivia Martin on "What makes a good theory, how do we make a theory good?" <a href="https://youtu.be/67X0TpnQe00">https://youtu.be/67X0TpnQe00</a>
7		Maatman, F. O. (2021). Psychology's Theory Crisis, and Why Formal Modelling Cannot Solve It. <a href="https://psyarxiv.com/puqvsl/">https://psyarxiv.com/puqvsl/</a>	<b>Formal theories are helpful but first be determined.</b> The cause of the theory crisis stems from tests of experiments not being specific enough as to support only one theory and falsify all other alternatives, and many psychological theories containing auxiliary assumptions such that the theories are not severely tested. Better methods that force precise and unlikely predictions from theories will solve the core issue, not necessarily formal modeling alone.	proto-theory, formal theory, theory building, theory specification	A Twitter thread by Freek Maatman (@psychedfreak) summarizing their paper. <a href="https://twitter.com/psychedfreak/status/1414982603082506242">https://twitter.com/psychedfreak/status/1414982603082506242</a>
8	Taking steps to improve psychological theory	Flake, J. K., & Fried, E. I. (2020). Measurement schmeasurement: Questionable measurement practices and how to avoid them. <i>Advances in Methods and Practices in Psychological Science</i> , 3(4), 456–465. <a href="https://doi.org/10.1177/2515245920952393">https://doi.org/10.1177/2515245920952393</a>	<b>Better measures to inform theory building.</b> Developing and testing theories requires construct measures to be scrutinized and valid. Echoing questionable research practices, questionable measurement practices (e.g. the arbitrary summing of subscales) are defined and a list of questions are provided to help the researcher promote the validity of their measures.	guide, measurement, transparency, construct validity	Jessica Flake on "Measurement schmeasurement: Questionably measurement practices and how to avoid them" for the RIOT Science Club: <a href="https://youtu.be/Cq6n7AS_rfW">https://youtu.be/Cq6n7AS_rfW</a>
9		van Rooij, I., & Blokpoel, M. (2020). Formalizing verbal theories: A tutorial by dialogue. <i>Social Psychology</i> , 51(5), 285. <a href="https://doi.org/10.1027/1864-9335/a000428">https://doi.org/10.1027/1864-9335/a000428</a>	<b>Formalizing verbal theories.</b> A guide to translating verbal theories into formal theories starting with basic mathematical definitions and notation before a toy example of building formal theories presented through multiple dialogues between fictional Dr Verbal and Dr Formal.	guide, theory building, formal modeling	Smaldino, P. E. (2020). How to translate a verbal theory into a formal model. <i>Social Psychology</i> , 51(4), 207. <a href="https://osf.io/preprints/metaarxiv/n7qsh">https://osf.io/preprints/metaarxiv/n7qsh</a>
10	Are we ready to test our theories?	Oberauer, K., & Lewandowsky, S. (2019). Addressing the theory crisis in psychology. <i>Psychonomic bulletin &amp; review</i> , 26(5), 1596–1618. <a href="https://doi.org/10.3758/s13423-019-01645-2">https://doi.org/10.3758/s13423-019-01645-2</a>	<b>Discovery-oriented research versus theory-testing research.</b> A critical and comprehensive revisit of the reproducibility crisis and proposed solutions, such as preregistration, formal modeling and stricter statistical standards. A distinction is made between two paths: discovery-oriented research, where it is accepted that theory cannot yet lead to strong inferences and necessitating empirical standards through direct replication, versus theory-testing research, where theories are formulated as precisely as possible as to close the gap between theory and hypothesis.	reproducibility crisis, preregistration, statistical inference, formal modelling, exploratory versus confirmatory, theory specification	Eiko Fried contextualizes and summarizes the field of theoretical psychology in his blogpost "On Theory". The inspiration for this resource, and a good place to inform where to go next to continue learning about psychological theory. <a href="https://eiko-fried.com/on-theory/">https://eiko-fried.com/on-theory/</a>

# Estimating the statistical power to detect set-size effects in contralateral delay activity

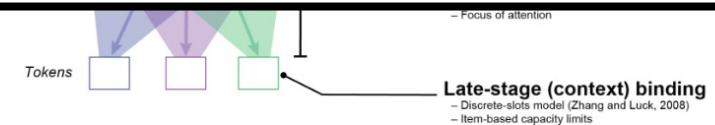
William X. Q. Ngiam<sup>1</sup> | Kirsten C. S. Adam<sup>2</sup> | Colin Quirk<sup>1</sup> | Edward K. Vogel<sup>1</sup> | Edward Awh<sup>1</sup>



It's not either/or – your goals can include improving science while conducting empirical research.



**FIGURE 6** Simulated statistical power for observing a significant difference in CDA amplitude between set sizes 2 and 4 beyond the bounds of the Hakim et al. (2019) dataset



*Figure 1.* A simplified schematic of the Memory for Latent Representations (MLR) model architecture (Hedayati et al., 2022) with visual working memory phenomena and current models mapped on to its components: the variational autoencoder (VAE), the binding pool, and the tokens. This theory map aims to provide a coherent framework within which to organize visual working memory phenomena and discuss the relevant explanatory models. As such, the compatibility or inconsistencies between models can be better identified, and subsequently tested. For example, one could use a working definition for the noisy representation in VWM as the noise held in the pattern of neuron activity in the binding pool that follows a summation of information from various perceptual sources.

This seems like a lot **more work...**

What is **your goal** in science?

Do you want your attention taken up by  
the *Incentives*?

Or do you want your work to pave the  
way towards better understanding?

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# Personal **benefits** of Open Science

- May **improve the quality and reliability** of your scientific research
  - For example, preregistrations prompt **theory development**, justifications of sample sizes and analyses, and **statistical power considerations** to protect against researcher bias
- **Increases the impact** of your scientific research
  - Increase reviewers' quality of feedback if they reproduce your results and analyses
  - **Increase citations** from re-analysis and re-use of open datasets
- Can become part of your **academic brand**
  - Increasingly considered in grants and job applications



Exponential growth of scientific publications

Feeding a capitalistic academic system devalues the work.

Slow down, refocus, think again, test carefully.

Jan '95

Jan '00

Jan '05

Jan '10

Jan '15

Jan '20

The credibility revolution in science can only succeed if ***we take action together.***

