Autonomous agents
Lecture 10, 20160222

Behavioral economics, utility, and rational decision-making

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Today's learning goals

- After this lecture you should be able to:
  - Describe the concept of utility, and its use in decision-making
  - Formulate and describe the various axioms on which the utility concept is based.
  - Define and describe risk-averse, risk-neutral, and risk-seeking behavior

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The concept of utility

- How should one make rational decisions in a given situation?
- The process of rational decision-making was formalized by von Neumann and Morgenstern in 1943.
- They considered the choices facing a decision-maker in the form of *lotteries.*

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The concept of utility

- Intuitively, the *expected payoff* would determine a person's willingness to participate in a lottery.
- However, this is not the case!
- Instead, in the theory of von Neumann and Morgenstern, it is the *perception* of the payoff (which, in the case of money, is related to the person's wealth) that determines his or her willingness to participate.

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The concept of utility

- Example 1: A lottery in which a person wins $3 (net) with probability 0.5 and loses $2 with probability 0.5.
  - Here, most people would participate, with an expected payoff of 0.5 x 3 – 0.5 x 2 = $0.5.
- Example 2: A lottery in a person wins $300,000 (net) with probability 0.5 and loses $200,000 with probability 0.5.
  - Here, most people would not participate, even though the expected payoff is $50,000, since few people would be willing to take the risk of losing $200,000.

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The concept of utility

- von Neumann and Morgenstern used the concept of *utility* as a kind of common currency that can be used when comparing different possibilities.
- Given certain assumptions (see below), one can show that a utility functions exists, with certain properties (described in the lecture notes).

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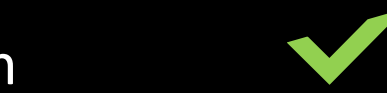

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Axioms

- Ordering
  - An individual can decide, and remain consistent, regarding his or her preferences.
- Transitivity

If $c_1 \geq c_2$ and $c_2 \geq c_3$ then $c_1 \geq c_3$.

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Axioms

- The Archimedean axiom

Misprints:
Should be]0,1[
(open interval)

Axiom 3 (The Archimedean axiom) If $c_1 \succ c_2 \succ c_3$, there exists a $p \in [0,1]$ such that $pc_1 + (1-p)c_3 \succ c_2$ and a $q \in [0,1]$ such that $c_2 \succ qc_1 + (1-q)c_3$.

- Independence

Axiom 4 (Independence) For all outcomes c_1, c_2, and c_3, $c_1 \succeq c_2$ if and only if $pc_1 + (1-p)c_3 \succeq pc_2 + (1-p)c_3$ for all $p \in [0,1]$.

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Critique of the utility concept

- The utility concept has been criticized by Kahneman and others, who noted (for example) that people tend to …
  - …consider the merits of different outcomes relative to a reference point (rather than the perception of the payoff), and have strong loss aversion (i.e. losing $100 elicits more negative feelings than the positive feelings evoked by someone who wins $100).
  - …overreact to low probability events and underreact to high probability events.
- *Prospect theory* attempts to handle those problems.

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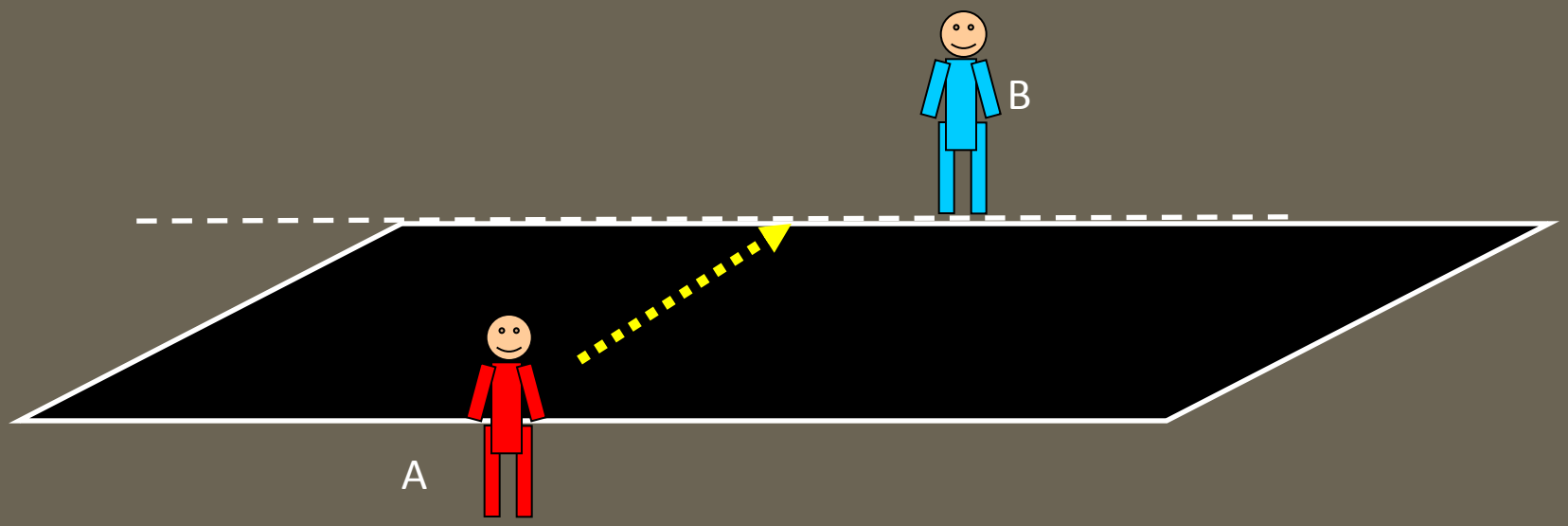
Using the utility concept



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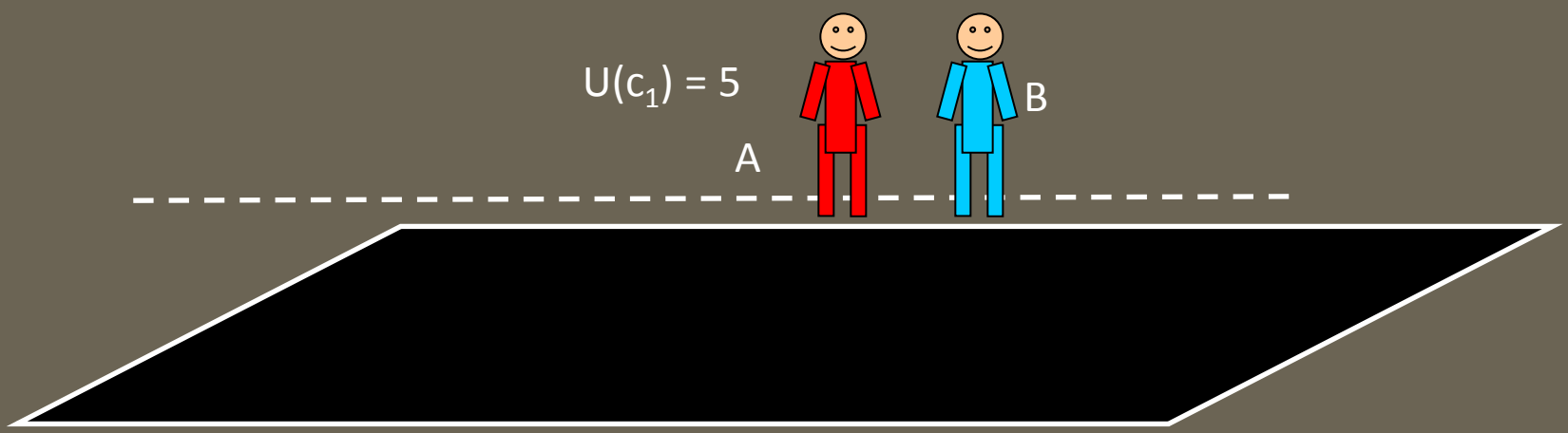
Outcome 1: (C_1)



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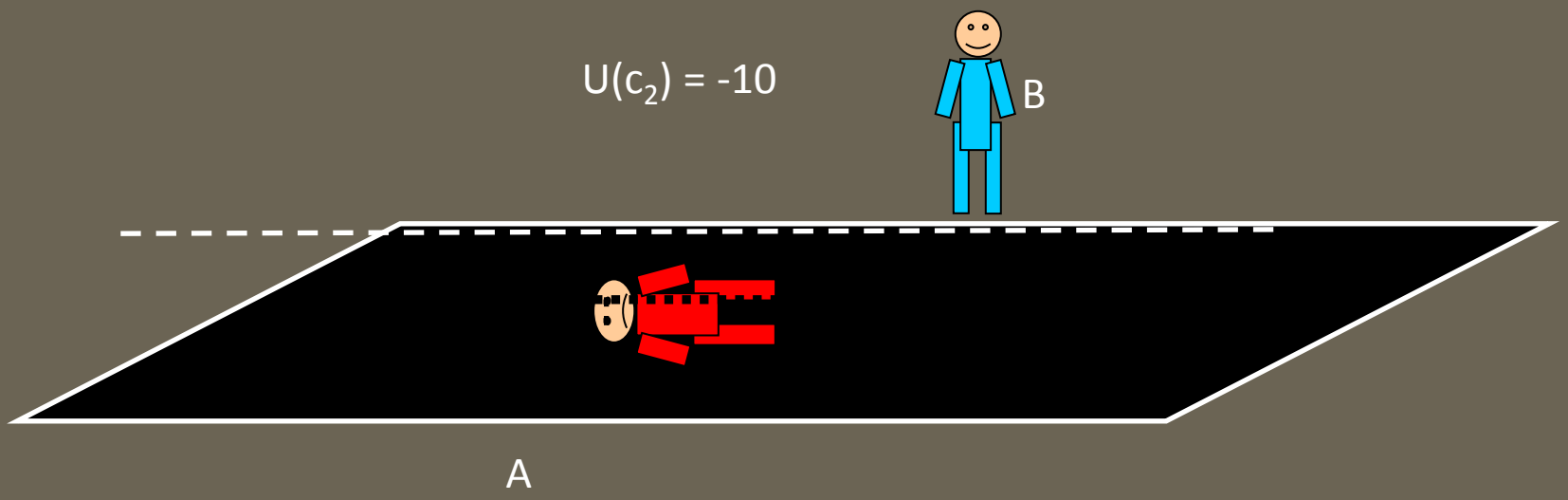
Outcome 2: (C_2)



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Example 2:

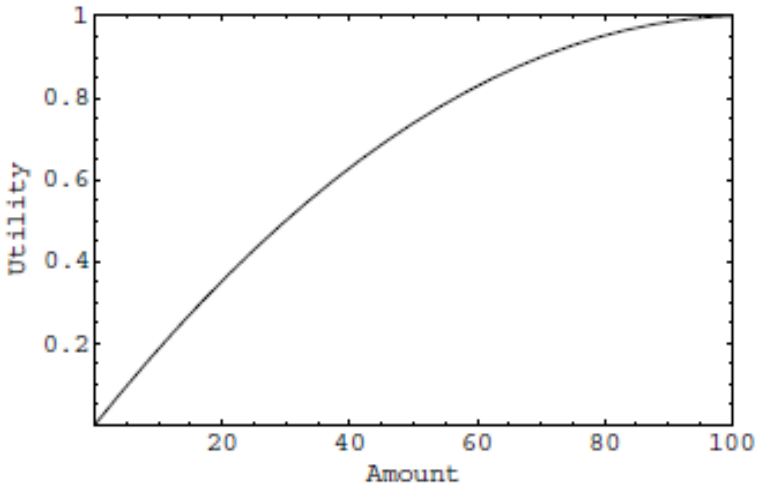

Figure 7.1: *A typical utility function, showing diminishing (sub-linear) utility values for larger amounts.*

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Behavior selection in Stentor

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Behavior selection in Stentor

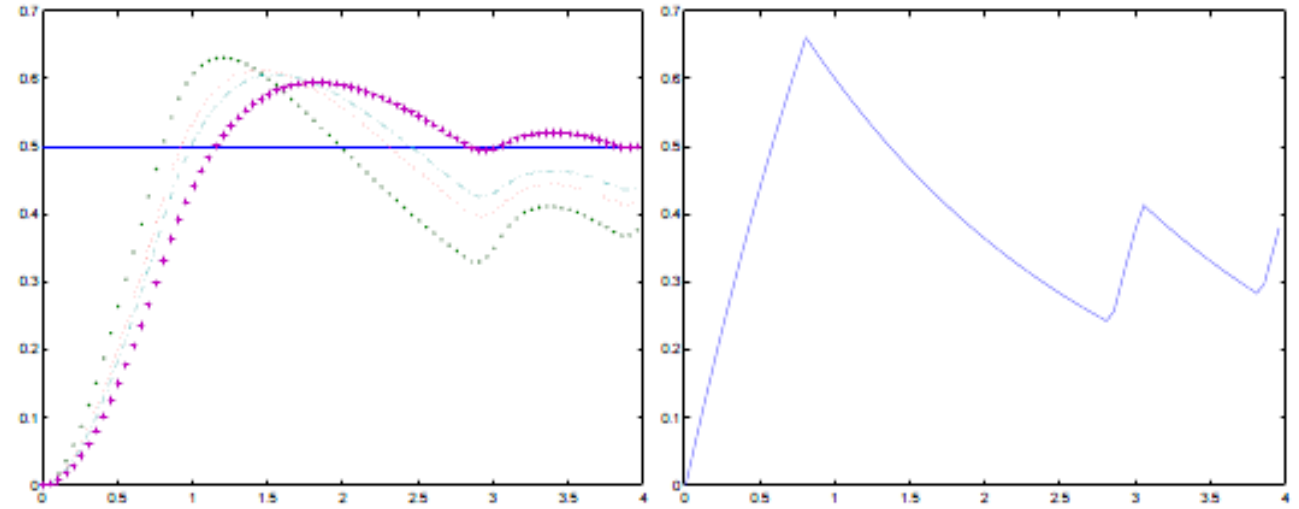

Figure 7.4: *Left panel: The variation of the utility functions for the 5 behaviors. Solid curve: B_1, large-dotted curve: B_2, small-dotted curve: B_3, dot-dashed curve: B_4, plus-sign curve: B_5. Right panel: The variation $X(t)$ of the concentration of the noxious substance.*

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