McMaster University

SCIENCE
Department of Kinesiology

Metascience of Motor Learning

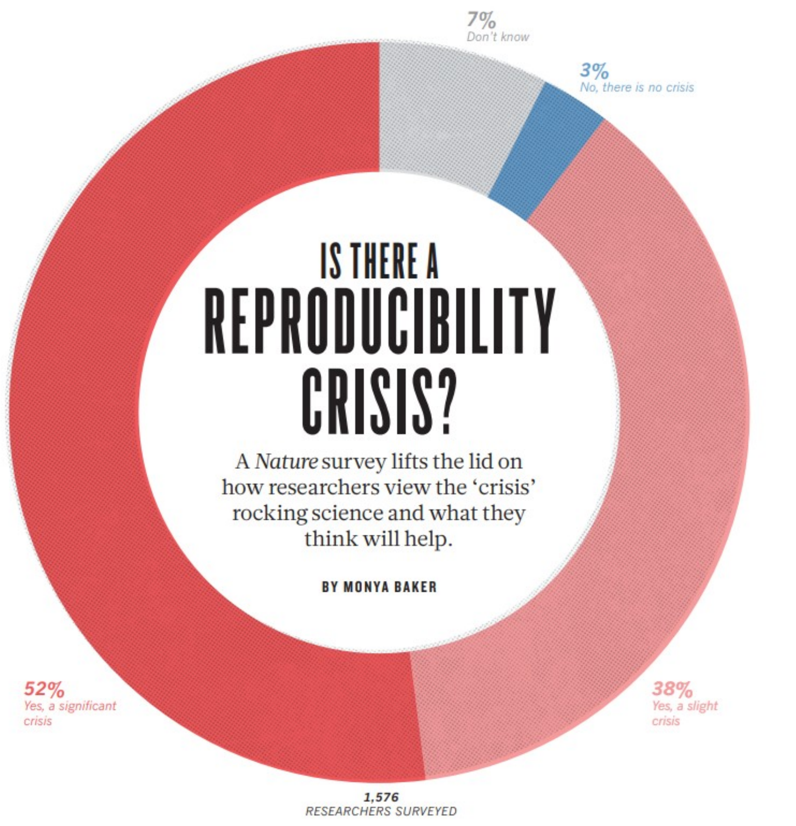
KINESIOL 1E03 - Motor control and learning

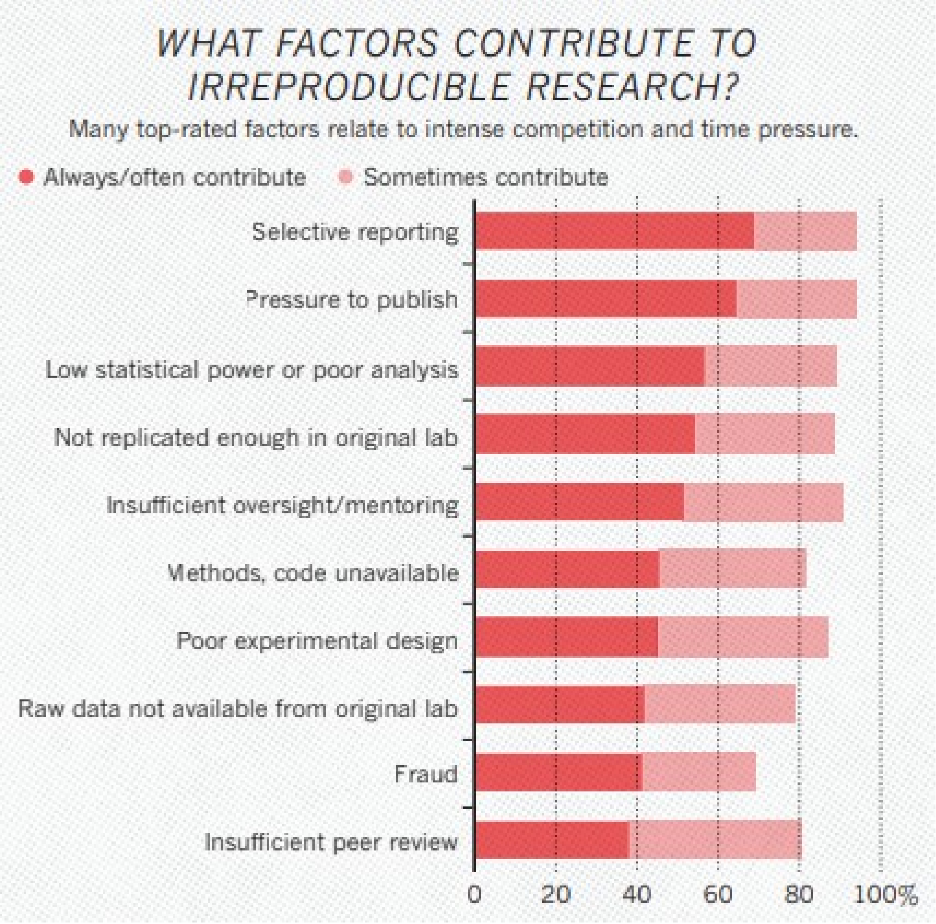
Brad McKay

Fall 2022
Lecture 21

Review from last lecture

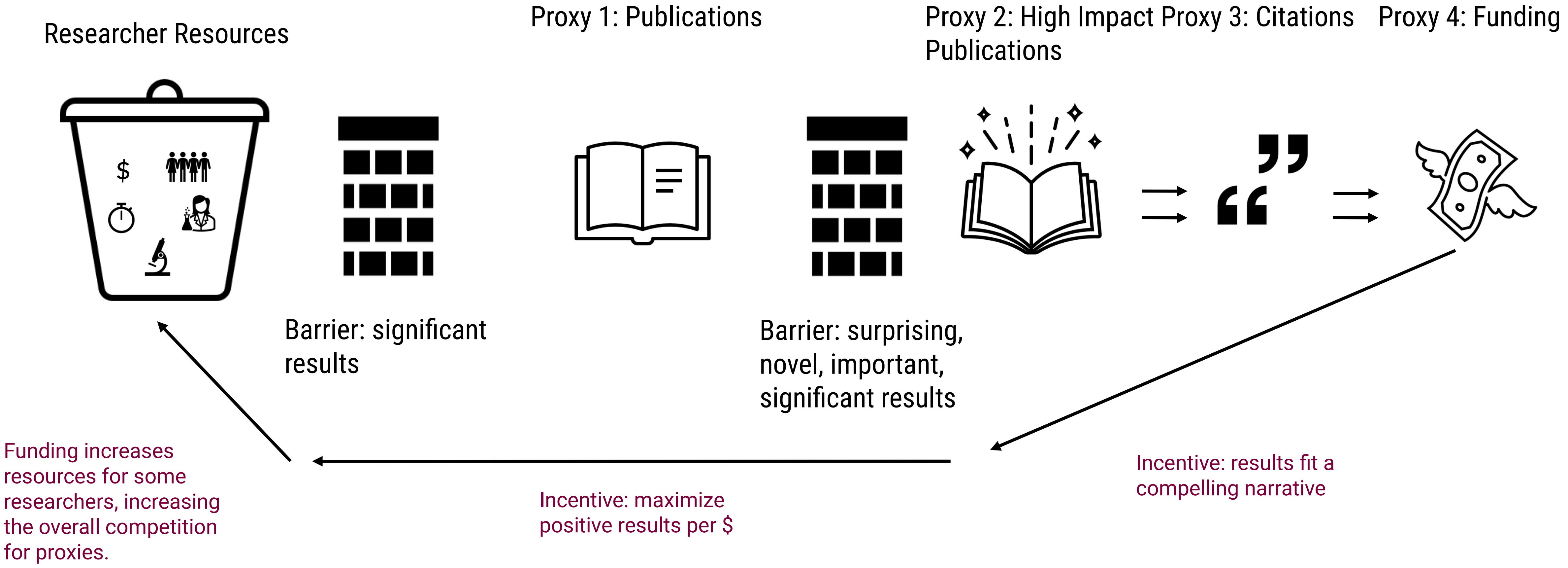
What is causing the replication crisis?





Source: Baker (2016) https://doi.org/10.1038/533452a

The perverse incentive feedback loop



Open science reforms

Methods reform: Preregistration, registered reports, open materials, open data.

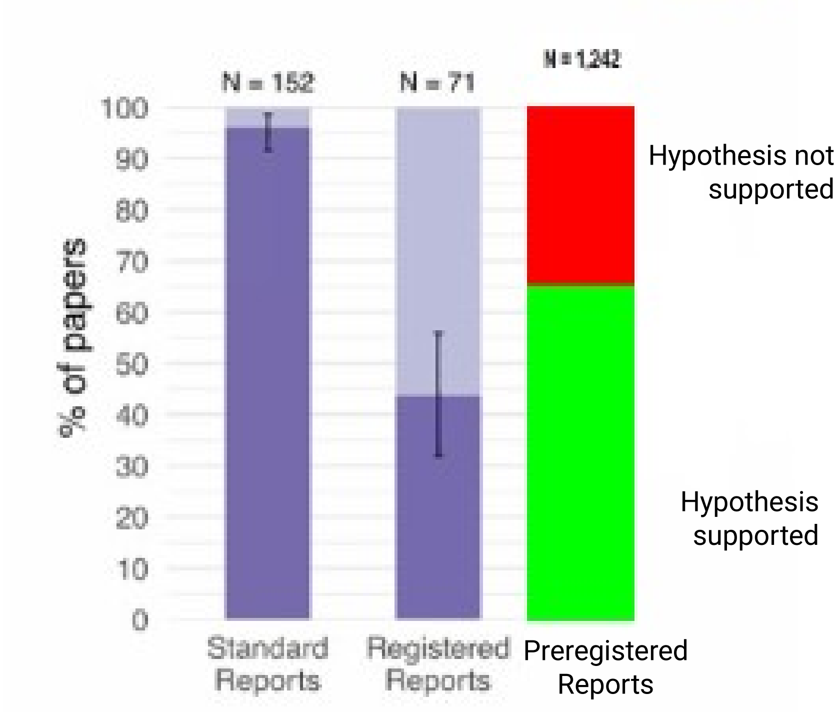
Incentive reform: Badges to signal best practices have been followed.

Source: Schweitzer & Schulz (2019) https://doi-org. /10.1111/jnc.14536

Effectiveness of methods reforms

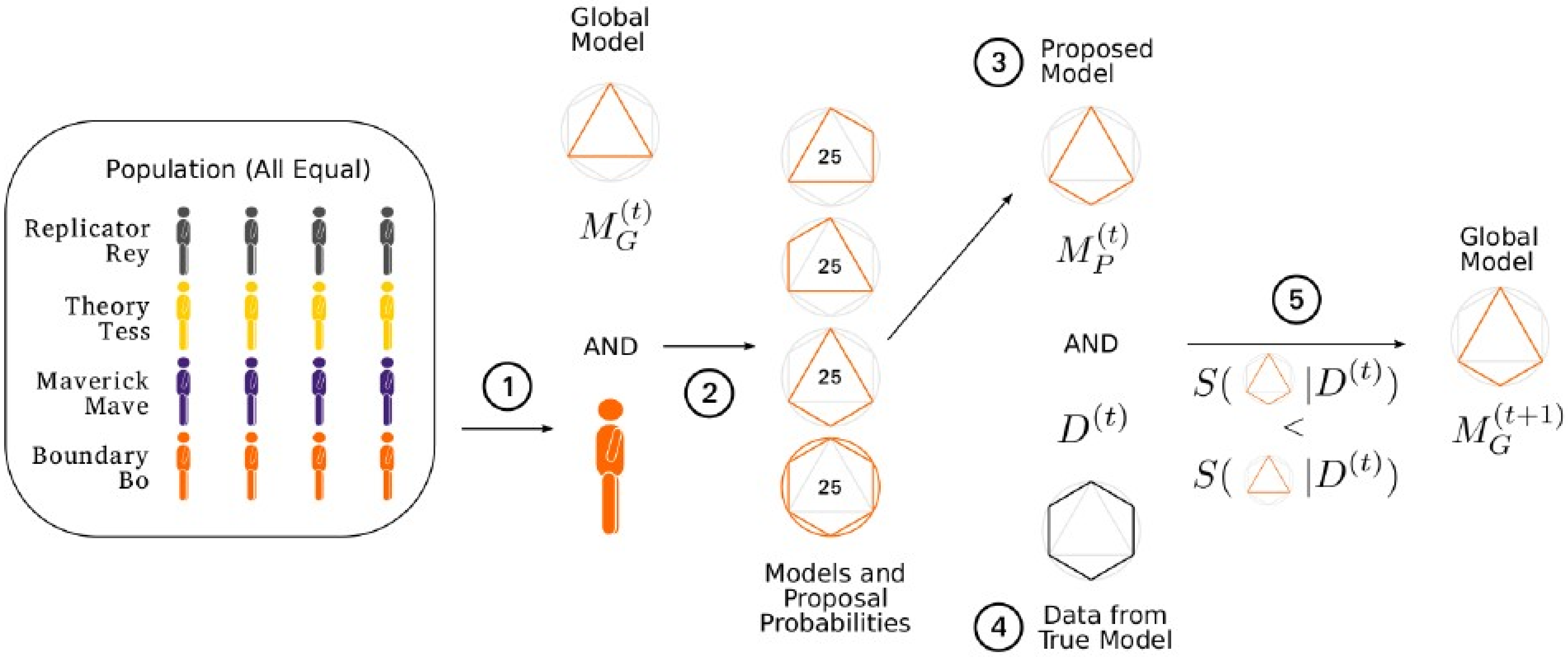
Percentage of positive results

Standard reports: 96%
Registered reports: 44%
Preregistered reports: 65%



Source: Van den Akker, 2021 https://osf.io/6qsf4/

Simulating scientific discovery



Source: Devezer et al., 2019 https://doi.org/10.1371/journal.pone.0216125

Any questions?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Learning objectives

1. Discuss the evidence of a **replication crisis** in motor learning.
2. Describe what a **meta-analysis** is and what we can learn from one.
3. Compare and contrast evidence from standard and preregistered studies of **self-controlled learning**.
4. Discuss the adoption of **best practices** in recent motor learning research.

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Take-home message:

Metascience of motor learning suggests a replication crisis exists and will continue without adoption of rigorous methods.

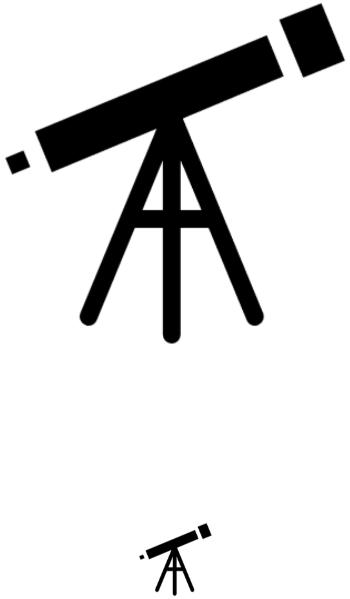
What is statistical power?

Power is the probability of observing a significant result, conditional on a true effect of a given size.

The larger the sample, the more powerful the experiment.

A more powerful experiment is like having a more powerful telescope: Smaller details (or differences) can be detected, and larger details (or differences) can be measured more accurately.

If an experiment is severely underpowered, it's akin to doing astronomy with binoculars.



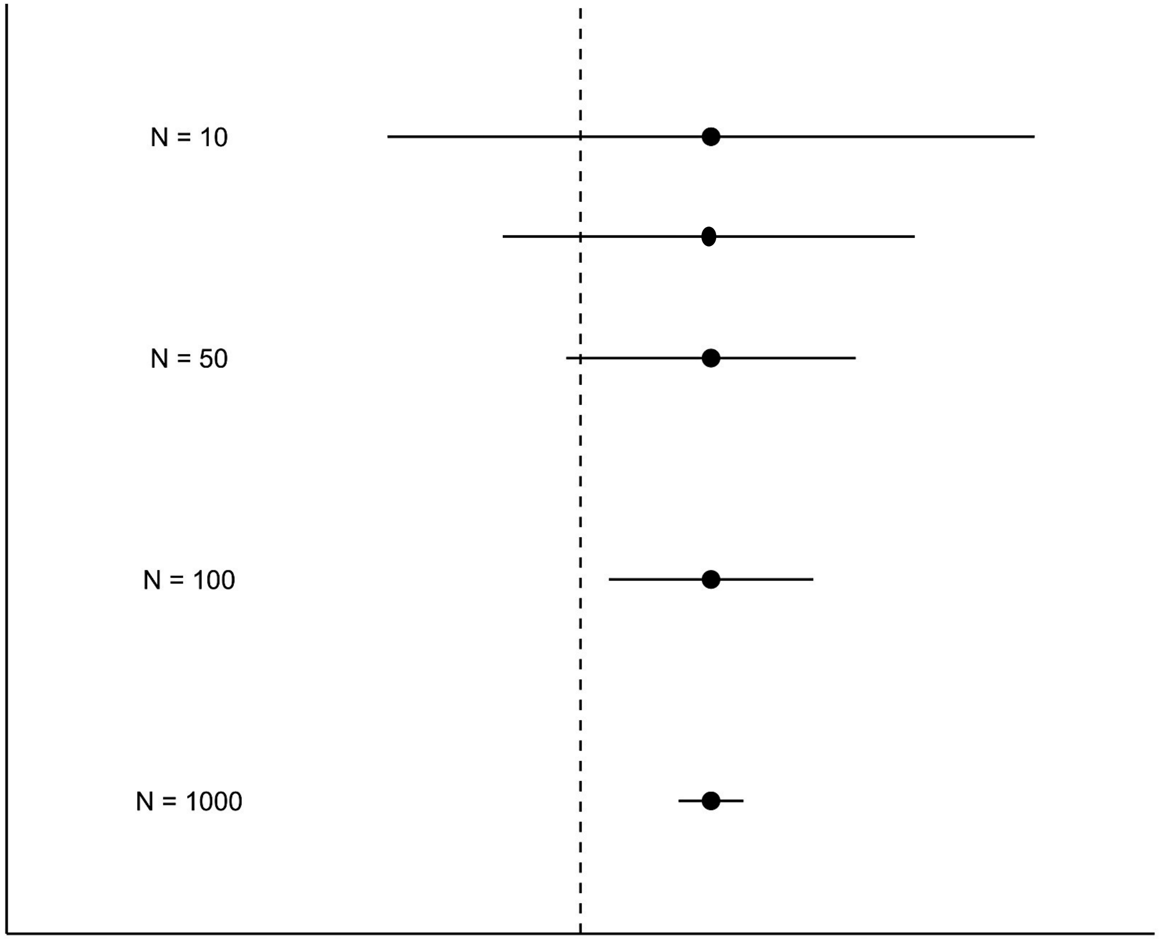
What is statistical power?

When we conduct an experiment, we calculate the mean difference between groups (black circle).

We also estimate our uncertainty, often with 95% confidence intervals (black lines).

As our sample size increases, the width of our uncertainty interval decreases.

This example illustrates average values from thousands of experiments. Individual experiments might fall anywhere within the interval and occasionally outside it.



Source: Turner et al. (2020) https://doi-org./10.1111/head.13991

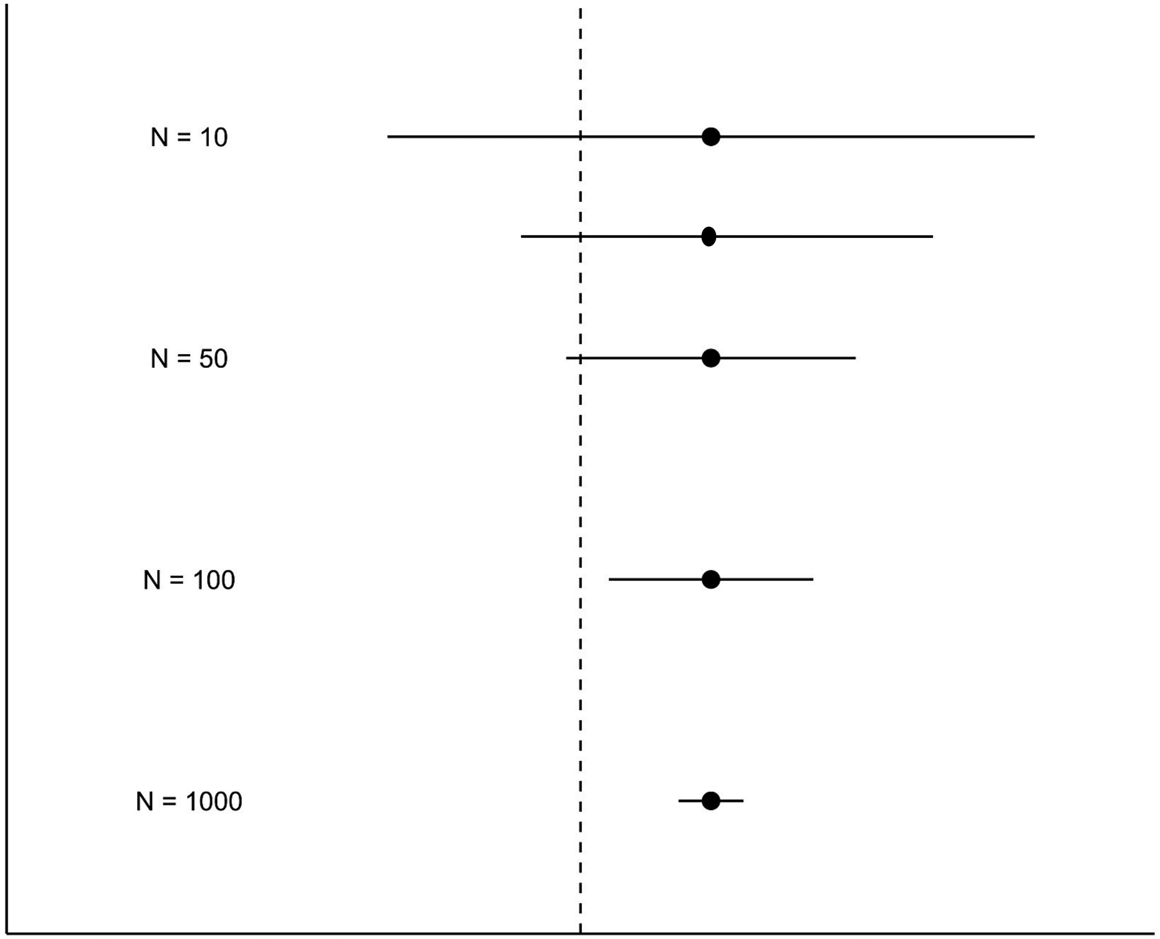
Low power plus publication bias

If experiments have low power, they have wide uncertainty intervals. So, they are less likely to find a significant result.

What happens when we combine low power with publication bias?

The low power studies either provide exaggerated estimates…

Or get ignored.



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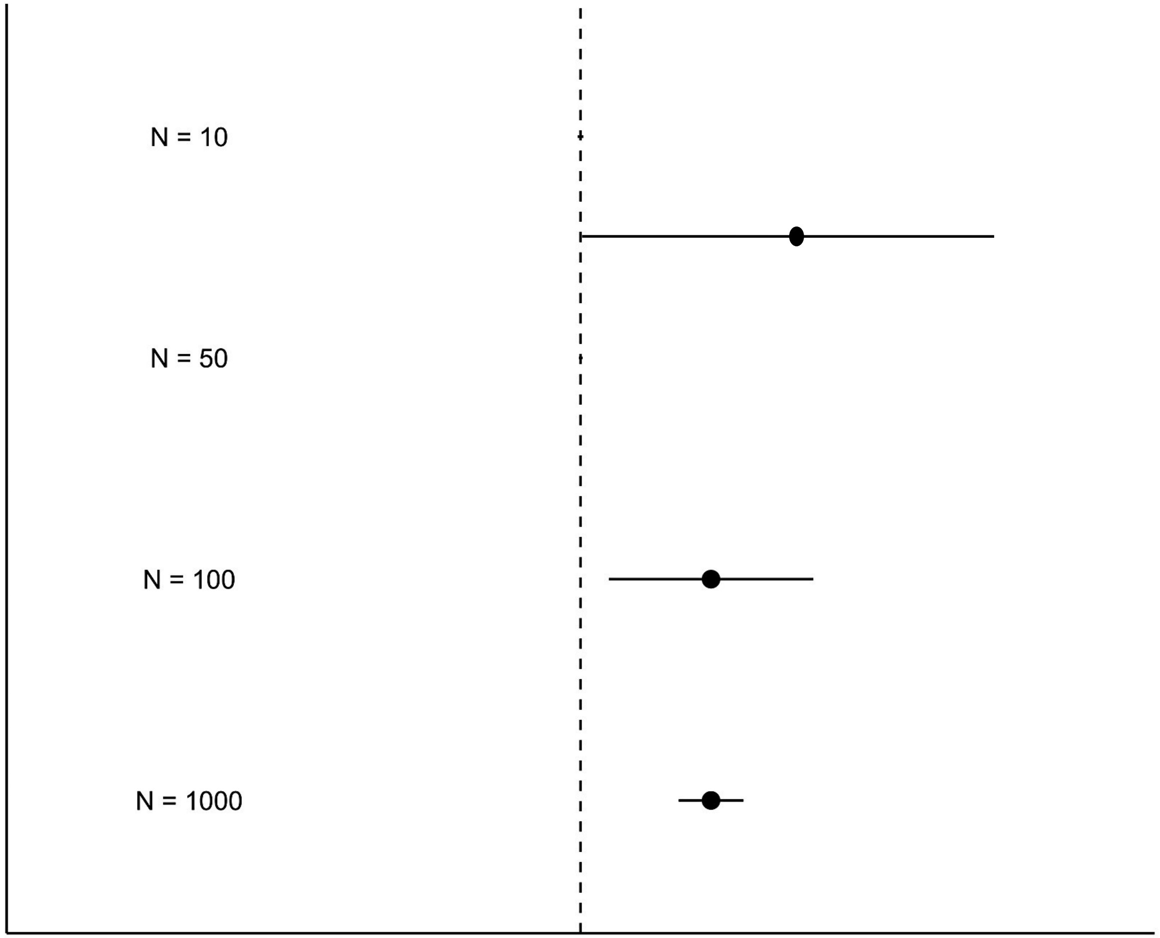

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Low power plus publication bias

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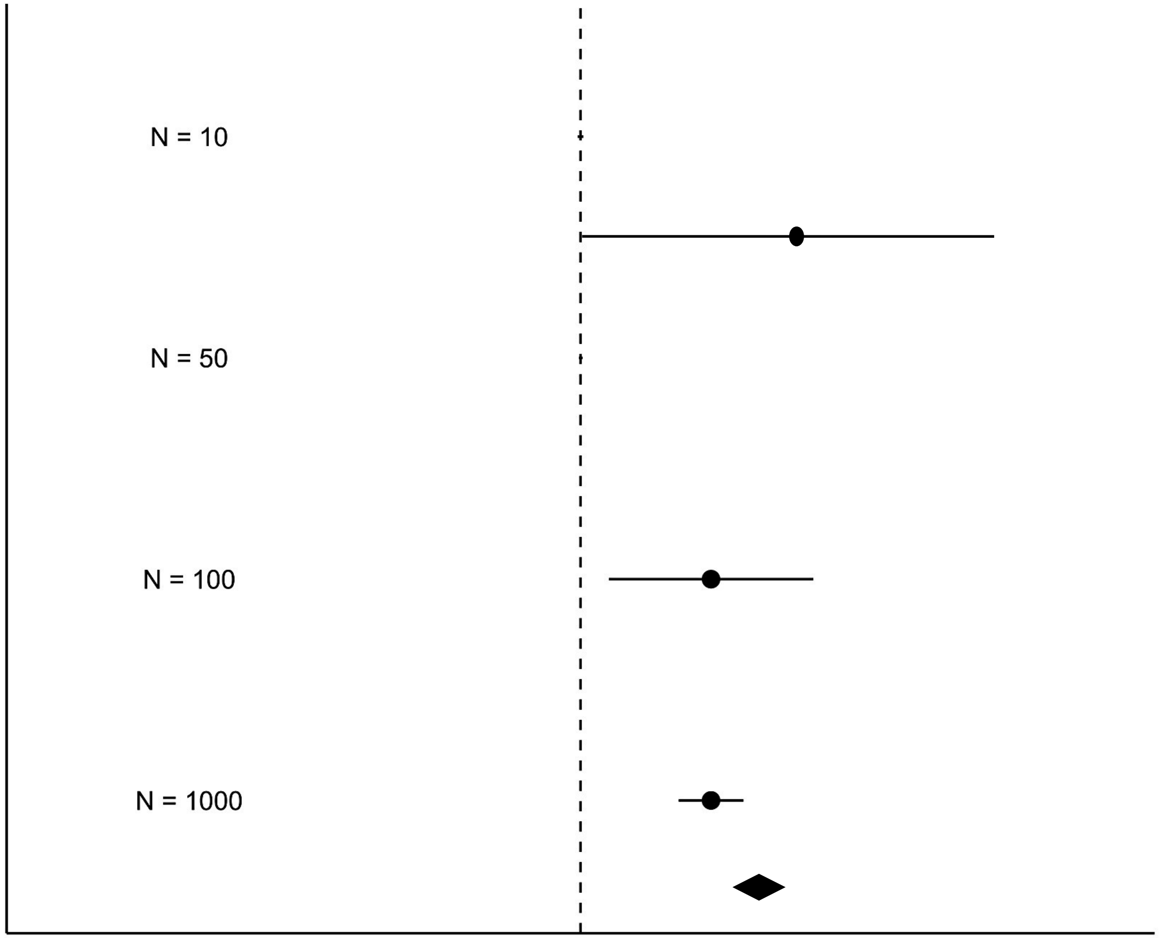
What happens when we combine low power with publication bias?

The low power studies either provide exaggerated estimates…

Or get ignored. Distorting the literature.



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Motor learning: Underpowered

Systematic review of motor learning papers published between 2014-2016.

Evidence that motor learning experiments were underpowered, and results might be exaggerated.

Proposed multiple reforms.

Did not investigate any specific phenomenon.

Underpowered and Overworked: Problems With Data Analysis in Motor Learning Studies

Keith Lohse, Taylor Buchanan, and Matthew Miller
Auburn University

Appropriate statistical analysis is essential for accurate and reliable research. Statistical practices have an immediate impact on the perceived results of a single study but also remote effects on the dissemination of information among scientists and the cumulative nature of research. To accurately quantify potential problems facing the field of motor learning, we systematically reviewed publications from seven journals over the past 2 years to find experiments that tested the effects of different training conditions on delayed retention and transfer tests (i.e., classic motor learning paradigms). Eighteen studies were included. These studies had small sample sizes (*Mdn n*/group = 11.00, interquartile range [*IQR*]= 9.6–15.5), multiple dependent variables (*Mdn* = 2, IQR = 2–4), and many statistical tests per article (*Mdn* = 83.5, *IQR* = 55.8–112.5). The observed effect sizes were large ($d = 0.71$, *IQR* = 0.49, 1.11). However, the distribution of effect sizes was biased, $t(16) = 3.48$, $p < .01$. These metadata indicate problems with the way motor learning research is conducted (or at least published). We recommend several potential solutions to address these issues: a priori power calculations, prespecified analyses, data sharing, and dissemination of null results. Furthermore, we hope these data will spark serious action from all stakeholders (researchers, editorial boards, and publishers) in the field.

Source: Lohse et al. 2016 http://dx.doi.org/10.1123/jmld.2015-0010

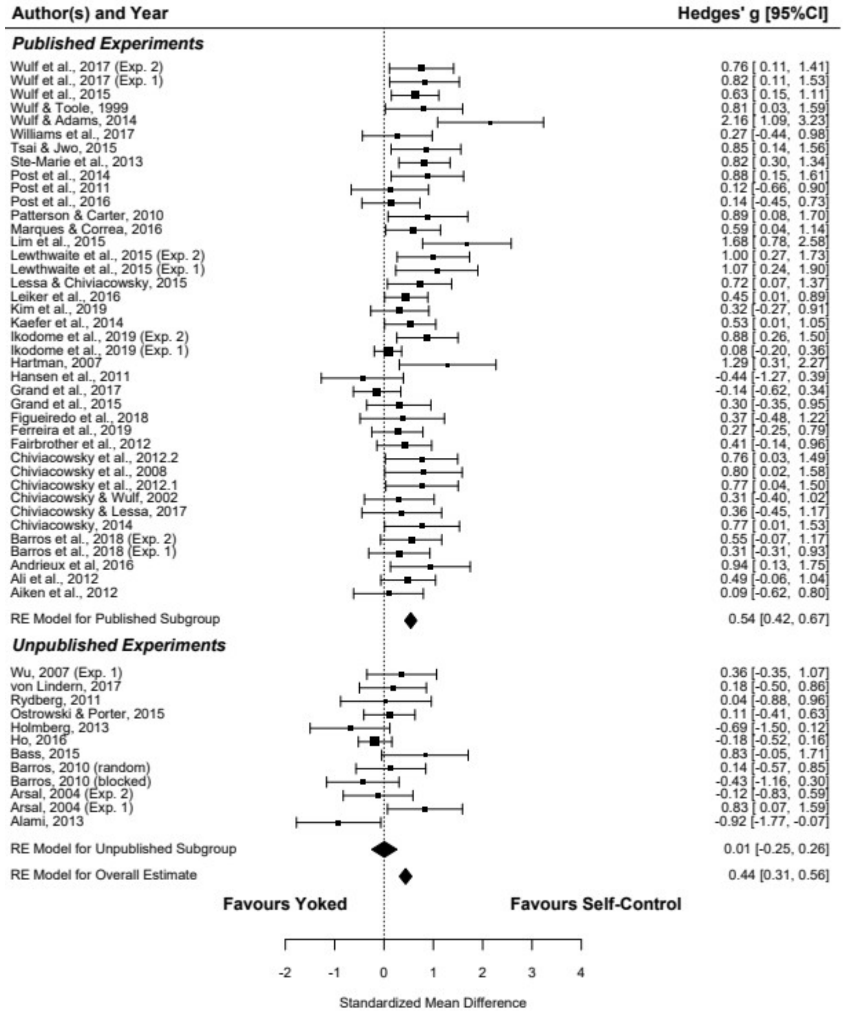
Self-controlled learning: Meta-analysis

A meta-analysis pools together the findings of all the experiments conducted on the same phenomenon.

Experiments comparing self-controlled practice to a yoked group were included.

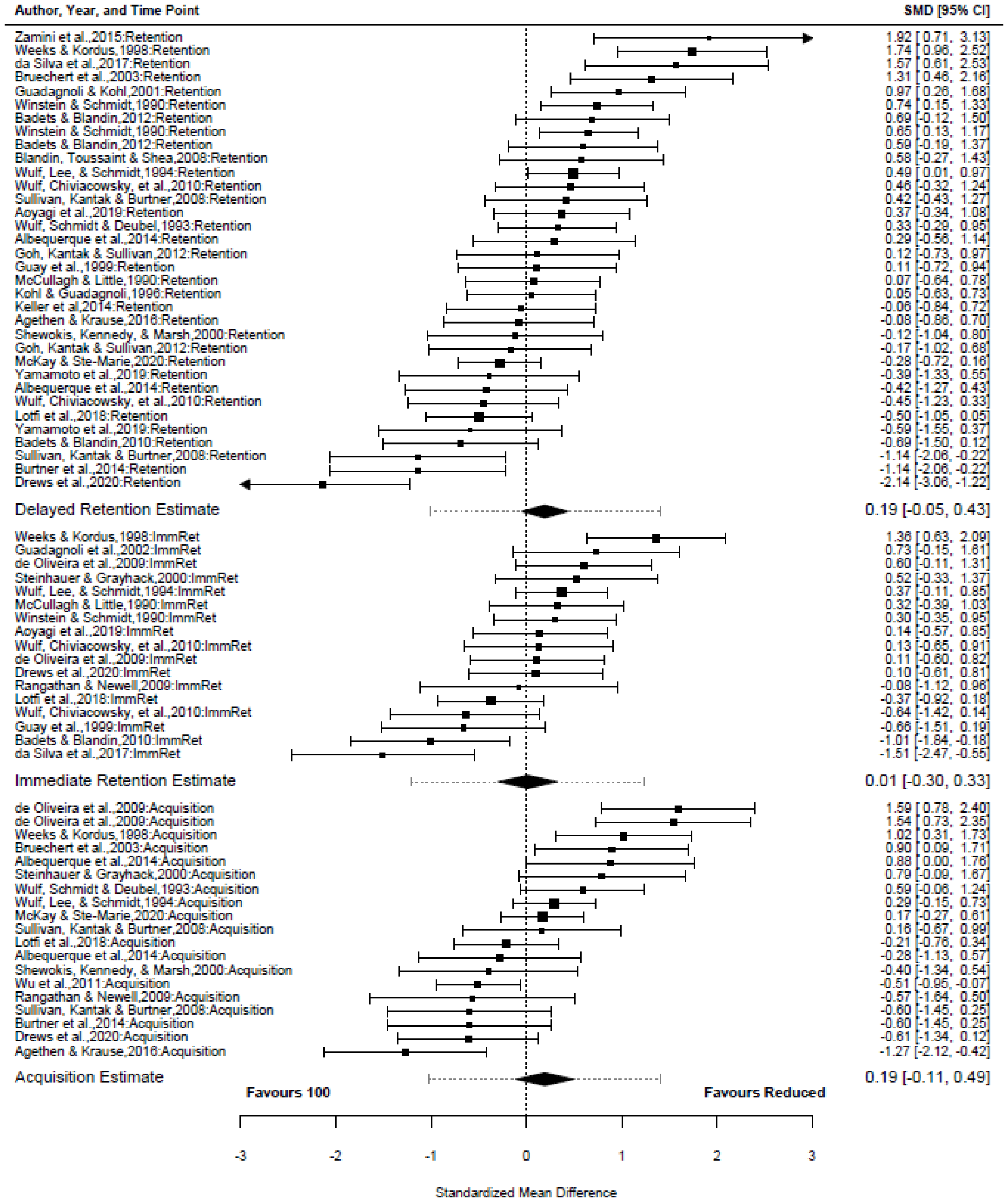
Published studies suggested a strong benefit.
Unpublished studies suggested none.

Four preregistered experiments have corroborated the estimate from the unpublished studies.



Source: McKay et al (2021) https://doi:10.31234/osf.io/8d3nb

Feedback: Meta-analysis



Experiments comparing groups that received feedback 100% of the time to groups receiving a reduced frequency.

Effects were uncertain at all three time points.

The guidance hypothesis was not supported.

Again, the individual studies were underpowered and produced imprecise estimates.

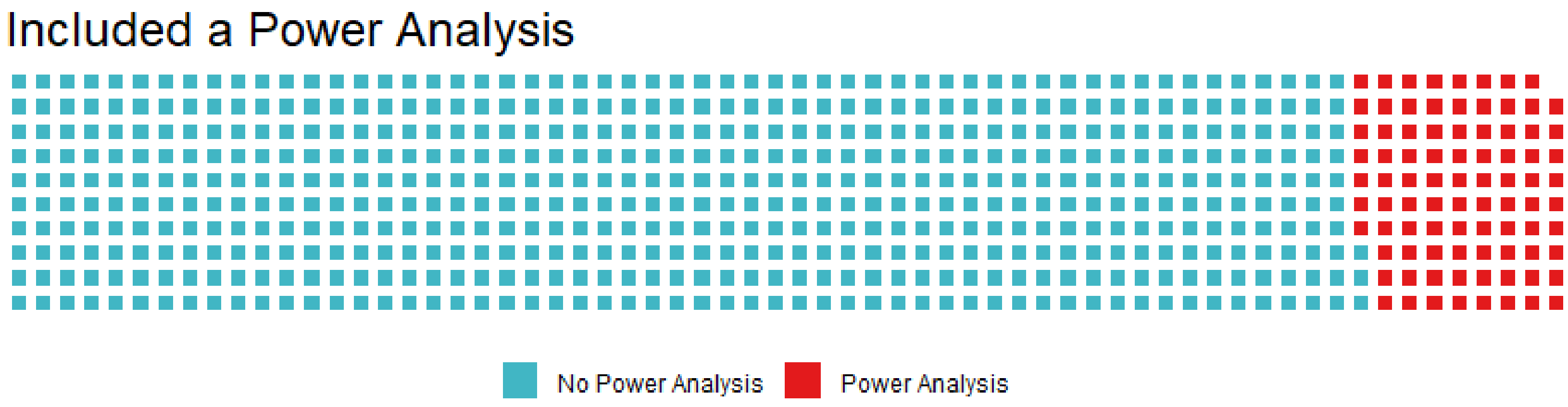
Source: McKay et al (2021) https://doi:10.31234/osf.io/v2cp7

Adoption of best practices

All articles in three motor behaviour journals published since 2019 were analyzed.

Lohse and colleagues (2016) recommended conducting a power analysis:

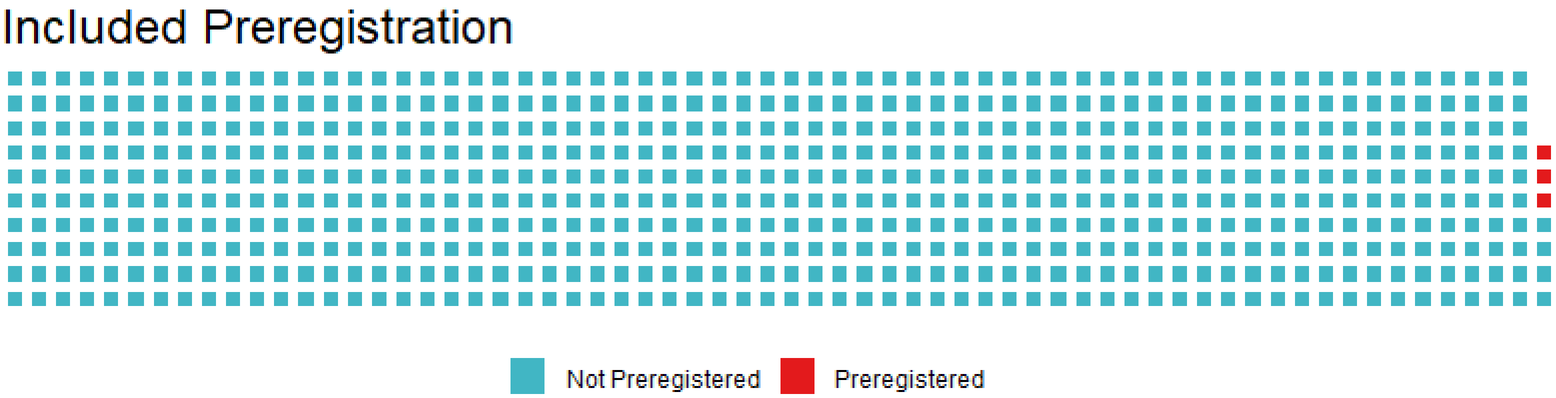
Calculate how many participants are necessary to detect the effect of interest.



Source: McKay et al. (2021)

Adoption of best practices: Preregistration

In the same sample of recent motor behaviour journal articles only three studies were preregistered.



Source: McKay et al. (2021)

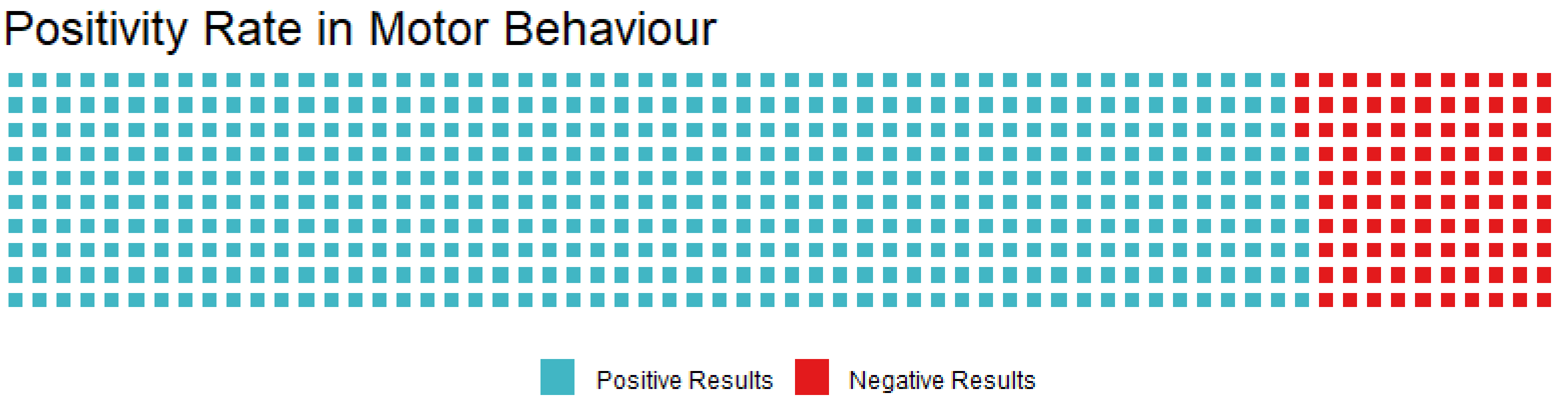
Percentage of positive results

Overall, 84% of studies reported support for their primary hypotheses.

Estimated power in motor learning literature:

6% (self-controlled learning)
20% (underpowered and overworked paper)
27% (feedback frequency)

The gap between estimated power and actual positivity rate suggests substantial publication bias.



Source: McKay et al. (2021)

Positive signs of progress

Source: https://storkinesiology.org/

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What questions do you have?

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