LMU
LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN
FAKULTÄT FÜR MATHEMATIK, INFORMATIK UND STATISTIK
INSTITUT FÜR INFORMATIK
ARBEITSGRUPPEN MEDIENINFORMATIK UND MENSCH-MASCHINE-INTERAKTION

Human-Computer Interaction 2

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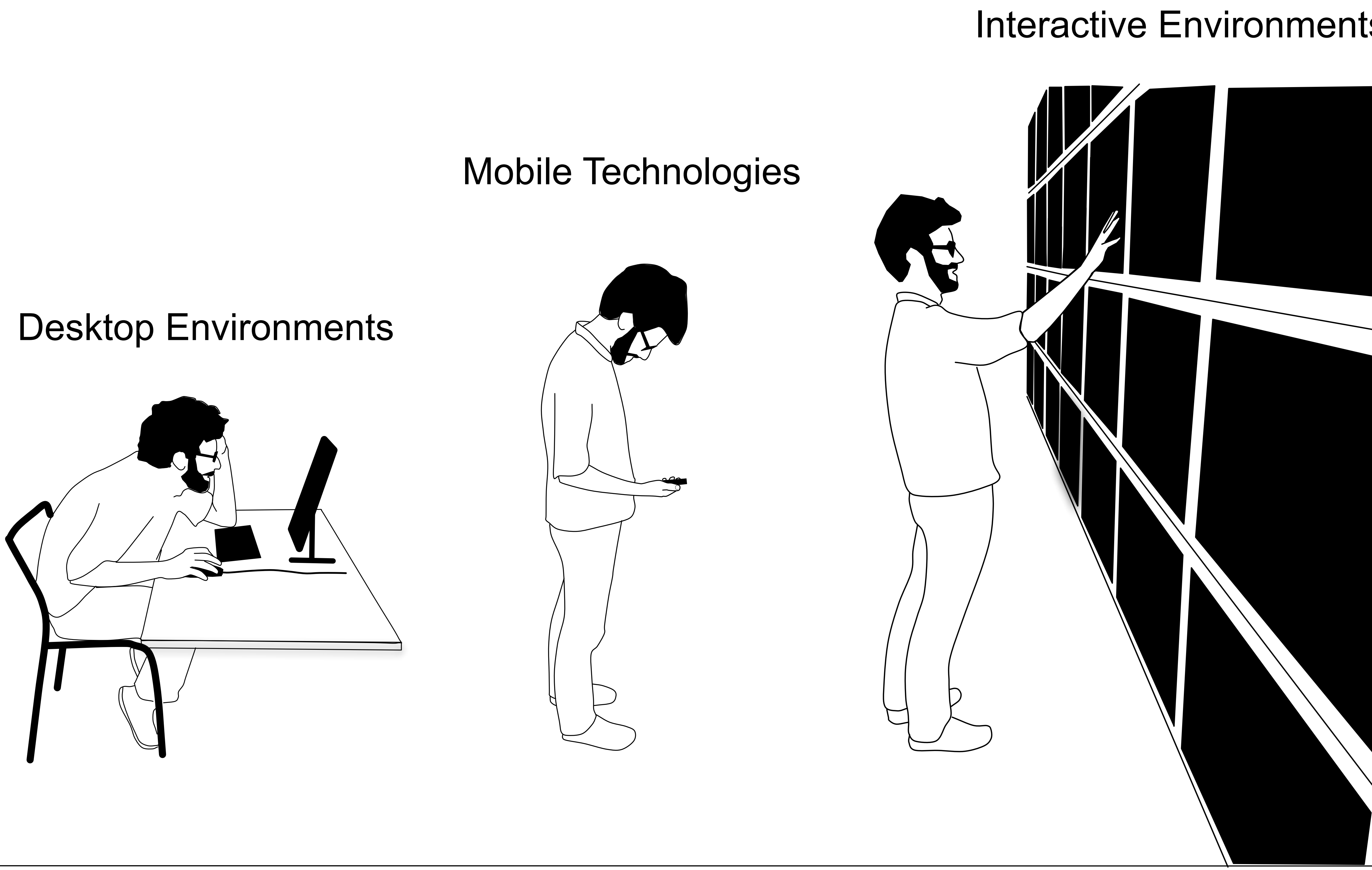
exercises and exam

- Exam: 11.2.2015
- Monday 2:15 PM
  - –room B 106 (LMU main building)
  - –voluntary, meant to prepare you for the exam.
  - –lecture Q&A
  - –collaborative elaboration of solutions

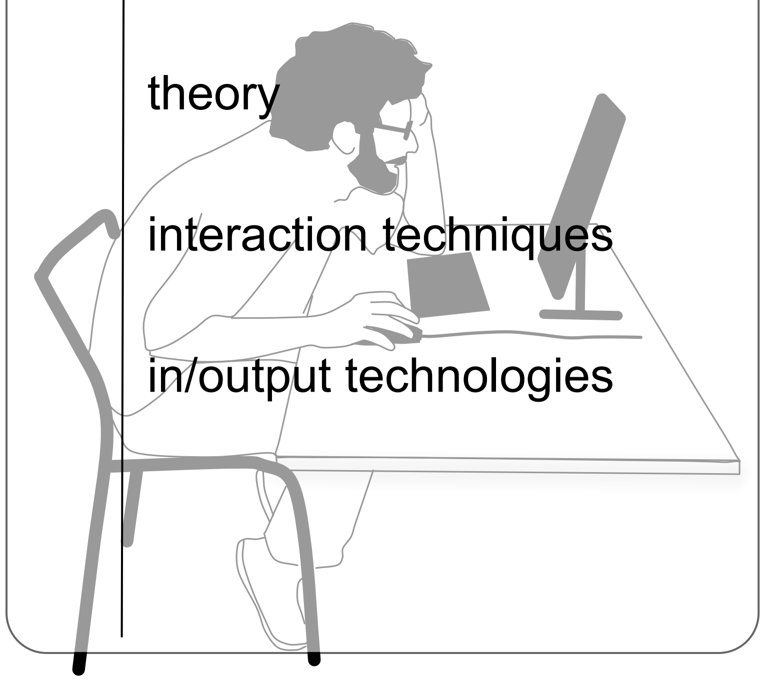
Human-Computer Interaction 2

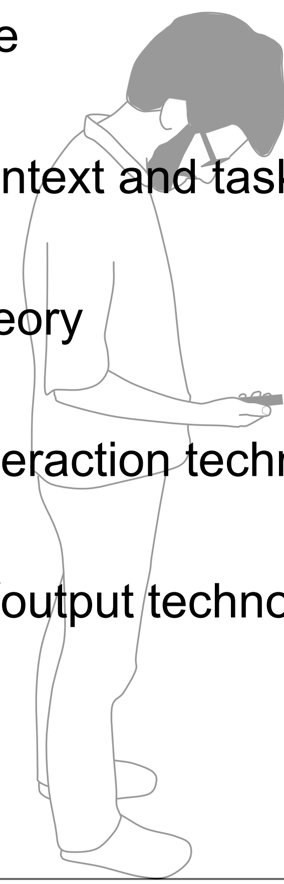


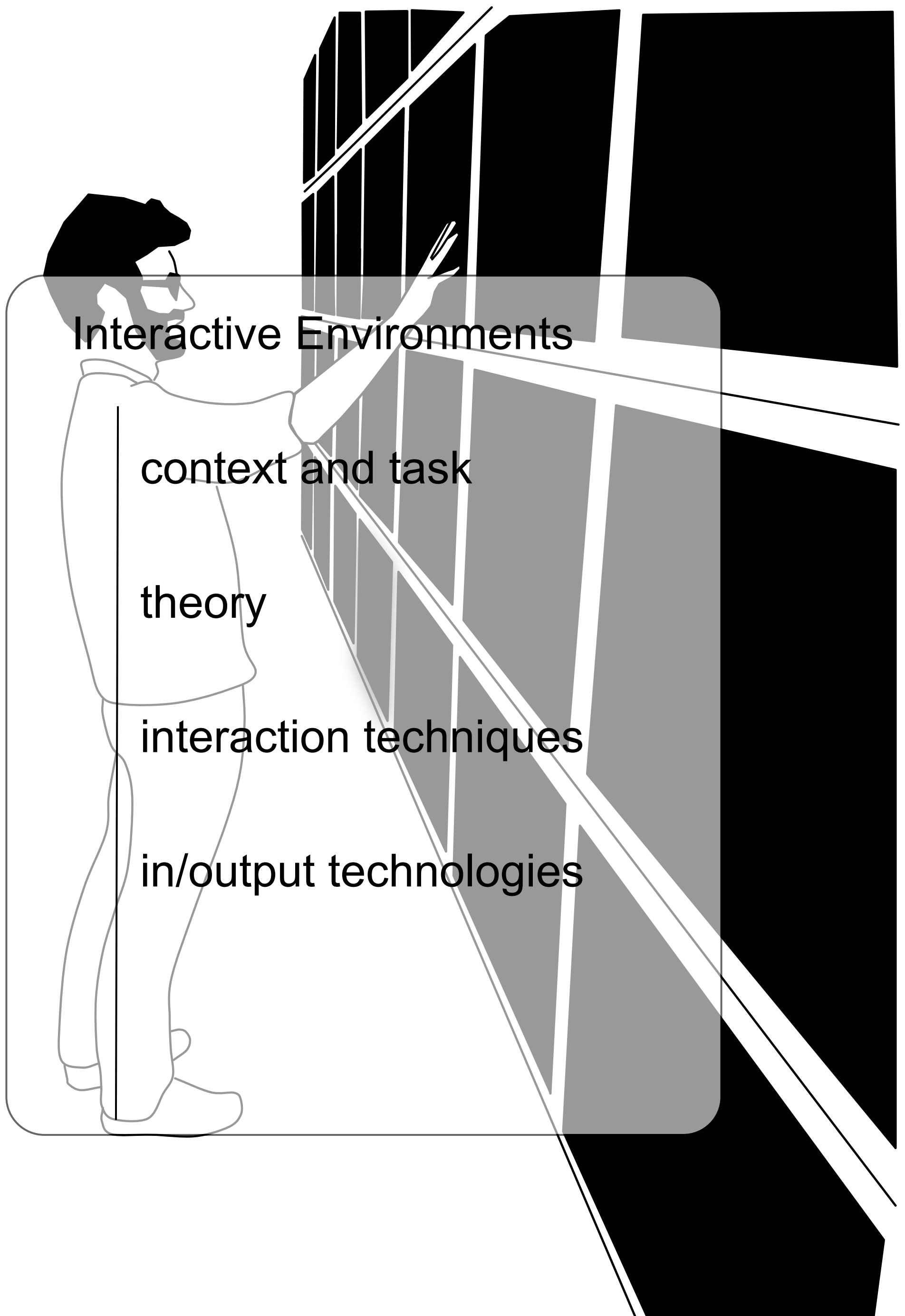
Human-Computer Interaction 2

Interactive Environments

Mobile Technologies







Desktop

Desktop Environments

- context and task
- theory
- interaction techniques
- in/output technologies

Mobile

- context and task
- theory
- interaction techniques
- in/output technologies

Interactive Environments

- context and task
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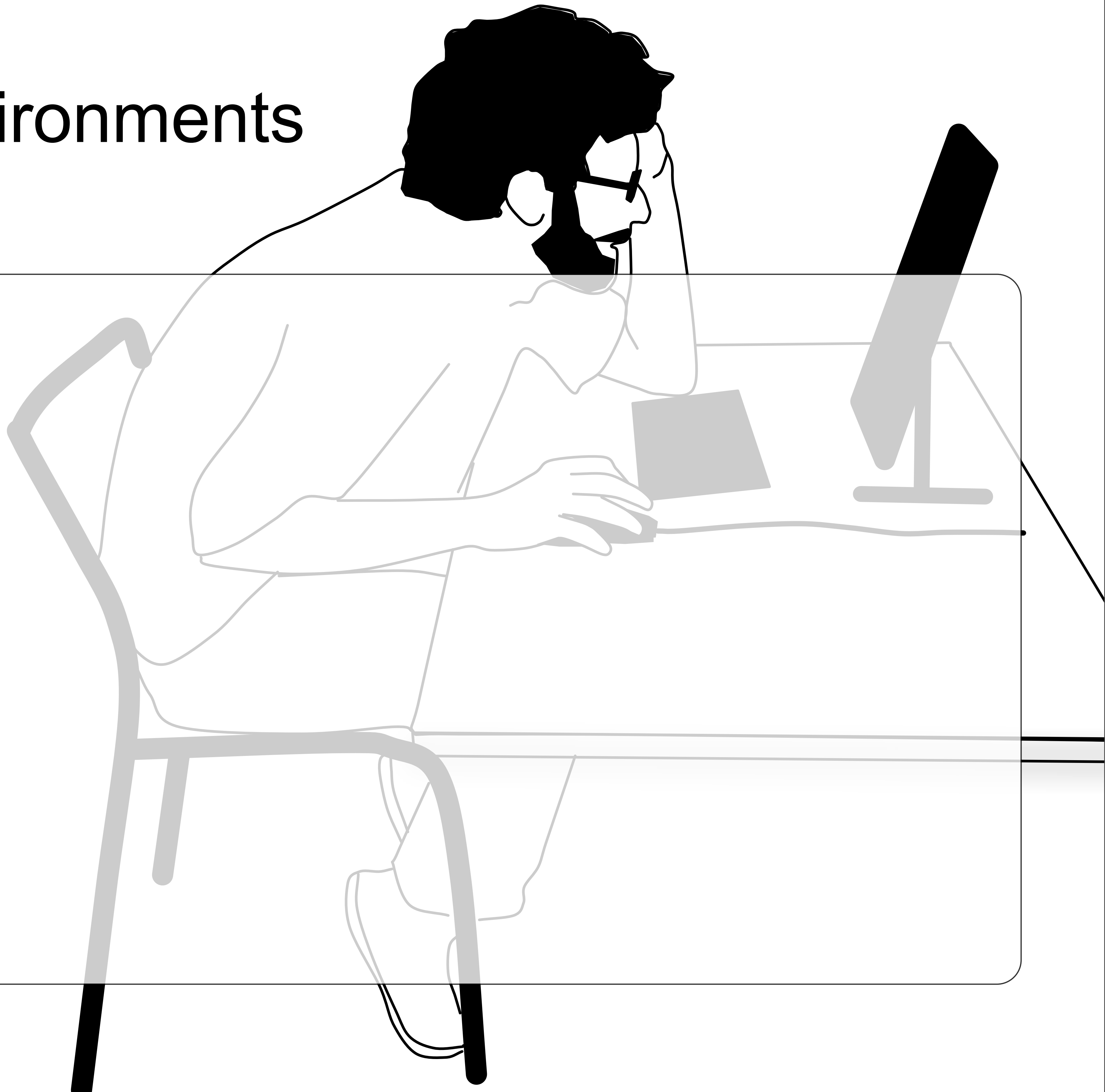
Desktop Environments

context and task

theory

interaction techniques

in/output technologies



context and task

theory

interaction techniques

in/output technologies

- 1973 Xerox PARC’s ‘Alto’
- hardware:
  - bit-mapped display
  - mouse
  - chord-keyboard (like 5 piano keys)
- single person setup, seated

http://www.catb.org/esr/writings/taouu/html/ch02s05.html

http://www.youtube.com/watch?v=zVw86emu-K0

Xerox star 1981, commercial product of ‘Alto’

http://www.catb.org/esr/writings/taouu/html/ch02s05.html

- 1973 Xerox PARC’s ‘Alto’
- hardware:
  - bit-mapped display
  - mouse
  - chord-keyboard (like 5 piano keys)
- single person setup, seated
- GUI features:
  - WYSIWYG
  - sliders, scrollbar
  - windows
  - icons
  - menus
  - pointer

= WIMP

Design Rationale

- Who was it designed for?

context and task

theory

interaction techniques

in/output technologies

http://www.youtube.com/watch?v=zVw86emu-K0

Design Rationale

- Who was it designed for?
- What do they do?
- What is their context?
- Goal:

Design Rationale

- Who was it designed for?
- What do they do?
  - collect information
  - arrange/rearrange information
  - process information
- What is their context?
  - working under pressure, deadlines
  - typing skills
  - no time for learning "complex piece of office equipment"
  - cope with a lot of content
- Goal: optimizing/eliminating time-consuming tasks, deal with information ... not with tools

similar questions

new tasks we want to use computers for

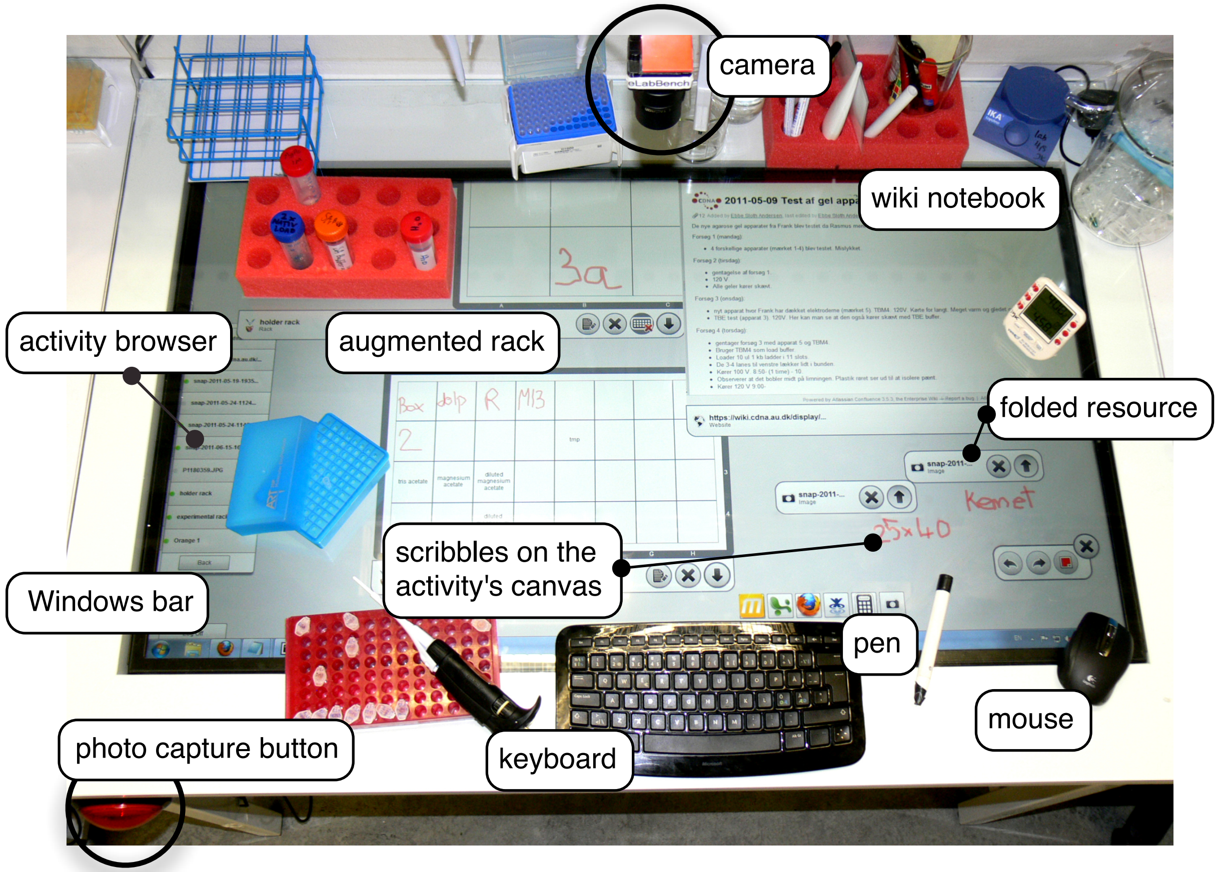
new context we use technology in

Might that be the reason for getting rid of chord keyboard?

Multiple “work places”

- example: biologists
- problem: redundancy in working process

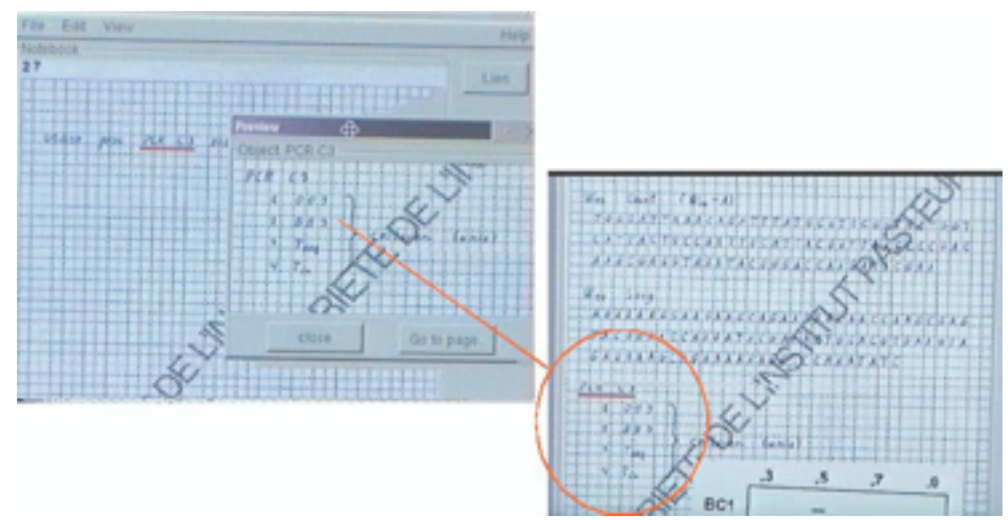
http://www.tabard.fr/publications/elabbench-deployment.pdf



http://www.tabard.fr/publications/elabbench-deployment.pdf

Imposed External Decisions

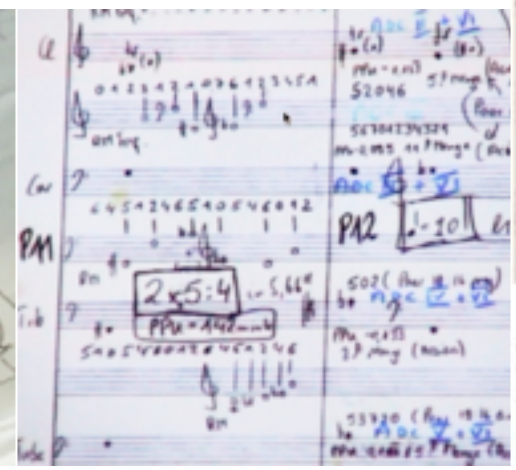
- example: biologists at Institut Pasteur (in Paris)
- problem: multiple media

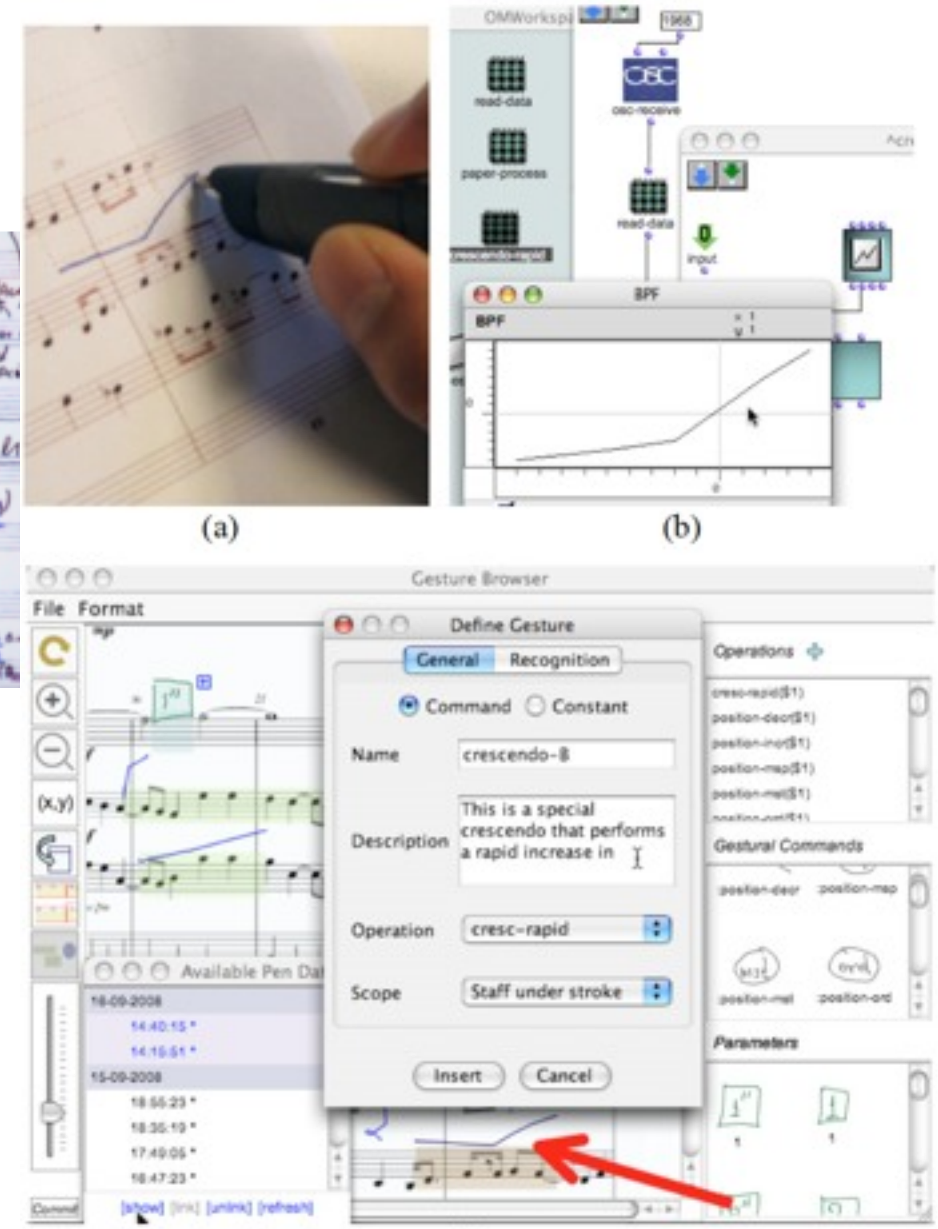


https://www.lri.fr/~mackay/pdffiles/ERCIM.News.pdf

Creative Tasks

- example composer
- problem: express your ideas, support creativity



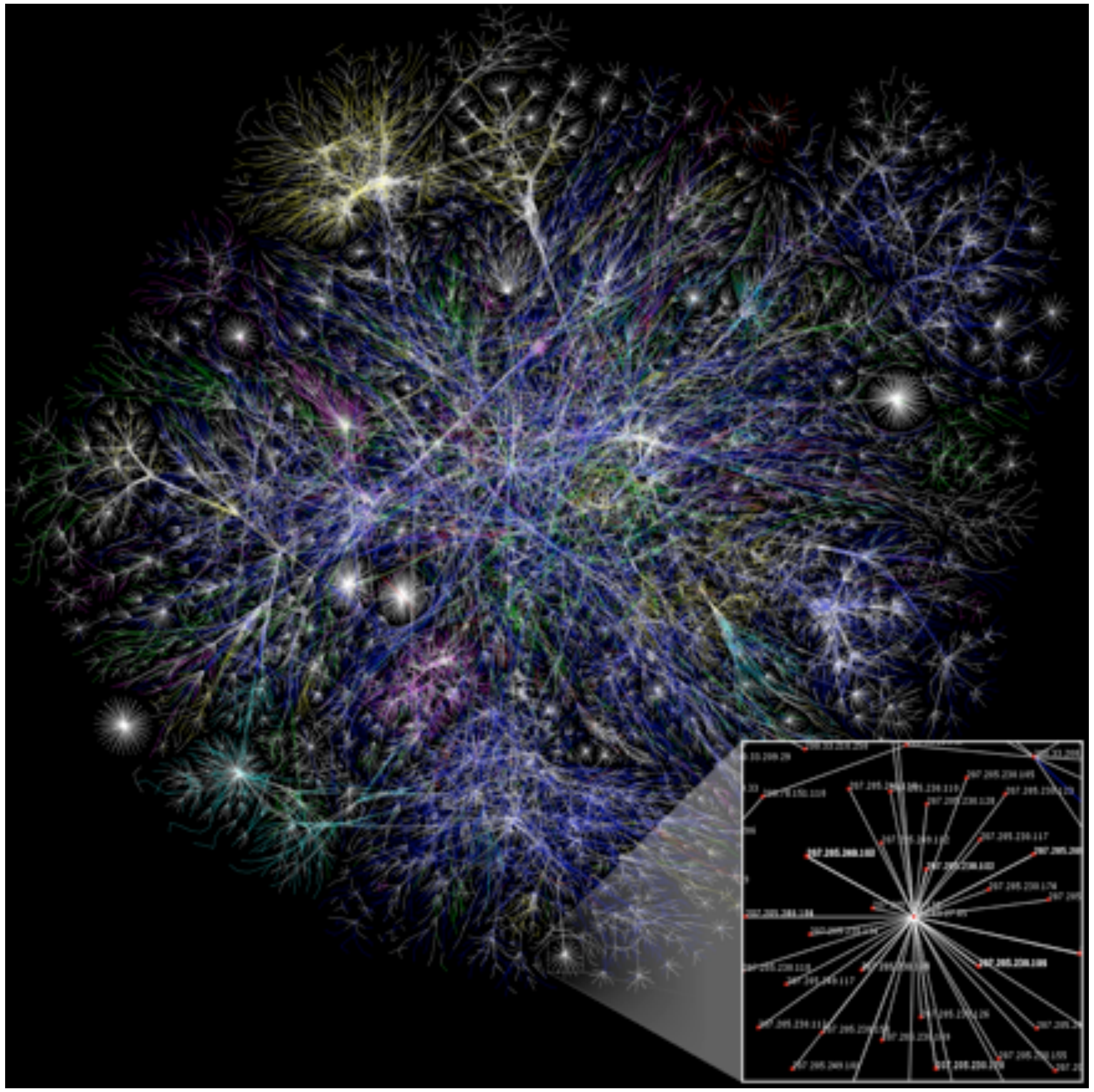


(a) (b) (c)

https://www.lri.fr/~fanis/

Exploration of Large Datasets

- example: researchers
- problem: navigate in large datasets



http://upload.wikimedia.org/wikipedia/commons/d/d2/Internet_map_1024.jpg

Exploration of Large Datasets

- example: collaborative data exploration
- problem: social aspects of interaction

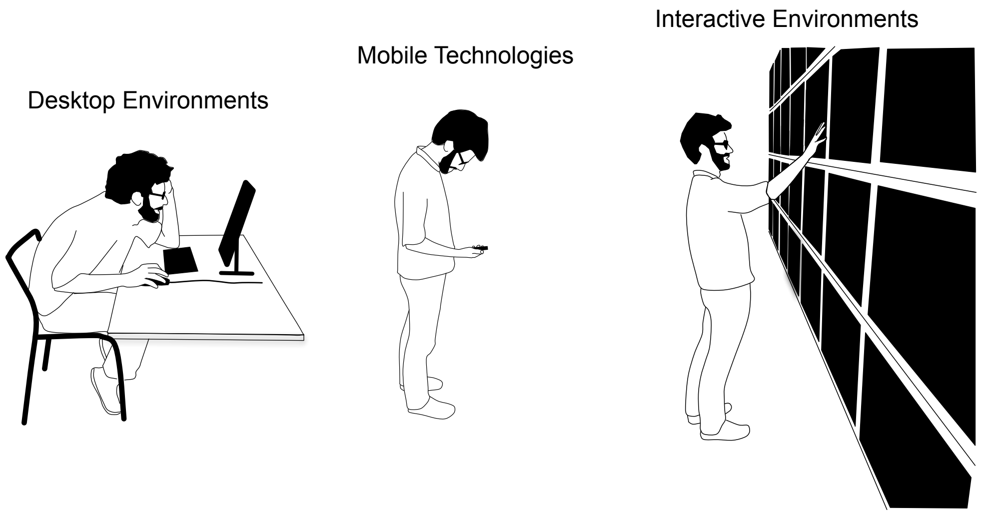
http://insitu.lri.fr/Projects/WILD

Interactive Cognitive Aids in Medicine

http://www.youtube.com/watch?v=UoMHzX36Gmg

Take-away message

- understand complex way of history to understand how we got where we are!
  - technical and economic constraints
  - changes by living with technology
- there is no single setup that can model all human tasks.
  - Let’s push the boundaries in shape, functionality and usage.



Take-away message

- understand complex way of history to understand how we got where we are!
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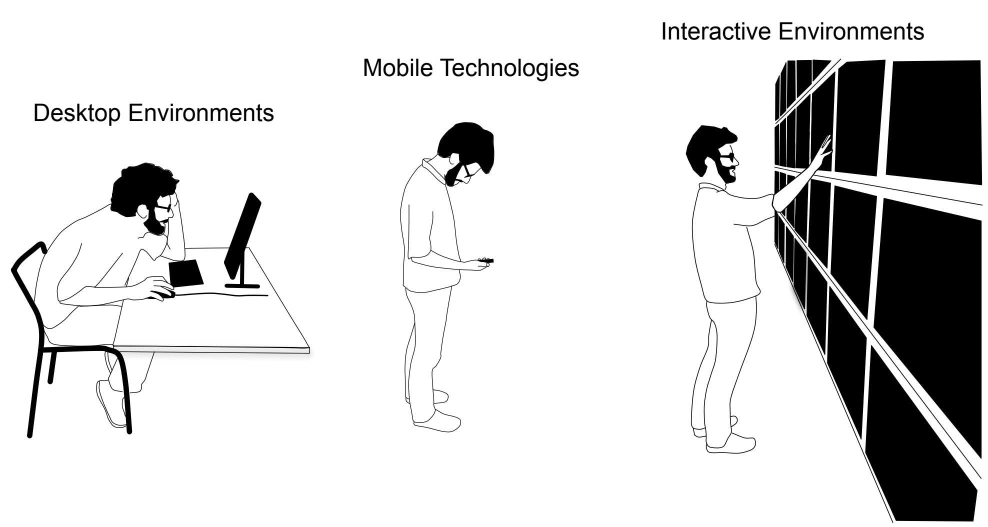
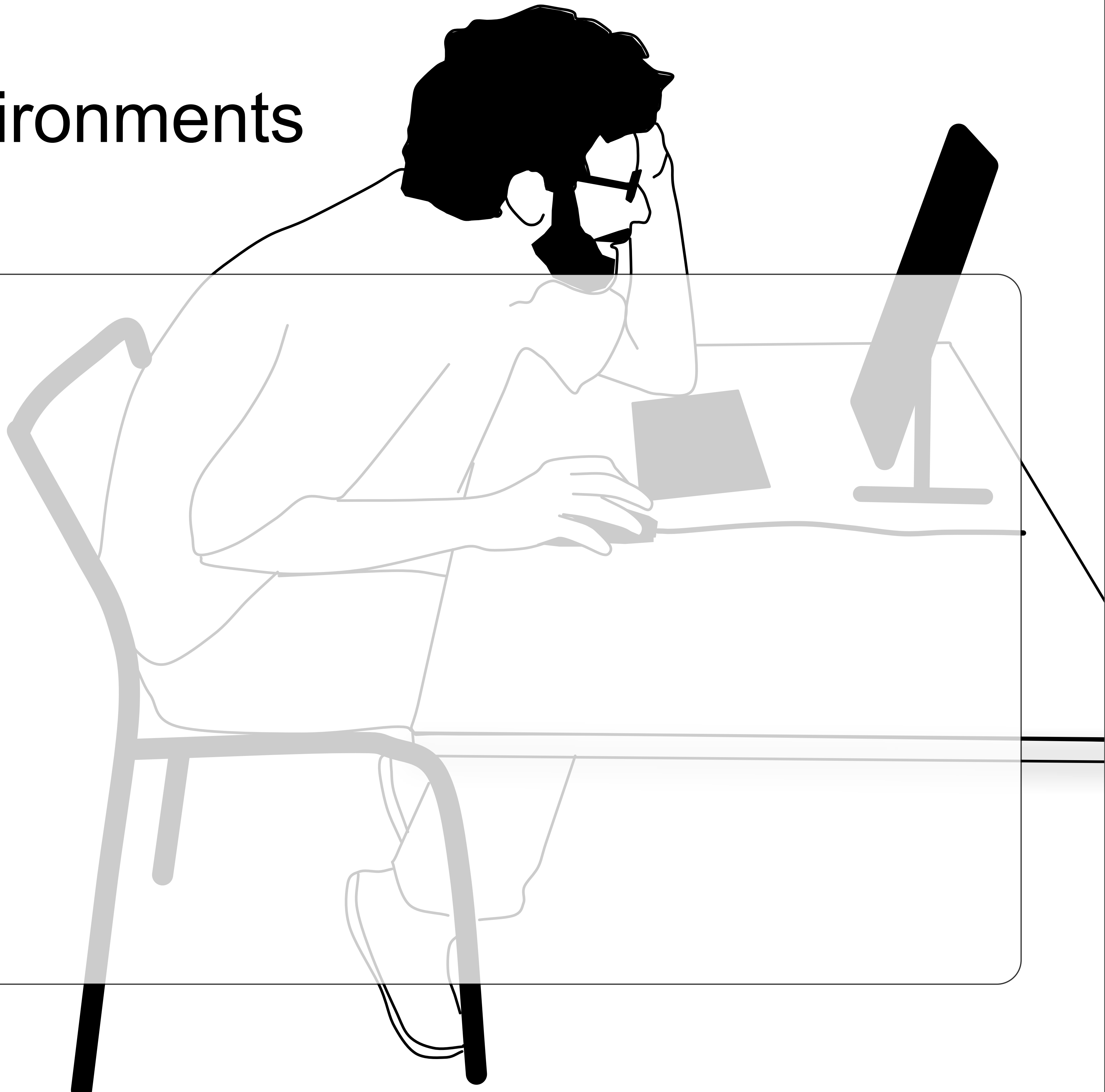
  - changes by living with technology
- there is no single setup that can model all human tasks
  - Let's push the boundaries in shape, functionality and usage.

5 MINUTE MICRO-TASK

Come up with professions and their task that are not well modeled with a desktop setup and might take advantage of other forms or shapes of technology.



Desktop Environments



context and task

theory

interaction techniques

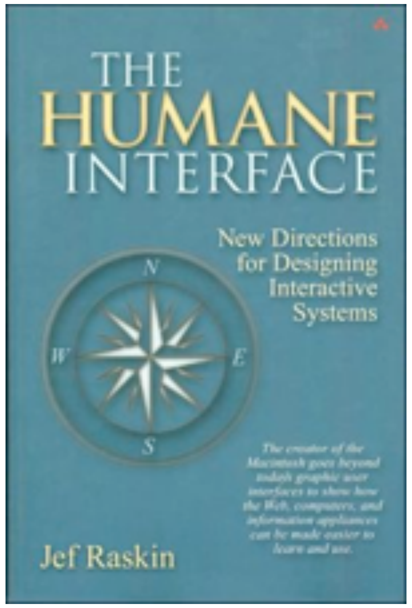
in/output technologies

Overview

- Quantification:
  - GOMS keystroke-level method
- two particular challenges in HCI:
  - predictive model — Predictive Power
    - value and decide between two alternatives.
  - systematic exploration of design alternatives
    - are there more than two alternatives? what are the other alternative? — Generative Power
    - why did I choose these two designs? what are their differences? — Descriptive Power

Jef Raskin

- expands the meaning cognetics: the ergonomics of the mind
- “Imagine if every thursday your shoes exploded if you tie them the usual way. This happens to us all the time with computers and nobody thinks of complaining” (Jef Raskin)



Modes

- source of errors, confusion, unnecessary restrictions and complexity in interfaces
- Gesture: a sequence of human actions completed automatically once set in motion. (Raskin's definition)
  - typist writing "the"
- Combining a sequence of actions into gestures related to the psychological process is called chunking
  - combination of separate items of cognition into a single mental unit
  - dealing with many items as though they were one

Jef Raskin: the humane interface, new directions for designing interactive systems (book)

Modes

- "modes cause problems because they make habitual actions have unexpected effects"(Larry Clark)
- Norman: mode errors as result from inadequate feedback.
- Raskin: provided indicator is not the user's locus of attention!
- Raskin's Definition of Modes:
  - a human-machine interface is modal with respect to a given gesture when (1) the current state of the interface is not the user's locus of attention and (2) the interface will execute one among several different possible responses to the gesture, depending on the system's current state.

Jef Raskin: the humane interface, new directions for designing interactive systems (book)

Modes

- gesture g invokes action a in mode A and action b in B
  - if you are in B, you need to first switch mode to A before g invokes a.
- range of g: a set of states in which the gesture g has a particular interpretation.
  - certain ranges are large: Command↓ x↓
- Raskin: humane interfaces have exactly one range.

Quasi-modes

- modes that vanish after a single use cause fewer errors than do those that persist.
- caps lock vs. holding shift key
  - studies at the university of Toronto confirms holding a key, pressing a foot pedal or any other physical holding action does not induce mode errors (Sellen, Kurtenbach and Buxton 1992)
- quasi-modes, user-maintained mode: modes that are maintained kinesthetically

GOMS Keystroke-Level Model

- GOMS: goals, operators, methods, selection rules.
  - KLM is a simplification of GOMS
- Interface timing: micro-experiments to measure time for elementary tasks.
  - Keying: tapping a key (0.2s)
  - Pointing: pointing time (1.1s)
  - Homing: move between keyboard and mouse (0.4s)
  - Mental preparation for next step (1.35s)
  - Responding
- higher level tasks needs to be dissembled into smaller steps.

Heuristics for Placing Mental Operators

- Rule 0: Initial insertion of Ms in front of all Ks and Ps
  - Insert Ms in front of Ks, Place Ms in front of all Ps that select commands, but do not place Ms in front of any Ps that point to arguments of those commands.
- Rule 1: Deletion of anticipated Ms
  - If an operator following an M is fully anticipated in an operator just previous to that M, then delete that M. For example, if you move the Mouse with the intent of tapping the mouse button when you reach the target of your mouse move, then you delete, by this rule, the M you inserted as a consequence of rule 0. In this case PMK becomes PK
- Rule 2: Deletion of Ms within cognitive units
  - If a string of M Ks belongs to a cognitive unit, then delete all the Ms but the first. A cognitive unit is a contiguous sequence of types characters that from a command name or that is required as an argument to a command

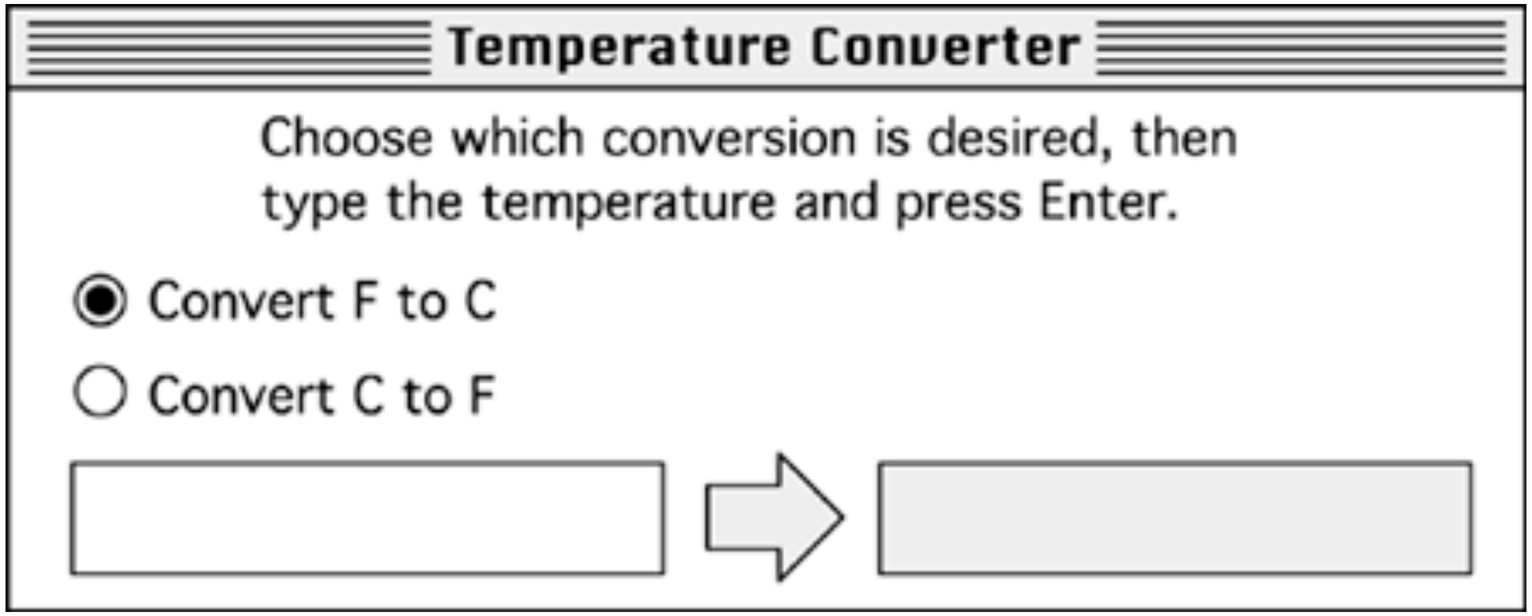
Heuristics for Placing Mental Operators

- Rule 3: Deletion of Ms before consecutive terminators
  - If a K is a redundant delimiter at the end of a cognitive unit, such as the delimiter of a command immediately following the delimiter of its arguments, then delete the M in front of it.
- Rule 4: Deletion of Ms that are terminators of commands
  - If a K is a delimiter that follows a constant string (e.g. a command name or other typed entity that is the same every time that you use it) then delete the M in front of it. (adding delimiter became a habit!) But if the delimiter is any string that can vary, then keep the M.
- Rule 5: Deletion of overlapped Ms
  - Do not count any portion of an M that overlaps an R, a delay with the user waiting for a response from the computer.

Hal's Interface: an example

- Hal works at a computer, typing reports; he is occasionally interrupted by one or another of the researchers in the room, and is asked to convert a temperature reading from degrees Fahrenheit (F) or Celsius (C) to degrees C or F, respectively.
- Hal uses a keyboard or mouse to enter the temperature (no voice or other input means available).
- output must appear on display (no other means)
- assume an avg. of 4 types characters in an entered temperature.
- -> minimize time it takes to do the conversion.

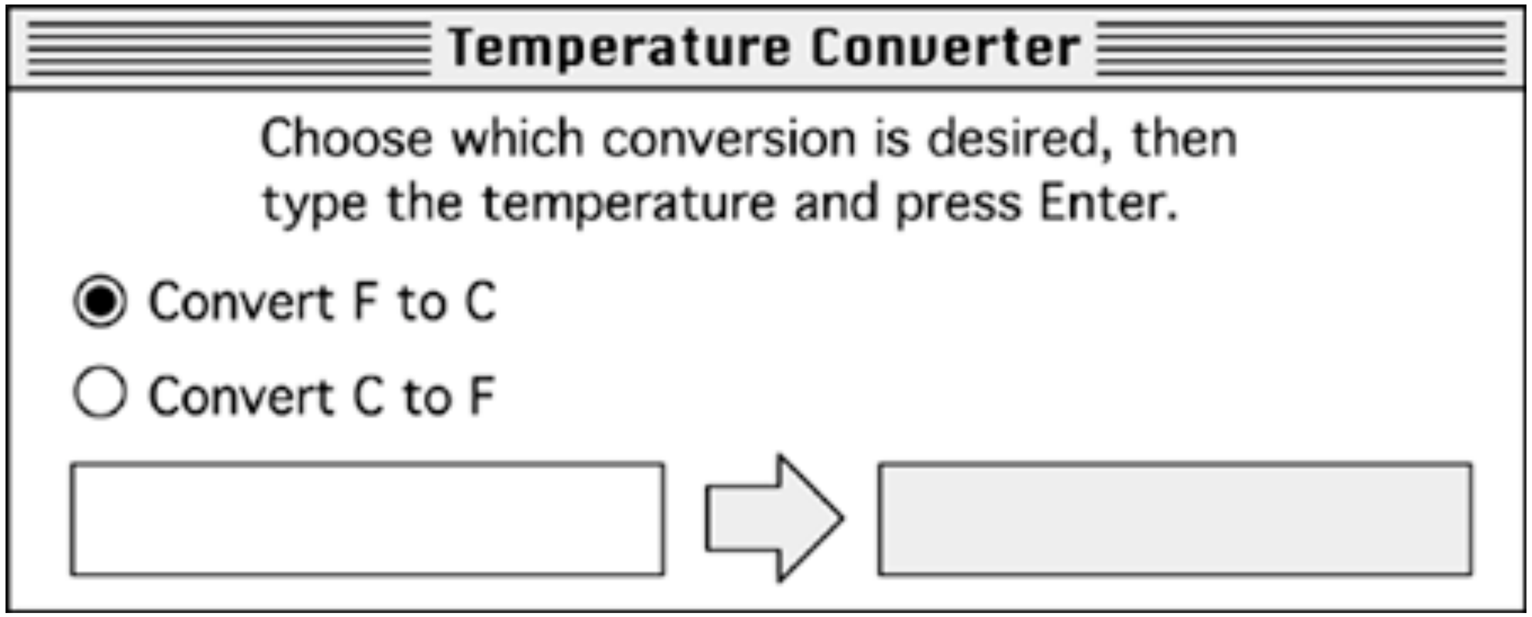
One solution



	H P K H K K K K K
applying rule 1	H MP MK H MK MK MK MK MK
applying rule 2 + 4	H MP MK H MK MK MK MK MK

Rule 3 + 5 do not apply in this example

One solution



H MP K H M K K K K MK

K=0.2s, P=1.1s, H=0.4s, M=1.35s

0.4 + 1.35 + 1.1 + 0.2 + 0.4 + 1.35 + 4*0.2 + 1.35 + 0.2 = 7.15s

It is equally likely that the right conversion is already selected:

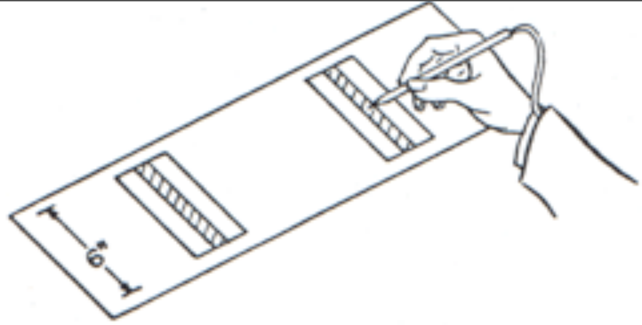
H MP K H M K K K K MK = 3.7s

(7.15s + 3.7s)/2 ≈ 5.4s

Take-away message

- reflect about structures of tools and interaction techniques
- formal analysis of an interface design
- provides a measurement for interface design

Predictive Model



- Fitts' law is a robust model of human psychomotor behavior
- Predicts movement time for rapid, aimed pointing tasks
  - Clicking on buttons, touching icons, etc.
- Developed by Paul Fitts in 1954
- Fitts' discovery "was a major factor to the mouse's commercial introduc Xerox" [Stuart Card]

http://plyojump.com/classes/images/computer_history/sage_lightpen.jpg

Literature:
Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement.

Desktop

context and task

theory

Quantification

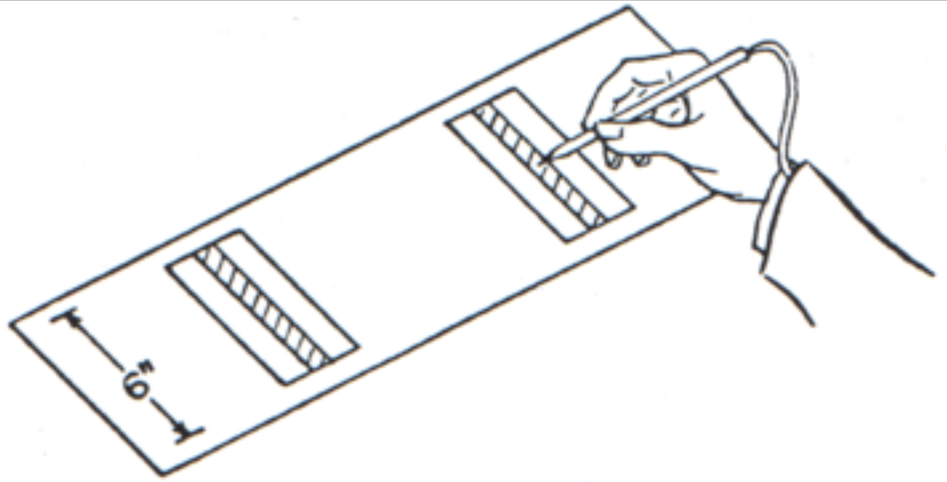
Fitts' law

Card's design space

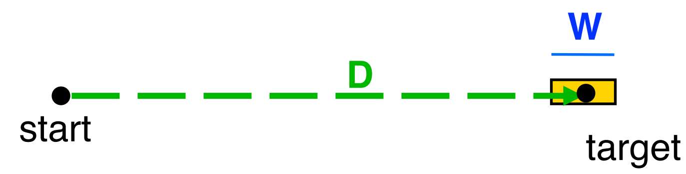
interaction techniques

in/output technologies

Predictive Model



$$MT = a + b\log_2\left(1 + \frac{D}{W}\right)$$

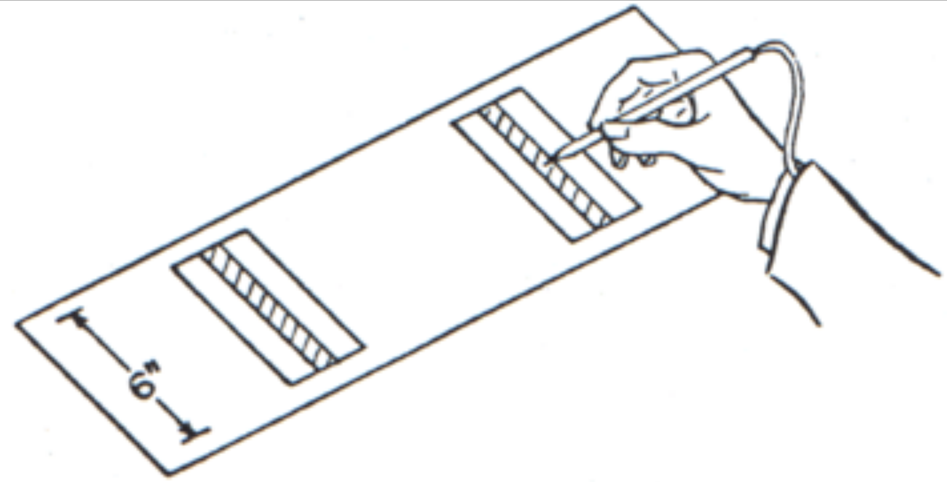


- **MT**: movement time
- **a and b**: constants dependent on the pointing system (user/input device)
- **D**: distance to the target area
- **W**: width of the target

Literature:

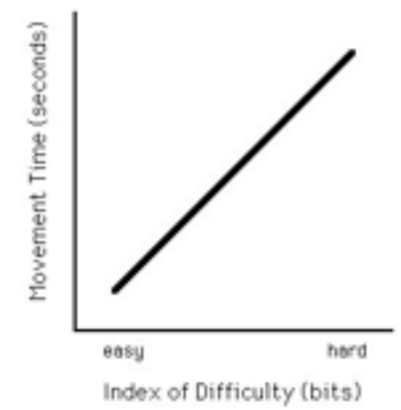
Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology*, *47*, 381-391.

Predictive Model



$$MT = a + b\log_2\left(1 + \frac{D}{W}\right)$$

$$ID = \log_2\left(1 + \frac{D}{W}\right)$$

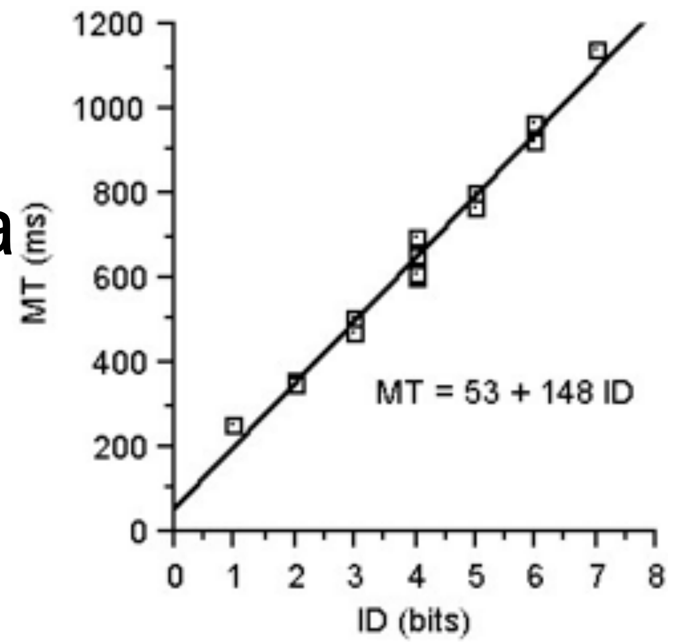


http://www.yorku.ca/mack/GI92.html

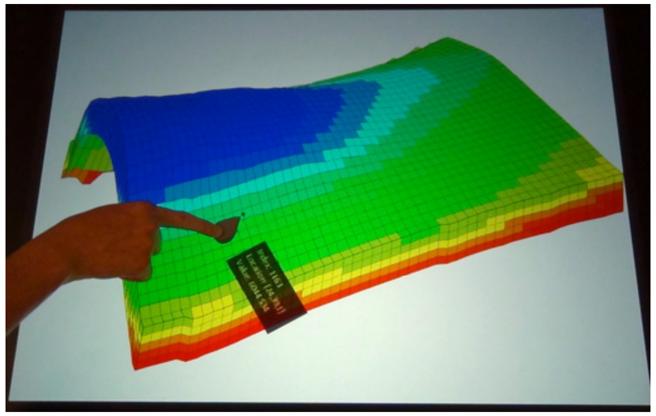
- index of difficulty
  - ID difficulty of task independent of device / method
- units
  - constant a measured in seconds
  - constant b measured in seconds / bit
  - index of difficulty, ID measured in bits

Building a Fitts' Law Model

- interactive computing systems: manipulating a cursor with the mouse, selecting icons in virtual space using a glove, grabbing tangible objects.
- determine slope and intercept coefficients
  - controlled experiment
  - one or more input devices
  - task condition
- cover range of difficulties
- conduct multiple trials in each condition and measure the required time.
- perform tests of correlation and linear regression.



http://www.yorku.ca/mack/GI92.html



http://utouch.cpsc.ucalgary.ca/docs/PointItSplitItPeelItViewIt-ITS2011-NS.pdf

Importance for HCI

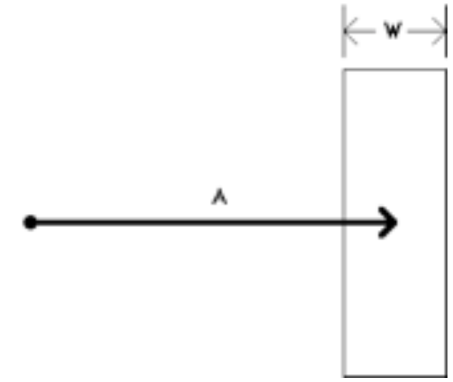
$$MT = a + b \log_2\left(1 + \frac{D}{W}\right)$$

- inspire interaction techniques for optimizing MT:
  - increase W
  - decrease D
  - do both
  - improve hardware, reduce b
  - reduce a?
- create standards
- give a value to a design solution and justify why design A is better than design B.
- attention: findings can be different between lab studies and field studies.
- model does not capture complete complexity of a situation.

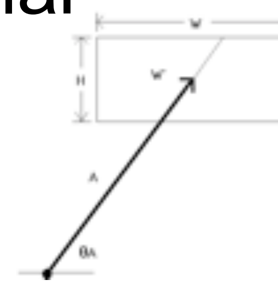
Assumptions

- one-dimensional movement
- straight line movement
- constant velocity
- undivided attention of movement

no one-dimensional task



- two models:
  - W' model: substitutes for W the extend of the target along an approach vector through the center
    - "+" : theoretically attractive, retains one-dimensional model
    - "-" : requires angle of movement
  - SMALLER-OF model: substitutes for W either the width or height of the target, whichever is smaller.
    - "+": easy to apply
    - "-": but limited to rectangular targets.

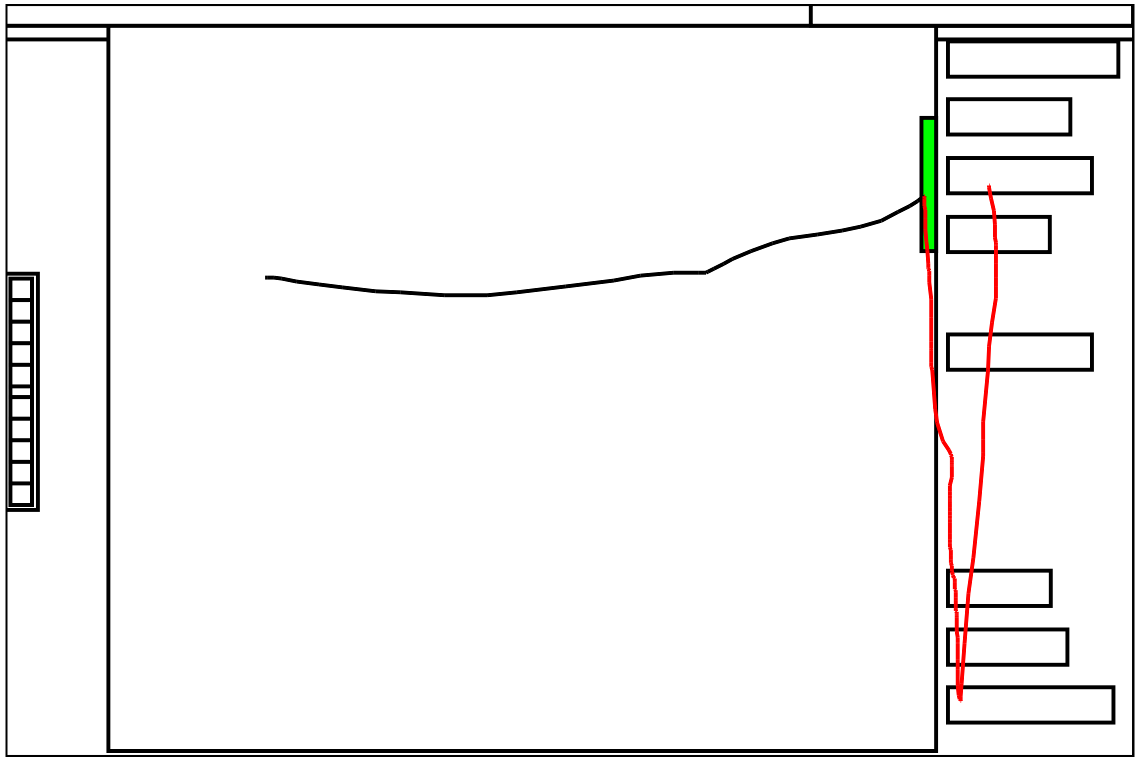


http://www.billbuxton.com/fitts92.html

Literature:
MacKenzie et al. (1992): Extending Fitts' law to two-dimensional tasks. CHI'92

no straight line movement

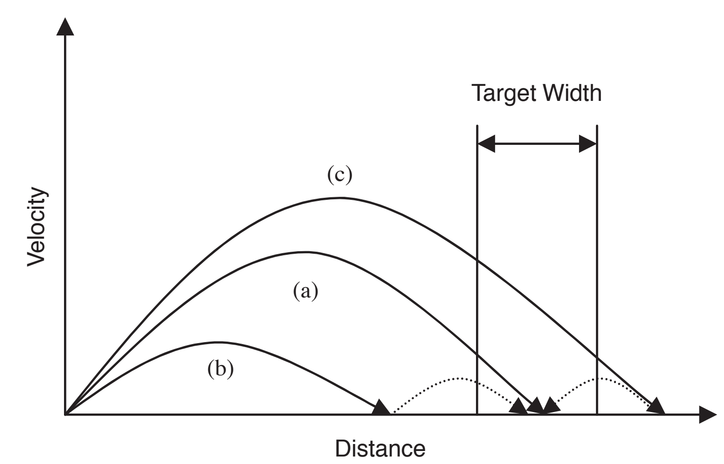
- length-distance ratio
  - Motion is not always straight: spiral or zig-zag
    - to measure this deviation from ideal trajectory use length-distance ration (LD)
    - LD = length of movement/actual distance



Literature:
Chapuis, O. et al. (2007). *Fitts' Law in the Wild: A Field Study of Aimed Movements.* Technical Report LRI

no constant velocity

- no single smooth motion
- motion composed of sequence of one or more sub-movements
  - ballistic phase: first movement is large and fast, cover most of distance
  - corrective control phase: small and slower movements
- deterministic iterative-corrections model
  - sub-movements have equal duration, each travel a constant fraction of the remaining distance toward the target and are all executed



Literature:
Meyer et al. *Optimality in human motor performacne: ideal control of rapid aimed movements,* 1988

bimanual pointing

- perform a bimanual aiming task
  - one hand reaches for target in 10cm distance
  - other hand reached for target in 30cm distance
- What happened? What is MT in this case?

Literature:

Marteniuk, R.G. et al. (1984). *Bimanual movement control: Information processing and interaction effects.* Quarterly Journal of Experimental Psychology, 36A, 335-336

bimanual pointing

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MICRO-EXPERIMENT

try a bimanual pointing task yourself!

Literature:

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bimanual pointing

- perform a bimanual aiming task
  - one hand reaches for target in 10cm distance
  - other hand reached for target in 30cm distance
- What happened? What is MT in this case?
- Bimanual tasks are not just two simultaneously performed uni-manual tasks.
  - inter-limb coordination has tendency towards symmetry
  - limited degree of independence
- von Holst (1939), "*Beharrungstendenz*" vs. "*Magnetoeffekt*"
- more about bimanual interaction in section "*mobile technologies*".

Literature:
Marteniuk, R.G. et al. (1984). *Bimanual movement control: Information processing and interaction effects.* Quarterly Journal of Experimental Psychology, 36A, 335-336

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  - increase W
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  - do both
  - improve hardware, reduce b
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- create standards
- give a value to a design solution and justify why design A is better than design B.
- attention: findings can be different between lab studies and field studies.
- model does not capture complete complexity of a situation.

adapt and refine models to new situations

- contributes to understanding
- helps communicating observed phenomena

Systematic Exploration

- variety of input devices: keyboards, mice, headmice, pen+tablet, dialboxes, polhemus sensors, gloves, body suits.
- descriptive power:
  - 'my design is...'
  - 'design A and B differ in...'
- predictive power
  - design A is faster than B because...
- generative power
  - the combination of X and Y had not been explored before...

Literature: Card et al., "A Morphological Analysis of the Design Space of Input Devices". ACM Transactions on Information Systems, Vol.9, No. 2, 1991

Systematic Exploration

- morphological design space analysis.
- input device = point in a parametrically described design space.
  - primitive movement vocabulary
  - set of composition operators
- formal and visual description of input devices.
- testing points in design space
  - expressiveness
  - effectiveness
- limitations: idealized devices (no lag, noise etc.), speech excluded.

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Primitive Movement Vocabulary

"an input device is a transducer from the physical properties of the world into logical parameters of an application" (Baeker and Buxton)

$$\langle \mathbf{M}, \mathbf{In}, \mathbf{S}, \mathbf{R}, \mathbf{Out}, \mathbf{W} \rangle,$$

where

- —**M** is a manipulation operator,
- —**In** is the input domain,
- —**S** is the current state of the device,
- —**R** is a resolution function mapping from the input domain set to the output domain set,
- —**Out** is the output domain set, and
- —**W** is a general-purpose set of device properties that describe additional aspects of how a device works (perhaps using production systems).

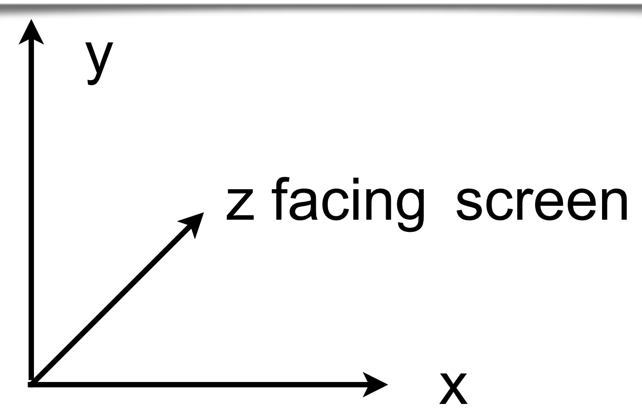
Literature: Baecker et al., "Reading in Human-Computer Interaction: A Multidisciplinary Approach". Kaufmann, Los Altos, Calif., 1987

Manipulation operators *M*

Table I. Physical Properties Used by Input Devices

	Linear	Rotary
Position		
Absolute	Position **P**	Rotation **R**
Relative	Movement **dP**	Delta rotation **dR**
Force		
Absolute	Force **F**	Torque **T**
Relative	Delta force **dF**	Delta torque **dT**

user-centered coordinates



- What are the limitations of this approach?
  - what about speech interaction?
  - what else is not modeled?

Literature: Card et al., "A Morphological Analysis of the Design Space of Input Devices". ACM Transactions on Information Systems, Vol.9, No. 2, 1991

Desktop

context and task

theory

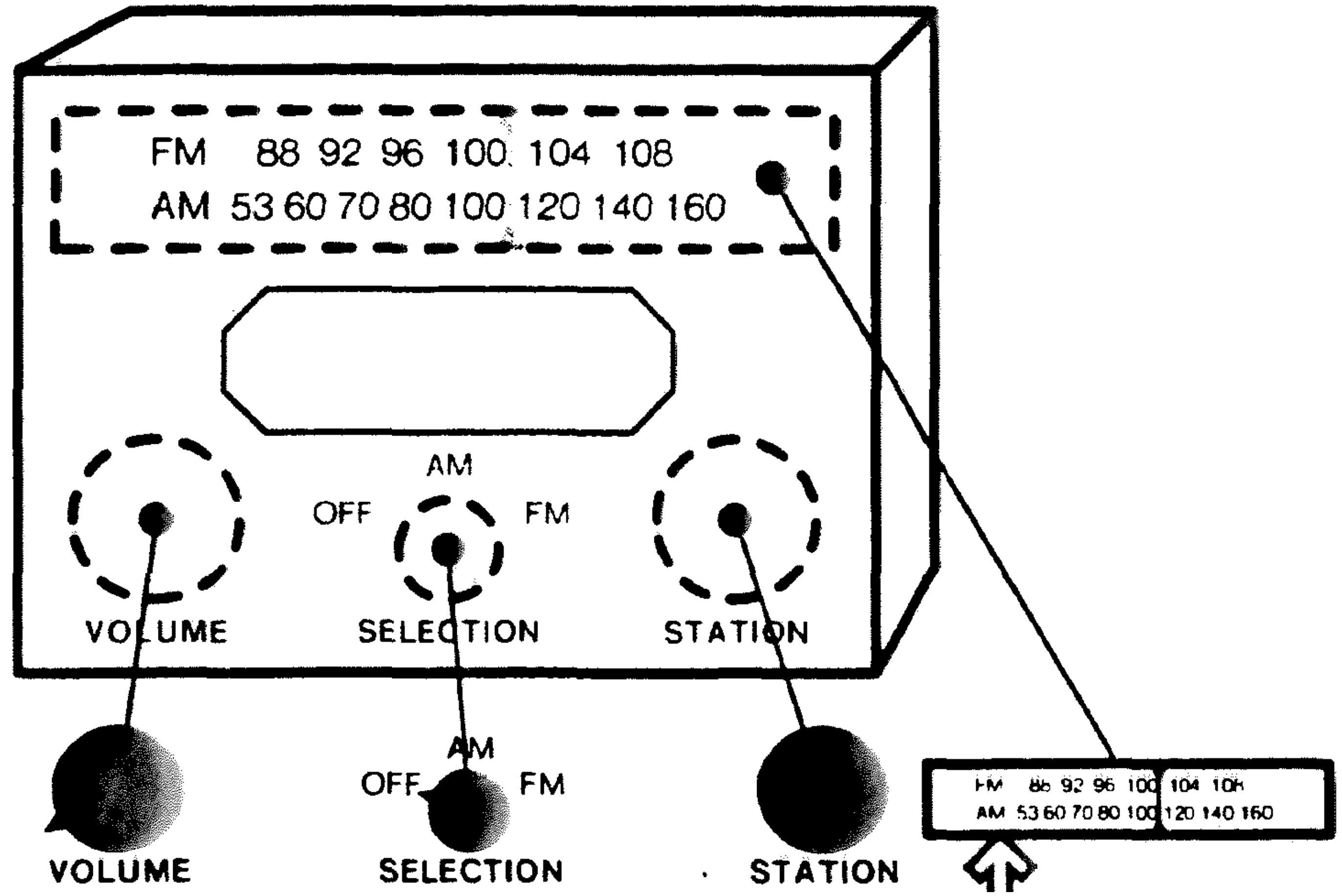
Quantification

Fitts' law

Card's design space

interaction techniques

in/output technologies



$$\langle \mathbf{M}, \mathbf{In}, \mathbf{S}, \mathbf{R}, \mathbf{Out}, \mathbf{W} \rangle,$$

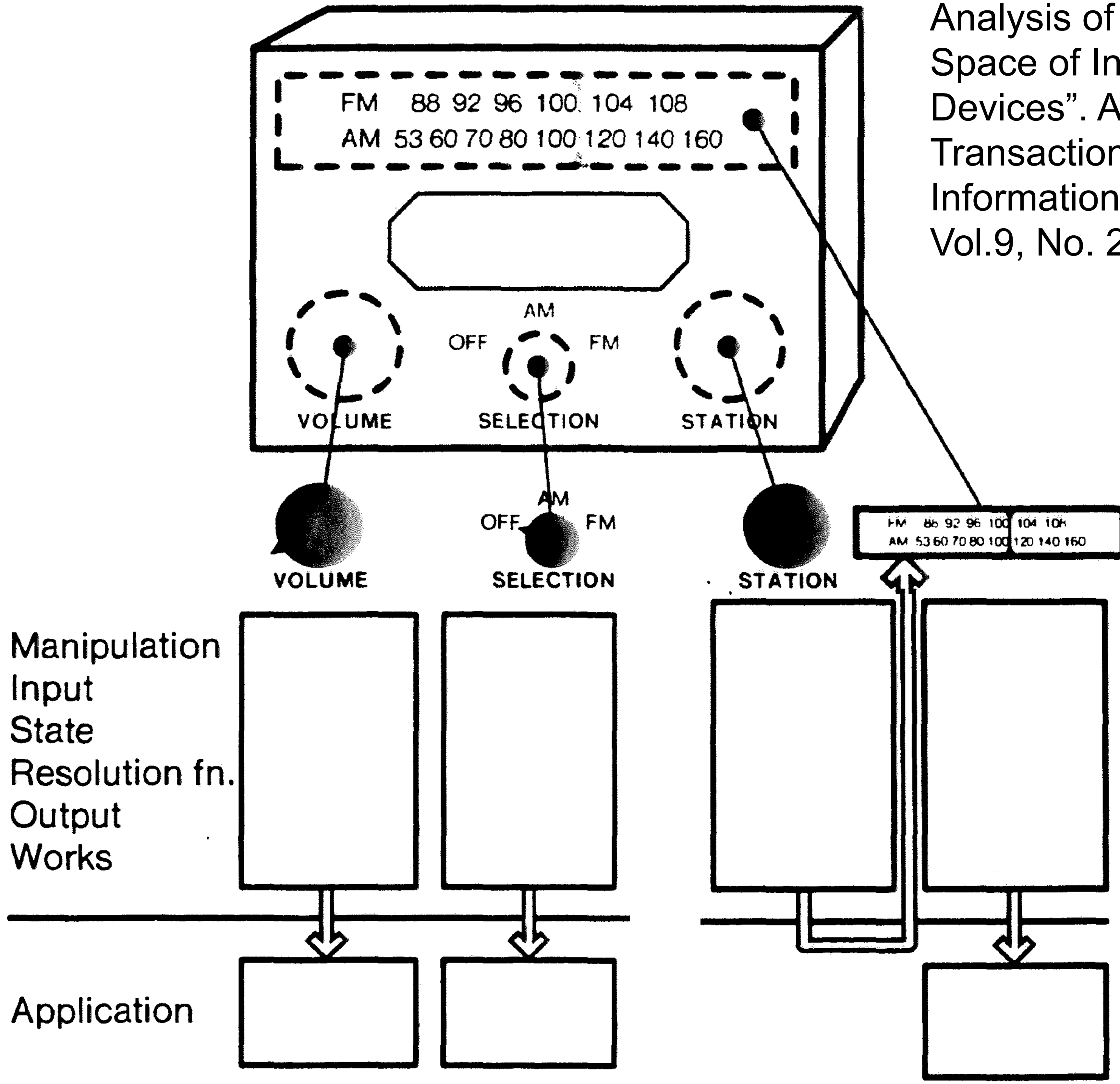
where

- —**M** is a manipulation operator,
- —**In** is the input domain,
- —**S** is the current state of the device,
- —**R** is a resolution function mapping from the input domain set to the output domain set,
- —**Out** is the output domain set, and
- —**W** is a general-purpose set of device properties that describe additional aspects of how a device works (perhaps using production systems).

VolumeKnob =
<Rz, [0°,270°],0°, I, [0°,270°], {}>

Try it yourself!

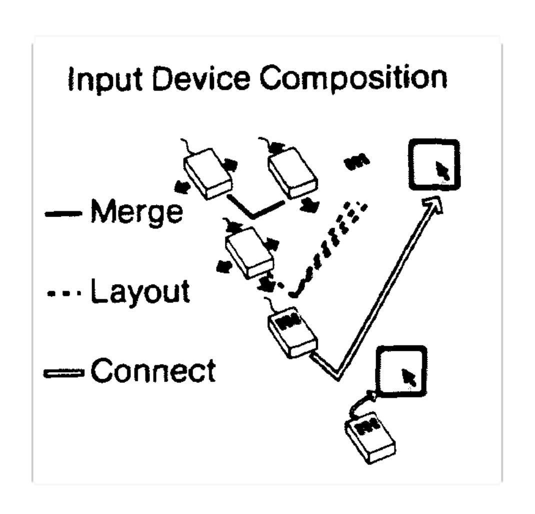
Literature: Card et al., "A Morphological Analysis of the Design Space of Input Devices". ACM Transactions on Information Systems, Vol.9, No. 2, 1991



Tuesday, October 7, 14

Composition Operators

- merge composition
  - two devices can be composed so that their common sets are merged
- layout composition
  - several devices laid out together in a control panel
- connect composition
  - two devices connected that the output of one is cascaded to the input of the other



Literature: Card et al., "A Morphological Analysis of the Design Space of Input Devices". ACM Transactions on Information Systems, Vol.9, No. 2, 1991

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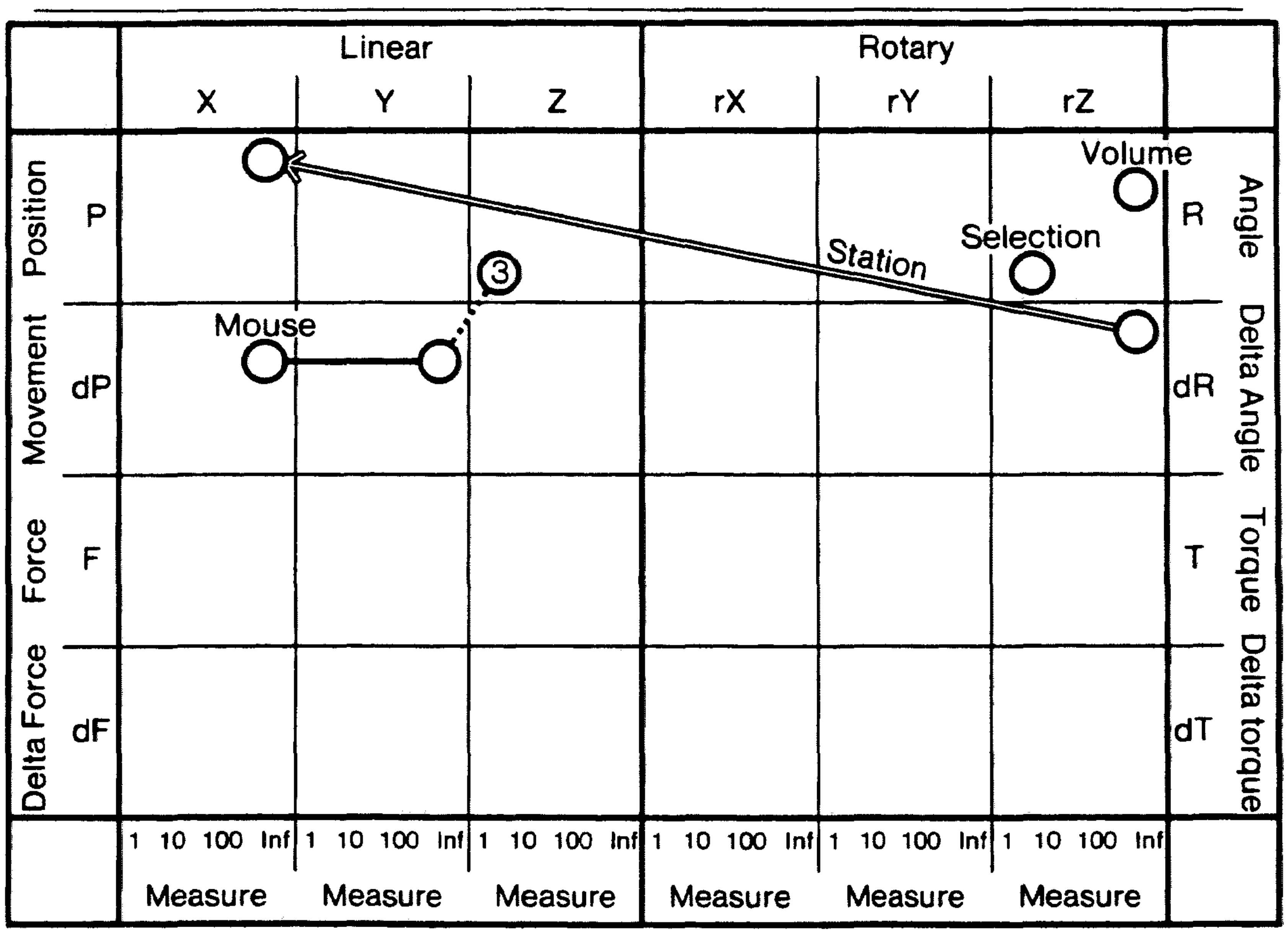
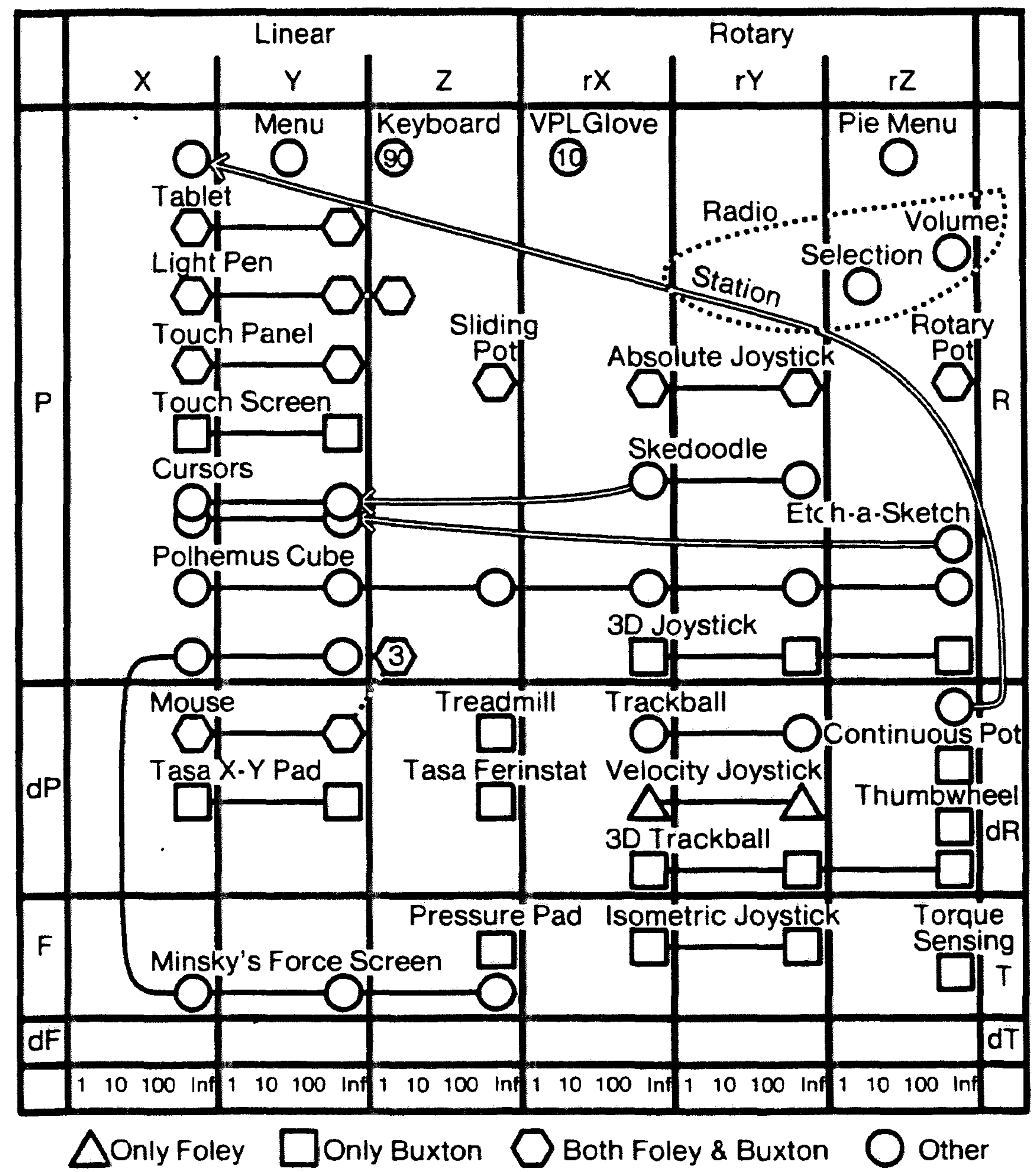
Visual Description



Importance for interaction design?

- Morphological Approach
  - cope with complexity, cope with large number of alternatives.
- Descriptive power (how?)
- Generative power (how?)



Take-away Message

- models are important
  - research:
    - communicate interdisciplinary field
    - establish understanding of a phenomena
    - work on systematic ways of exploring designs
  - industry:
    - can reduce costs of testing different designs
    - generate ideas for the next product
- require models that enable
  - description
  - prediction
  - generation of new ideas.
- reality vs. model