LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

TWEAKING DEMOCRACY: INNOVATIONS IN DEMOCRATIC DECISION MAKING

THE WISDOM OF CROWDS

THE GROUP CAN BE SMART, SO YOU DON'T HAVE TO

Adrian Haret
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December 13, 2023

Let's warm up with a little pop quiz.

This bridge connects Manhattan to what other New York borough?

- ☐ Brooklyn
- ☐ Queens

Before we find out the answer, let's get comfortable with the idea behind the wisdom of crowds.

THE WISDOM OF THE CROWDS IN THE WILD

PARTY-BOY ARISTOTLE

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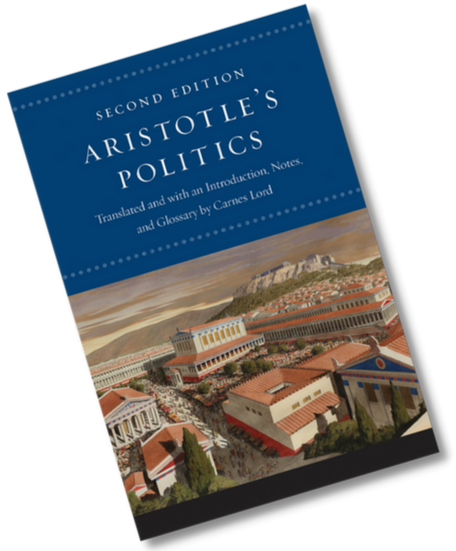
…just as feasts to which many contribute are better than feasts provided at one person's expense.



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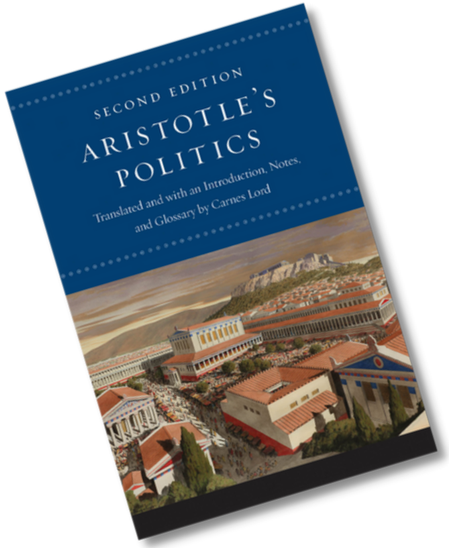

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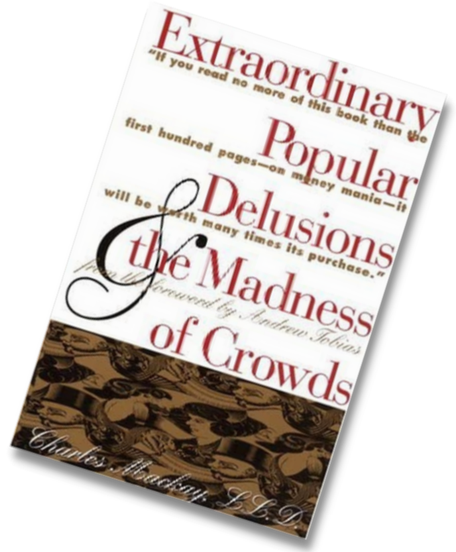

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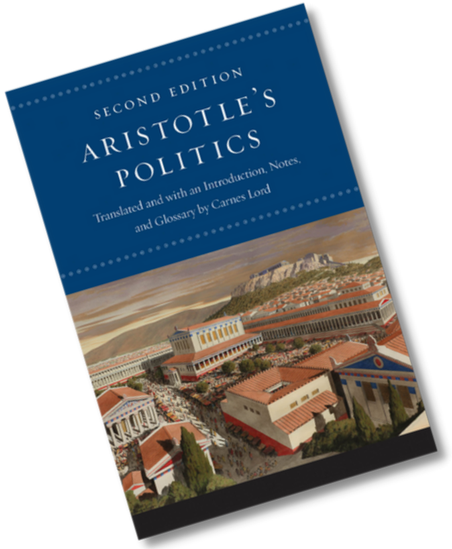

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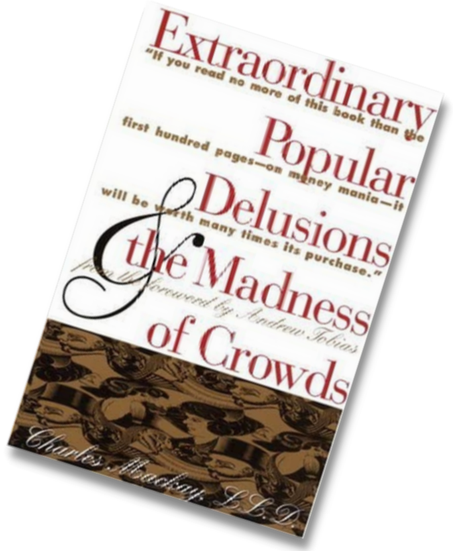

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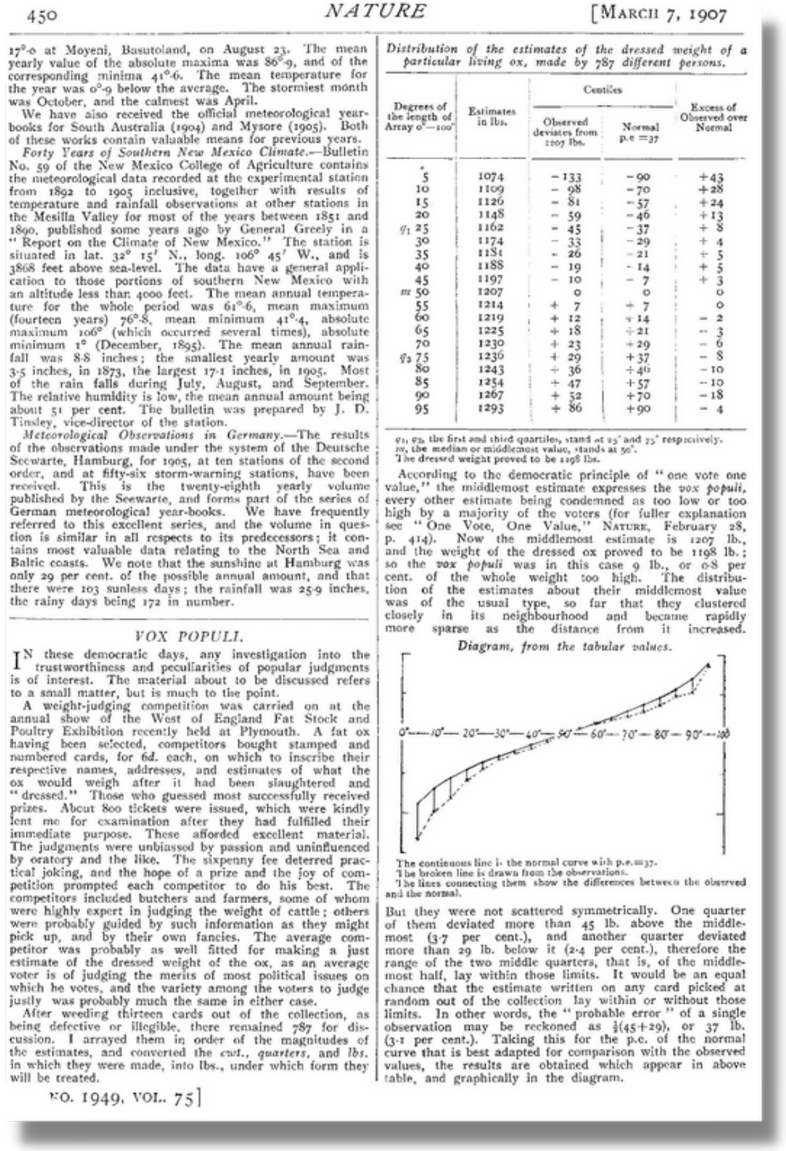

450 NATURE [MARCH 7, 1907

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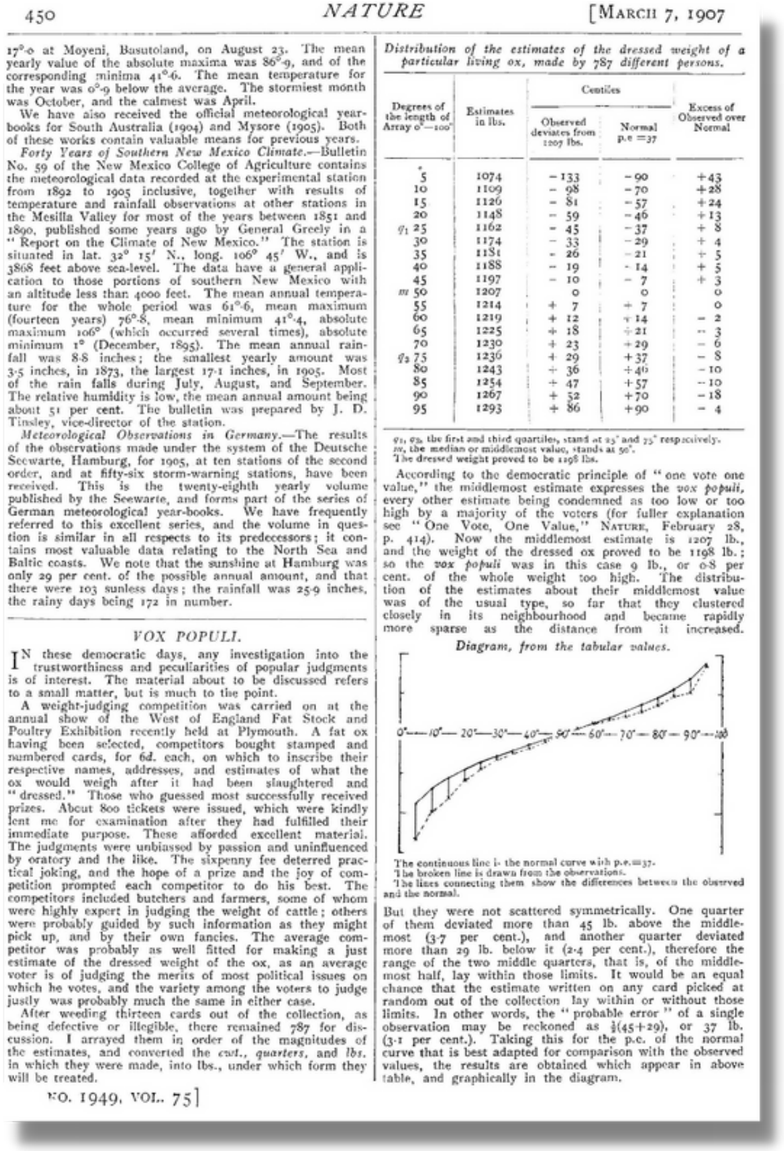

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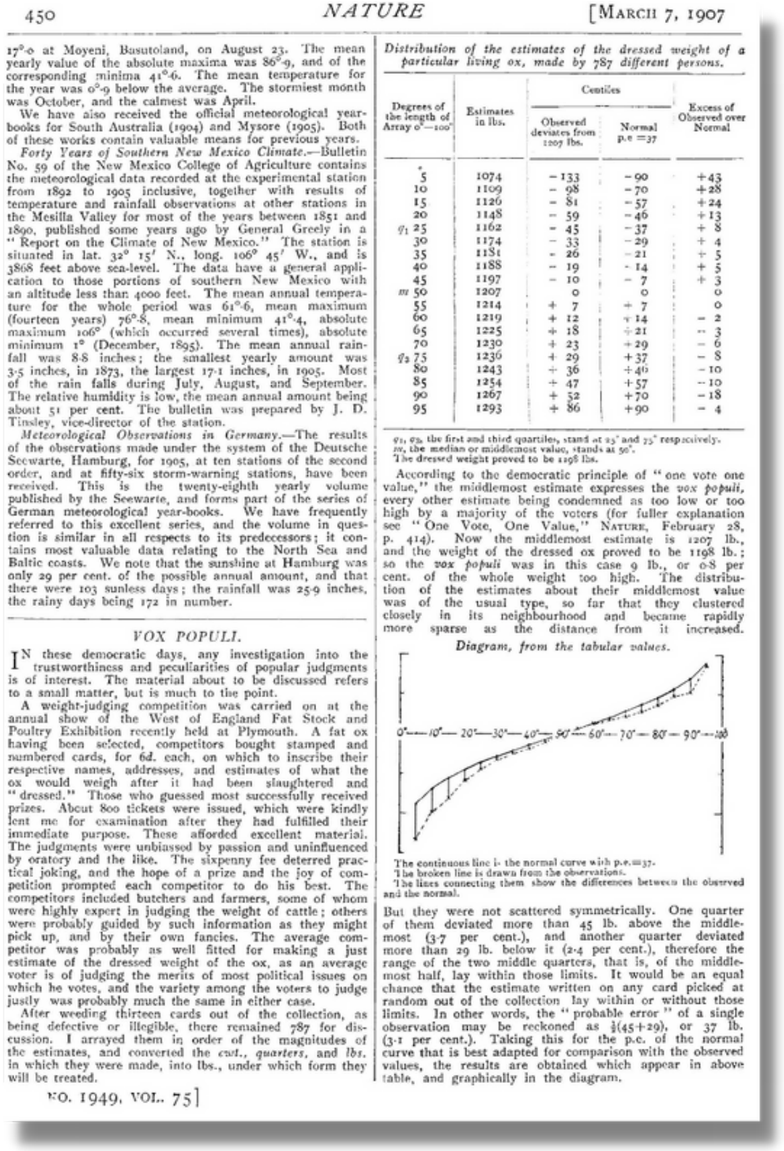

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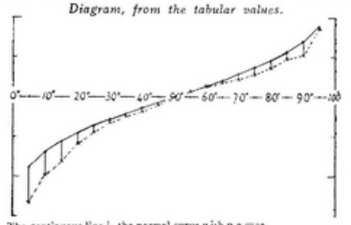

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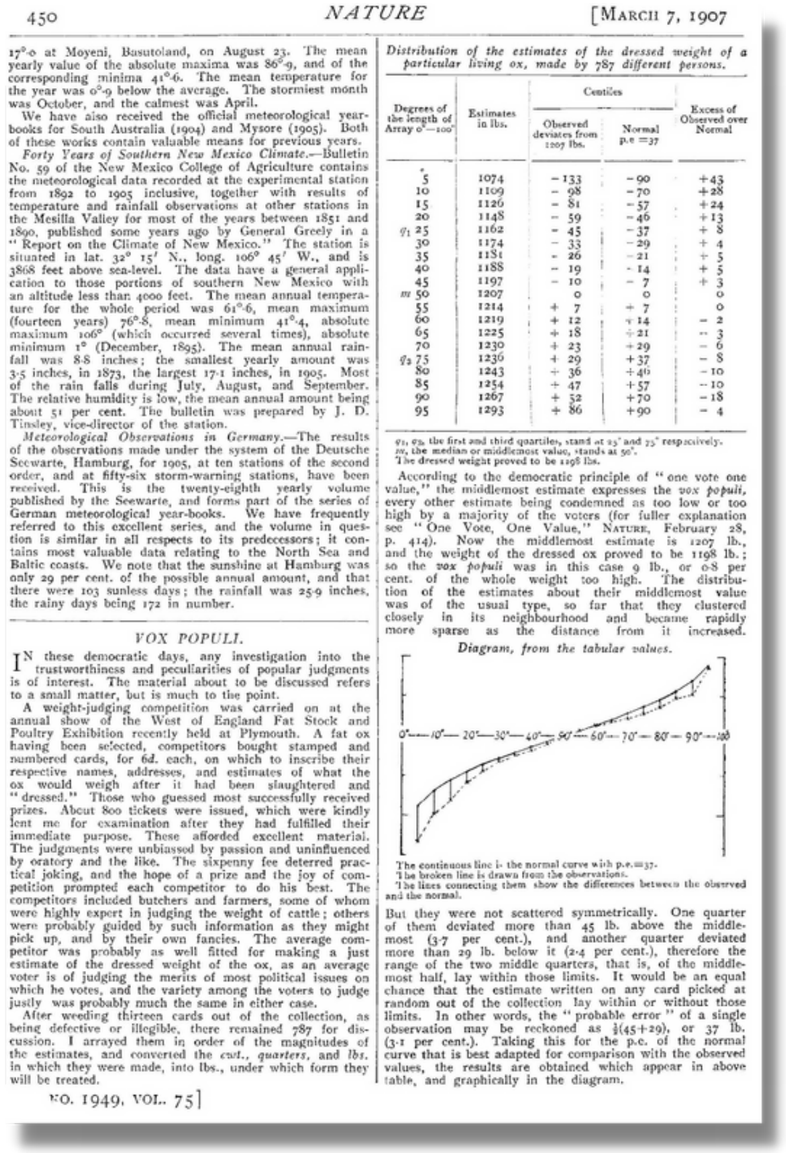

450 NATURE [MARCH 7, 1907

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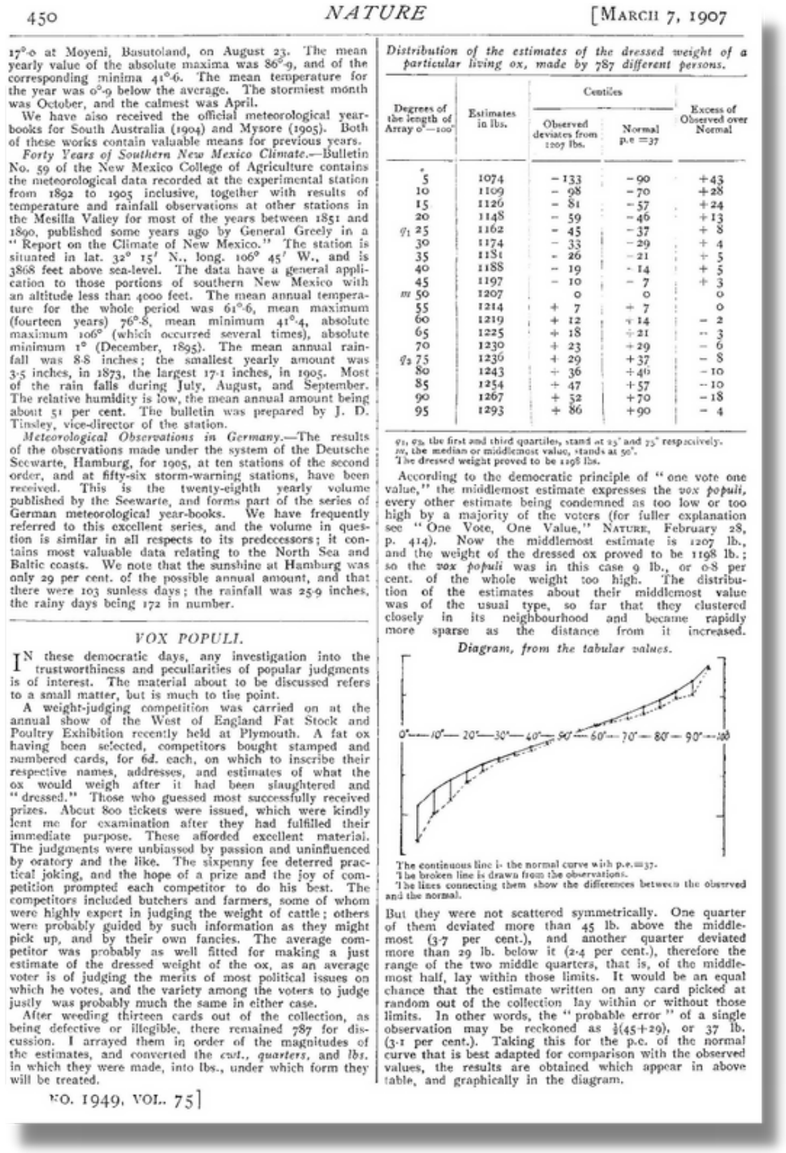

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NO. 1949, VOL. 75]

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So groups can be used to estimate the weights of oxen…

What's the big deal?

JAMES SUROWIECKI

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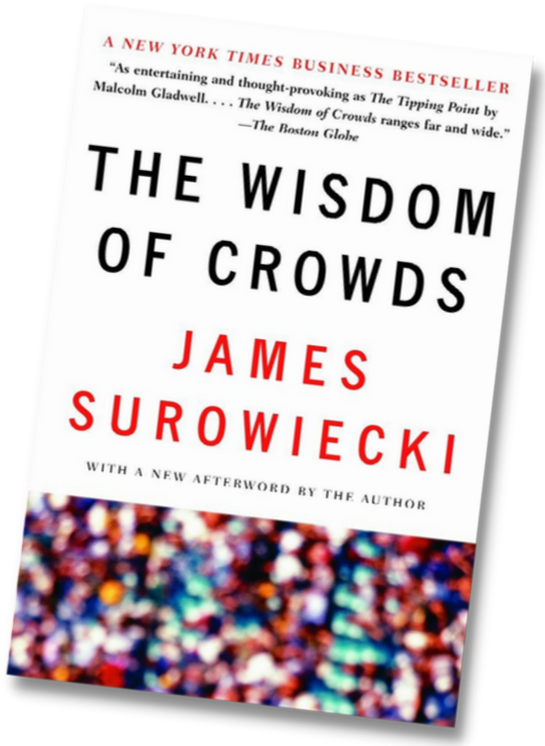
Like the market response to the *Challenger* disaster.

Or the finding of the *Scorpion* submarine.



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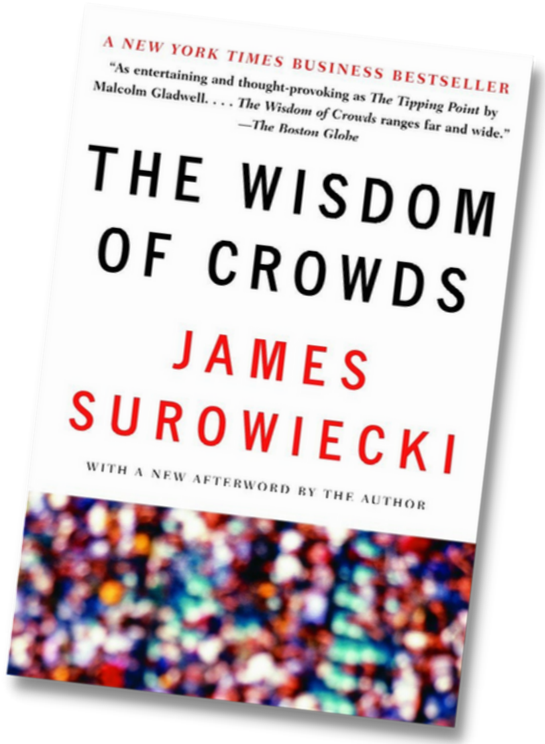
IAIN COUZIN

Or golden shiners, as a group, finding patches of shade.

Even though individuals are bad at it.



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Yong, E. (2013). The Real Wisdom of Crowds. *National Geographic*.

Wise crowds also give us a way of looking at democratic institutions: not just fair, but also good at finding solutions.

PARTY-POOPER PLATO

When you give people democratic choice they end up doing something stupid.

Good statecraft is like flying a plane.

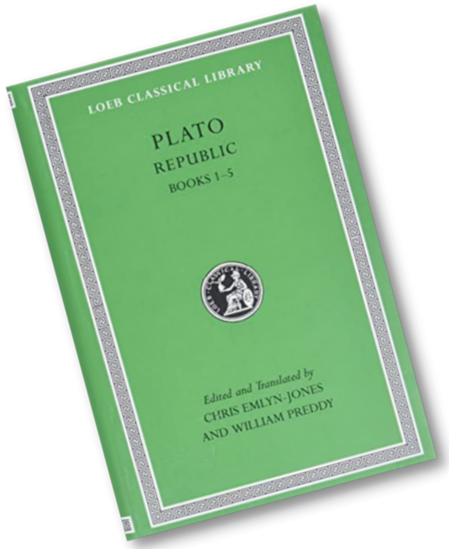
And you need a good pilot for that.

EDWIN HUTCHINS

Actually… flying a plane (or running a ship) requires a lot of coordination and teamwork.

HÉLÈNE LANDEMORE

Similarly, modern societies need the input of as many and as diverse parties as possible to work well.



Plato. *Republic*. Translated by Paul Shorey, 2 volumes. Loeb.
Hutchins, E. (1995). *Cognition in the Wild*. MIT Press
Landemore, H. (2012). *Democratic Reason*. Princeton University Press

Applications?

JUSTIN WOLFERS

Prediction markets!

Simple markets can be used to aggregate disparate information into efficient forecasts of uncertain future events.

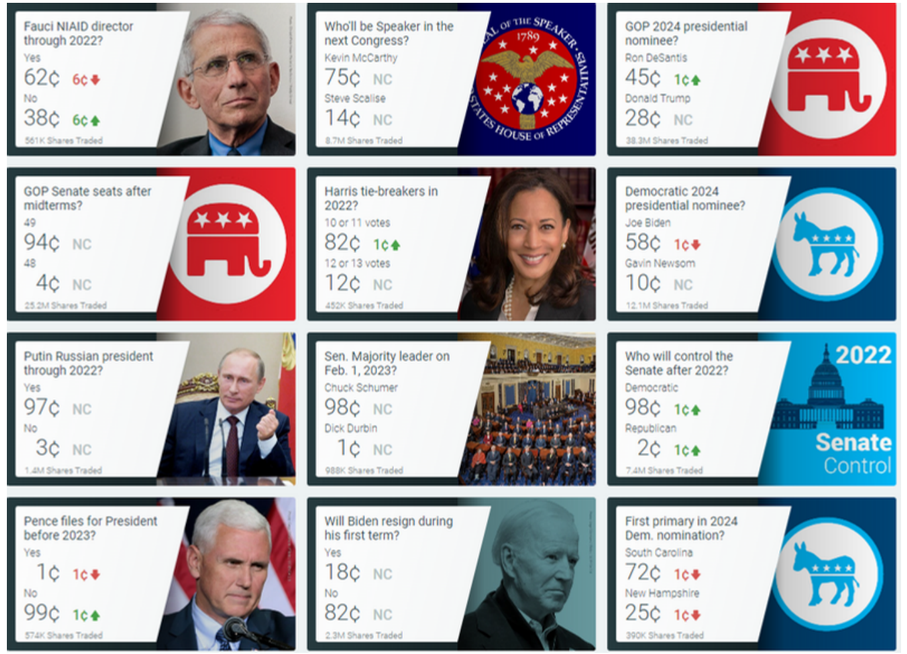
ERIC ZITZEWITZ

People buy and sell shares in future events (by a double auction).

The price indicates the collective estimate of the probability of the event.

See PredictIt.

PREDICTIT



JUSTIN WOLFERS

And other prediction platforms, like Metaculus or Good Judgment Open.

Wolfers, J., & Zitzewitz, E. (2004). Prediction Markets. *The Journal of Economic Perspectives: A Journal of the American Economic Association*, 18(2), 107–126.

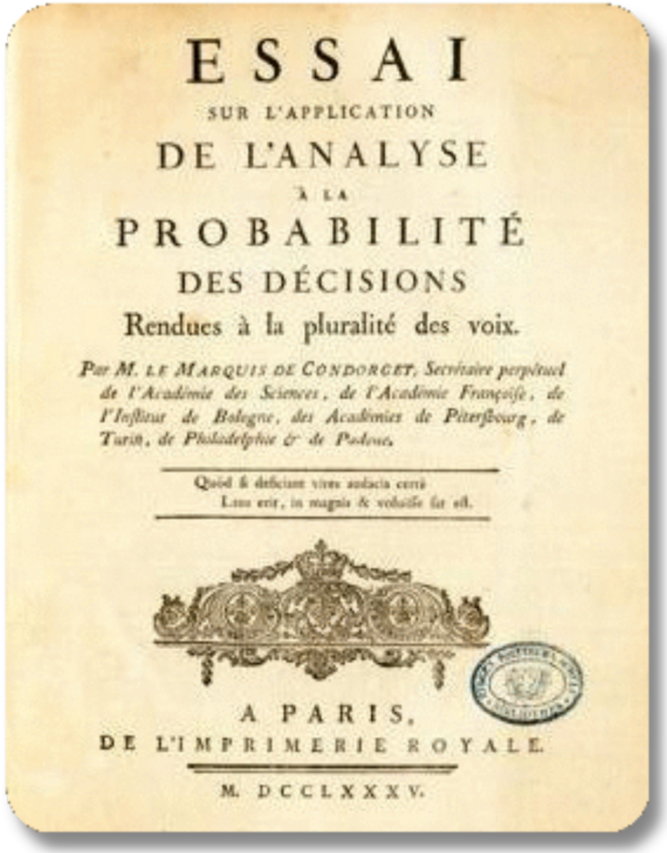
Where did it all start?

CONDORCET

The role of the government is to implement measures that are in the best interest of society.

But how to decide on what outcomes are good?

Democratic procedures can work well.



ESSAI

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DE L'ANALYSE

À LA

PROBABILITÉ

DES DÉCISIONS

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Par M. LE MARQUIS DE CONDORCET, Secrétaire perpétuel de l'Académie des Sciences, de l'Académie Françoise, de l'Institut de Bologne, des Académies de Pétersbourg, de Turin, de Philadelphie & de Padoue.

Quòd si deficiunt vires audacia certè
Laus erit, in magnis & voluisse sat est.

A PARIS,

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M. DCCLXXXV.

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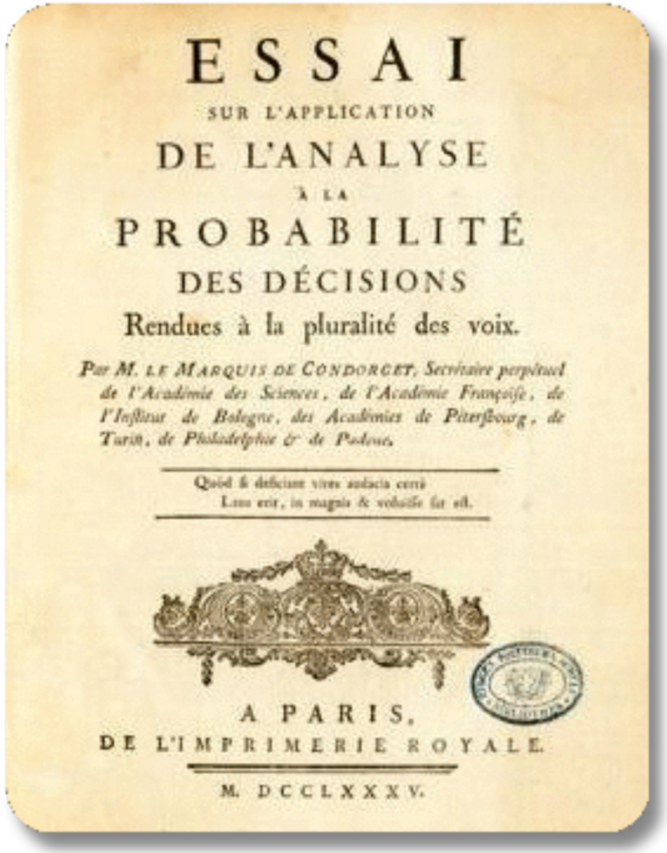

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THE CONDORCET JURY THEOREM

We work in a setting where an odd number of *agents* vote on two issues, one of which is correct.

Each agent has a specific *competence*, which is the probability of voting for the correct alternative.

agents	$N = \{1, \ldots, n\}$
alternatives	$A = \{a, b\}$
correct alternative	a
voter i's vote	v_i
profile of votes	$\boldsymbol{v} = (v_1, \ldots, v_n)$
voter i's competence	$p_i = \mathbb{P}[v_i = a]$
majority opinion	$F_{MAJ}(\boldsymbol{v}) = x$, such that $v_i = x$ for a strict majority of voters

assumed odd

i's guess of the right answer

probability that *i* gets the right answer

we write profiles as words:
(*a*, *a*, *b*, *a*, ...) → *aaba*...

CONDORCET

I want to make some assumptions.

ASSUMPTIONS

Competence

Agents are *competent*, i.e., better than random at being correct:

$$p_i > \frac{1}{2}, \text{ for every agent } i \in N.$$

ASSUMPTIONS

Competence

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Equal Competence

All agents have *the same competence*:

$$p_i = p_j = p, \text{ for any two agents } i, j \in N.$$

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Equal Competence

All agents have *the same competence*:

$$p_i = p_j = p, \text{ for any two agents } i, j \in N.$$

Independence

Agents vote *independently* of each other:

$$\mathbb{P}[v_i = x, v_j = y] = \mathbb{P}[v_i = x] \cdot \mathbb{P}[v_j = y], \text{ for any two agents } i, j \in N.$$

CONDORCET

I claim that under these conditions, the majority tends to get it right!

We want to understand the probability that the majority opinion is correct, that is:

$$\mathbb{P}[F_{MAJ}(v_1, \ldots, v_n) = a].$$

Computing the probability of a correct majority becomes more and more involved as the number of agents grows.

But let's start simple.

ONE VOTER

$$\boldsymbol{v} = (v_1)$$

$$\begin{aligned}\mathbb{P}[F_{\mathsf{MAJ}}(v_1) = a] &= \mathbb{P}[v_1 = a] \\ &= p \\ &> 1/2.\end{aligned}$$

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by the Equal Competence assumption

by the Competence assumption

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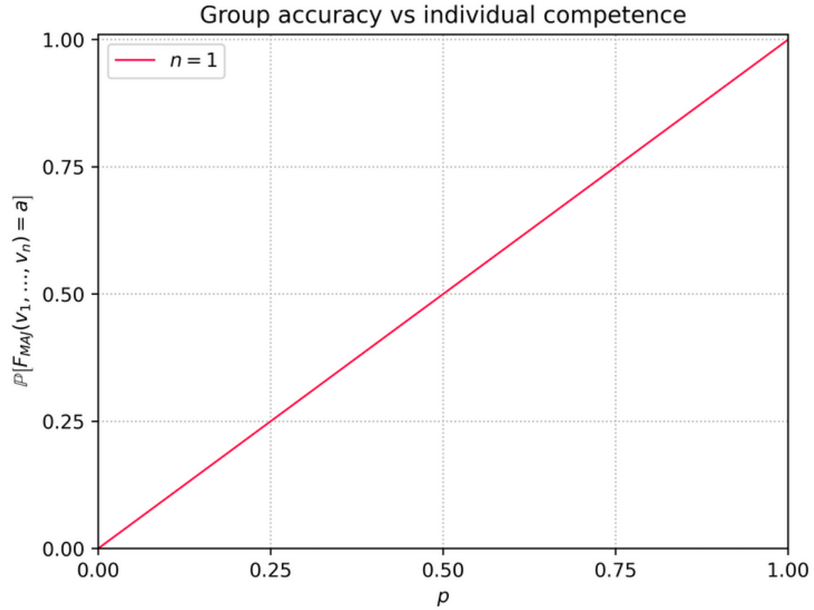

Note

As p grows, so does group accuracy.

in this case, trivially

$$\boldsymbol{v} = (v_1, v_2)$$

TWO VOTERS

$$\boldsymbol{v} = (v_1, v_2)$$

TWO VOTERS

Oh yeah, we're not looking at this case.

THREE VOTERS

$$\boldsymbol{v} = (v_1, v_2, v_3)$$

$$\begin{aligned}
\mathbb{P}[F_{\mathsf{MAJ}}(\boldsymbol{v}) = a] &= \mathbb{P}[\boldsymbol{v} \in \{aab, aba, baa, aaa\}] \\
&= \mathbb{P}[\boldsymbol{v} = aab] + \mathbb{P}[\boldsymbol{v} = aba] + \mathbb{P}[\boldsymbol{v} = baa] + \mathbb{P}[\boldsymbol{v} = aaa] \\
&= \mathbb{P}[v_1 = a] \cdot \mathbb{P}[v_2 = a] \cdot \mathbb{P}[v_3 = b] + \\
&\quad \mathbb{P}[v_1 = a] \cdot \mathbb{P}[v_2 = b] \cdot \mathbb{P}[v_3 = a] + \\
&\quad \mathbb{P}[v_1 = b] \cdot \mathbb{P}[v_2 = a] \cdot \mathbb{P}[v_3 = a] + \\
&\quad \mathbb{P}[v_1 = a] \cdot \mathbb{P}[v_2 = a] \cdot \mathbb{P}[v_3 = a] + \\
&= p \cdot p \cdot (1-p) + p \cdot (1-p) \cdot p + (1-p) \cdot p \cdot p + p \cdot p \cdot p \\
&= 3p^2(1-p) + p^3 \\
&> p. \ (?)
\end{aligned}$$

by the Independence assumption

by the Equal Competence assumption

by the Competence assumption

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$$\boldsymbol{v} = (v_1, v_2, v_3)$$

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&\quad \mathbb{P}[v_1 = a] \cdot \mathbb{P}[v_2 = b] \cdot \mathbb{P}[v_3 = a] + \\
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\end{aligned}$$

by the Independence assumption

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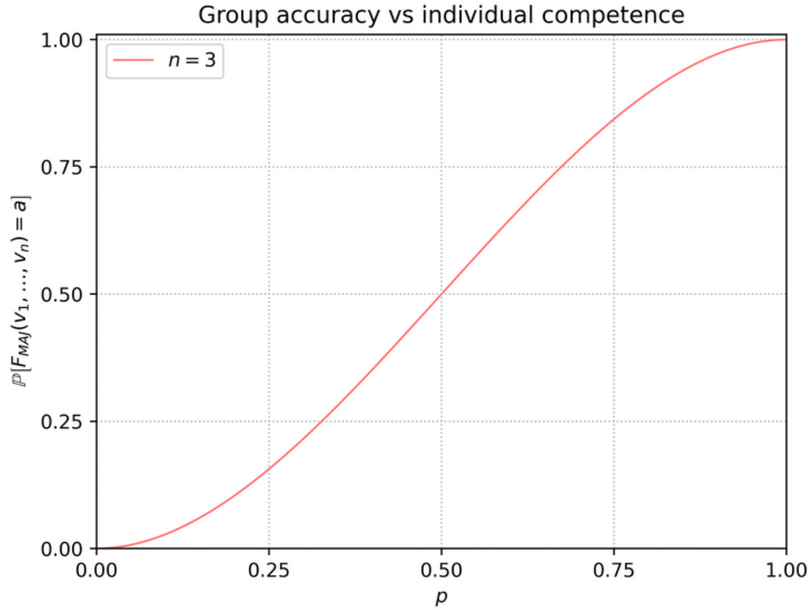

Note

As p grows, so does group accuracy.

THREE VOTERS

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&\quad \mathbb{P}[v_1 = a] \cdot \mathbb{P}[v_2 = a] \cdot \mathbb{P}[v_3 = a] + \\
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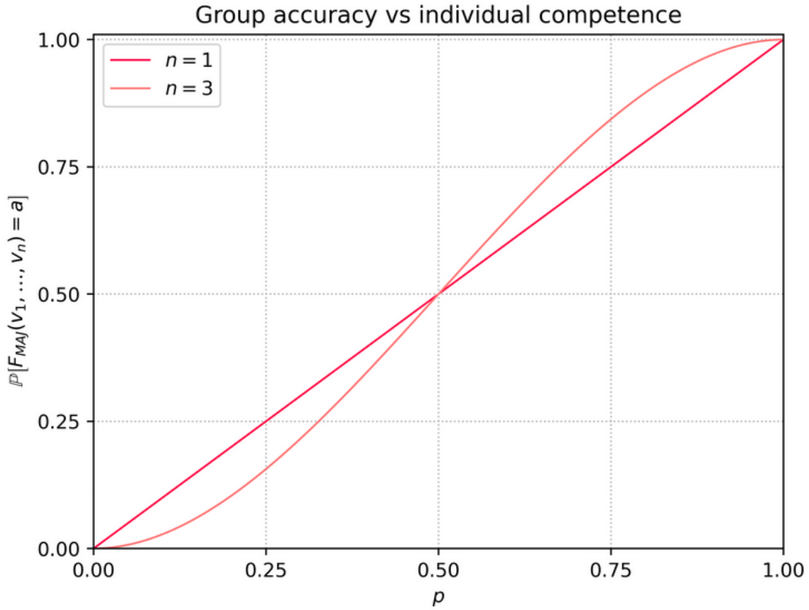

Note

As p grows, so does group accuracy.

A group of size 3 is more likely to be correct than a group of size 1.

$$\boldsymbol{v} = (v_1, v_2, v_3, v_4, v_5)$$

FIVE VOTERS

$$\begin{aligned}
\mathbb{P}[F_{\mathsf{MAJ}}(\boldsymbol{v}) = a] &= \mathbb{P}[\boldsymbol{v} \in \{aaabb, aabab, abaab, abbba, aabba, ababa, baaba, abbaa, babaa, bbaaa\}] + \\
&\quad \mathbb{P}[\boldsymbol{v} \in \{aaaab, aaaba, aabaa, abaaa, baaaa\}] + \\
&\quad \mathbb{P}[\boldsymbol{v} \in \{aaaaa\}] \\
&\quad \cdots \\
&= 10p^3(1-p)^2 + 5p^4(1-p) + p^5 \\
&= \binom{5}{3}p^3(1-p)^2 + \binom{5}{4}p^4(1-p)^1 + \binom{5}{5}p^5.
\end{aligned}$$

$$\boldsymbol{v} = (v_1, v_2, v_3, v_4, v_5)$$

FIVE VOTERS

$$\begin{aligned}
\mathbb{P}[F_{MAJ}(\boldsymbol{v}) = a] &= \mathbb{P}[\boldsymbol{v} \in \{aaabb, aabab, abaab, abbba, aabba, ababa, baabc \\
&\quad \mathbb{P}[\boldsymbol{v} \in \{aaaab, aaaba, aabaa, abaaa, baaaa\}]+ \\
&\quad \mathbb{P}[\boldsymbol{v} \in \{aaaaa\}] \\
&\quad \dots \\
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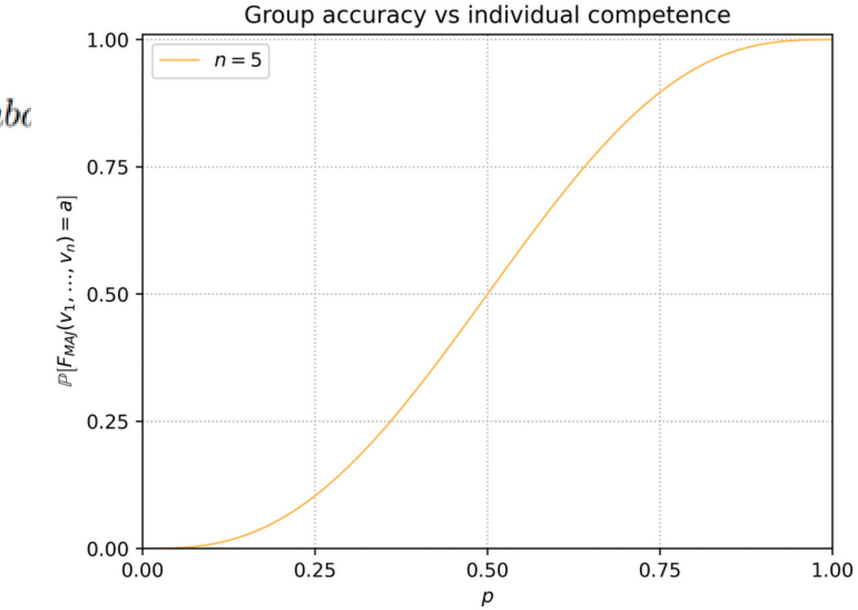
\end{aligned}$$



Note

Again: as *p* grows, so does group accuracy.

$$\boldsymbol{v} = (v_1, v_2, v_3, v_4, v_5)$$

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\mathbb{P}[F_{MAJ}(\boldsymbol{v}) = a] &= \mathbb{P}[\boldsymbol{v} \in \{aaabb, aabab, abaab, abbba, aabba, ababa, baabc \\
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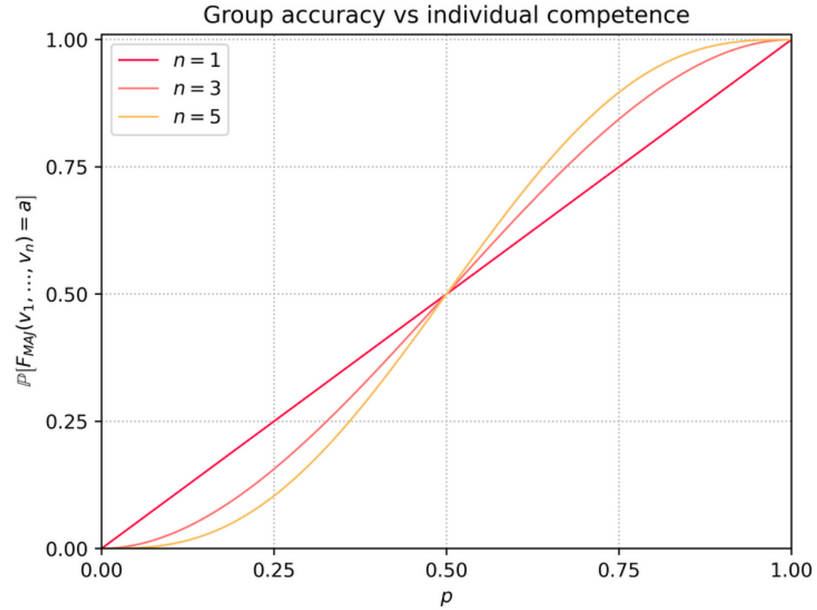


Note

Again: as *p* grows, so does group accuracy.

A group of size 5 is more likely to be correct than a group of size 3.

ANY ODD NUMBER OF VOTERS

$$\boldsymbol{v} = (v_1, \ldots, v_n)$$

$$\begin{aligned}
\mathbb{P}[F_{MAJ}(\boldsymbol{v}) = a] &= \mathbb{P}\left[\boldsymbol{v} \text{ such that } > n/2 \text{ agents vote for } a\right] \\
&= \mathbb{P}\left[\boldsymbol{v} \text{ s.t. } \lfloor n/2 \rfloor + 1 \text{ agents vote for } a\right] + \cdots + \mathbb{P}\left[\boldsymbol{v} \text{ s.t. } n \text{ agents vote for } a\right] \\
&= \left(\mathbb{P}\left[\boldsymbol{v} = \underbrace{a \ldots a}_{\lfloor n/2 \rfloor + 1} b \ldots b \right] + \cdots + \mathbb{P}\left[\boldsymbol{v} = b \ldots b \underbrace{a \ldots a}_{\lfloor n/2 \rfloor + 1} \right] \right) + \ldots \\
&\qquad + \mathbb{P}[\boldsymbol{v} = \underbrace{a \ldots a}_{n}] \\
&= \binom{n}{\lfloor n/2 \rfloor + 1} p^{\lfloor n/2 \rfloor + 1} (1-p)^{n - (\lfloor n/2 \rfloor + 1)} + \cdots + \binom{n}{n-1} p^{n-1} (1-p)^1 + \binom{n}{n} p^n \\
&= \sum_{i = \lfloor n/2 \rfloor + 1}^{n} \binom{n}{i} p^i (1-p)^{n-i}.
\end{aligned}$$

CONDORCET

By the croissants of my ancestors: I claim that the larger the group, the more accurate it is!

And that in the limit, groups are infallible.

Provided there are no dumdums and people make their minds up independently.

THEOREM (THE CONDORCET JURY THEOREM, OR CJT)

If all agents have the same, larger than ½, competence and vote independently of each other, then, for odd *n*, it holds that:

- the accuracy of the group improves as its size grows:

$$\mathbb{P}[F_{MAJ}(v_1, \ldots, v_{n+2}) = a] > \mathbb{P}[F_{MAJ}(v_1, \ldots, v_n) = a]$$

- the accuracy of the group is better than that of any of its members:

$$\mathbb{P}[F_{MAJ}(v_1, \ldots, v_n) = a] > \mathbb{P}[v_i = a], \text{ for } n \geq 3$$

- the accuracy of the group approaches 1 asymptotically:

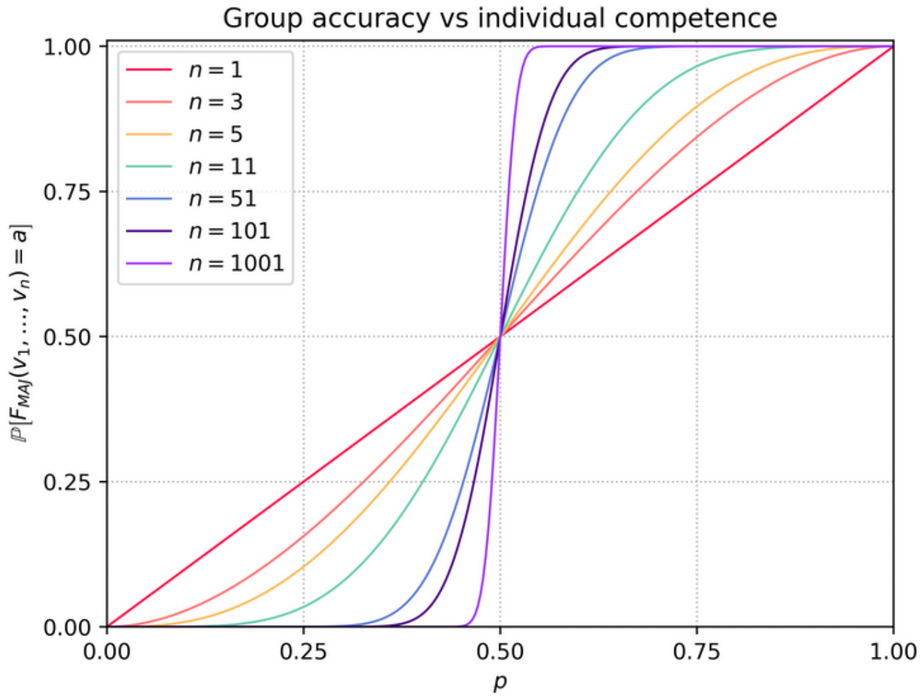
$$\lim_{n \to \infty} \mathbb{P}[F_{MAJ}(v_1, \ldots, v_n) = a] = 1$$

CONDORCET

Groups are better than their members.

The larger the group, the better.

In the limit, performance is perfect.



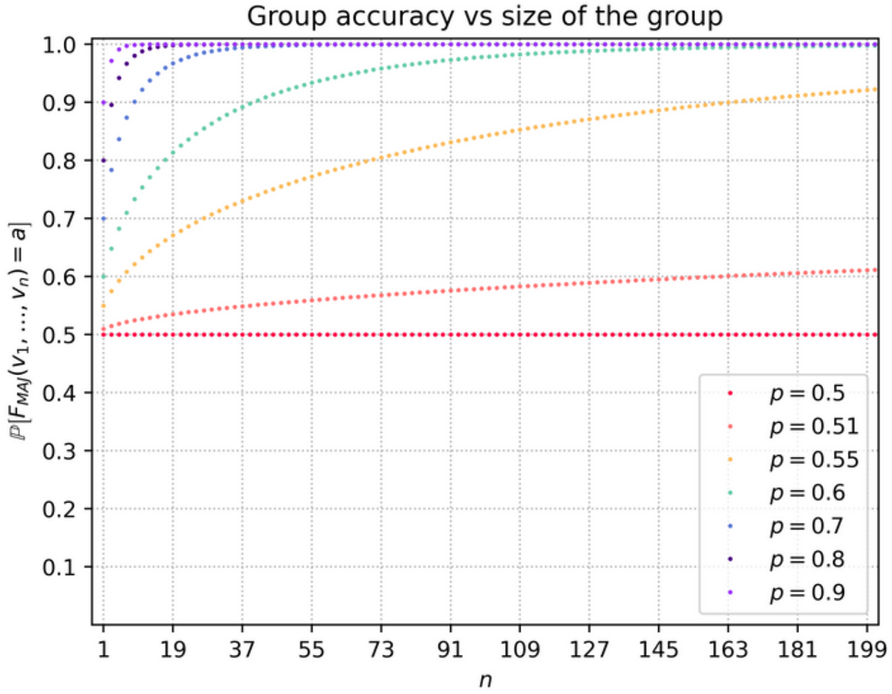
CONDORCET

Groups are better than their members.

The larger the group, the better.

In the limit, performance is perfect.

And performance grows fast with the size of the group.



CONDORCET

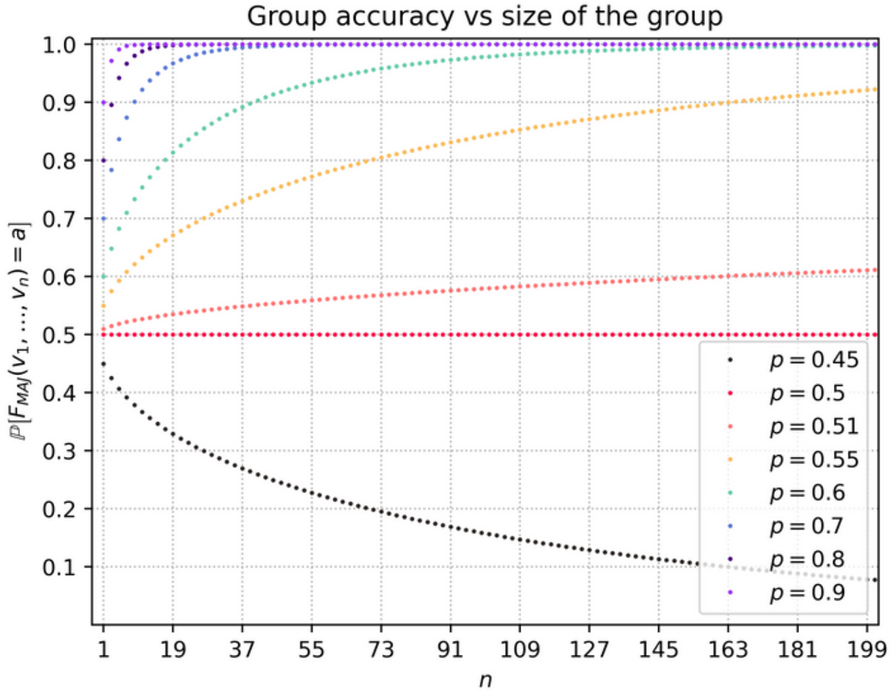
Groups are better than their members.

The larger the group, the better.

In the limit, performance is perfect.

And performance grows fast with the size of the group.

Provided $p > 0.5$.



RELAXING THE ASSUMPTIONS OF THE CONDORCET JURY THEOREM

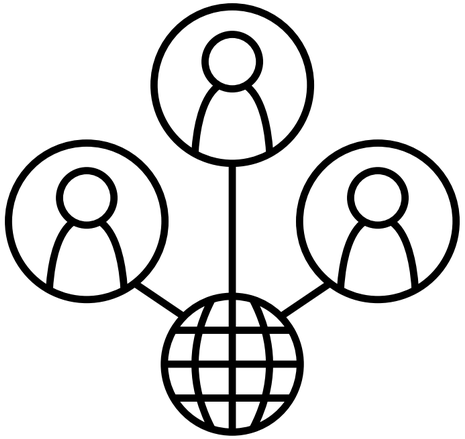
Relaxing independence.

CONDORCET

No point in denying it: the CJT has a major blindspot.

Independent voter beliefs.

Out there people interact and are exposed to common information sources, e.g., mass media.



KRISHNA K. LADHA

Introducing correlation between voters can make the optimistic results go away.

HÉLÈNE LANDEMORE

At the same time, there is more and more evidence that certain forms of communication, e.g., deliberation, are good for decision making.

Ladha, K. K. (1992). The Condorcet Jury Theorem, Free Speech, and Correlated Votes. *American Journal of Political Science*, 36(3), 617–634

Landemore, H. (2013). *Democratic Reason: Politics, Collective Intelligence, and the Rule of the Many*. Princeton University Press.

Landemore, H. (2020). *Open Democracy: Reinventing Popular Rule for the Twenty-First Century*. Princeton University Press.

Relaxing the competence assumption.

CONDORCET

What would be a reason for p to be below 0.5?

CONDORCET

What would be a reason for p to be below 0.5?

DANIEL KAHNEMAN

Biases!

You thought it was Brooklyn, didn't you?

This bridge connects Manhattan to what other New York borough?

- ☐ Brooklyn
- ☑ Queens

Kahneman, D. (2013). *Thinking, Fast and Slow*. Farrar, Straus and Giroux.

CONDORCET

What would be a reason for p to be below 0.5?

DANIEL KAHNEMAN

Biases!

You thought it was Brooklyn, didn't you?

BRYAN CAPLAN

Most people can't be relied on take good decisions.

JASON BRENNAN

Especially when it comes to political issues.

HÉLÈNE LANDEMORE

Let's not exaggerate.

Kahneman, D. (2013). *Thinking, Fast and Slow*. Farrar, Straus and Giroux.
Caplan, B. (2011). *The Myth of the Rational Voter: Why Democracies Choose Bad Policies*. Princeton University Press.
Brennan, J. (2017). *Against Democracy*. Princeton University Press.
Landemore, H. (2013). *Democratic Reason: Politics, Collective Intelligence, and the Rule of the Many*. Princeton University Press.

This bridge connects Manhattan to what other New York borough?

- ☐ Brooklyn
- ☑ Queens

And what does this p even mean, anyway?

CONDORCET

Can we rate people's accuracies, especially if predicting rare, or unique, events?

GLENN BRIEN

Sure!

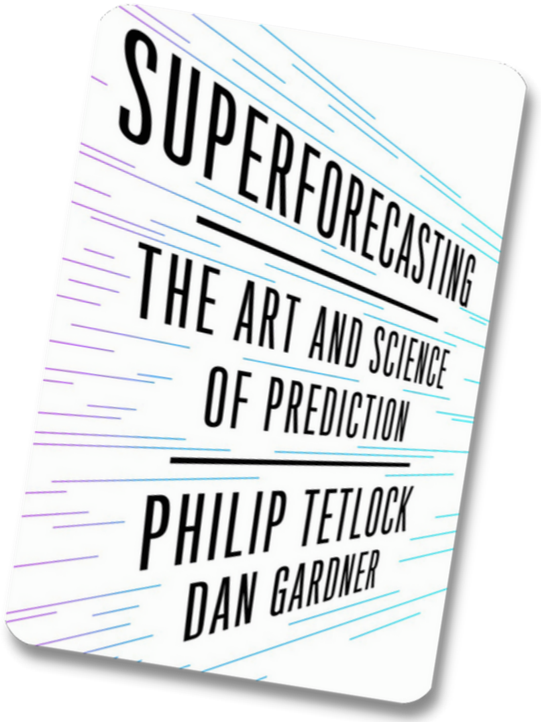
Check out the Brier score.

CONDORCET

Even so: is it realistic to assume that $p > 0.5$?

PHILIP E. TETLOCK

Some people seem to manage it: superforecasters.



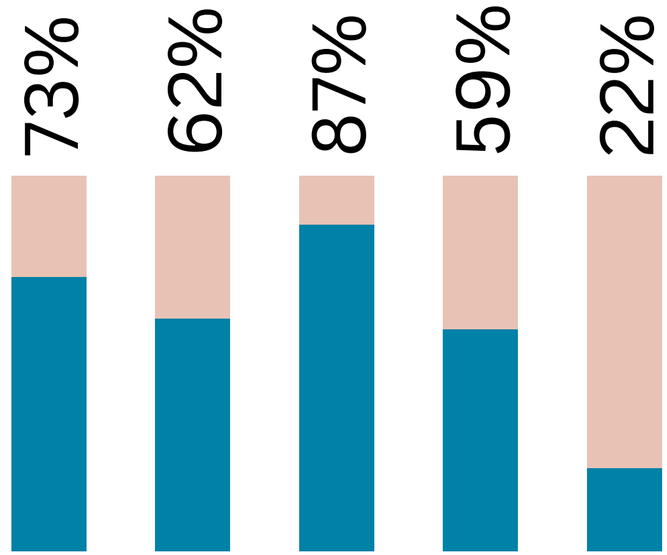
Tetlock, P. E., & Gardner, D. (2016). *Superforecasting: The Art and Science of Prediction*. Random House.

And what if agents don't all have the same competence p?

BERNARD GROFMAN

It's not so clear if the conclusions of the CJT still hold.

It gets kind of complicated...



Grofman, B., Owen, G., & Feld, S. L. (1983). Thirteen theorems in search of the truth. *Theory and Decision*, 15(3), 261–278.
Owen, G., Grofman, B., & Feld, S. L. (1989). Proving a distribution-free generalization of the Condorcet Jury Theorem. *Mathematical Social Sciences*, 17(1), 1–16.

Wrapping up...

CONDORCET

The Condorcet Jury Theorem is a cornerstone of the idea that groups can be wise.

But it also feels like a fragile result, based on unrealistic assumptions.

Can we find better results, for modern-day challenges?