tough choices

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outlook: making choices in a group

- there's more than one voting rule

- the majority rule is sometimes pretty bad

- but at other times it is an exceptionally good rule

- importance for computer science and artificial intelligence

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

2 × 🍺 ≻ 🍷 ≻ 🥛

3 × 🍷 ≻ 🍺 ≻ 🥛

4 × 🥛 ≻ 🍺 ≻ 🍷

outcome?

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

outcome?

1. just vote . . . ?

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

outcome?

1. plurality rule:

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

2 × 🍺 ≻ 🍷 ≻ 🥛

3 × 🍷 ≻ 🍺 ≻ 🥛

4 × 🥛 ≻ 🍺 ≻ 🍷

outcome?

1. plurality rule: 🥛

2. french rule ... ?

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

2 × ≻ ≻

3 × ≻ ≻

4 × ≻ ≻

outcome?

1. plurality rule:

2. french rule:
   – 1st round ⤳ 2 frontrunners
   – 2nd round: majority

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

$2 \times$ 🍺 $\succ$ 🍷 $\succ$ 🥛

$3 \times$ 🍷 $\succ$ 🍺 $\succ$ 🥛

$4 \times$ 🥛 $\succ$ 🍺 $\succ$ 🍷

outcome?

1. plurality rule: 🥛

2. french rule: 🍷

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

$2 \times$ 🍺 $\succ$ 🍷 $\succ$ 🥛

$3 \times$ 🍷 $\succ$ 🍺 $\succ$ 🥛

$4 \times$ 🥛 $\succ$ 🍺 $\succ$ 🍷

2   **1**   **0**

outcome?

1. plurality rule: 🥛

2. french rule: 🍷

3. Borda rule ... ?

choosing together: three voting rules

two germans, three frenchmen, and four dutchmen have to choose a drink for their lunch (the same drink for everyone)

$2 \times$ 🍺 ≻ 🍷 ≻ 🥛

$3 \times$ 🍷 ≻ 🍺 ≻ 🥛

$4 \times$ 🥛 ≻ 🍺 ≻ 🍷

outcome?

1. plurality rule: 🥛

2. french rule: 🍷

3. Borda: 🍺

systematic approach required

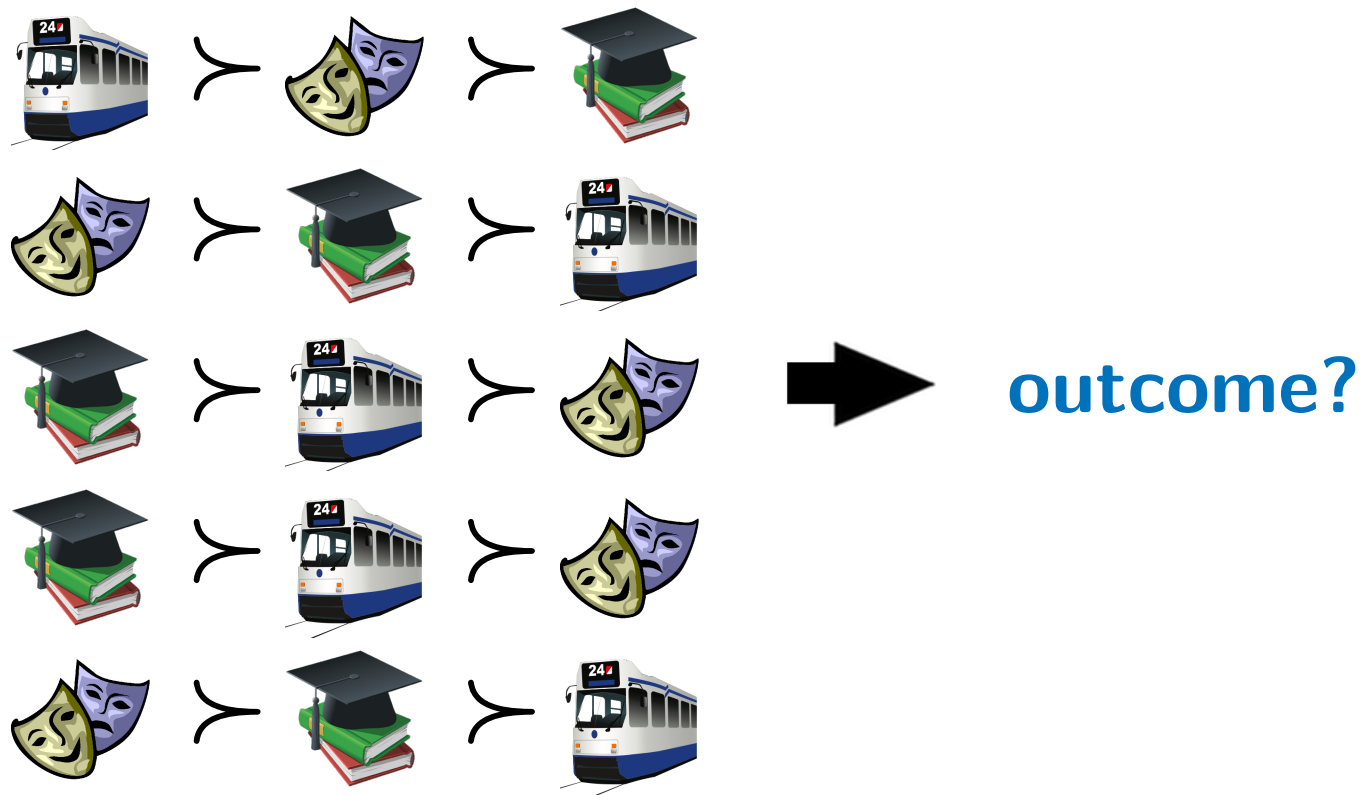three different voting rules, three different outcomes ... **?**

social choice theory: systematic analysis of voting rules

<u>**next:**</u> two observations by the grandfather
of social choice theory, Marie Jean
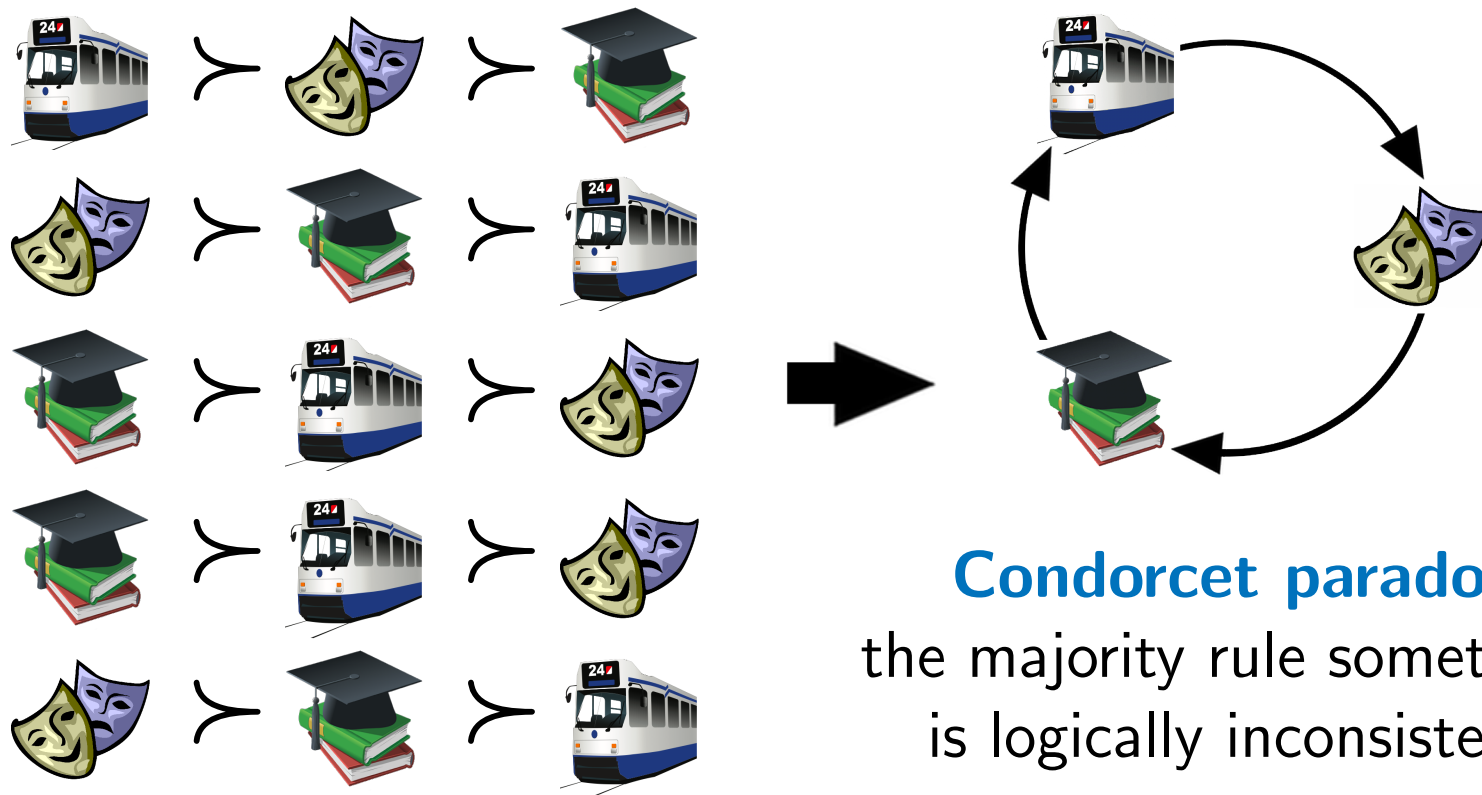Antoine Nicolas de Caritat (1743–1794),
better known the Marquis de Condorcet

majority rule

five members of parliament are looking for a compromise on their priorities w.r.t. public transport, culture and education
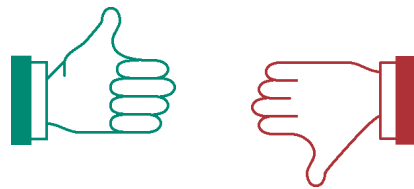

outcome?

majority rule

five members of parliament are looking for a compromise on their priorities w.r.t. public transport, culture and education

Condorcet paradox
the majority rule sometimes
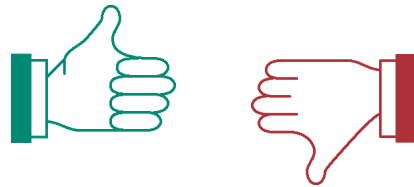is logically inconsistent

majority rule, again

fifteen experts assess whether the new vaccine is working well

everyone gives correct advice with a probability of $p = 75\%$

idea: think of this as an election with two candidates

is the majority rule a good method?

discovering the truth, since 1785

Condorcet's theorem: if n people independently from each other pick correctly with $p > 50\%$, then the chance of getting a correct majority decision converges to 100%, for $n \to \infty$
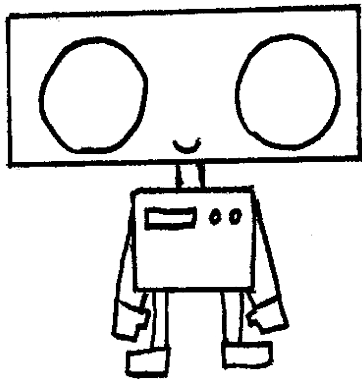
our example:

$$\sum_{k=\lceil \frac{n}{2} \rceil}^{n} \binom{n}{k} \cdot p^k \cdot (1-p)^{n-k} \approx 98\% \ \textit{for} \ \begin{cases} n = 15 \\ p = 75\% \end{cases}$$

innovative applications

various applications in artificial intelligence and computer science have to do with collective decision making

- multi-robot systems
- online recommendation
- internet meta-search engines
- crowdsourcing

new perspectives

vice versa, there are many methods originating in computer science that are now used in social choice

- algorithms for complex voting rules

- representation of complex preferences

- automatic verification

conclusion

decision making: from social choice theory to computer science

- various voting rules for collective decision making

- collective decision making is everywhere

- a challenging research area

information | contact: `www.illc.uva.nl/~ulle/`

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