MMI

Lecture Content Overview

Basics of Cognitive Science
- Human Information Processing
- Perception

Formative Design and Evaluation of human computer interaction
- Methods & tools for design

Summative Evaluation of HCI
- Basics of Human studies & statistics for studies

Best practice in HCI
- Concepts, models, guidelines, methods

Multidisciplinary challenge:
Computer science + Psychology + Sociology + Anthropology + creativity in design + Industry

Designer need to know about:
people (Sociology, antropology, psychology, culture, ..)
technology (SW, systems, electronics, communications, materials, databases, ..)
activities & contexts (communities of practice, information systems, organization, knowledge management ..)
design (Fashion, interior, information design, architecture, product design)

Process of creativity usually involves multiple iterations
- problem & solution evolve over time of design

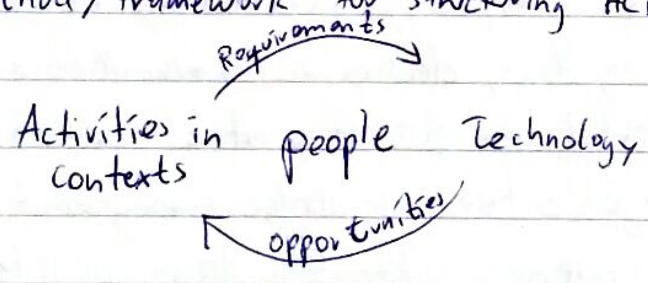
Usability Heuristic: Nielsen's heuristic for UI-Design

UI:
Input: tell the machine what to do, need for navigation, enter data
Output: provide feedback of what is happening, display content

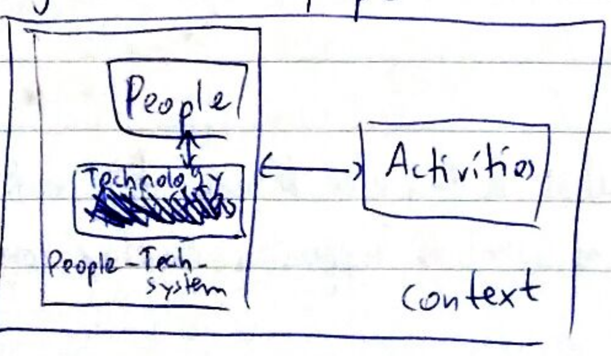
UI Aspects:
physical: buttons, keys, ...
perceptual: visible things, displays, ...
conceptual: mappings
logical: input and/or output

Human-centered approach to designing interactive systems:
think about what people want to do rather than about what the technology can do
design new ways to connect people
involve people in the design process
design for diversity /inclusion

PACT (People, Activities, Contexts, Technology)
leads to Design, than to evaluation
People do activities in a context using technology, an method/framework for structuring HCI design



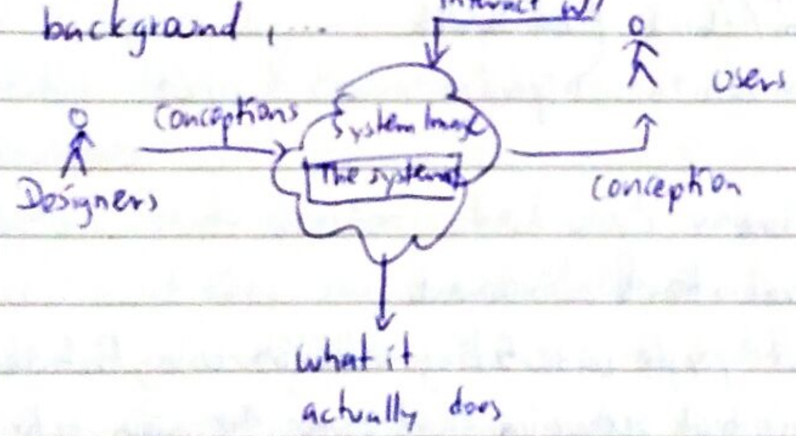
Activities + Contexts -> Requirements for technologies
Technology offers opportunities to people
Designers try to design technologies within some domain
Design influence people's activities



People use technology to fulfil an activity within a context

People are different from each other
physically: height, weight, ...
psychologically: different ways of thinking, attention resources, mental models, perception, memory
usage: Experts vs. novices

Mental models ≈ conceptual models
describe the ways in which we think about things - about how we conceptualize things
Goal: provide a clear mental model
people should develop a clear mental model, but that depends on ~~what~~ what they already know (experience), background, ...



Mental Models
fill in the details that people don't tell you

Characteristics of different activities
- temporal (timing, frequency) can we be interrupted? Refinding place
- Co-operation & complexity
- safety critical (what if something goes wrong?)
- content (what information/media are we dealing w/?)

PACT

for knowing about people & activities

characteristics of an activity:

Regular / infrequent, peaks / throughs / interruptible, Response time, co-operation, vague / well-defined, Safety-critical, errors, data requirement, media, ...

Context

- can glue activities together
  - social context?
  - organizational context (power structure / change in life style)

HW / SW to consider:

input / output / communication / content

stream / chunks — bandwidth, speed

Scenarios

good for evaluation & envisionment

stories about people undertaking activities using tech in a context

develop conceptual scenarios that cover the main activities that the tech has to support

develop concrete versions of these for specific designs of the tech

"Pete logs onto the computer" - conceptual

"Pete clicks the login-icon" - concrete

Personas

archetypical person in the domain, synthsized from knowledge of real people in the domain

have typical goals, hard characteristics (age, interest, name ...)

abstract form of a story

good approach for design

2 Observation

by studying a human

Formative: @ beginning to inform about context and to study possible options

Summative: to judge on the impacts of a HCI design
- can be a formative evaluation for the next step in design

Role of studies & evaluation:

Requirements gathering, ethnographic understanding, acquiring the PACT scope, identifying specific problems / performance values in a specific HCI design, acquiring overall usability metrics

Iterative design & evaluation is a continuous process that examines:

Why?: study question, check user's requirements and if they can use it & like it

What?: a conceptual model → early prototypes → complete prototypes → human behavior

Where?: in natural & laboratory settings

When?: formative, throughout design / summative, after design

Measures: Effectivity / Efficiency / Satisfaction

Effectivity	Efficiency	Satisfaction
% tasks completed	Time	Voluntary use of system
% users completed tasks		Frequency of re-using
% tasks completed @ first attempt		Ease of learning
% tasks completed after long non-use		

Types of evaluation:

1. Setting

Controlled setting: conditions are controlled
non-controllable conditions are measured

Natural setting study in every day - and natural conditions
some, but not all, uncontrollable conditions are measured

2. Evaluation Time

Inspective: while run of an experiment /use
Retrospective: after use / experiment
short term: short session
long term: long session

3. Evaluation Partner

User: (subject) best for new-experience
gives direct feedback for use
Expert: allows for best-practice information
may require many users to collect experience

4. Result type

Subjective: can't be directly compared between subjects
Objective: can be ″ (using statistics)
Quantitative: results are numbers
Qualitative: ″ ″ text

Data Gathering: Interview

1. setting goals (how to analyze collected data)
2. identify participants (who to gather data from)
3. Relationship w/ participants (be professional, consent)
4. Triangulation (more than one perspective, qualitative & quant.)
5. Pilot studies (small trial of main study)

Interviews can be structured / semi-structured / unstructured
order of questions plays a role
have different questionnaires for different population
clear instructions
no long questionnaires / jargon / compound sentences
pick a scale (example: Lickert's) / language
make free-questions: let the subject answer something you haven't thought about

Lickert's scale: 5-points: strongly agree O, agree O, neutral O, disagree O, strongly disagree O

contextual factors influence the subject's attitude
don't influence the participant w/ your attitude
don't make him say what you want to hear

Introduction -> Warm-up -> main part -> cool-off - Closure
Warm-up: easy questions; main part: logical order; cool-off: easy questions; Closure: kthxbye
Purpose of interview must be clear, promise anomymity

Standard questionnaires:
SUS: quick & dirty usability measurement, subjective
covers aspects: Effectivity / Efficiency / Stistaction
Lickert scale, useful in small sample sizes,
Validity ok. Score: 0-100
positive / negative questions alternating
sum up -> over 68: good

User Observation

Not all tasks are easy to grasp by interviews
- difficulty of the task
- undescribable things
- telling how ≠ doing it (you might obstrue the subject)

Your role is important: insider / outsider
How to handle privacy, sensitive topics vs. taking photos
When to stop

Ethnography

experience participant and it's context
Ethnographers immerse themselves in the culture they study
analyzing videos is time intensive + make notes of incidents
cooperation of people being observed is required, use informants
continuous data analysis, questions get refined as understanding grows, reports usually contain examples

Online - Ethnography (Netnography)

differs from face-to-face, different results
Direct observation: Think-aloud (subjective, qualitative)
Indirect " : Diaries, user-logs, web analytics

Field Studies

Living labs: evaluate people's daily use of interactive systems in a made-up daily environment that is a lab

Ubicomp studies

field study, result includes measurements of the context
more expensive, but might find novel insight

Ubicomp normally also requires:
control conditions / pre-studies
calculation of # participants and selection thereof
data selection & statistics

3 main types:
1. Studies of current behavior (what they do now)
2. proof-of-concept
3. Experience studies (how does the prototyp change things or allow new things?)

Results of 1: better understanding of current use
Implications for future technology
2: Validation of new technology
3: Experiences w/ " "

Questions for 1: open-ended
2: Give out technology [sic!]
Question for certain properties
3: Experience over a longer period of time

Witzard-of-Oz studies
Person controls system from behind the scenes
good for simulating a system, that would be difficult to build

Experience studies
Surveys
often used as prestudy
carried out after change of condition in a between-subject study

Logging use mobile devices to collect data select appropriate data to log, make questions that should be answered after observation beforehand

Web analytics

optimizing web usage by measuring, collecting, analyzing & reporting web data

ESM (Experience Sampling Method)

a study method using questionnaires

fill out a questionnaire periodically over the day

schedule is freely to be chosen (annoying vs precision)

human as a sensor

Diaries

Like ESM, but subject may freely chose, when to make an entry (collect data)

Study Design & Evaluation

Start w/ a concrete question that should be answered (clear goal!)

what data will you collect?

how long will the study take?

What will your participants do during study? (they need advices)

create a study design document containing

research question / hypothesis

detailed participant profile

method description

timeline " (minutes - weeks) understanding & comparing

Types of data to collect (qualitative & quantitative)

Analysis method

How to draw conclusion / validate hypothesis

Evaluation methods

	Controlled settings	Natural settings	w/o users
Observing	X	X	
Asking users	X	X	
Asking experts		X	X
Testing	X		
Modeling			X

Things to consider when interpreting data
Reliability: does the method produce the same results on separate occasions
Validity: does the method measure what is intended to be measured?
Internal validity (certainty that you know the cause)
External validity (result can be generalized)
Ecological validity: does the environment of the evaluation distort the results? => is the result transferable into a general environment?
Biases: Are there biases that distort the result?
Scope: How generalizable are the results?

Evaluation & design go along hand in hand
Some data-gathering methods are used for establishing requirements & identification of user's needs
Evaluations can be done in controllable laboratories or in the field, or where users are not present
Usability testing or experiments are widely controllable
evaluations typically impose little control

Human Memory

- Memory
  - ~~[illegible]~~ ?
  - Working Memory
    - Think aloud, ESM
  - Long term memory
    - declarative (explicit)
      Facts & events
      - episodic
        Experiences, events, their contexts
        Decreases w/ age
        Diary, Intervies asking for recall of situation
      - Cognitive maps
      - Semantic
        Facts, meaning, concepts
        stays (or improves) w/ age
        Questionnaires asking for facts
    - Procedural (implicit)
      Motor skillz
      logging

Participants

Selecting participants

1. Representation of participants to the intended user group
2. grouping of participants (representative vs. non-rep. set)
3. data sampling strategy

Groups can be made by

- self-reported expertise
- frequency of use
- amount of experience
- Demographics (gender, age, location, ...)
- Activities

Sampling strategy

random / systematic / stratified / samples of convenience

equal prob. every 10th meet given merit in the end volunteer based

# of evaluators: Nielsen: 5

Cockton & Woolrych: depends on context & nature of problem

Validity depends on the strength of big numbers

Sample size depends on acceptable error

major problems can be identified by 3-4 persons

early stage design (formative evaluation) requires less participants

Perform a pre-test: participants have to detect known usability issues

calculate avg. percentage p of found usability issues over all n participants: $1-(1-p)^n$

=> percentage of found issues in average

assumption unknown issues are as easy to find as the known ones

Within subject

one subject w/ multiple tasks, results are compared between this participant

between subject

multiple subjects w/ same task. results are compared in between the subjects, user groups can be "

Test order

participants learn quickly, the test order may have a significant impact on the results

if tasks are related: re-schedule them for each participant

Sometimes (if dependencies occur) it is not possible

Evaluation w/o user

Aims: describe key concepts associated w/ inspection methods

explain how to do heuristic evaluation and walkthroughs

" the role of analytics in "

Inspection: experts use their knowledge of users & technology

expert critiques can be formal / informal

heuristic evaluation is a review guided by a set of heuristics

Walkthroughs involve stepping through a pre-planned scenario noting potential problems

Heuristic evaluation

destilled from 249 usability problems

revised by Nielsen for web, mobile phone, wearables

=> design guidelines:

1. visibility of system's status
2. match between system's status & real world
3. user control & freedom
4. consistency & standards
5. Error prevention (help to recognize, recover, diagnose errors)
6. Recognition rather than recall
7. Flexibility & efficiency of use
8. Aesthetic & minimalistic design
9. help & documentation

Heuristics by Budd:

1. Clarity
2. minimize cognitive load & unnecessary complexity
3. provide users w/ context
4. Promote positive & pleasurable user experience

3 stages of doing heuristic evaluation

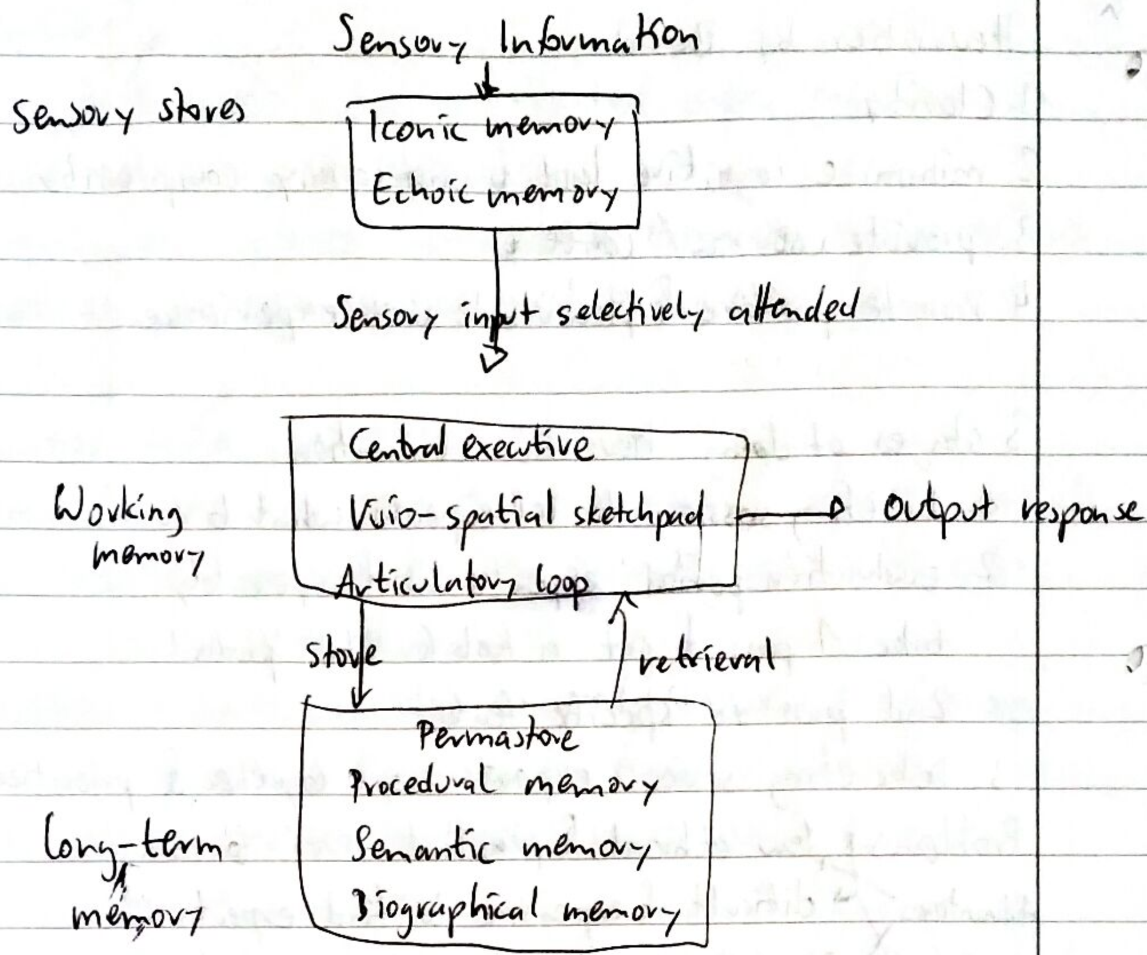
1. briefing session to tell experts what to do
2. evaluation period: experts work seperately
   - take 1 pass to get a feel for the product
   - 2nd pass for specific feature
3. Debriefing session: experts work together & prioritize problems

Problems: few ethical & practical issues to consider
Advantages: difficult & expensive to find experts
Best experts have knowledge of application domain & users
Important problems may get missed
Many trivial problems are identified
Experts have biases

Cognitive Walkthrough

Focus on ease of learning & usage
Designer presents an aspect of the design & usage scenarios
Expert is told the assumptions about user population, context, task, ...
One or more expert(s) walk(s) through the designed prototype
Experts are guided by questions:

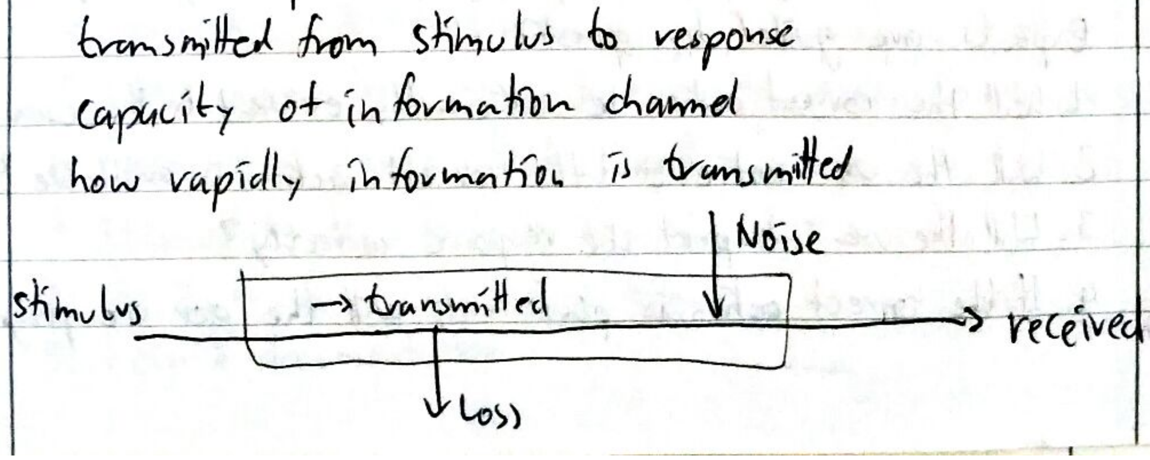
1. Will the correct action be sufficiently evident to the user?
2. Will the user notice that the correct action is available?
3. Will the user interpret the response correctly?
4. If the correct action is performed, will the user see progress?



Short-term sensory storage != short-term-memory
holds information while processing them
fills in blanks if small enough
stores stimuli automatically
echoic memory active while listening
iconic memory to get rid of letters

Perception

Limited capability: of interest how much information is transmitted from stimulus to response
capacity of information channel
how rapidly information is transmitted



psychologic metrics:

heart rate, muscle activity, brain activity

respiration, oxygen uptake, eye-tracking

→ precise, but expensive & difficult to set up

subjects need to be on same (comparable) psychologic level

→ conditioning by baseline-phase, relaxing

→ interaction-phase (recording measurements)

→ recovery-phase (until level of baseline)

popular workload metrics:

SWAT / SWORD / WCI/TE / NASA-TLX

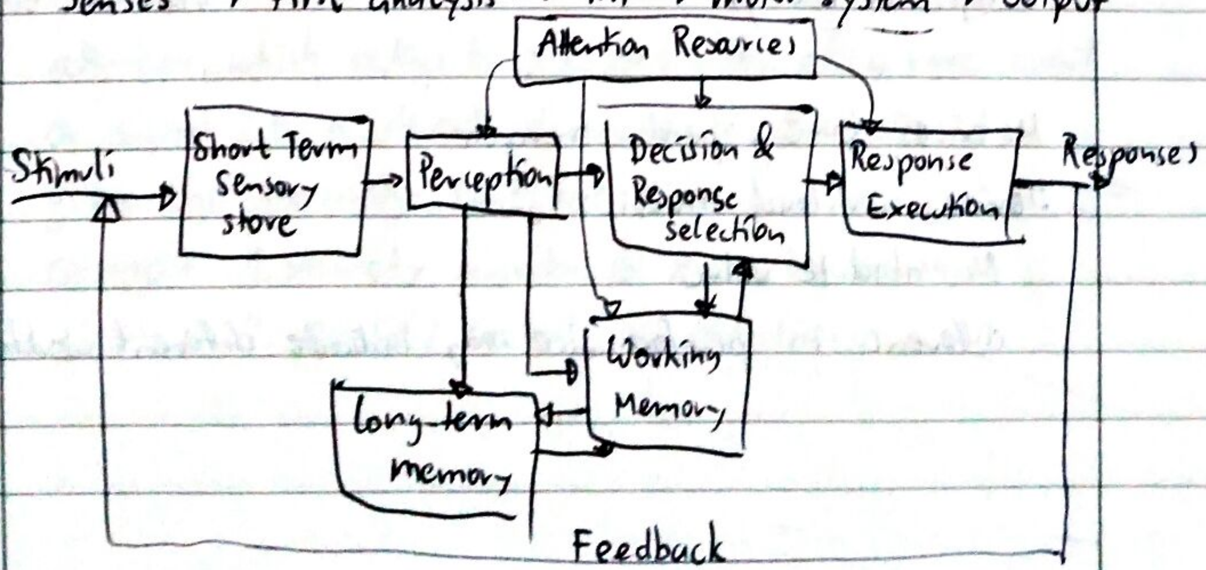
NASA TLX (Task-Load-IndeX)

5 dimensions:

Mental demand	20-scale, increments of 5
Physical "	user has to decide pairwise,
Temporal "	which of the factors was a
Performance	greater contributor to the
Effort	workload
Frustration	

Human Information Processing

Senses → first analysis → HIP → motor system → output



Any negative answer → usability problem

Pluralistic Walkthroug
performed by carefully managed team
begin separated, come to agreement in discussion
next step: participatory design

Workload measurement
Sensitivity; Index must be sensitive to changes in task difficulty or resource demand
Selectivity; Index should not be sensitive to unrelated changes
Diagnosticity: index shows cause of variation
(Un-)obstrusiveness: index should not interfere task
Reliability: index should be reproducible
Bandwidth: index should respond to high-frequency changes in workload

4 primary approaches
primary task: direct
Secondary task: indirect, rhythmic tapping, random numbers, time estimation, reaction time
Physiological correlates
subjective ratings

Metrics: time, speed, strength
Derive workload metrics
No absolute value
difference in performance may indicate different workload

Raw information is given a meaning (called "perception")
fast, automatic
can happen in reaction to stimulus (bottom-up)
or because of expectations due to experiences (top-down)

Attention

cognitive process of selecting aspects of the environment, while ignoring others.
selective attention is driven by willingness } one stimulus source
focused attention is a respond to external events }
divided attention is a simultaneous focus on multiple events
limited resource
controlled attention demands that resource, slow, concious
automatic attention doesn't demand that resource, fast, difficult to modify, unconcious
Attention can be directed to a certain degree and to a certain number of tasks, can be practised
Attention & awareness are closely linked

Vigilence

attention which refers to the detection of a rare event or signal in a desert of inactivity or noise, given the knowledge that the occur
example : 1. security inspector @ X-raying luggage
2. quality control in production

Vigilence Paradigms

1. free-response paradigm:
   a target event occurs @ any time
   non-events aren't defined
   } @ power-plant
2. inspection paradigm:
   events occur @ fairly regular intervals
   some are events, some are non-targets
   } @ production
3. successive vigilance paradigm:
   target stimulus has to be remembered
   successive events have to be compared
   } @ color comparison
4. simultaneous vigilance paradigm:
   all events / stimuli needed for discrimination are present @ same time
   } @ comparing garments
5. sensory vigilance paradigm:
   signals represent changes in the auditory or visual intensity
   } @ changing colors
6. cognitive vigilance paradigm:
   signals represent information: symbolic or alpha-numeric stimuli
   } @ proof-reading

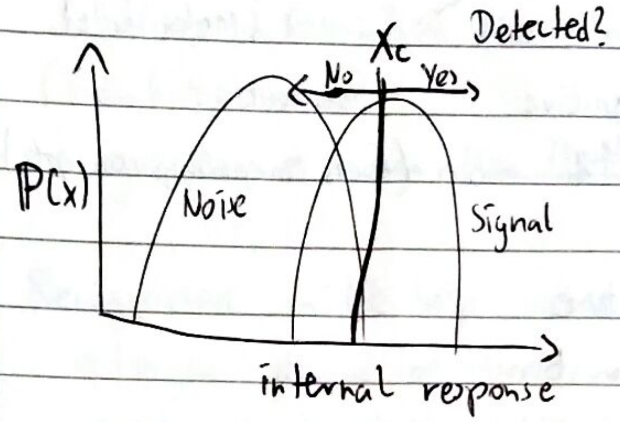
Workload & Measurement

Signal Decision Theory

state of the world

response		Signal	Noise
	Yes	Hit	False Hit
	No	Miss	Correct rejection

Types of noise
internal: in the brain
external: in the data
internal response



Response bias $\beta = \frac{P(X|S)}{P(X|N)}$

decision criterion X_c

optimal beta (bias) should be set, where the $P(X)$ is equal
$\Rightarrow \beta_{opt} = \frac{P(N)}{P(S)}$

humans usually adapt their β not enough
$\Rightarrow$ over-estimation of rare events &
under-estimation of frequent events
Sensitivity is the resolution of the detection mechanism
$\Rightarrow$ separation of the two means of the two distributions

Memory
working memory (≈ short term memory) & long-term memory
memory processes: recall, recognition, chunking, rehearsal
LTM (long-term memory)
"unlimited" capacity, slow access (~100ms)
smell is best trigger (flashback)
episodic - serial memory of events
procedural → knowledge of how to do things
semantic → structured memory of facts, concepts, skills

- Memory
  - ...
  - Working memory
  - LTM
    - declarative
      - Episodic (Experiences & events)
      - Cognitive Maps →
      - Semantic (facts, meaning, concepts)
    - procedural (Motor skillz)

Semantic memory structure
- provides access to information
- represents relationships between bits of information
- supports interference

Semantic network
- inheritance like Java classes
- relationships bits of information explicitely
- supports inference through inheritance

Forgetting
- decay : information is slowly lost
- interference
  - retroactive: new information replaces old
  - proactive: old may interfere w/ new
  - affected by emotion, unconsously choosing to forget
- Encoding → storing information
- Retrieval → recovering memories from LTM
- Forgetting → failure to recover
- Recall (Erinnerung) → active search in memory
- Recognition (Wiedererkennung) → passive search & matching received information w/ desired information, quicker

Rehearsal
no direct link from perception to LTM
process of repeating information in working memory
brings information from short-term recall to LTM
Chunking
grouping information into more meaningful units

Recognition might help remembering information over a longer period of time (recognition over recall !!)
use icons: understandable, familiar, unambiguous, memorable, informative, few, distinct, attractive, légible, compact, coherent, extensible (this is a checklist for good icons)

Memory Design Guidelines:
M1: Organize information into small # chunks
M2: Create short linear sequence of tasks
M3: Use persistance, don't flash important information for short time
M4: Don't overwrite the content of the working memory
M5: Organize data to match user's expectations (format phone nos)
M6: Provide reminders or warnings of state of operation
M7: Provide ongoin feedback of what is or has happened
M8: UI should behave in consistent way
M9: Terminology, icons & use of colors should be consistent

Guideline ≙ specific, practical rules to solve problems (of UI design, ...)
Principle ≙ help for analyzing & comparin design alternatives
Theories & Models ≙ describe objects and actions w/ consistent terminology & give a comprehensive explanation of connections

Decision Making

Bellen Hunde? Ja, geht schnell die Antwort zu finden aufgrund von Assoziation

Atmen Hunde? Ja, dauert aber länger, die Antwort zu finden, da keine Assoziation der Begriffe gängig ist.

=> semantic coding

w/o memory, there is no thinking or decision making

After perception of stimulus, decision has to be made

automatic decision: fast, little or no attention required, learned reflexes or behavior

Controlled decision: slower, requires attention, conscious, interaction with working memory (WM) & LTM

Response & Feedback

Decision has been made -> motors form complex signals into actions in physical environment

feedback-loop: observation of consequences of our actions

circular model

CMN - Model: 3 interactive systems in our brain: Perceptual, cognitive, motor

running parallel, having different capacity, timings

Perceptual processor: sensory inputs -> code information symbolically -> output into audio & visual image storage (WM)

Cognitive processor: input from sensory buffers, access LTM for determining response, output response to WM

Motor Processor: input response from WM, carry out response

HIP Parameters
based on empirical data
cycle time T
storage capacity μ
decay rate δ
info code type K
T(perception) ≈ 100ms
T(cognition) ≈ 70ms } total time ≈ 240ms
T(motor) ≈ 70ms

Visual image store μ ≈ 17 letters visual, 5 letters audio
storage capacity working memory μ ≈ 3 chunks if unexpected,
≈ 7 chunks else
Decay time δ(perception) = 200ms visual, 1500ms audio
Decay time δ(working memory) = 7 sec for 3 chunks
≈ 73 sec for 1 chunk
info code type K ≙ physical (intensity, color, curvature, length)

Power Law of practice:
task time on th nth trial follows a power law
$T_n = T_1 n^{-a}$ $a \approx 0.4$ ⇒ you get faster, the more times you do it
⇒ developing skillz

Perception
Eye
Memory & experience make up the cognitive image
Presbyopia: natural process
Visual perception ≙ process of extracting information w/ meaning from sensory information. Concerned w/ recognition & understanding

Vision

is an easier process concerned w/ detecting color, shapes or edges of objects. Does not necessairily require an understanding of the surrounding

Gestalt Laws:

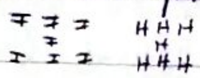
proximity: objects that are close (spatial or temporal) tend to be perceived together, "Common Fate"

closure (Prägnanz): seperate unknow figures into known ones , we tend to see things as complete objects even though it is not visually sensored

Continuity: We tend to see smooth, continuous patterns instead of disrupt, disjoint patterns

Similarity: Similar figures tend to group together

Part-whole-relationship: Same parts, different whole



The area principle: Objects with small area tend to be seen as the figure, not the ground (smallness principle)

Suroundedness principle: An area that is surrounded will be seen as the figure and the surrounding figure as the ground

Stimulus intensity: we first react to the intensity of a stimulus and then to the meaning

Proportion: Proportions can be used to represent logical hierachies

Golden Ration $\frac{a+b}{a} = a/b \Rightarrow a = 0{,}618 \quad b = 0{,}382$

Fibonacci, both seen as asthetic

Screen Complexity $C = -N \sum_{n=1}^{m} p_n \log(2)\, p_n$

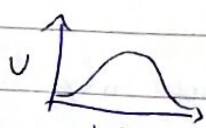
$C \hat{=}$ complexity of the system bits $N \hat{=}$ # of events

$m \hat{=}$ # of event classes $p_n \hat{=} P$(occurence of n)

To calculate the measure of complexity for a particular screen, do this:

1. place a rectangle around every screen element
2. count # of elements & # of columns
3. count # of elements & # of rows

lowering above numbers reduce complexity
Original formular is for text only
Complexity vs usability:
overly simple & overly complex designs have poor usability



complexity decreases ⇒ predictability increases
⇒ harder to differentiate screen objects
⇒ fewer ways to group objects
complexity increases ⇒ screen looks artificially irregular
⇒ could occur from increased utility

HIP: Depth Perception
3D vision enabled through position of eyes
primary depth cues: retinal disparity
stereopsis (process of combining two images to one 3D image)
accommendation (muscle process to change focus)
Convergence (moving eyes inwards to focus)
Secondary depth cues: information gathering from 2D screens
Cues: shadowing, adding texture, size, motion parallax, overlap

Usability Goals
Easy to use

Design Principles
Simplicity: simple things require little effort and can often be accomplished w/o much thought. If interaction designs are guided by the principle of simplicity, they will be easier to use

Project Guideline
Dialog Boxes: show only basic functions & provide "more options" button

Colors
RGB additive color mixing (Displays)
CYM subtractive color mixing (Printing)
Blue can be perceived worst, don't use it for small objects/Text
Edges are faster perceived than colors
Distinguishing colors is related to the size of an object
Green is perceived best (middle of spectrum)
Colors can cause emotions, leading to divided attention
Use colors for clarification, relation, differentiation
support finding of spots
help to remember valid values (for example)
can improve recall, search-and-locate-tasks, decision judgement → overall performance
Does not replace a good structure
Different people (cultural background) may perceive different colors differently well
Targets may be highly diverse colored from their surrounding

Western color conventions

red : Danger, fire, hot

yellow: caution, slow, test

green: Go, okay, clear, vegetation, safety

blue: water, cold, sky, calm

warm colors: Action, response required, proximity

cool colors: status, background information, distance

greys, white & blue: Neutrality

color perception varies over day

avoid incompatible / ineffective coloring

~5 colors is okay, avoid more @ same time

Hearing

Loudness expressed in Bel (deci-bel, dB)

logarithmic scale, +3 dB ⇒ double loudness

frequency band varies between 20 - 20000 Hz

Auditory Perception

1. Transduction : sound vibrations → neural impulses
2. Auditory grouping: Segregation into streams, integration into coherent (harmonic) streams
3. scene analysis
4. interpretation

Vision & hearing go together

cover different areas around human, vision is directed, audition not and can tell the eyes where to look

sounds can get habituated and are being ignored

audio is processed faster, but sounds are transitory

Speech
we speak faster than we write
spoken content may contain more redundancy
requires knowledge of language
we can read faster than we can listen
=> often more efficient, reading can jump

Non-Speech
Auditory feedback
beyond simple forms, sounds need to be learned
can be annoying / ambiguous

Use of sound
redundant "click" sound when pressing a button
can be used for emotions
can help recalling an action through additional assotiation
can be reacted to quickly => more efficiently
people w/ ~~[illegible]~~ deficits may benefit from sounds
most important: positive / negative feedback

Design analysis
Physical Models
Fitt's Law
Predicting efficiency based on the physical aspects of design
Calculates time it takes to perform actions
Index of Difficulty (ID) ≙ difficulty of a task based on width / height & distance to object

Movement Time (MT) ≙ time to complete task based on ID + empirically derived parameters

Index of Performance ≙ Throughput (TP)

$$MT = a + b \underbrace{\log_2(2A/W)}_{ID}$$

improvement: $MT = a + b \log_2((A/W)+1)$

A = Amplitude, distance from starting point

W = Width or height (smaller one, or the approached side)

a has unit seconds (can be negative)

b has unit seconds/bits

ID has unit bits

In case of mouse as pointing device: a = 50ms, b = 150ms/bit

For precision pointing tasks:

$PPMT = a + b \log_2((A/W)+1) + c \log_2(d/W)$

c is another constant, dependent on user context

d ≙ distance between hand location & spot where the user first touched the screen

Object width ratios of 3+ aren't useful

Hick's law

Time T needed to make a decision (e.g. a selection) is proportional logarithmic to # alternatives given

H is the information-theoretic entropy of a decision

$T = a + b H$

n alternatives of equal propability $H = \log_2(n+1)$

case unequal propabilities:

$$H = \sum p_i \log_2((1/p_i)+1)$$

$T = a + b \log_2(n+1)$ assumptions: no learning effect, no linear search, equal propabilities

Power Law of practice

$Time = BN^{-\alpha}$

N = Trial no.

B, α : constants

assumption: no disturbance & no decay effect

Mental Models

unsharp basic understanding of what is going on

a method for prediction & explanation of things

unscientific, based on guesswork

partial: only describe simplified parts of the system

unstable: evolve, change, adapt overtime

inconsistent: may be conflicting w/ parts of the system

personal: individual-specific

Mapping can be used to foster understanding and building a correct model => increase usability

Major principles of design:

Mapping (to a form / to provide overview)

Constraints (to guide / support affordance)

Example: Error prevention guidelines

Exploit natural mappings

between intentions & possible actions

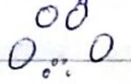
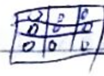
between actions & their effects

between system state & needs

between intentions & expectations

Interface should include good mappings that show the relationship between stages

correlation between control element & action
good mapping is understandable, consistent, recognizable, quickly learnable, natural

Cooking plates:  Buttons 

Constraints

lead human to build correct mental model & minimize chance to make errors
physical constraints: dial vs buttons
semantic " : assumption that creates something meaningful
cultural " : borders provided by cultural convention, e.g traffic signs, colors, ...
logical " : restrictions due to reasoning

Affordance Concept

refers to the perceived and actual properties of the thing
=> match perceived & actual properties
make usable properties visible
use natural associations
give feedback
imply the usage through Gestalt

Finding usability Problems by evaluating mapping correctness
Execution / Evaluation Action Cycle (EEAC)

Goals
We begin w/ some idea what we want to happen
↙ ↖
Execution Evaluation
↓ ↑ => compare w/ goals
World / action

Goal
Messages should be recorded

Concept: Forming action: delete old msgs
Usage: Specifying action: press delete button
Access to function: Executing action: look for button & press it

Evaluating: new msgs can be recorded
Interpreting: no more msgs
Perceiving world state: counter is 0

World

Problems: not enough knowledge about concept, usage, access to function
comparing goal & state
interpretation of state
perception of state

Check, how easy it is to determine function, what actions are possible, mapping from intention to physical movement, performing action, determine wether system is in desired state, mapping from system state to interpretation

Difference between allowed actions & intentions ≙ Gulf of Execution
The Gulf of Evaluation reflects the amount of effort needed to interpret the state of the system & how well this can be compared to the intentions

Good Design:
Stage & alternatives are always visible
consistent system image
show mappings between stages
provide continuous feedback

Critical points / failures

Inadequate goal formed by the user

user does not find the correct interface / interaction object

" may not be able to specify / execute desired action

Inappropriate / mismatching feedback

Task Analysis

understanding people & how they carry out their work

part of human centered design

looking, which set of methods people use

calculate, how long it takes to reach goal

=> studying, how work is achieved by tasks

Task ≙ set of actions (ordered) to achieve a goal

goal ≙ state of system that is desired, can be specified @ different levels of abstraction

A task is a structured set of activities required, used or believed to be necessary to achieve a goal. It uses technology

Broken into sub tasks (lower abstraction). May require selection among alternatives

Action ≙ task which has no problem solving association

has no control structure

varying for different people

Technologies have pros and cons, needs to be selected before tasks can be defined, selection should base on available knowledge

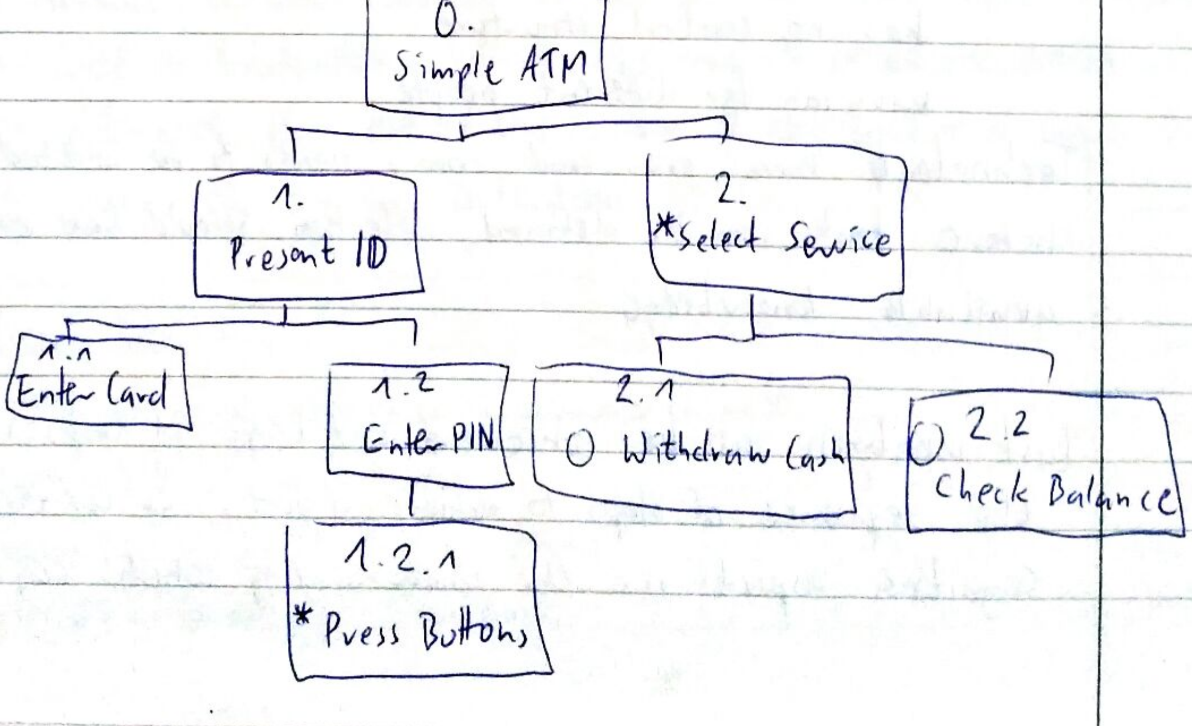
Task analysis can be concerned w/ logic of tasks, i.e the sequence of steps to achieve a goal, or w/ the cognitive aspects i.e. the understanding which cog-

nitive Processes the work-system will have to undertake
to achieve a goal
Cognition: thinking, solving problems, learning, memory → HIP
& representations of things that people are assumed to have
in their heads: mental models

4 Dimensions of task analysis
1. notation
2. usability of communication
3. usability of modelling-tasks
4. adaptability to new types of systems, aims & requirements

Task analysis as part of system's development
during analysis of technology, current way of doing things
understanding essentials
design, especially cognitive load minimization
evaluation

Hierarchical task analysis (HTA)
graphical representation of task structure



GOMS

Goals, Operators, Methods, Selection Rules
Cognitive load - focused task analysis
hierarchy of goals & sub-goals
define goals & refine them in "lower" GOMS descriptions
Goals ≙ whatever user would state a goal is for him
Operators ≙ actions to complete a task
Methods ≙ (subgoals) sequence of actions
Selections ≙ rules for choosing appropriate Method

GOAL: GET-MONEY
↳ GOAL: USE-ATM
↳ Insert card
enter pin
select "get cash"
enter amount
collect money (outer goal satisfied, design to lose your card!)
collect card

KLM (Keyboard Level Modelling)

Input: A task (and its subtasks, if any)
Command language of a system
Motor skill parameter of user
Response time parameters
Output: Prediction of time it will take to execute the task
Assumption: No errors occur

The KLM is comprised of
Operators (Key, Pointing, Home hands, Drawing, Mental preperation, Response awaiting)

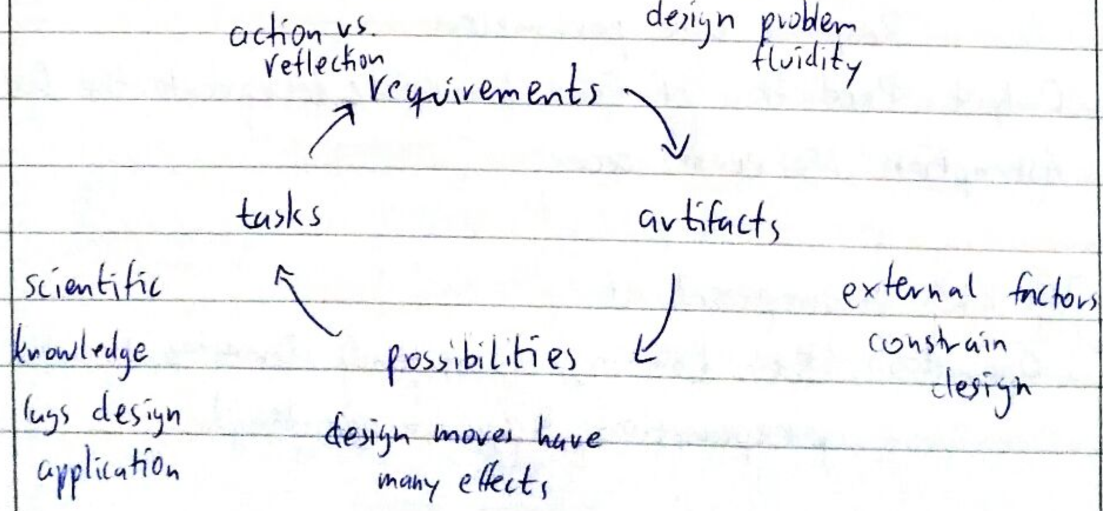
Encoding methods
Heuristics, when to place M - operators

K ≙ 0,2 s
P ≙ 1,1 s
H ≙ 0,4 s
M ≙ 1,35 s
R ≙ needs to be measured

Design

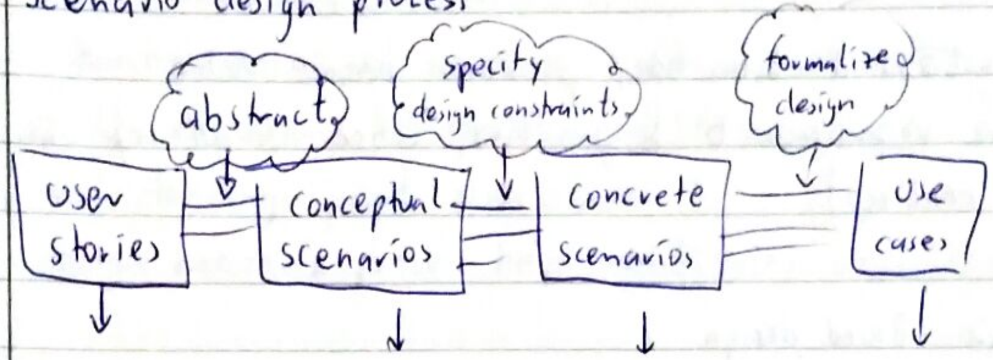
Scenarios are a foundation for the design of interactive systems, they help w/ understanding current practices, help identifying existing problems, help documenting and managing as well as strengthen communication w/ stakeholders

scenario engineering involves
1. requirements work
2. prototyping
3. envisionment
4. evaluation
5. conceptual design
6. physical design



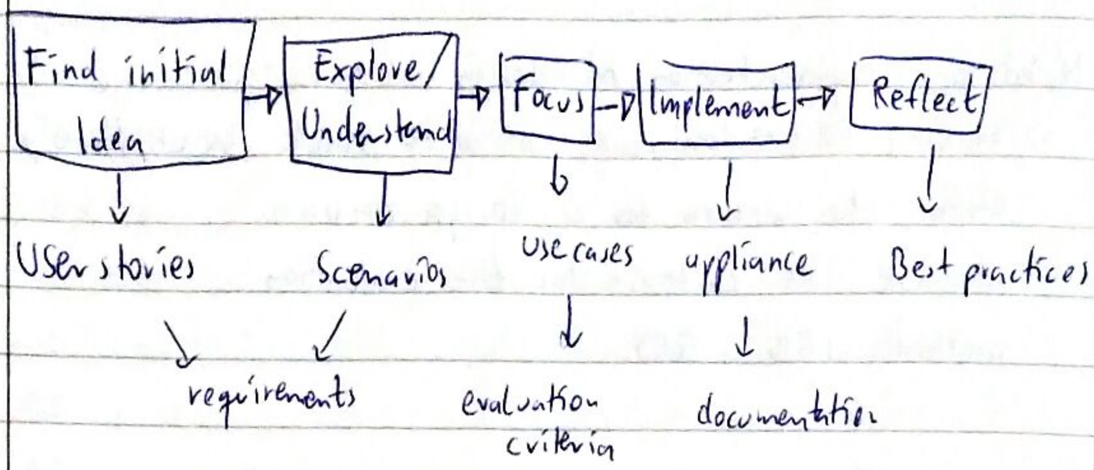
Need for documentation of design issues
=> making the underlying rationale visible by explicitely stating the reason for a design decision
also note the criteria for the evaluation
methods: IBIS, QOS

Scenario design process



- **user stories:** use for understanding what people do and what they want (ideas, anecdotes, knowledge of people, real-world experiences, activities, context) used to identify problems, stakeholders and their constraints
- **conceptual scenarios:** use for generating ideas & specifying requirements (abstract from user stories, combination of some) do not include technology and don't provide how functions are implemented
- **concrete scenarios:** use for prototyping ideas & evaluation (derived & generated from conceptual scenarios, can be many, suggest UI design, good for prototyping)
- **use cases:** use for documentation & implementation (describes interaction between human & system, can be result from concrete scenario, covers slight variations, sum of use cases form system design

Documentation (as in SWT-2)
needs information on authorship, description, history, cross-references, rationale, data



By analisys & abstraction, problems become visible
derive requirements & priorities (since not all req. can be realized)

Scenario - Based design
Goal: representative set of scenarios
should cover a wide range of user stories of mixed granularity
Conceptual Model / Design
Object or data model
includes scenarios & their analysis
main objects, attributes & relationships among them
ensures an accurate mental model of the system
⇒ examples of mental models (Metaphors)
Design language
may be in place before concrete design application
Interaction patterns include:
physical attributes
adds conceptional actions & objects
key elements of the design
principles and rules

common languages reduce # elements for the involved designers

Requirements ("something a system must do / should have")
" analysis means understanding
- what people do & want to do
- problems w/ existing systems
- how people want to interact
Goal: better interactive systems
requirement work is the transformation of observation & information
not always easy to elicit
iterative process on: analysis -> design -> evaluation
result: requirements specification (formal, precise!)
good starting point: user stories
design rationale process helps identifying requirements

functional Requirements
: what the system must do
non-functional:
a quality that the system must have
the "how" things are done

} don't specify technology

Priorization
MoSoCoW
"Must have": without them: operation unable
"Should have": essential, but operation is possible without them
"Can have": eases a few functions, but neglectable
"Want have": do it, if time allows
recommended: use requirements template
Requirements Activity:
gathering: pick up obvious requirements pros: easy, quick
cons: unstructured, incomplete

generation: create requirements through creativity
pro: may cover more aspects cons: not user-centered
elicitation: collect requirements from user pro: user-designer collaboration
cons: limited by user creativity
engineering: suggest a formal approach pros: goal oriented
cons: too early formalized, kills creativity

Techniques:
interview, observation, documentation, focus-groups, workshops
↘ ↓ ↙
artefacts
⇒ additional insights
most tasks require artifacts to complete

Envisionment
making ideas visible by externaliting thoughts,
goal is to represent design work to the designers & stakeholders
↳ stories, scenarios, presentation, sketches, formal models, sw/hw prototypes, mockups...
fundamental to user-centered design, enables designers to see things from other people's perspective & to communicate ideas to people
generation, communication & evaluation of ideas
not all representations are suitable for all setups

Exploring Design Concepts
interaction design ≙ design for human use
~~leading~~ guiding questions:
how do you do it? (handles vs. buttons)
how do you perceive things? (hot media vs. cool media)
how do you know? (paths vs. maps)

Scenarios in envisionment

Scenarios in their most concrete form can be used to envision or evaluate specific interactions

concrete scenarios -> prototype -> envisionment scenarios

complement scenarios w/ some of the most visual envisioning techniques

include real data & material to allow direct involvement

think hard about underlying assumptions

include characterizations & personas -> talking about characters

provide rich contextual background

Produced scenarios should cover

- interactions which are typical for a number of situations
- important design issues (for the focus of design purpose)
- areas where requirements are unclear
- any safety-critical aspects

Issues w/ design space

people are only able to comment meaningfully, if they have a concrete representation

this can be achieved by ~~notations~~ notes on the scenario on a blackboard, etc.

often: requirements have to be changed

listing positive & negative features for a concrete design

Scenarios are effective to bring open issues on the surface

Prototyping

effective way for communicating ideas & design

complements / procedes techniques of envisionment

select appropriate method / technology & abstraction level

may be only a partial system

High-Fidelity prototypes (Hi-Fi)
real-feeling brought through simulation environment
used in client-acceptance tests & when ideas are stable
costly, makes people think, that the HiFi Prototype
is the final system

Low Fidelity Prototypes (Lo-Fi)
more focused on the ideas, contents, forms & structures,
key functionality
produced quickly, cheap, thrown away afterwards
often: paper, can be broken during use, doesn't provide
many details -> instructions can be unclear, unless explicitely
told, low flexibility of UI in use
need wizard of Oz, they don't work / live
recording feedback through video
user needs to be instructed, make up scenes
if prototype is too fragile, designers themselves interact
w/ it & let themselves be guided by the user's approach

In general
think of PACT, who is the prototype aimed for, what is the
desired goal to achieve w/ it, product stage, context, technologies..
Realistic prototypes increase user test data validity
but are in case of re-iterating through stages subject
to be thrown away => costly!
Test users might get tired of using the system over & over again
Prototyping is faster & cheaper than re-implementing failures
animate requirements: show sample usage w/ prototypes
rapid prototyping w/ throw away-prototypes
Tools: Animation: Power Point etc.. rapid: flash / web tools etc..
HiFi: 3D printers, clay, wood...

Interface

WIMP (Windows, Icons, Menus, Pointers)

Window Manager are responsible for a common look & feel

need for consistent behavior

Interfaces bring information into physical environment

There are multiple possible interfaces for the same information

They differ in Form, Structure, Content, Description

They may show some information easier, others more difficult

Window arrangement: drag & drop, overlap, cascading, maximized, tiled, tabbed

Human reading process

- jerky movement, 8-10 letters (saccades)
- stops @ interesting spots (fixations)
  - ↳ cognitive process happens here
- 1. distinguish letters or word shapes
- 2. associate meaning

Single letters are better to identify, if they are upper case

long phrases better lower-case

Paper vs screens

- humans often rely on spatial memory (⇒ web-problem)
- Ability to annotate aids comprehension

Text use in interactive design

- for comments, feedback & instructions (help text)

Contextual help: provides help within a given context, that the user does not need to leave (pop-ups, ...)

Procedural help: Instructions for carrying out a task

Reference help: serves as an online reference book

Conceptual help: provides background information, feature overviews & process overviews

Instrumental text ("that does work")
the control's function & its label are seen as an entity
Buttons / Checkboxes / Radio Buttons / Icons / Hyperlinks
Hypertext must give unambiguous information on the target
"Don't make the user think"

Other design issues
Legibility: age, context → size, contrast
Readability: Line Length, spacing, formatting, margins, scrolling
→ affects comprehension!
9pt - 12 pt ≈ equally readable
but depends on reading distance, screen resolution, background contrast, visual capability of user, type of reading (scanning vs. word-by-word)

Line length: longer lines are read quicker
human prefer medium-lengths

Margin width: more margin → more whitespace → ~~...~~ shorter lines → increased reading performance

Vertical line spacing: (called "leading") double spacing has been shown to improve reading performance

left-alignment preferred for lengthy texts
Text should be considered a graphical component of a page

Contrast sensitivity decreases w/ age
Luminance preferred over color contrast (⇒ black/white)

Scrolling vs paging
depends on the application (and its contexts)

Fonts
Serifs guide the reader, good for reading books, bad from distance
Sans-serif good for presentation

Variable width vs. fixed width
Font creation is a science

Information Architecture
structures the presented information
=> influencing the conceptualization of the user
Ontologies define the concept of information
Grouping information is concern of taxonomy
should be presented consitently (using on taxonomy)
even though they can co-exist
Coarse-grained structuring
few steps to reach goal, big menu, one taxomony
Fine-grained
multiple menus, all have an own taxomony
How to build:
Volatility: select an ontology that stays stable
=> don't have to change menu logic
Size: moving in / out of an object preferred? => scrolling vs. pagi
Conceptual / physical: 20 buttons on a mobile phone?
Support all platforms
Topology: determines ease to move through information space
Distance: # clicks needed
Direction: plays a role for navigation

Use only one classification scheme

- Alphabetical
- Chronological
- geographical
- Topic oriented
- Task based
- Audience oriented
- Semantic

Find out, how the user moves through the sites of information
Aim: uncover complexity, reduce it
poor navigation is a good reason for users to stop using a product

Interaction Styles
Command line
no recognition possible, recall only
steep learning curve
repitition of tasks easy
cascading & piping of commands lead to high cognitive load
Menu based Interface
Recognition enabled
Better for seldomly used functions, icons are self-explanatory
Range of possible actions shown, allows user to build a concept of system
Menu types: Single / Sequential / hierarchical / Network / Meshed
Norm Fill-in
Special for gather strings of information
User must know its position in Form & how long it is
varying input formats and errors annoy users
Witards
flow for beginners
"most-used" design flow
present only very restricted information
inappropriate, if multiple control flows exist
Direct Manipulation
representation of objects of interest w/ Metaphors
actions done have immediate effect on the "
user learns w/o loss in information

often used: real-world associations
not always consistent

Touch Interaction
are also a direct manipulation
no mouse mediation

Object-Action / Action-Object-Interaction
Object-Action-Model
The user first selects an object and then selects an action to be performed on the selected object
Action-Object-Model
First select the action, and then the object on which the action will be performed