

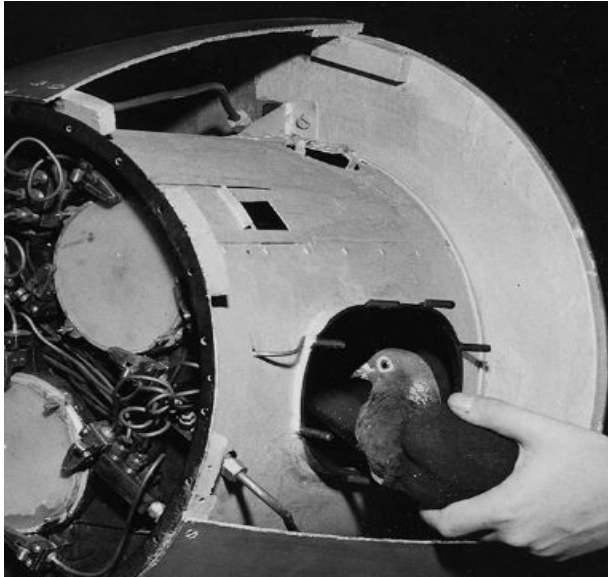
FAIR COINS TEND TO LAND ON THE SAME SIDE THEY STARTED: EVIDENCE FROM 350,757 FLIPS

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Arxiv (???) - 2024

IG Nobels

- Prix “parodique” des Prix Nobels
- Objectif : “Honorer la recherche qui fait d'abord les gens rire, puis les fait ensuite réfléchir”
- Souvent (pas toujours) de la recherche faite sérieusement, mais sur des sujets rigolos
- Tous les ans depuis 1991, 10 lauréats, pas de catégories fixes.

IG Nobels - Examples



Missiles guidés par Pigeons voyageurs
(Paix, 2024)



Lévitacion magnétique d'une grenouille
(Physique, 2000)
Auteur: Prix Nobel 2010 - graphène

IG Nobels - Examples

Les politiciens aussi, ont des IG Nobels :

[Jair Bolsonaro](#) of Brazil, [Boris Johnson](#) of the United Kingdom, [Narendra Modi](#) of India, [Andrés Manuel López Obrador](#) of Mexico, [Alexander Lukashenko](#) of Belarus, [Donald Trump](#) of the United States, [Recep Tayyip Erdoğan](#) of Turkey, [Vladimir Putin](#) of Russia, and [Gurbanguly Berdimuhamedow](#) of Turkmenistan

“

Pour avoir utilisé la pandémie virale COVID-19 afin d'enseigner au monde que les hommes politiques peuvent avoir un effet plus immédiat sur la vie et la mort que les scientifiques et les médecins.

“

(Éducation médicale, 2020)

IG Nobels - Examples

Les politiciens aussi, ont des IG Nobels :

[Alexander Lukashenko](#) and the Police of Belarus:

“

Pour avoir rendu illégal l'action d'applaudir en public et à la police pour avoir arrêté un manchot pour avoir applaudit.

“

(Paix, 2013)

Hypothèse DHM [Diaconis 2007] :

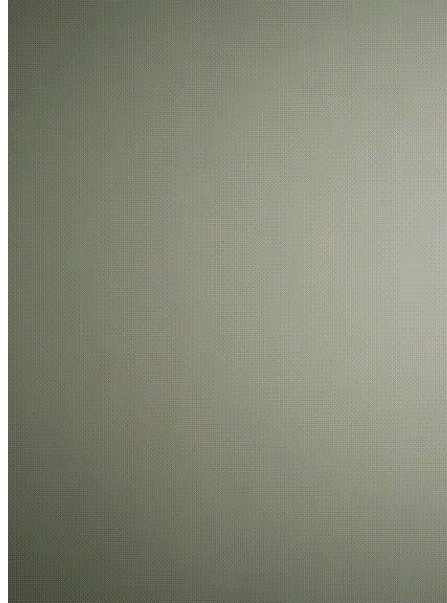


Précession : changement de
l'axe d'orientation

Hypothèse DHM [Diaconis 2007] :



Précession : changement de
l'axe d'orientation

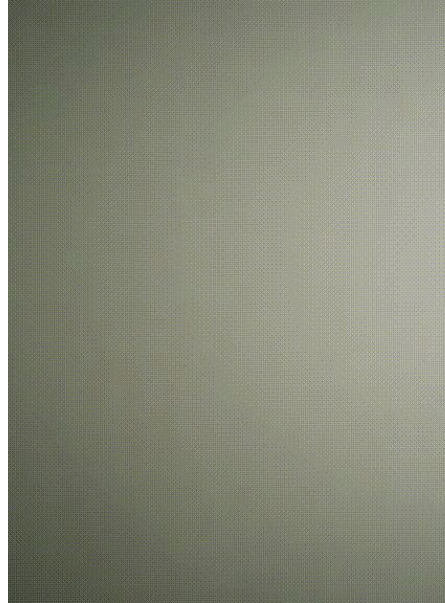


Lancé de pièce
en slow-mo

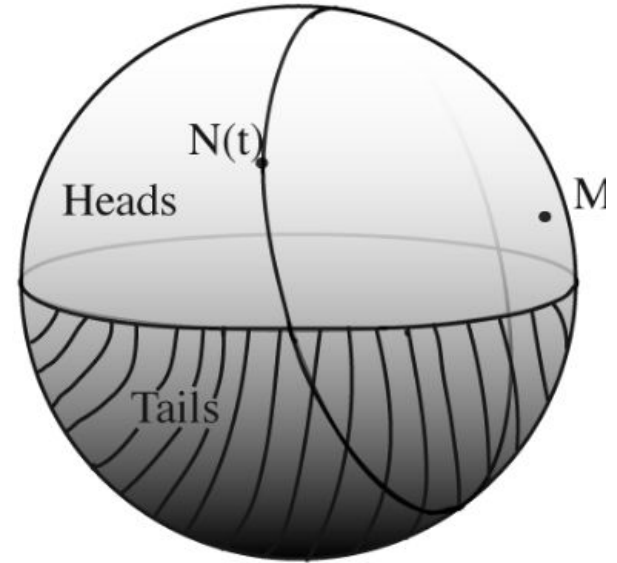
Hypothèse DHM [Diaconis 2007] :



Précession : changement de l'axe d'orientation



Lancé de pièce en slow-mo



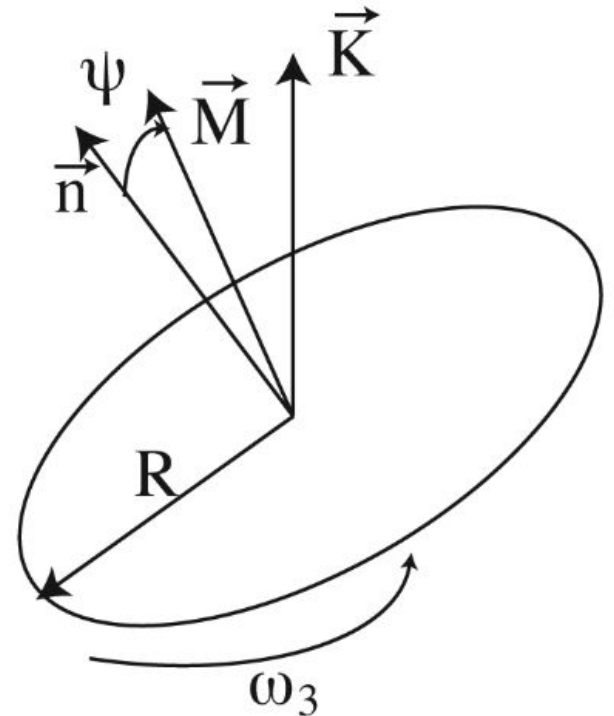
La normale est plus de côté Face lorsque le moment angulaire n'est pas sur l'équateur. 8

Hypothèse DHM [Diaconis 2007] :

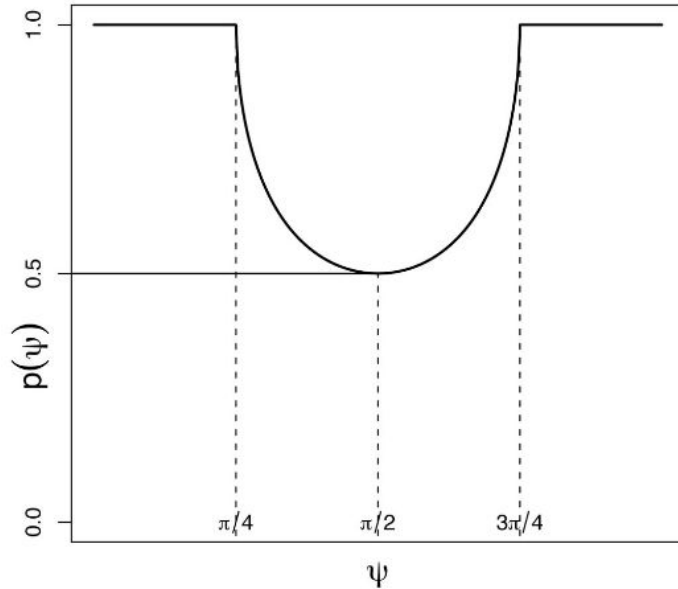
Théorème: La probabilité d'obtenir face (en partant de face) est donnée par :

$$p(\psi, \phi) = \begin{cases} \frac{1}{2} + \frac{1}{\pi} \sin^{-1}(\cot(\phi) \cot(\psi)) & \text{if } (\cot \phi)(\cot \psi) \leq 1, \\ 1 & \text{if } (\cot(\phi)) \cot(\psi) \geq 1. \end{cases}$$

- M = moment angulaire ($t = 0$)
- K = "Up"
- n = normale ($t = 0$)
- Ψ = Angle entre K et M
- Φ = Angle entre M et K



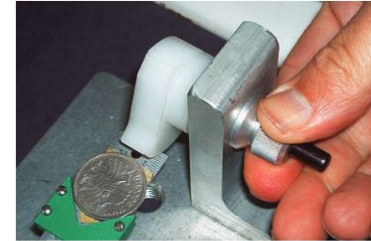
Hypothèse DHM [Diaconis 2007] :



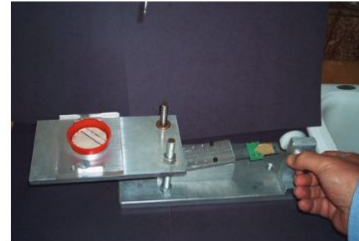
Si $\psi = 0$, ie le moment angulaire est parfaitement vertical



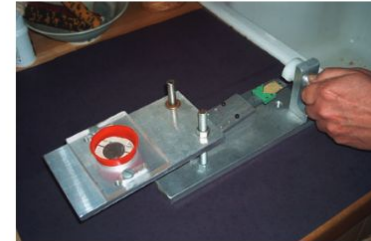
(a)



(b)



(c)



(d)

The mean of these probabilities is 0.508, and we have rounded this up to the 0.51

Collection des données

We collected data in three different settings using the same standardized protocol. First, a group of five bachelor students collected at least 15,000 coin flips each as a part of their bachelor thesis project, contributing 75,036 coin flips in total. Second, we organized a series of on-site “coin flipping marathons” where 35 people spent up to 12 hours coin-flipping (see e.g., [blinded for review] for a video recording of one of the events), contributing a total of 203,440 coin flips². Third, we issued a call for collaboration via Twitter, which resulted in an additional seven people contributing a total of 72,281 coin flips.

- Séquences de 100 lancers minimum (en vidéo)
- Échanges de pièces entre les participants
- 48 personnes (dont 7 venant de Twitter)
- Position aléatoire de début, puis ils continuaient
- Vérification manuelle partielle des résultats

Test d'hypothèse : Same-side bias

Preregistered analysis: Same-side bias

Prior to data collection, we preregistered ([blinded for review]) an informed Bayesian binomial test with k same-side outcomes out of N trials,

$$k \sim \text{Binomial}(\beta, N),$$

assuming that the coin flips are independently and identically distributed across people and coins. We specified two competing hypotheses for the binomial success parameter β , where success denotes the coin landing on the same side it started from:

$$\begin{aligned} \text{No same-side bias, } \mathcal{H}_0 : \beta &= 0.5 \\ \text{DHM same-side bias, } \mathcal{H}_1 : \beta &\sim \text{Beta}(5100, 4900)_{[0.5, 1]}. \end{aligned} \tag{1}$$

Test d'hypothèse : Same-side bias

Person	Same side	Flips	Coins	Proportion [95% CI]	Joined
XiaoyiL	780	1600	2	0.487 [0.463, 0.512]	Marathon-MSc
JoyceP	1126	2300	3	0.490 [0.469, 0.510]	Marathon-MSc
AndreeaZ	2204	4477	4	0.492 [0.478, 0.507]	Marathon-MSc
KaleemU	7056	14324	8	0.493 [0.484, 0.501]	Bc Thesis
FelipeFV	4957	10015	3	0.495 [0.485, 0.505]	Internet
ArneJ	1937	3900	4	0.497 [0.481, 0.512]	Marathon-MSc
AmirS	7458	15012	6	0.497 [0.489, 0.505]	Bc Thesis
ChrisGI	4971	10005	5	0.497 [0.487, 0.507]	Marathon-Manheim
AdamF	4335	8328	2	0.520 [0.510, 0.531]	Marathon
AlexandraS	9080	17434	8	0.521 [0.513, 0.528]	Marathon
MadlenH	3705	7098	1	0.522 [0.510, 0.534]	Marathon
DavidKL	7895	15000	1	0.526 [0.518, 0.534]	Bc Thesis
XiaochangZ	1869	3481	4	0.537 [0.520, 0.553]	Marathon-MSc
FranziskaA	2055	3800	4	0.541 [0.525, 0.557]	Marathon-MSc
JanY	956	1691	2	0.565 [0.542, 0.589]	Marathon-MSc
TianqiP	1682	2800	3	0.601 [0.582, 0.619]	Marathon-MSc
Combined	178079	350757	44	0.508 [0.506, 0.509]	

Test d'hypothèse : Head-tails bias

Exploratory analysis: Heads-tails bias

A similar analysis was conducted to test for heads-tails bias. Again an informed Bayesian binomial test was specified with h heads outcomes out of N trials,

$$h \sim \text{Binomial}(\alpha, N),$$

assuming that the coin flips are independently and identically distributed across people and coins. We defined two competing hypotheses in terms of the binomial success parameter α , where success denotes the coin landing heads:

$$\begin{aligned} \text{No heads-tails bias, } \mathcal{H}_{0a} : \alpha &= 0.5 \\ \text{Small heads-tails bias, } \mathcal{H}_{1a} : \alpha &\sim \text{Beta}(5000, 5000). \end{aligned} \tag{2}$$

Test d'hypothèse : Head-tails bias

Coin	Heads	Flips	People	Proportion [95% CI]					
0.25CAD	48	100	1	0.480 [0.379, 0.582]	2CAD	1502	3000	3	0.501 [0.483, 0.519]
20DEM-silver	484	1000	1	0.484 [0.453, 0.515]	2MAD	1503	3000	1	0.501 [0.483, 0.519]
5CZK	1222	2500	2	0.489 [0.469, 0.509]	100JPY	752	1500	1	0.501 [0.476, 0.527]
0.05NZD	984	2011	1	0.489 [0.467, 0.511]	2CHF	2259	4503	2	0.502 [0.487, 0.516]
0.10EUR	4515	9165	6	0.493 [0.482, 0.503]	5MAD	1007	2001	1	0.503 [0.481, 0.525]
1DEM	2464	5000	5	0.493 [0.479, 0.507]	0.20GBP	1516	3005	2	0.504 [0.486, 0.523]
50CZK	3207	6500	7	0.493 [0.481, 0.506]	1CNY	757	1500	1	0.505 [0.479, 0.530]
2HRK	4258	8596	1	0.495 [0.485, 0.506]	1CZK	505	1000	1	0.505 [0.474, 0.536]
1MXN	4180	8434	1	0.496 [0.485, 0.506]	2ILS	506	1000	1	0.506 [0.475, 0.537]
1SGD	7655	15400	2	0.497 [0.489, 0.505]	5JPY	1772	3500	2	0.506 [0.490, 0.523]
5ZAR	3645	7325	1	0.498 [0.486, 0.509]	5SEK	8052	15902	7	0.506 [0.499, 0.514]
2EUR	24276	48772	28	0.498 [0.493, 0.502]	0.25USD	2180	4300	4	0.507 [0.492, 0.522]
0.01GBP	498	1000	1	0.498 [0.467, 0.529]	1MAD	1014	2000	1	0.507 [0.485, 0.529]
0.50EUR	28617	57445	32	0.498 [0.494, 0.502]	0.50RON	1442	2844	3	0.507 [0.488, 0.526]
0.20EUR	15665	31373	20	0.499 [0.494, 0.505]	0.05EUR	3821	7514	6	0.509 [0.497, 0.520]
0.25BRL	1998	4000	2	0.499 [0.484, 0.515]	0.50GBP	765	1504	1	0.509 [0.483, 0.534]
0.10RON	1000	2001	1	0.500 [0.478, 0.522]	2BDT	2038	4003	2	0.509 [0.494, 0.525]
1CHF	2249	4500	4	0.500 [0.485, 0.514]	10CZK	4572	8905	7	0.513 [0.503, 0.524]
1EUR	18920	37829	25	0.500 [0.495, 0.505]	0.20CHF	518	1000	1	0.518 [0.487, 0.549]
0.20GEL	4501	8998	5	0.500 [0.490, 0.511]	0.50SGD	1449	2781	3	0.521 [0.502, 0.540]
1CAD	5604	11200	11	0.500 [0.491, 0.510]	0.02EUR	158	300	1	0.527 [0.468, 0.584]
					1GBP	791	1500	2	0.527 [0.502, 0.553]
					2INR	552	1046	1	0.528 [0.497, 0.558]
					Combined	175421	350757	48	0.500 [0.498, 0.502]

Test d'hypothèse : People and Coins

Exploratory analyses: Accounting for dependencies due to people and coins

In order to account for possible dependencies due to people and coins, the following hierarchical Bayesian logistic regression model was applied to the data. For the i^{th} flip of the k^{th} person with the j^{th} coin, the starting position $y_{t=0,ijk}$ and landing position $y_{t=1,ijk}$ (heads: $y_{t=1,ijk} = 1$, and tails: $y_{t=1,ijk} = 0$),

$$\mu_{ijk} = \begin{cases} \text{logit}(\alpha_j) + \text{logit}(\beta_k) & y_{t=0,ijk} = 1 \\ \text{logit}(\alpha_j) - \text{logit}(\beta_k) & y_{t=0,ijk} = 0 \end{cases} \quad (3)$$

$$y_{t=1,ijk} \sim \text{Bernoulli}(\text{logit}^{-1}(\mu_{ijk})),$$

where $\text{logit}(\alpha_j)$ denotes the j^{th} coin's heads-tails bias (i.e., $\text{logit}(\alpha) = 0$ corresponds to the absence of same-side bias, as the probability of the same side is 0.50) and $\text{logit}(\beta_k)$ denotes the k^{th} person's same-side bias. The coin-specific and person-specific biases allow for differences from the overall heads-tails bias α_μ and the overall same-side bias β_μ through the addition of a coin-specific and person-specific random-effects γ_{α_j} and γ_{β_k} respectively:

$$\gamma_{\alpha_j} \sim \text{Normal}(0, \sigma_\alpha^2) \quad (4)$$

$$\gamma_{\beta_k} \sim \text{Normal}(0, \sigma_\beta^2)$$

$$\text{logit}(\alpha_j) = \text{logit}(\alpha_\mu) + \gamma_{\alpha_j}$$

$$\text{logit}(\beta_k) = \text{logit}(\beta_\mu) + \gamma_{\beta_k}.$$

Test d'hypothèse : People and Coins

$$\mathcal{H}_{\beta,1} : \beta_{\mu} \sim \text{Beta}(5100, 4900)_{[0.5,1]} \text{ vs. } \mathcal{H}_{\beta_{\mu},0} : \beta_{\mu} = 0.5$$

$$\mathcal{H}_{\alpha,1} : \alpha_{\mu} \sim \text{Beta}(5000, 5000) \quad \text{vs. } \mathcal{H}_{\alpha_{\mu},0} : \alpha_{\mu} = 0.5$$

$$\mathcal{H}_{\sigma_{\beta},1} : \sigma_{\beta} \sim \text{Gamma}(4, 200) \quad \text{vs. } \mathcal{H}_{\sigma_{\beta},0} : \sigma_{\beta} = 0$$

$$\mathcal{H}_{\sigma_{\alpha},1} : \sigma_{\alpha} \sim \text{Gamma}(4, 200) \quad \text{vs. } \mathcal{H}_{\sigma_{\alpha},0} : \sigma_{\theta} = 0.$$

Beaucoup d'hypothèses à tester...

TLDR: ils confirment l'hypothèse du
“same-side bias” et que les pièces ne
sont pas biaisées a priori.

$$\mathcal{M}_1 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_2 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

$$\mathcal{M}_3 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_4 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

$$\mathcal{M}_5 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_6 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

$$\mathcal{M}_7 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_8 = \mathcal{H}_{\beta,1}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

$$\mathcal{M}_9 = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_{10} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

$$\mathcal{M}_{11} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_{12} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,1}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

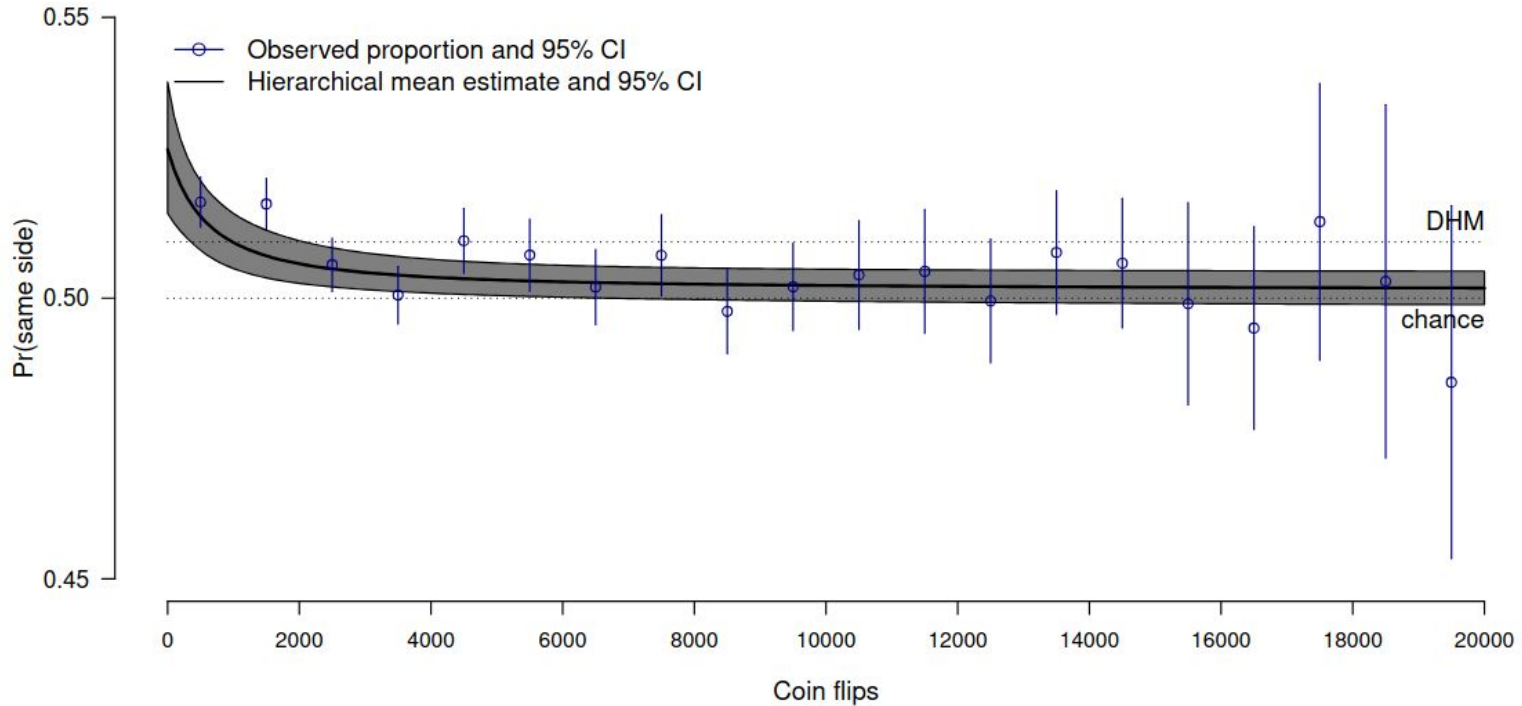
$$\mathcal{M}_{13} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_{14} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},1}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}$$

$$\mathcal{M}_{15} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},1}$$

$$\mathcal{M}_{16} = \mathcal{H}_{\beta,0}, \mathcal{H}_{\alpha,0}, \mathcal{H}_{\sigma_{\beta},0}, \text{ and } \mathcal{H}_{\sigma_{\alpha},0}.$$

Test d'hypothèse : Learning effects



Pas d'explications de pourquoi ?
Pas d'analyse sur la continuité ?

Conclusion

Could future coin tossers use the same-side bias to their advantage? The magnitude of the observed bias can be illustrated using a betting scenario. If you bet a dollar on the outcome of a coin toss (i.e., paying 1 dollar to enter, and winning either 0 or 2 dollars depending on the outcome) and repeat the bet 1,000 times, knowing the starting position of the coin toss would earn you 19 dollars on average. This is more than the casino advantage for 6 deck blackjack against an optimal-strategy player, where the casino would make 5 dollars on a comparable bet, but less than the casino advantage for single-zero roulette, where the casino would make 27 dollars on average [33]. These considerations lead us to suggest that when coin flips are used for high-stakes decision-making, the starting position of the coin is best concealed.

FIN