Lecture notes/summary

Cognitive Psychology and its Applications (Vrije Universiteit Amsterdam)

Lecture 1

Cognitive psychology is about information processing and behavior.

Human factors is the study of interaction between humans and systems in order to improve performance, safety, health and usability.

Costs of human factors design are lower early in design process. The more specific the research the more expensive it becomes.

Investing in human factors has benefits later on. Prevention of accidents, compensation payments.. Higher productivity and job satisfaction. Lower costs for training.

Front end analyses:
User analysis: Determine goals, functions, tasks.
- goal: highest level (for moibile phone: communication)
- function: functionalities (making a call, sending a text)
- task: actions of the user (selecting number, starting call)

Goal important because it may be reached with a completely different system.

Task analysis: Physical and Cognitive

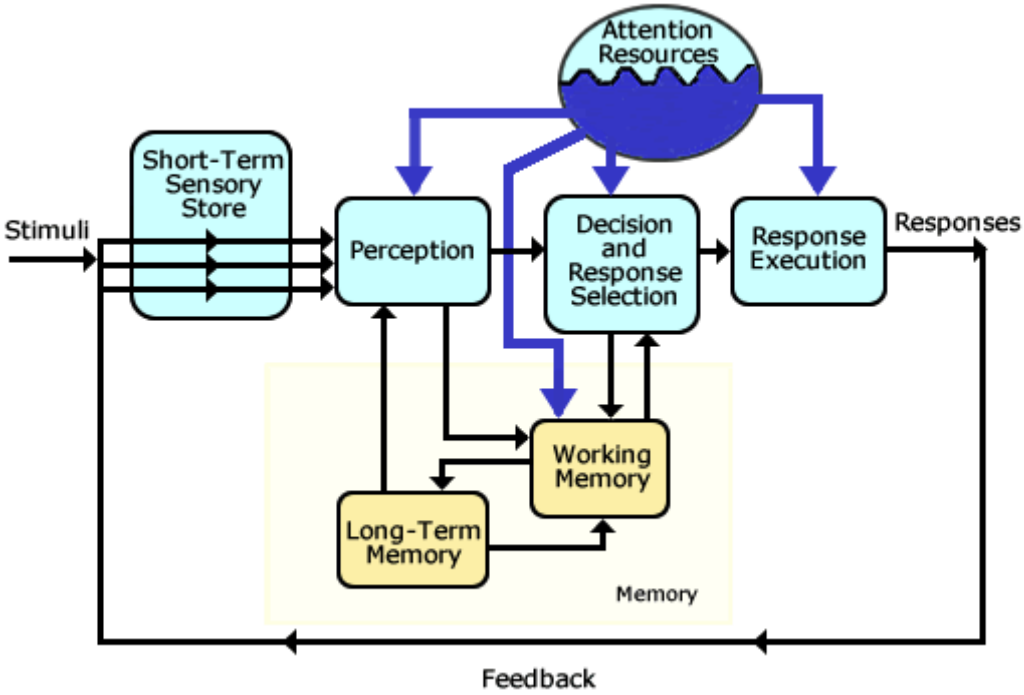
Research methods:
- Literature
- Experimental (controlled) (lab/field study)
- Descriptive (less/not controlled) (observations, surveys, incident/accident analysis)

Experiment problems: subjects are not representative, confounding variables, power too low

Surveys, observations problems: No causal relationship, suitable answers, interpretation of questions, preferred solution is not always optima, population may not be representative.

Lecture 2

What is human information processing?
- Sensory systems (vision, audition, tactile, etc)
- Cognitive systems (perception, attention, memory, language, decision-making)



Cones for color

Attention determines which information is processed and which information is ignored.

How is it determined?

To what extent is attention selective?

Dichotic listening technique. Pay attention to the message in one ear, detailed aspects such as language, individual words and semantic content are unnoticed in the other ear. Only if information is physically different, such as harder tones, the brain processes it automatically, even if there was no attention payed to it. (Cherry)

Early selection:
Broadbent's filter theory. Bottleneck at stimulus-identification. Filtering (attentional filter) based on physical dimension, eg. location, loudness.

Filter is not perfect:
Treisman's filter attenuation theory. Cocktail party effect. Relevant information passes the filter.

Late selection:
Deutsch & Deutsch: bottleneck (filter) occurs after stimulus-identification.

Directing visual attention:
- Spatial (selectivity of location)
- Feature-based (bases on features such as color, orientation or size)

Attentional control:
- Top-down
- Bottom-up

Attention & eye movements

Covert attention = eye are still

Overt attention = eye movements

Memory

0 – 250 ms **iconic memory**

250 ms – seconds **visual short-term**

Hours- days – years **long term**

Visual short term memory is a memory system that stores visual information for a few seconds so that it can be used in the service of ongoing cognitive tasks.

Visual short term memory representations can survive eye movements, eye blinks, and other visual interruptions.

A limited amount of information to be maintained in an “on-line” or readily accessible state.

Baddely and Hitch model of working memory: splitted in visuospatial sketchpad and phonological (verbal (speech-based) information).

Memory span is larger for items that are easy to rehearse.

<u>Visual attention:</u>
mechanism by which we select relevant and ignore irrelevant visual information.

<u>Visual working memory:</u>
Mechanism by which we actively retain relevant, and prevent interference form irrelevant visual information.

“Both attention and working memory processes selectively activate and prioritize particular representations above others. In the case of working memory, this occurs in the absence of the actual stimulus.”

Lecture 3

Eye movements are intrinsically linked with information processing.

We do not use saccades to paint a complete internal representation of a visual scene.

Saccades constitute a way to select task relevant information.

What drives information processing during visual search?
- target features (top-down)
- visual salience (bottom-up)
- scene context (learned expectations)

Reading & eye movements: saccade size and fixation duration are also both modulated by text difficulty, as the text becomes more difficult, saccade size decreases, fixation durations increase, and regressions increase.

Lecture 5

Task analysis driving:

Strategic:
- choice of route
- choice of travel time

Tactical:
- choice of speed
- lane choice, overtaking
- taking turns

Control:
- longitudinal (speed, distance from other cars)
- lateral (position on road)

Assessment of driving performance based on:
- Strategic
- Tactical
- Control

Primary tasks: lane keeping and hazard monitoring

Secondary tasks: navigation, scanning for signs, radio, cell phone, eating…

Intelligent / automatic systems

Vehicle control: lane departure warning; collision avoidance (intelligent cruise control)

Navigation: trip planning, route information. Up-to-date information (traffic jams, weather, services)

Risks: overconfidence in system, less attention for driving task, trade safety against efficiency.

Lecture 6

Why are tasks automated?

3Ds: dull, dirty, dangerous: repetitive tasks, working with explosives or radioactive material.

For multi-tasking, difficult or unpleasant tasks: process control, welding, autopilot.

Extension of human capability: decision support.

Because the technology makes it possible: telephone services using speech recognition

Stages and levels of automation:

Information acquisition, selection and filtering: spelling checkers, word spotting.

Data integration: pattern recognition, complex (prioritized) warning systems.

Advisory systems: collision avoidance systems.

Control, execution of actions: industrial robots.

8 levels in terms of control; from human in complete control to system in complete control.

Causes of unreliability:
- errors, eg because of complexity
- use outside the operating range
- wrong setting are entered
- logic of system is not understood by user (who thinks that it malfunctions)

In most cases **the user-system combination** is unreliable, or the system is **imperfect** (not unreliable).

Trust:
- perceived reliability
- critical for acceptance of automated systems
- trust is often not well calibrated
- which is better, mistrust or overtrust

Mistrust: high false alarm rate; failure to understand (limitations) of system
→ inefficient, slow; errors (eg because warnings are not taken seriously)

Overtrust or complacency: actual reliability is difficult to judge when few errors occur
→ slow detection of failures; poor situation awareness because user is not actively involved.

Automation should be tuned to keep workload within right bandwidth:
- clumsy automation makes easy tasks easier and hard tasks harder.

Training should be adapted to the level of automation

Human-system communication is less rich than human-human communication: eg tone of voice.

Hick – Hyman law: more complex decisions have longer reactions times. How more possible alternatives, how longer reaction time.

This does not mean fewer alternatives is better:
- information transfer greater with small number of complex decisions: decision complexity advantage.
- keyboard is faster than morse code.

Speed-accuracy tradeoff:
- when we try to do things quicker, then we become less accurate
- however, in many cases speed and accuracy are *positively* correlated
- because both correlate with task difficulty
- tradeoff can occur as a result of user strategy

4 types of position control devices:
- direct control of position (eg touchscreen)
- indirect control of position (eg mouse, trackball)
- indirect control of speed (eg joystick: spring brings stick back to resting position, sometimes no movement (pressure sensitive stick))
- voice control

Continuous control and tracking

Closed loop control: negative feedback; operator tries to minimize error.

Gain = Δ output / Δ input

Change of position of control device changes: position (0^{th} order), speed (1^{st} order), acceleration (2^{nd} order).

Closed loop control may become instable because of time delay, too large gain or too large input bandwidth.

Open-loop control: operator does not correct based on the error; advanced knowledge and experience with the system; experienced pilot does not constantly check the instruments during landing.

Stress and workload

- Environmental factors
- Psychological factors
- Fatigue, sleep disruption

Effects:

- Experience: frustration, arousal…
- Physiological: heart rate, hormones…
- Information processing often impaired
- Long term health consequences

(slides doornemen)

Lecture 7

Models of thinking:

Normative: the ideal standard to reach goals

Descriptive: how people normally think

Prescriptive: how we should improve our thinking

Rational thinking helps people the best in achieving their goals. Considered the best kind of thinking.

There is not one best way of rational thinking.

Rationality not always leads to good outcomes. Rational = invariance.

We do not always think rationally, influenced by"
- recent experiences
- the way information is presented
- intuition
- comparison with others

Dual-process thinking:

Two different reasoning systems: 1. Heuristic (intuitive) system 2. Analytical system

A cognitive bias is a systematic error in judgement.
- systematic deviation from a normative model

A very large number of cognitive biases have been identified. Researches develop prescriptive models, in order to de-bias peoples reasoning and get it closer to normative models.

Representativeness heuristic: considering how much the hypothesis resembles available data as opposed to estimating the probability.

Availability heuristic: the probability of an event is evaluated by the ease with which it come to mind. Frequent events are easier to recall or imagine than infrequent ones. (example with the “K’s”)

It is useful to remember important events.

Types of decision making:

- Decision making under certainty
    - The decision maker knows with certainty the consequences of every alternative
- Decision making under uncertainty
    - The decision maker knows the probabilities of the various outcomes (risk)
    - The decision maker does not know the probabilities of the various outcomes

Decision under uncertainty: Expected value:

EV = value of payoff * probability

People’s value of money is not linear, so Expected utility theory was introduced.

Decision making based not on monetary values, but based on utility values. Utility = usefulness (good/goodness). Not only wealth, but also our attitudes.

People can be risk avoiders (utility), risk seekers (monetary) or risk neutral.

Entire risk profile cannot be captured with a single number, utility has no meaning to most people.

Famous alternative theory: the prospect theory

- The preferences do not depend on overall wealth and attitudes only
- Preferences are reference dependent (gains and losses), just like perception.

“we have an irrational tendency to be less willing to gamble with profits than with losses.”

Risk aversion with profits and risk seeking with losses:

People have an aversion towards losses.

Framing negative outcomes as costs rather than losses improves subjective feelings.

Prospect theory: risky prospects can be framed different, as gains or as losses.

Changing the description of a prospect should not change decisions, but it does, in a way predicted by Prospect Theory.

Bayes theorem: takes prior probabilities into account; interpretation of the test results should always be considered in a certain context.

Summary:

Models of thinking: normative, descriptive, prescriptive

Rationality not always accurate and irrational thinking not always leads to errors

Dual processing is an explanation for irrational thinking: heuristic and analytical system.

Two main theories of decisions under uncertainty:

- Expected utility theory: decisions not on monetary values but also incorporates our attitude toward risk
- Prospect theory: preferences are reference dependent. Decisions influenced by e.g. framing.

Bayes theorem: Taking prior probabilities into account.