## PHIL309P

# Philosophy, Politics and Economics 

Eric Pacuit<br>University of Maryland, College Park<br>pacuit.org<br>Politics cases maxan  Nimpen Philosophy Game The May's Theorem Gaus Nash Condorcet's Paradox kneeted<br>Rational Choice Theory. ParetoHarsany<br>ArrowSocial Choice TheorySen<br>Rationality<br>Arrow's Theorem

## Announcements

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- Course website https://myelms.umd.edu/courses/1133211
- Problem set 1
- Online quiz 2
- Reading: Gaus, Ch 2; Reiss, Ch 3; Briggs SEP article.
- Weekly writing: Due Wednesday, 11.59pm.


## Decision Problems

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Arrows theorem

In many circumstances the decision maker doesn't get to choose outcomes directly, but rather chooses an instrument that affects what outcome actually occurs.

## Decision Problems

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ArrowSocial Choice TheorySen $\underset{\text { arrows theorem }}{\text { Rationa }}$

In many circumstances the decision maker doesn't get to choose outcomes directly, but rather chooses an instrument that affects what outcome actually occurs.

Choice under

- certainty: highly confident about the relationship between actions and outcomes
- risk: clear sense of possibilities and their likelihoods
- uncertainty: the relationship between actions and outcomes is so imprecise that it is not possible to assign likelihoods


## Decision Problems

 Nash Consorcet's Paradox LCO R Pational Choice' Theory ParetoHarsanyi ArrowSocial Choice
Rationality

## Decision Problems

| $w_{1}$ |
| :--- |$w_{2} \quad \cdots \quad w_{n-1} \quad w_{n}$.

## Decision Problems



An act is a function $A: W \rightarrow O$

## Making an omelet

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States: \{the sixth egg is good, the sixth egg is rotten\}
Consequences: $\{$ six-egg omelet, no omelet and five good eggs destroyed, six-egg omelet and a cup to wash....\}

Acts: $\{$ break egg into bowl, break egg into a cup, throw egg away $\}$

## Making an omelet

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Rationality

Good egg ( $s_{1}$ )
Bad egg ( $s_{2}$ )
Break into a bowl $\left(A_{1}\right)$

Break into a $\operatorname{cup}\left(A_{2}\right)$

Throw away $\left(A_{3}\right)$

| six egg omelet $\left(o_{1}\right)$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right)$ |
| :---: | :---: |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right)$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right)$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right)$ | five egg omelet $\left(o_{6}\right)$ |

## Making an omelet

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## Good egg ( $s_{1}$ )

Bad egg ( $s_{2}$ )

Break into a
bowl $\left(A_{1}\right)$
Break into a $\operatorname{cup}\left(A_{2}\right)$

Throw away $\left(A_{3}\right)$

| Good egg $\left(s_{1}\right)$ | Bad egg $\left(s_{2}\right)$ |
| :---: | :---: |
| six egg omelet $\left(o_{1}\right)$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right)$ |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right)$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right)$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right)$ | five egg omelet $\left(o_{6}\right)$ |

$$
A_{1}\left(s_{1}\right)=o_{1} \quad A_{1}\left(s_{2}\right)=o_{2}
$$

## Making an omelet

 Rational Choice Theory ParetoHarsany
ArrowSocial Choice TheorySen Arrowsocial Rality

$$
\text { Good egg }\left(s_{1}\right)
$$ Bad egg ( $s_{2}$ )

Break into a
bowl $\left(A_{1}\right)$
Break into a $\operatorname{cup}\left(A_{2}\right)$

Throw away $\left(A_{3}\right)$

| six egg omelet $\left(o_{1}\right)$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right)$ |
| :---: | :---: |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right)$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right)$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right)$ | five egg omelet $\left(o_{6}\right)$ |

$$
A_{1}\left(s_{1}\right)=o_{1} \quad A_{1}\left(s_{2}\right)=o_{2}
$$

## Making an omelet

Good egg ( $s_{1}$ )
Bad egg ( $s_{2}$ )
Break into a
bowl $\left(A_{1}\right)$
Break into a $\operatorname{cup}\left(A_{2}\right)$

Throw away $\left(A_{3}\right)$

| six egg omelet $\left(o_{1}\right)$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right)$ |
| :---: | :---: |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right)$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right)$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right)$ | five egg omelet $\left(o_{6}\right)$ |

$$
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2}
$$

## Making an omelet

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|  | Good egg $\left(s_{1}\right)$ | Bad egg $\left(s_{2}\right)$ |
| :---: | :---: | :---: |
| Break into a <br> bowl $\left(A_{1}\right)$ | six egg omelet $\left(o_{1}\right)$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right)$ |
| Break into a <br> cup $\left(A_{2}\right)$ | six egg omelet and a cup <br> to wash $\left(o_{3}\right)$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right)$ |
| Throw away <br> $\left(A_{3}\right)$ | five egg omelet and one <br> good egg destroyed $\left(o_{5}\right)$ | five egg omelet $\left(o_{6}\right)$ |
|  |  |  |

$o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad$ How should $A_{1}, A_{2}$ and $A_{3}$ be ranked?

## Strict Dominance

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Rational Choice Theory ArrowSocial Choice TheorySen $\underset{\text { Rrows theorem }}{\text { Rationaly }}$


$$
\forall w \in W, u(A(w))>u(B(w))
$$

## Weak Dominance

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Rationality


$$
\forall w \in W, u(A(w)) \geq u(B(w)) \text { and } \exists w \in W, u(A(w))>u(B(w))
$$

## MaxMin (Security)



$$
\min (\{u(A(w)) \mid w \in W\})
$$

Politics

## MaxMax



$$
\max (\{u(A(w)) \mid w \in W\})
$$

## Maximize (Subjective) Expected Utility



$$
\sum_{w \in W} P_{A}(w) * u(A(w))
$$

## Subjective Expected Utility


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Probability: Suppose that $W=\left\{w_{1}, \ldots, w_{n}\right\}$ is a finite set of states. A probability function on $W$ is a function $P: W \rightarrow[0,1]$ where $\sum_{w \in W} P(w)=1$ (i.e., $P\left(w_{1}\right)+P\left(w_{2}\right)+\cdots+P\left(w_{n}\right)=1$ ).

Suppose that $A$ is an act for a set of outcomes $O$ (i.e., $A: W \rightarrow O$ ). The expected utility of $A$ is:

$$
\sum_{w \in W} P(w) * u(A(w))
$$

## Making an omelet

|  | Good egg $\left(s_{1}\right)$ | Bad egg $\left(s_{2}\right)$ |
| :---: | :---: | :---: |
| Break into a <br> bowl $\left(A_{1}\right)$ | six egg omelet $\left(o_{1}\right)$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right)$ |
| Break into a <br> cup $\left(A_{2}\right)$ | six egg omelet and a cup <br> to wash $\left(o_{3}\right)$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right)$ |
| Throw away <br> $\left(A_{3}\right)$ | five egg omelet and one <br> good egg destroyed $\left(o_{5}\right)$ | five egg omelet $\left(o_{6}\right)$ |
|  |  |  |

## Making an omelet

Good egg ( $s_{1}$ ) 0.8

| six egg omelet $\left(o_{1}\right) \mathbf{6}$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right) \mathbf{1}$ |
| :---: | :---: |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right) 4$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right) 3$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right) \mathbf{2}$ | five egg omelet $\left(o_{6}\right) \mathbf{5}$ |

$$
\begin{gathered}
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2 \\
u\left(o_{1}\right)=6, u\left(o_{6}\right)=5, u\left(o_{3}\right)=4, u\left(o_{4}\right)=3, u\left(o_{5}\right)=2, u\left(o_{2}\right)=1
\end{gathered}
$$

## Making an omelet

| Good egg $\left(s_{1}\right) \mathbf{0 . 8}$ | Bad egg $\left(s_{2}\right) \mathbf{0 . 2}$ |
| :---: | :---: |
| six egg omelet $\left(o_{1}\right) \mathbf{6}$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right) \mathbf{1}$ |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right) \mathbf{4}$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right) \mathbf{3}$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right) \mathbf{2}$ | five egg omelet $\left(o_{6}\right) \mathbf{5}$ |

$$
\begin{gathered}
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2 \\
E U\left(A_{1}\right)=P\left(s_{1}\right) * u\left(A_{1}\left(s_{1}\right)\right)+P\left(s_{2}\right) * u\left(A_{1}\left(s_{2}\right)\right)=0.8 * 6+0.2 * 1=5.0
\end{gathered}
$$

## Making an omelet

Break into a
bowl $\left(A_{1}\right)$
Break into a
cup $\left(A_{2}\right)$
Throw away
$\left(A_{3}\right)$

| Good egg $\left(s_{1}\right) \mathbf{0 . 8}$ | Bad egg $\left(s_{2}\right) \mathbf{0 . 2}$ |
| :---: | :---: |
| six egg omelet $\left(o_{1}\right) \mathbf{6}$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right) \mathbf{1}$ |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right) \mathbf{4}$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right) \mathbf{3}$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right) \mathbf{2}$ | five egg omelet $\left(o_{6}\right) \mathbf{5}$ |

$$
\begin{gathered}
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2 \\
E U\left(A_{2}\right)=P\left(s_{1}\right) * u\left(A_{2}\left(s_{1}\right)\right)+P\left(s_{2}\right) * u\left(A_{2}\left(s_{2}\right)\right)=0.8 * 4+0.2 * 3=3.8
\end{gathered}
$$

## Making an omelet



Break into a bowl $\left(A_{1}\right)$

Break into a $\operatorname{cup}\left(A_{2}\right)$
six egg omelet $\left(o_{1}\right) 6$
no omelet and five good eggs destroyed $\left(o_{2}\right) \mathbf{1}$
five egg omelet and a cup to wash $\left(o_{4}\right) 3$

## five egg omelet $\left(o_{6}\right) 5$

$$
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2
$$

$$
E U\left(A_{3}\right)=P\left(s_{1}\right) * u\left(A_{3}\left(s_{1}\right)\right)+P\left(s_{2}\right) * u\left(A_{3}\left(s_{2}\right)\right)=0.8 * 2+0.2 * 5=2.6
$$

## Making an omelet

|  | Good egg $\left(s_{1}\right) \mathbf{0 . 8}$ | Bad egg $\left(s_{2}\right) \mathbf{0 . 2}$ |
| :---: | :---: | :---: |
| Break into a <br> bowl $\left(A_{1}\right)$ | six egg omelet $\left(o_{1}\right) \mathbf{6}$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right) \mathbf{1}$ |
| Break into a <br> cup $\left(A_{2}\right)$ | six egg omelet and a cup <br> to wash $\left(o_{3}\right) 4$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right) \mathbf{3}$ |
| Throw away <br> $\left(A_{3}\right)$ | five egg omelet and one <br> good egg destroyed $\left(o_{5}\right) \mathbf{2}$ | five egg omelet $\left(o_{6}\right) \mathbf{5}$ |
|  |  |  |

$$
\begin{gathered}
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2 \\
E U\left(A_{1}\right)=5>E U\left(A_{2}\right)=3.8>E U\left(A_{3}\right)=2.6
\end{gathered}
$$

## Making an omelet

| Good egg $\left(s_{1}\right) \mathbf{0 . 8}$ | Bad egg $\left(s_{2}\right) \mathbf{0 . 2}$ |
| :---: | :---: |
| six egg omelet $\left(o_{1}\right) \mathbf{9}$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right) 0$ |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right) 8$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right) 7$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right) \mathbf{1}$ | five egg omelet $\left(o_{6}\right) \mathbf{9 . 5}$ |

Good egg ( $s_{1}$ ) 0.8
five egg omelet and one good egg destroyed $\left(O_{5}\right) 1$ Bad egg ( $s_{2}$ ) 0.2

Break into a bowl $\left(A_{1}\right)$

Break into a $\operatorname{cup}\left(A_{2}\right)$

Throw away $\left(A_{3}\right)$

$$
\begin{gathered}
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2 \\
u\left(o_{1}\right)=9, u\left(o_{6}\right)=9.5, u\left(o_{3}\right)=8, u\left(o_{4}\right)=7, u\left(o_{5}\right)=1, u\left(o_{2}\right)=0
\end{gathered}
$$

## Making an omelet

| Good egg $\left(s_{1}\right) \mathbf{0 . 8}$ | Bad egg $\left(s_{2}\right) \mathbf{0 . 2}$ |
| :---: | :---: |
| six egg omelet $\left(o_{1}\right) \mathbf{9}$ | no omelet and five good <br> eggs destroyed $\left(o_{2}\right) \mathbf{0}$ |
| six egg omelet and a cup <br> to wash $\left(o_{3}\right) \mathbf{8}$ | five egg omelet and a cup <br> to wash $\left(o_{4}\right) \mathbf{7}$ |
| five egg omelet and one <br> good egg destroyed $\left(o_{5}\right) \mathbf{1}$ | five egg omelet $\left(o_{6}\right) \mathbf{9 . 5}$ |

$$
\begin{gathered}
o_{1} \succ o_{6} \succ o_{3} \succ o_{4} \succ o_{5} \succ o_{2} \quad P\left(s_{1}\right)=0.8, P\left(s_{2}\right)=0.2 \\
E U\left(A_{2}\right)=7.8>E U\left(A_{1}\right)=7.2>E U\left(A_{3}\right)=2.7
\end{gathered}
$$

## Cardinal Utility Theory

 Nash Consorcets Parapox Theory ParetoHarsany
Rational Choice
ArrowSocial Choice TheorySen

$$
u: X \rightarrow \mathbb{R}
$$

Which comparisons are meaningful?

1. $u(x)$ and $u(y)$ ? (ordinal utility)
2. $u(x)-u(y)$ and $u(a)-u(b)$ ?
3. $u(x)$ and $2 * u(z)$ ?

## Cardinal Utility Theory

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Ratrows theosemality
$x \succ y \succ z$ is represented by both $(3,2,1)$ and $(1000,999,1)$, so we cannot say $y$ whether is "closer" to $x$ than to $z$.

## Cardinal Utility Theory

 Nashh Consorcets Paradox
Rational Choice Theory ParetoHarsany
ArrowSocial Choice TheorySen Arrowsocia Choice
$x \succ y \succ z$ is represented by both $(3,2,1)$ and $(1000,999,1)$, so we cannot say $y$ whether is "closer" to $x$ than to $z$.

Key idea: Ordinal preferences over lotteries allows us to infer a cardinal scale (with some additional axioms).

John von Neumann and Oskar Morgenstern. The Theory of Games and Economic Behavior. Princeton University Press, 1944.

## A Choice

Politicscass fumm tum
 Nastemace fiedatiect Arrowsocia Choice
R

B

W

$S$

## A Choice


 Arrow Socia Choice

## R <br> B <br> W <br> $S$ $S$



## A Choice

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## A Choice



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## A Choice

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$$
[1: B] \sim[p: R, 1-p: S]
$$

## A Choice


$1 * u(B)=p * u(R)+(1-p) * u(S)$

## A Choice

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$$
u(B)=p * 1+(1-p) * 0=p
$$

