Human Behavior Modeling

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Lecture „Cognitive Modeling“
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Decision Making

• Last time, we learned that evaluation of options is a central part of decision making

• Up to now, we assumed rational evaluation:
  • Homo oeconomicus
  • Game theory
  • Reinforcement Learning

• However, humans do not only make rational decisions but use a large number of indicators to make their judgments

• All those indicators are integrated (with varying influence) to form a decision
Heuristics

• We already know that adaptive, „resource efficient“ processes are a trademark of human cognition

• One major information source for evaluation of options are heuristics
  • Heuristics = Simple decision or judgment rules
  • Work with limited cognitive resources
  • Work with limited and uncertain information

• Heuristics are an efficient way to quickly assess a situation but can also lead to bias and “cognitive illusions”

• Many heuristics seem to be innate and of evolutionary benefit
Examples of Heuristics

• **Availability heuristic**
  - Ease of memory retrieval of an event $\rightarrow$ probability of this event (note that expected outcome of an event is: probability x value)
  - Fails for rare but memorable events (e.g. plane crashes covered in media)

• **Representativeness heuristic**
  - To evaluate the probability that a certain event belongs to some class...
  - ...use representativeness of this event for this class as heuristic
  - Example: The more typical symptoms are for a certain illness, the higher is the assessed probability of having this illness
  - Often leads to base rate neglect (e.g. base probability of the class)

• **Anchor and adjustment heuristic**
  - Take a hint contained in the task or in part of a solution as valid “anchor”
  - Example: Compare the results of...
    - Task 1: Calculate 1x2x3x4x5x6x7x8 in 3s! (result underestimated)
    - Task 2: Calculate 8x7x6x5x4x3x2x1 in 3s! (more realistic estimation)
Systems Model of Human Behavior (Huit, 2009)

- Studies the human as a dynamic system which reacts to observed input from the environment
- System consists of multiple, strongly interconnected components → study them together, not isolated
However, we already saw that emotion influences cognition
- Yerkes-Dodson Law: Level of arousal has impact on cognitive performance (inverted u-curve)
- The case of Phineas Gage (physical damage to the brain had impact on both emotion/personality as well as decision making abilities)

Sometimes, affective behavior seems to dominate rational decisions of humans
- How can we explain this if we describe humans as rational?

How can we describe the relation between emotion and decision making?
- For most of this lecture, we follow the text book by Betsch, Funke & Plessner (Springer, 2011)
Emotion as Epiphenomenon

- Keep the traditional three-step approach for decision making
- Emotions are only a by-product of rational decision making
- Emotions have no direct impact or relevance for decision making
- Empirical evidence indicates that this model is not accurate
Emotion as Process Determinants

- Emotions impact all aspects of decision making
- Each step is influenced individually by the emotional state of the human
  - Example: When feeling stressed, less alternatives are evaluated with less depth than under a calm conditions
  - Compare to the model of cognitive modulators in the PSI architecture
Emotion as Process Determinants

- Emotions act as „interrupts“
  - In a complex, dynamic world, emotions help to focus on critical events
  - Emotions inform of changes of the internal and external world
  - Negative emotions act as alarms, control attention and motivate the organism to turn to the most urgent tasks

- Mood has a general influence on behavior and decision making
  - Positive mood leads risk averse behavior concerning negative rewards
  - Positive mood leads to overestimation of positive reward probabilities
  - Influence is also measurable for weak moods which are not directly related to the decision situation
Emotion as Cognitive Evaluation Criterion

- Cognitive anticipation of emotions influences evaluation of options
  - Example: Anticipation of regret or pain as consequence can result in a worse evaluation than an evaluation only regarding objective rewards
- Deals not with the emotion itself but with its cognitive representation
Emotion as Cognitive Evaluation Criterion

- Emotions influence decision making even before they are actually realized but already when they are anticipated
- Important examples: Regret and Disappointment
  - Disappointment: Outcome is worse than expected
  - Regret: Selected option turns out worse than options not selected
  - Regret and disappointment experienced in a situation influence decision making in similar situations in the future
- However, humans are not good at accurately predicting future emotions!
  - Strength and duration of future emotions are regularly both over- and underestimated
Emotion as Direct Evaluation Criterion

- Emotions directly influence decision making
- In contrast to former model, this comprises both cognitive and affective aspects
- Most recent and most complex approach
Emotion as Direct Evaluation Criterion

- Damasio (1995): Deficits in emotional perception are correlated with deficits of decision making behavior
  - Indicates that emotional influence on decision making is not only indirect

- Empirical evidence: Iowa Gambling Task
  - Participant starts with 2,000$
  - Participant draw 100 cards from 4 stacks of face-down cards (A,B,C,D)
  - Drawing costs money and yields a reward depending on the stack
  - The expected values of the different stacks are initially unknown

<table>
<thead>
<tr>
<th>Stack</th>
<th>Reward on all cards</th>
<th>Penalty on some cards</th>
<th>Probability of penalty</th>
<th>Expected value</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>100$</td>
<td>-150$ to -300$</td>
<td>50%</td>
<td>-25$</td>
</tr>
<tr>
<td>B</td>
<td>100$</td>
<td>-1,250$</td>
<td>10%</td>
<td>-25$</td>
</tr>
<tr>
<td>C</td>
<td>50$</td>
<td>-25$ to -75$</td>
<td>50%</td>
<td>25$</td>
</tr>
<tr>
<td>D</td>
<td>50$</td>
<td>-250$</td>
<td>10%</td>
<td>25$</td>
</tr>
</tbody>
</table>
Observations in Iowa Gambling Task

• Healthy participants prefer stacks C and D with positive expected value
• Arousal was estimated by measuring skin conductivity
• Rise in emotional arousal directly before drawing a card from stack A or B → „affective warning“
• The warning was issued even when the participants had not yet cognitively abandoned stacks A and B!

• Interpretation: The affective evaluation of decks differs from the cognitive evaluation and can subconsciously lead to earlier better results
Observations in Iowa Gambling Task

- Participants which suffered from an injured prefrontal cortex preferred stacks A and B (high short-term rewards, negative expected value)
- Participants with neural injuries did not show the emotional response to stacks A and B
- Still, they showed the same emotional response after they draw a negative card as the healthy participants
- Prefrontal cortex is not responsible for producing emotions (➔ Amygdala, limbic system)!
- What the injured participants lacked was the integration of decision making and emotional cues
Emotional Decision Making

- Often, people follow their „gut feeling“ instead of doing a full rational analysis → They use the *affect heuristic*

- When does this happen?
  - Priming by context information (e.g. affective stimuli)
  - Person dependent, i.e. on personality

- Example: How much would you donate to support the survival of Pandas?
  - Neutral condition: Dot on a map represents pandas (1 or 4)
  - Affective condition: Image of a panda instead of dots
  - For one panda, people are willing to donate nearly twice as much in the affective condition than in the neutral condition
  - For four pandas, people are willing to donate more in the neutral condition
  - → affect heuristic is less sensitive for quantity of stimuli (e.g. utility function is concave)
The affect-infusion model tries to describe the influence of mood on judgement and decision making.

Fargas (1995/2000): Distinguish different types of judgement processes:
- Constructive: Non-goal-directed information processing
- Motivated: Goal-directed information processing

The influence of affect depends on the type of process:
- Motivated processing is not influenced by affect
- Constructive processing is influenced by affect in a congruent fashion: Positive mood leads to favorable evaluation of options
Humans in Context

- Humans do not develop in isolation
- They are exposed to constant interaction with various other people
  - Family
  - Peers
  - Society
- This context plays a major role in human development and behavior (Bridge, Judd & Moock, 1979 Bronfenbrenner, 1977-89)
Microsystem

- Microsystem: First level of the ecology or context of human development
  - This level has the most immediate and earliest influence
- Includes the family, along with local neighborhood or community institutions (school, religious institutions and peer groups) plus specific culture within which the family identifies.
Mesosystem

- Mesosystem: Second level
  - Intermediate level of influences and includes social institutions
- Involved in such activities as transportation, entertainment, news organizations, and the like
- Influence of these systems is filtered through the microsystem
Macrosystem

- Macrosystem: Third level
  - Comprised of the most distant influences (international region, global changes, culture)
- Example: Going from agriculture/industrial economies to an information and conceptual age is having widespread influence on the ways societies, communities, and families are operating
Influence of Social Context

- Like emotions, social context has a huge impact on human decision making processes
  - Indirect effects: Genetic influence, influence of parents, peers and society on development, ...
  - Direct effects: The immediate context of a decision situation
- Instead of only evaluating their own outcome of an event, people often compare with others
- People tend to follow authorities and people of higher social rank
- Rejection by other people is experienced in a similar way as physical pain
  - Consequence: Strong desire of belongingness
  - Typical strategy: Showing conformity, even beyond rational justification
  - Application of the follow-the-majority heuristic also reduces cognitive load (at the cost of sub-optimal decisions)
Examples of Conformity and Authority

**Conformity Experiment by Asch (1951):**
- A group of people solves a joint task: To which line (A,B,C) is line X equivalent in length?
- All group members but the uninformed true participant insist on a common wrong answer.
- In many trials, participants agree with the wrong answer (answers are correct if given alone).

**Authority Experiment by Milgram (1961):**
- Participants were given the role of a "teacher" for a "student" in a different room (the student actually was an instructed actor).
- Participants were asked to punish wrong answers with electric shocks of increasing intensity.
- When showing qualms, participants were told to go on by the authoritarian instructor (e.g. "The experiment requires you to continue!").
- Almost all participants continued the experiment to the end.
Social Networks

- To explicitly model the influence of social relations is difficult
  - Complex interaction effects
  - Long-term effects
- However, we can model and analyze social structures and investigate their effects on human behavior
- Social networks represent people as nodes of a graph interconnected by “relationship” edges
- Relationship is defined task-dependently:
  - “communicates with” to model information flow in a community
  - “is friend of” to model relations on a social network website
  - “publishes with” to model collaboration in the scientific community
  - …
- We can analyze them to identify clusters, hierarchies, important nodes and outliers, …
Example of a Social Network
Social Network Analysis

- Social networks can formally be represented as graphs
- All measures and algorithms from graph theory are available

**Degree**: Number of neighbors of one node

**Betweenness**: Number of shortest paths passing through

**Eigenvalue**: A node with high eigenvalue is connected to other nodes with other nodes of high eigenvalue
Examples of Social Network Analysis

• Homophily: Attraction to similar people (McPherson, 2001)
  • People how are close to each other in a social network are typically similar in certain characteristics
  • Most relevant traits: race, age, religion, education, occupation, gender

• Cigarette consumption of adolescents (Ennett, 1993)
  • Analysis of cliques allows to cluster pupils as clique members, clique liaisons or isolates
  • Isolates were much more likely to be smokers than members of the other groups
  • Not predicted by simple demographic statistics or number of friends

• Obesity spread (Christakis, 2007)
  • Obesity spreads over the edges of a social network
  • A person becoming obese increases the probability of direct and indirect neighbors in the network of becoming obese as well
Social Networks for Computer Systems

- There are a number of direct applications for social network analysis for computer systems
  - Recommender Systems (e.g. Golbeck, 2006)
    - A recommender system suggests items (movies, music, news articles, products, ...) which the user might like
    - Information can be based on individual preference for past items
    - It can also make use of the social network of the user (e.g. recommend items liked by close peers or opinion leaders)
  - Trust Networks (e.g. Sabater, 2002):
    - In networks with many interacting agents, it is important to know whom to trust (file sharing platforms, marketplaces, ...)
    - As each agent has not enough individual knowledge on all his peers, he can make use of the social network to predict trustworthiness based on information by his trusted peers
Consequences?

- How does all this help us when designing computer systems?
- Using a computer system boils down to a sequence of decision making situations
  - Which task to perform next?
  - Which system operations to take to fulfill the task?
  - How to perform a certain operation if there are several options?
  - How to react to error messages or unclear situations?
  - Quit the program and use another one?
- Designers of systems can use knowledge on human decision making to predict and understand user behavior
- This helps to optimally support the user to solve their task in a satisfying way
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