Prevalence-induced perceptual shift due to prior change

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Bayesian Modeling of Behavior Spring 2021

Modeling of

Levari, D. E., Gilbert, D. T., Wilson, T. D., Sievers, B., Amodio, D. M., & Wheatley, T. (2018). Prevalence-induced concept change in human judgment. Science, 360(6396), 1465-1467.

"When blue dots became rare, participants began to see purple dots as blue; when threatening faces became rare, participants began to see neutral faces as threatening; and when unethical requests became rare, participants began to see innocuous requests as unethical."

Levari et al. (2018)

Method


1000 trials
...
50
Blue (0, 0, 255)
Blue spectrum
~ (50, 0, 205)
0
Purple spectrum
~ (51, 0, 204)
-50
Purple (100, 0, 155)

Method

Study 1 - Stable condition / Decrease condition

Study 2 - Some offered verbal instructions

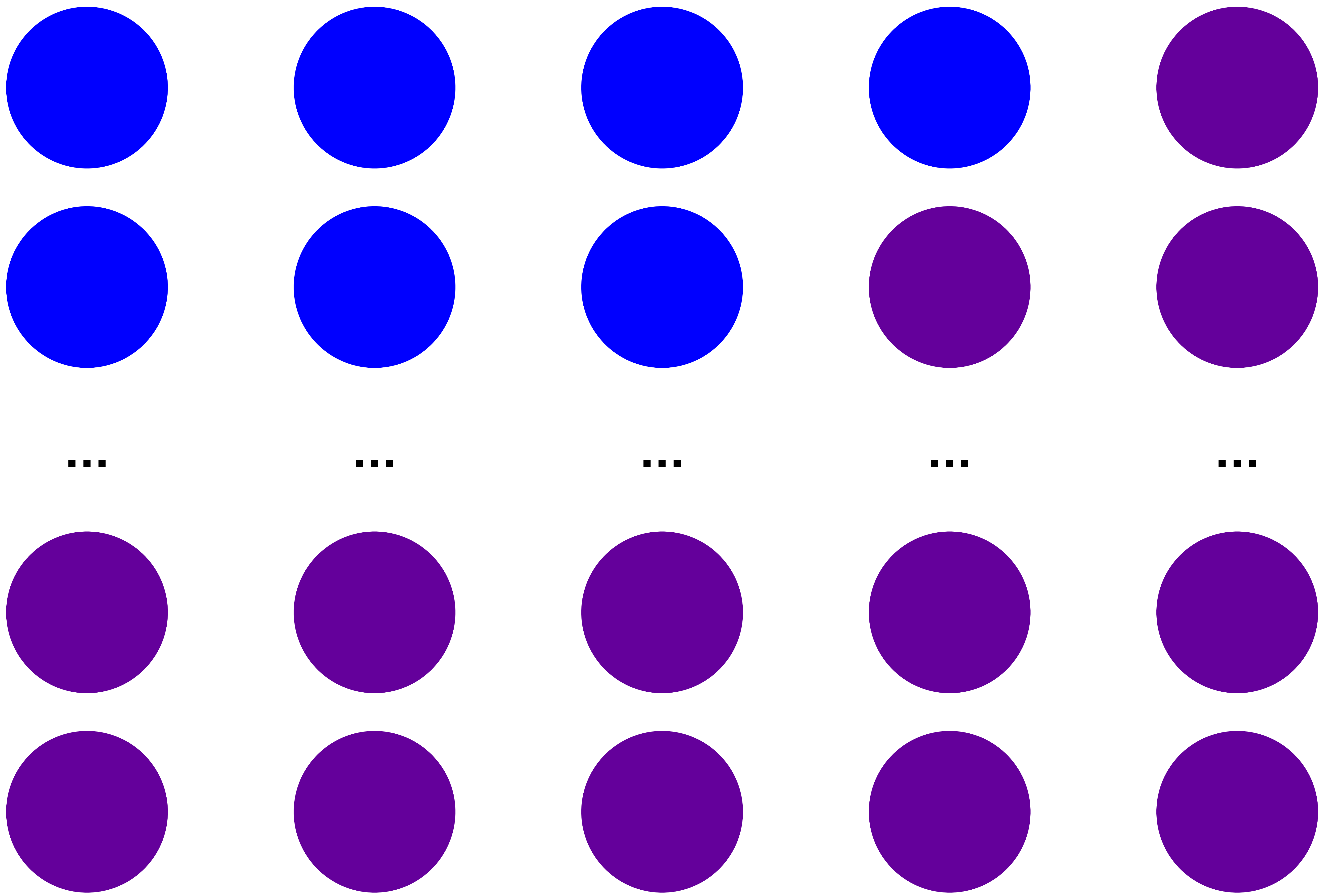
Study 3 - Some offered verbal instructions and monetary reward

Study 4 - Stable condition / Gradually decrease condition / Abruptly de. Condition

Study 5 - Stable condition / Increase condition

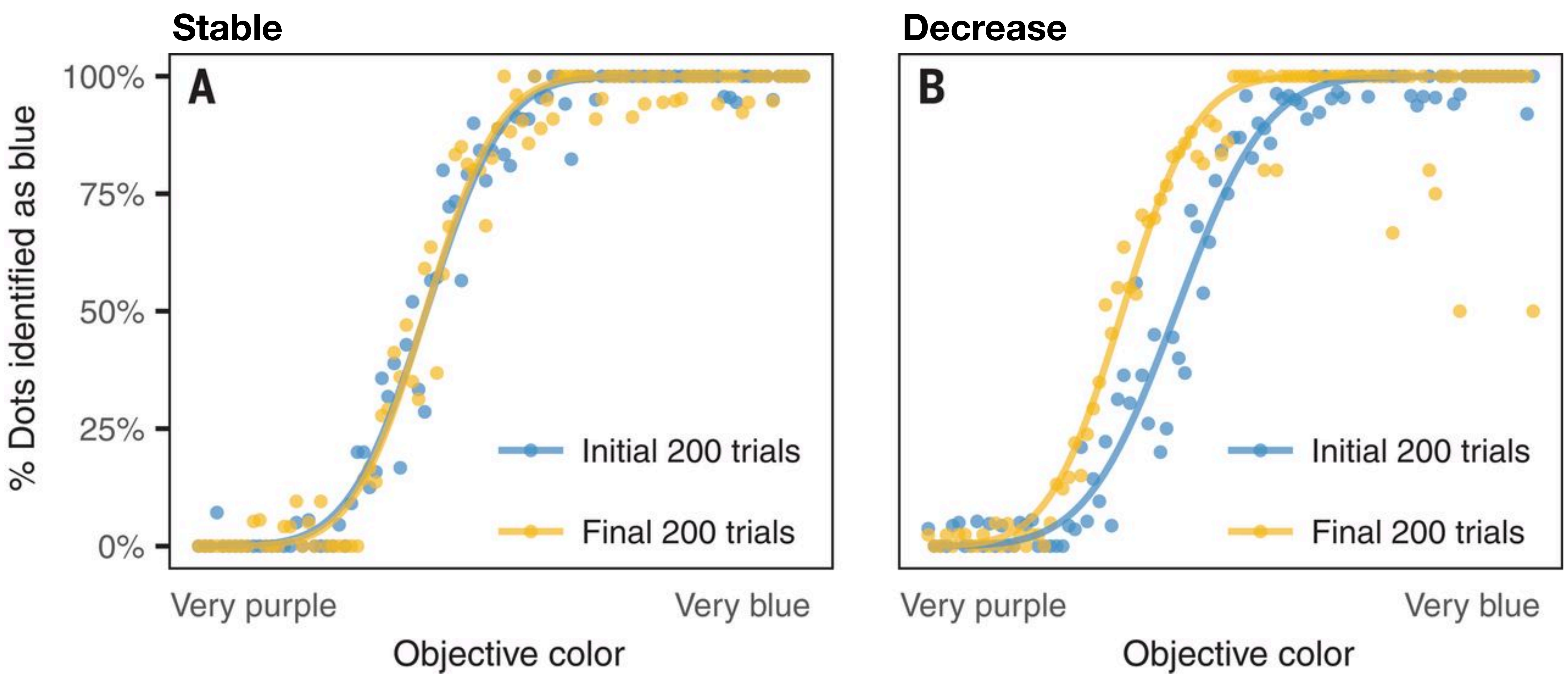
Method

Trials	1-200	201-250	251-300	301-350	351-1000



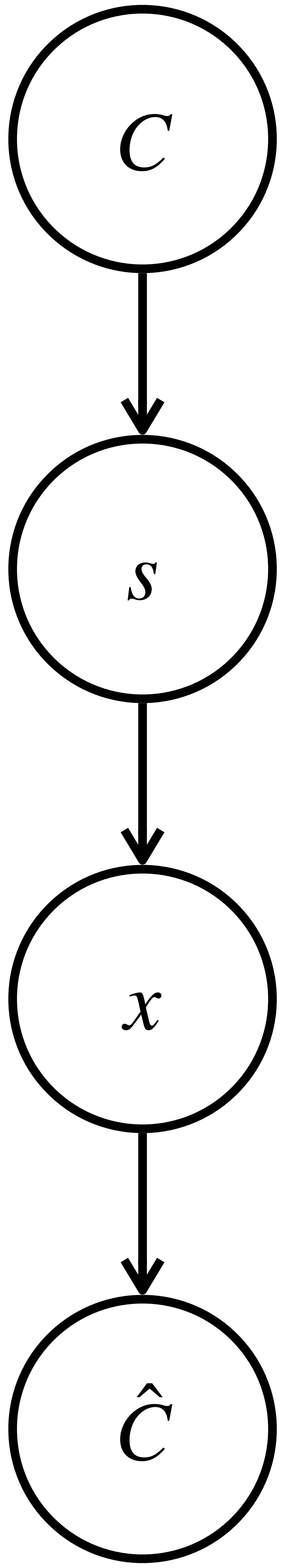
Probability color drawn from blue spectrum	50%	40%	28%	16%	6%

Results



Study 1

Modeling



$p(C)$

$p(s \mid C)$

$p(x \mid s)$

$p(\hat{C} \mid x)$

$$
\begin{aligned}
p(\hat{C}|x) &= p(C)p(x|C) \\
&= p(C)\int p(x|s)p(s|C)ds \\
\because p(x|s) &\sim \mathcal{N}(s,\sigma^2) \\
p(s|C) &= \frac{1}{a} \text{ when } \operatorname{sign}(s) = C \text{ and } |s| < a \\
\therefore d &= \log\frac{p(C=1)}{p(C=-1)} + \log\frac{\int p(x|s)p(s|C=1)ds}{\int p(x|s)p(s|C=-1)ds} \\
&= \boxed{\log\frac{p(C=1)}{p(C=-1)}} + \log\frac{\int_0^a \exp-\frac{(s-x)^2}{2\sigma^2}ds}{\int_{-a}^0 \exp-\frac{(s-x)^2}{2\sigma^2}ds}
\end{aligned}
$$

Hypothesis: the prior was updated continuously based on the previous observations towards a certain type of stimuli

Modeling

Rule A - Normal Dirichlet

i.e. (1, 1) + (1, 0) if reports blue / (0, 1) if reports purple

$$\log \frac{p(C=1)}{p(C=-1)} = \log \frac{\frac{\alpha'_1}{\sum_i \alpha'}}{\frac{\alpha'_{-1}}{\sum_i \alpha'}} = \log \frac{\alpha_1 + c_1}{\alpha_{-1} + c_{-1}}$$

Rule B - Signal search

i.e. (1, 1) + (1, 0) if reports blue / (0, 0) if reports purple

$$\log \frac{p(C=1)}{p(C=-1)} = \log \frac{\alpha_1 + c_1}{\alpha_{-1}}$$

Rule C - Twisted mind

i.e. (1, 1) + (0, 1) if reports blue / (1, 0) if reports purple

$$\log \frac{p(C=1)}{p(C=-1)} = \log \frac{\alpha_1 + c_{-1}}{\alpha_{-1} + c_1}$$

Rule D - Observation count

i.e. (1000, 1000) + (-1, 0) if reports blue / (0, -1) if reports purple

$$\log \frac{p(C=1)}{p(C=-1)} = \log \frac{\alpha_1 - c_1}{\alpha_{-1} - c_{-1}}$$

Rule A
Normal Dirichlet

	Reports	α_1	α_{-1}
Initial		1	1
1	P	0	1
2	B	1	0
3	P	0	1
4	P	0	1
5	B	1	0
6	P	0	1
7	P	0	1
8	B	1	0
Total		4	6

$$\frac{p(C=1)}{p(C=-1)} \qquad \frac{2}{3}$$

Rule B
Signal search

	Reports	α_1	α_{-1}
Initial		1	1
1	P	0	0
2	B	1	0
3	P	0	0
4	P	0	0
5	B	1	0
6	P	0	0
7	P	0	0
8	B	1	0
Total		4	1

$$\frac{4}{1}$$

Rule C
Twisted mind

	Reports	α_1	α_{-1}
Initial		1	1
1	P	1	0
2	B	0	1
3	P	1	0
4	P	1	0
5	B	0	1
6	P	1	0
7	P	1	0
8	B	0	1
Total		6	4

$$\frac{3}{2}$$

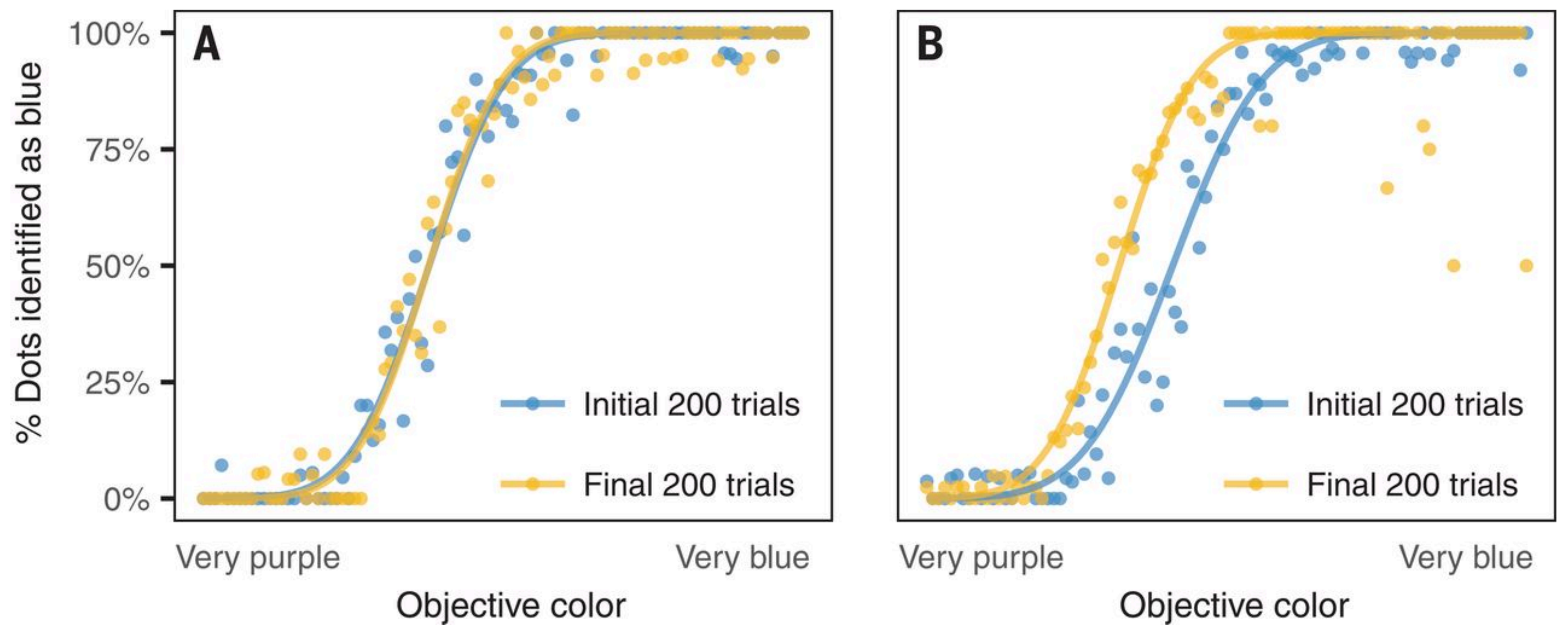
Rule D
Observation count

	Reports	α_1	α_{-1}
Initial		8	8
1	P	0	-1
2	B	-1	0
3	P	0	-1
4	P	0	-1
5	B	-1	0
6	P	0	-1
7	P	0	-1
8	B	-1	0
Total		5	3

$$\frac{5}{3}$$

Modeling Results

Study 1

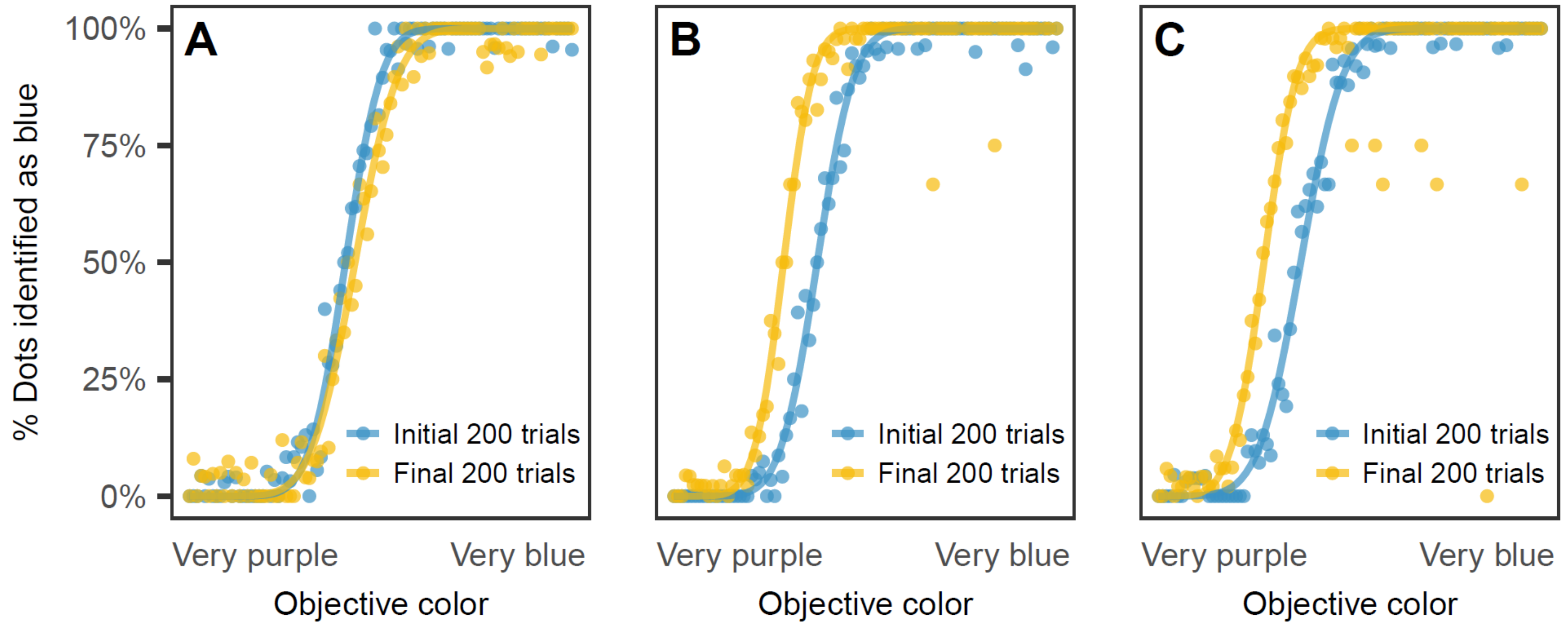


Stable

Decrease

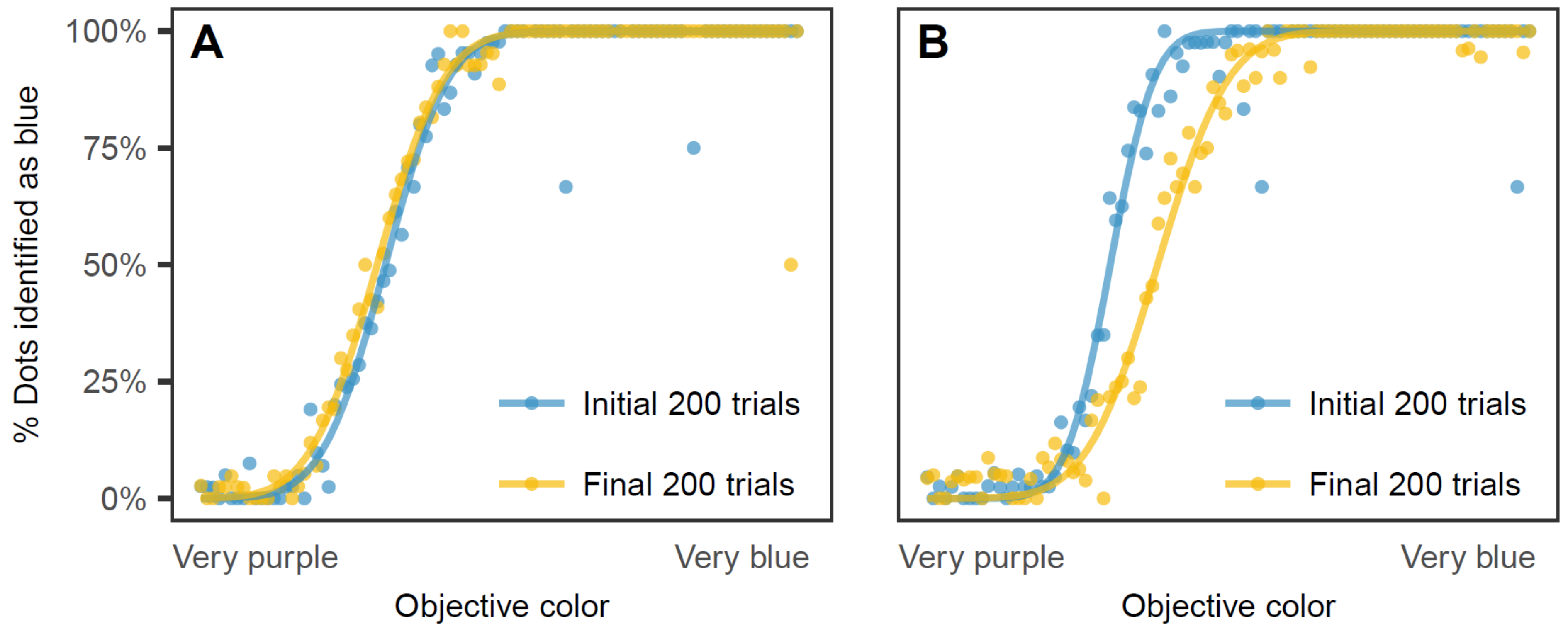
Modeling Results

Study 4



Modeling Results

Study 5



Stable

Increase

Modeling Results
New Study

Stable condition: stays at 20% instead of 50% for 1000 trials

Future Works

Statistical analysis of the simulation data.
Fit real experiment data.

Thank you.