COSC368 Humans and Computers:
Introduction to Human-Computer Interaction (HCI)

Andy Cockburn
University of Canterbury

People

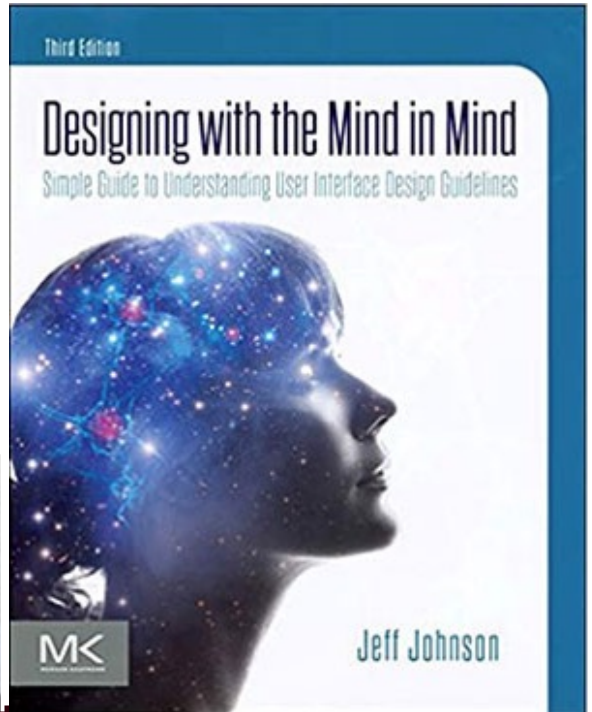
- Prof. Andy Cockburn
  - Course supervisor, lecturer
  - Room 313, andy.cockburn@canterbury.ac.nz
- Katia De Lu & Stewart Dowding
  - Tutors
  - team368@cosc.canterbury.ac.nz

Assessment

- Labs
  - 9% (1% per lab, starting this week)
- Usability Analysis and Storyboard
  - 25%
  - 5pm, Wed 22nd September
- Design Specification and Rationale
  - 15%
  - 5pm, Wed 20th October
- Exam
  - 51%
  - TBA

Recommended Text & Resources

- “Designing with the Mind in Mind”,
  2nd or 3rd Edition
  Jeff Johnson, Morgan-Kaufmann
- (Based on Jeff teaching COSC368)
- Papers on ACM Digital Library:
  canterbury.libguides.com/cosc
- Stuff posted on Learn



Schedule (short)

- Introduction
- Models of interaction and interface technology
- The human
- Interface design
- Evaluation
- (UI intellectual property)

Schedule (long)

Week	Beginning	LECTURES	LABS
1	19-July	Introduction to HCI	Lab 1: Python/TkInter refresher
2	26-July	Models of interaction	Lab 2: Python/TkInter: Keyboard GUI
3	2-Aug	The Human – senses	Lab 3: Python/TkInter: Canvas & Fitts law GUI
4	9-Aug	The Human – performance and phenomena	Lab 4: Fitts' law experiment and analysis
5	16-Aug	Interface Design – Iteration	Lab 5: Sketching Designs
6	23-Aug	Interface Design – Task Centred System Design	Assignment help
	30-Aug		
	6-Sept		
7	13-Sept	Interface Design – Heuristics	Lab 6: Visual search, decision, skill development
8	20-Sept	Interface Design – Heuristics II	Lab 7: Performance prediction
9	27-Sept	Interface Design – Graphical design	Lab 8: Heuristic evaluation
10	4-Oct	Interface Evaluation & Empirical Methods	Lab 9: Experimental data analysis
11	11-Oct	Interface Evaluation & Empirical Methods 2	Assignment help
12	18-Oct	Overflow and UI Intellectual Property	

Your Outcomes (my goals)

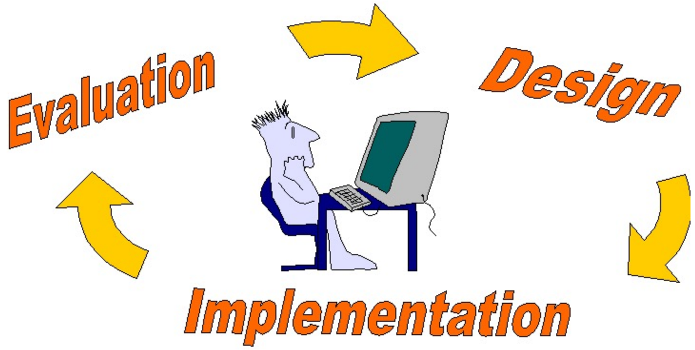
- Understand key human factors influencing human-computer interaction
- Know guidelines, models, and methods that aid interface design, and be able to apply them
- Be able to evaluate user interfaces and designs

- Make the interactive world better
- Stimulate your interest (please speak up!)

Introduction

Human-Computer Interaction (HCI)?

"HCI is a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use, and with the study of major phenomena surrounding them."
ACM SIGCHI Curricula, 1992



HCI Jobs

seek.co.nz “UX”

UX Architect

Farrow Jamieson Ltd

More jobs from this company

UX Architect

Trimble are seeking a UX Architect for their new user experience machine control team within the CTCT (Caterpillar Trimble Controls Technologies) Joint Venture. The successful candidate will act as the end user advocate in the design and implementation of machine control solutions that maximise the ease of doing business.

What is CTCT?

The CTCT division (a joint venture between Trimble and Caterpillar) develops positioning and control products for earth-moving and paving machines in the construction and mining industries, using technologies such as GPS, optical total stations, lasers and sonics. The products are used in a range of applications where the operator of the machine benefits from position and location data.

The Position
A successful candidate will assist the CTCT UX team with developing on-site, in-cab and office-based systems for precision control displays of the future for a vast array of construction and mining equipment.

Key Responsibilities

- Application of strategic thinking to deliver end-to-end user experience solutions with a focus on user needs and business goals
- Utilise end user requirements to create compelling representations of the solution’s high-level interaction, navigation, and organisation design
- Expertly craft documentation to represent the user experience, including: user scenarios / use cases, design specifications, detailed wire-frames, flow diagrams, and schematics
- Develop meaningful prototypes (high and low fidelity) that communicate design, architecture and UI flow
- Utilise UI prototypes to communicate with software development teams to assure UX quality and vision is maintained
- Build effective, collaborative working relationships with program strategy, product management, marketing, and engineering to deliver best in class solutions
- Shift easily among projects in a variety of size and scope.

Skills & Experience Required

- Bachelor’s degree preferred in design related discipline: Information Architecture, Interaction Design or Interface Design, Human Computer Interaction; Design Planning, or Psychology

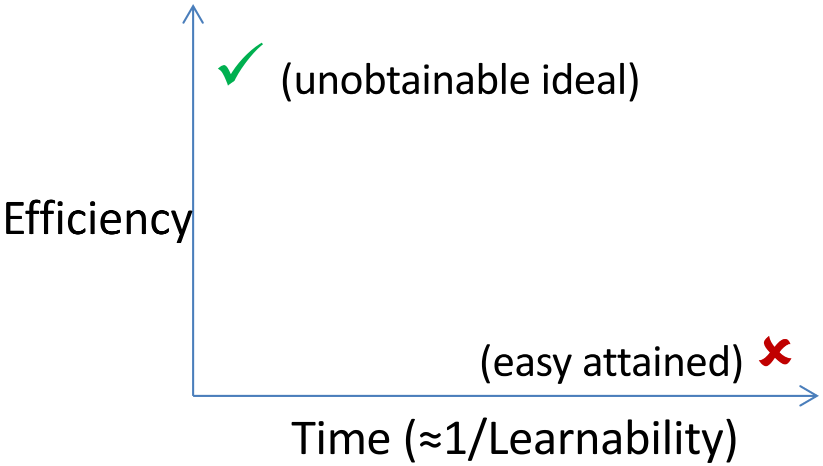
Goals of HCI

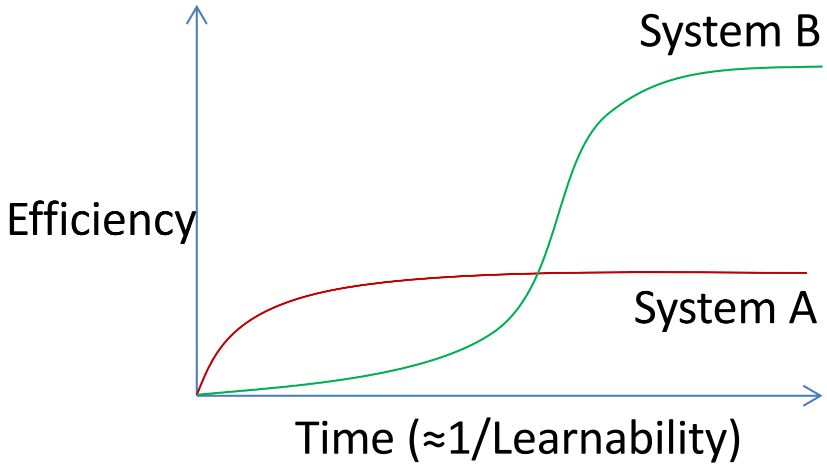
Improved usability:

1. Learnability
2. Efficiency
3. Subjective satisfaction
4. *Memorability*
5. *Errors*

Jakob Nielsen's Alertbox: http://www.useit.com/
"Usability 101"

Alert: Goal tradeoffs abound!





- Design focus depends on user needs
- *Know the user!*

Knowing the User: Preliminary Factors

- Safety considerations
- Need for throughput (efficiency)
- Frequency of use
- Physical space, lighting, noise, pollution
- Social context
- Cognitive factors: age, fatigue, stress, focus

Usability problems

- Everywhere: doors, gadgets, software, …
- "Usability is like oxygen… you only notice it when it's absent"

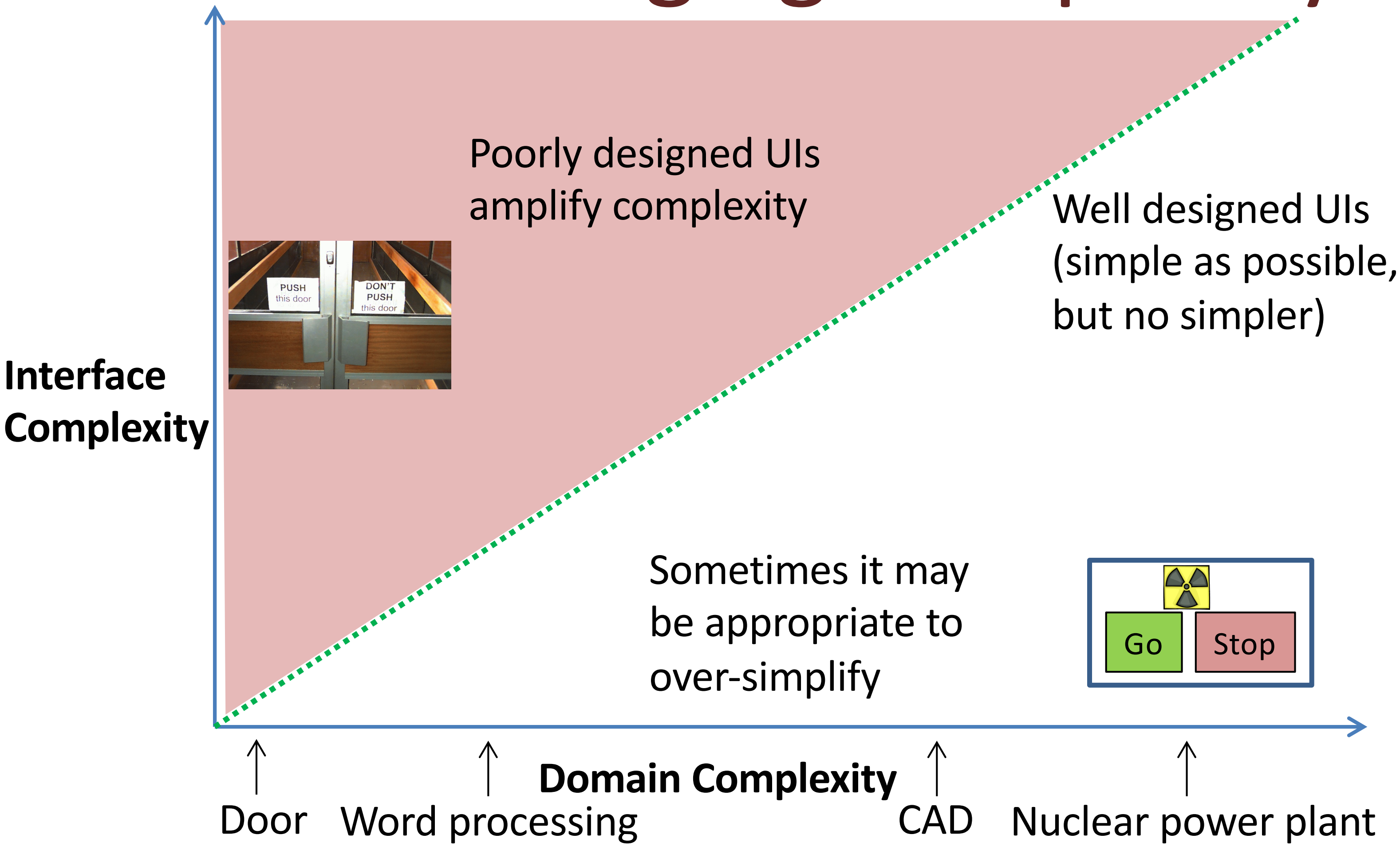

快
乐
PULL
推
PUSH

The Job of HCI: Managing Complexity

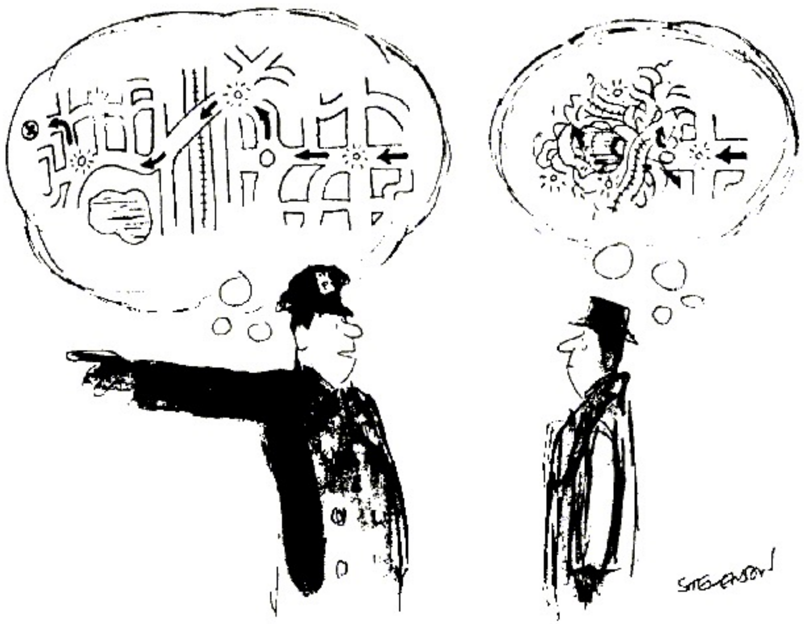
"Designing an object to be simple and clear… requires relentless pursuit of that simplicity even when obstacles appear which would seem to stand in the way" Ted Nelson, 1977

"Everything should be made as simple as possible, but not simpler" A. Einstein (maybe).

Managing Complexity

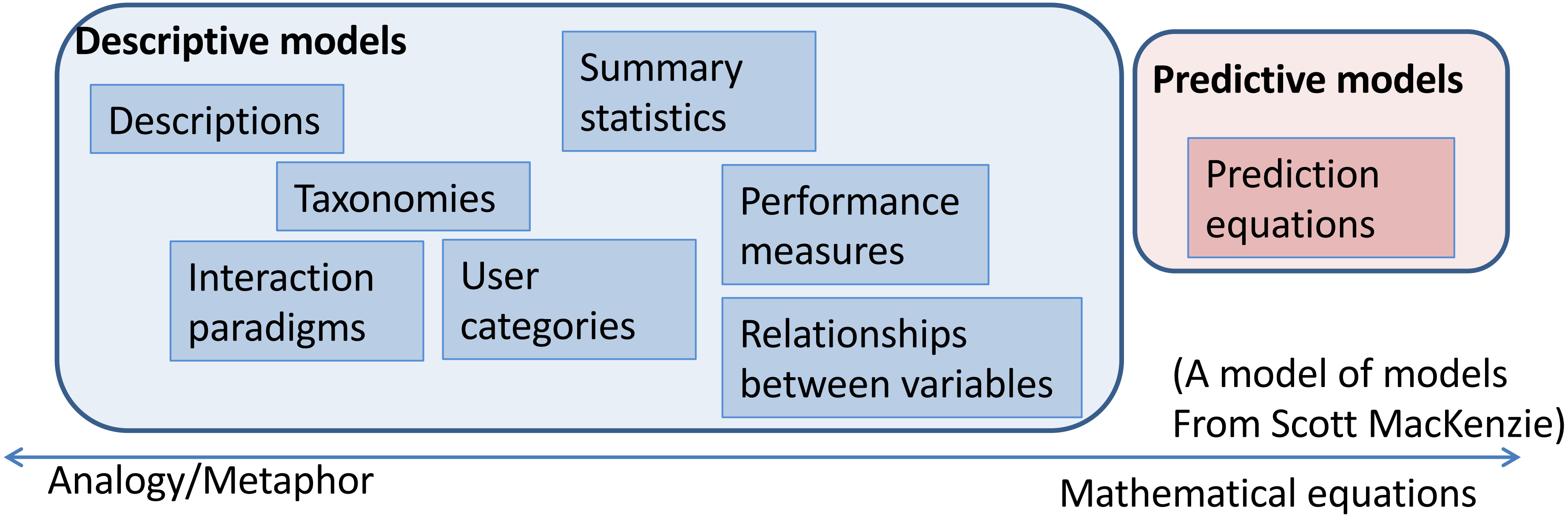


Models of Interaction



What is a model?

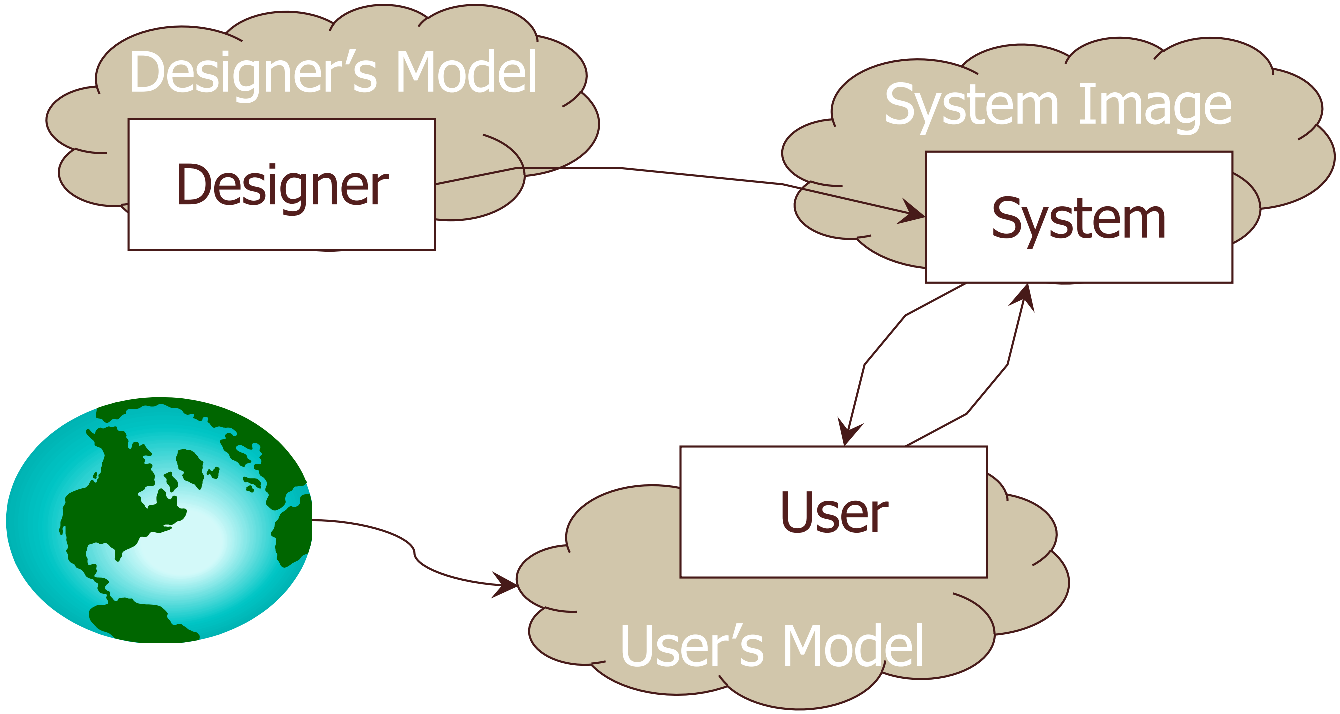
- A model is a simplification of reality
- They are useful when they help understand a complex artifact (e.g., a computer system)



Don Norman’s Model of Interaction

(Norman, ‘The Psychology/Design of Everyday Things’, 1988)

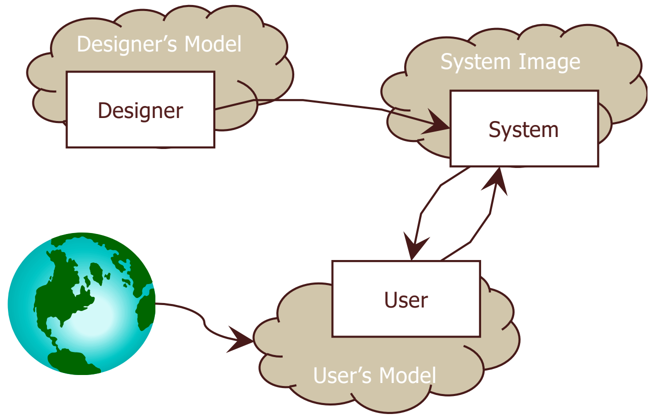
- Helps understand designer’s role in creating a system that is used by a thinking person



Don Norman’s Model of Interaction

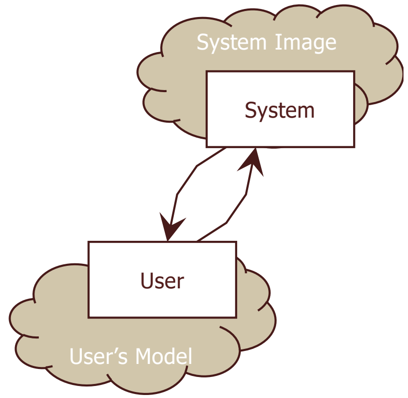
(Norman, ‘The Psychology/Design of Everyday Things’, 1988)

- Designer’s model
  - Designer’s conception of interaction
  - Hopefully intentional!
- System image
  - How the system *appears* to be used
  - Affordance
- User’s model
  - Drawn on to predict behaviour
  - Built and refined from feedback



Don Norman's Execute-Evaluate Cycle

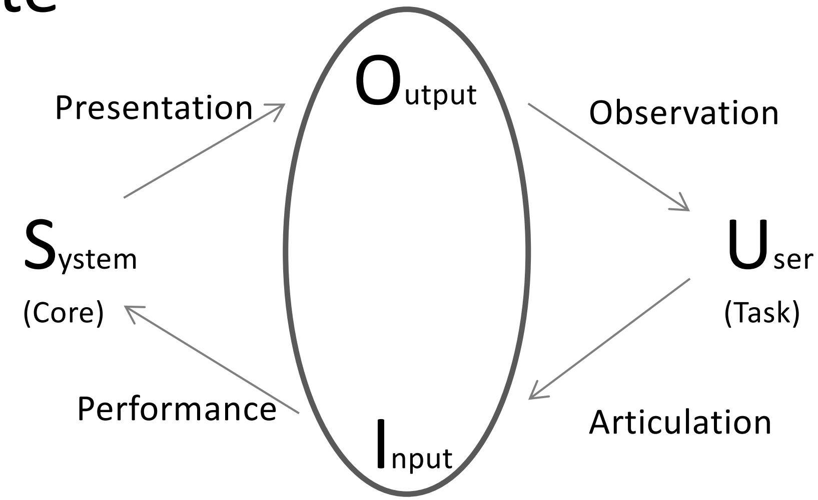
- Execute:
  - Goal > Intention > Actions > Execution
  - 'Gulf of Execution': problems executing intention/action
- Evaluate:
  - Perceive > Interpret > Evaluate
  - 'Gulf of Evaluation': problems assessing state, determining effect, etc.



UISO Interaction Framework

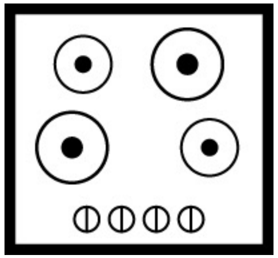
(Abowd and Beale '91)

- Emphasises translations during interaction
  - Articulation: user's task language to input language
  - Performance: callbacks, etc.
  - Presentation: show new state
  - Observation: interpretation

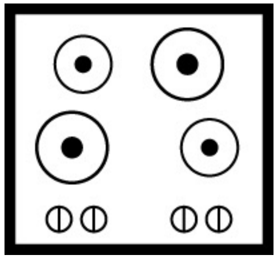


Mappings

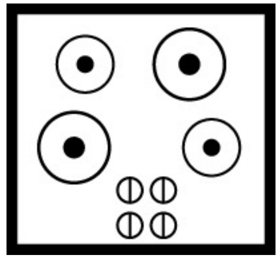
- Good mappings (relationships) between U and I/O increase usability



Arbitrary mapping



Slight disambiguation



Better (and better still?)

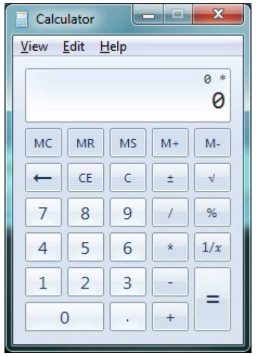
Stove tops

Affordance

(Gibson, 1977; Norman ’88)

- Objects afford particular actions to users
  - Buttons afford pushing, chairs sitting, glass smashing, sliders sliding, dials turning, handles pulling
- Poor affordance encourages incorrect actions

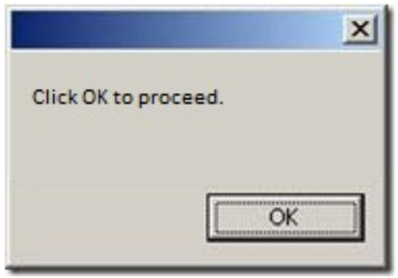
- Strong affordance may stifle efficiency



Over/Under-Determined Dialogues

- Ideally dialogue is 'well-determined' – natural translation from task to input language
- Under-determined – user knows what they want to do, but not how to do it

- Over-determined – user forced through unnecessary or unnatural steps



Direct Manipulation

(Shneiderman, 1982)

- Visibility of objects
- Direct, rapid, incremental, reversible actions
- Rapid feedback
- Syntactic correctness
  – disable illegal actions
- Replace language with action

Direct Manipulation

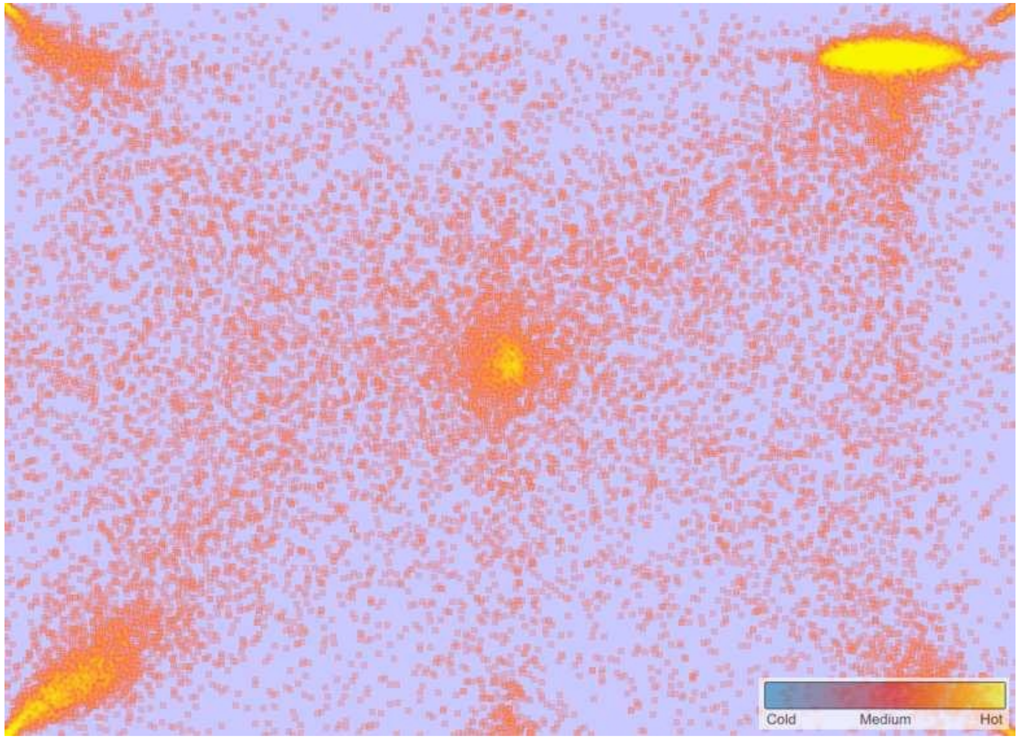
(Shneiderman, 1982)

- Advantages:
  - Easy to learn
  - Low memory requirements
  - Easy to undo
  - Immediate feedback to user actions
  - Enables user to use spatial cues
- Disadvantages:
  - Consumes screen real estate
  - High graphical system requirements
  - May trap user in ‘beginner mode’

The Human

Finished files are the result of years of scientific study, combined with the experience of many years.

blogoscoped.com/click2



Human Factors

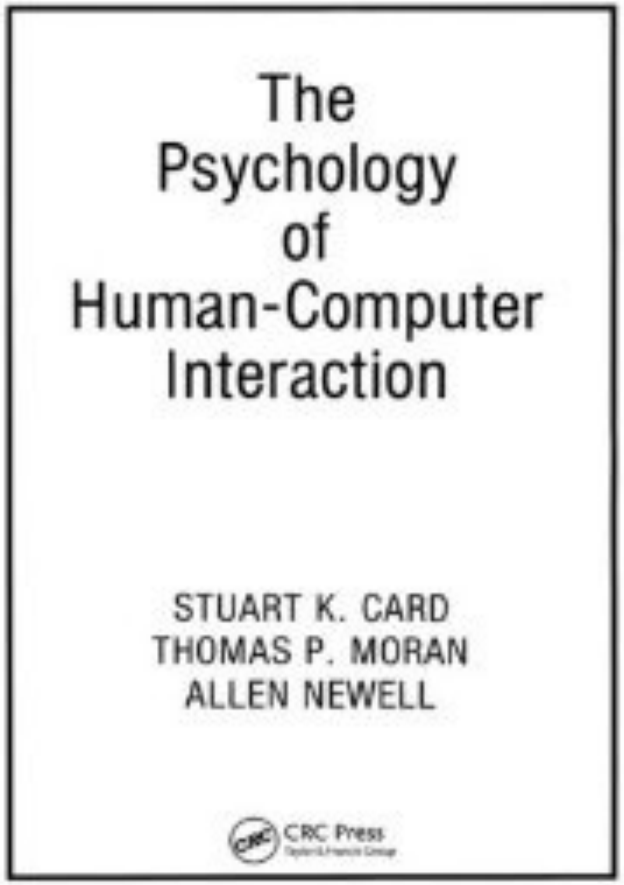
- Psychological and physiological abilities (users and designers) have implications for design
  - Perceptual: how we perceive things (input)
  - Cognitive: how we processes information
  - Motor: how we perform actions (output)
  - Social: how we interact with others
- Understand efficiencies, problems, causes, etc.
- Predict interaction

Also: NASA Man-Systems Integration Standards: https://msis.jsc.nasa.gov/Volume1.htm

The Human Information Processor

Card, Moran, Newell 1983

- Underlying psychology of interaction
- Predictive engineering models (GOMS/KLM)
- Extensive empirical validation
- Core computer science!



The Human Information Processor

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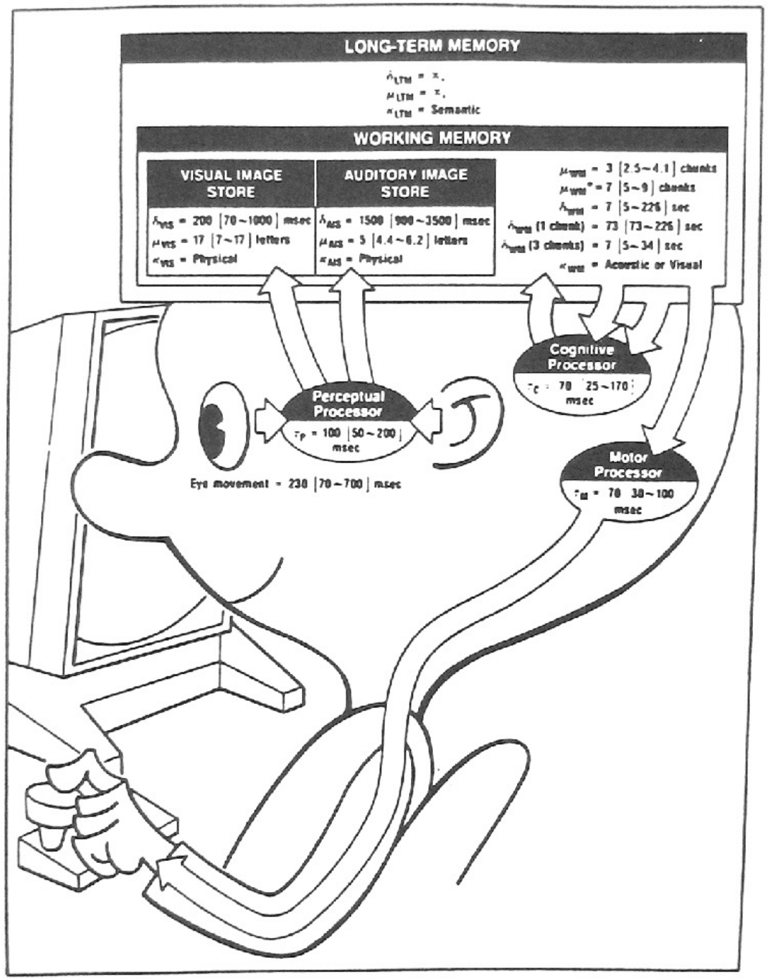
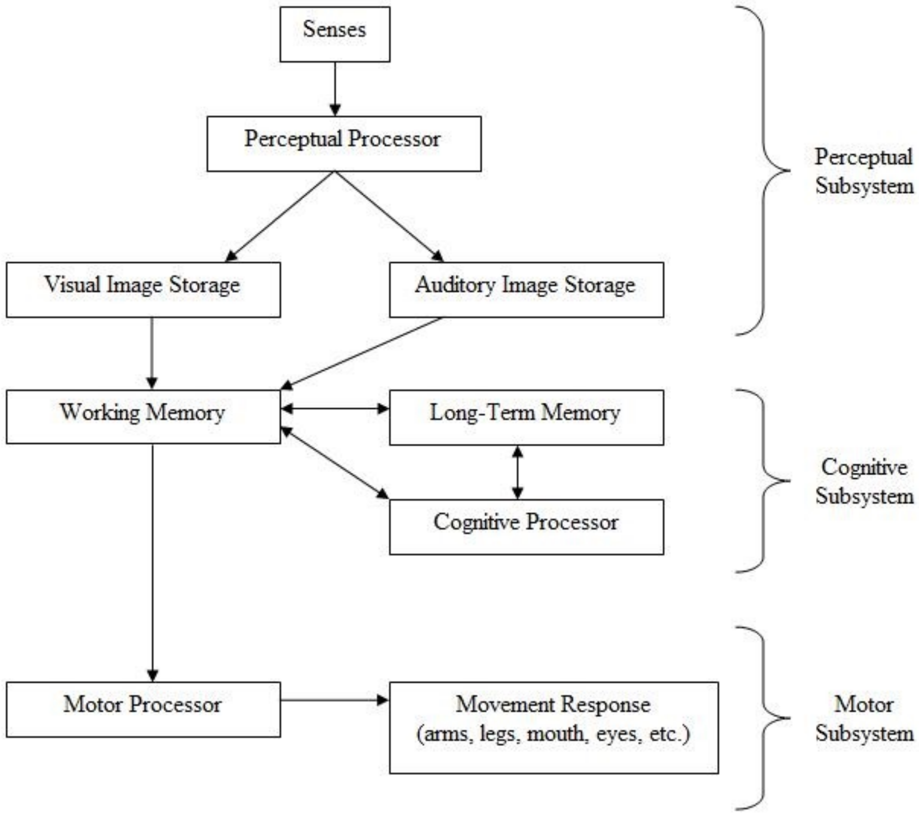




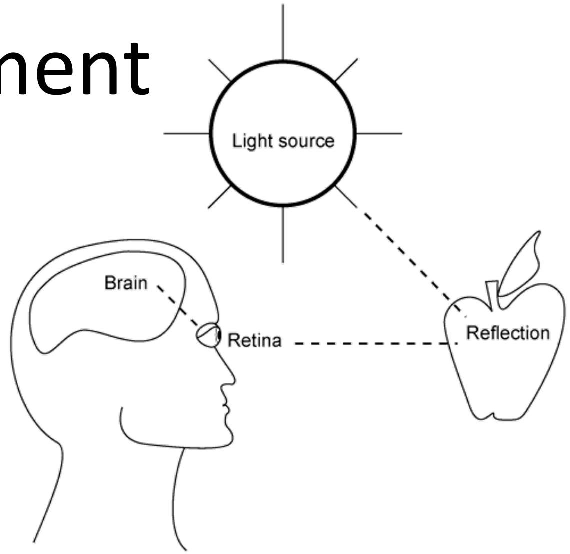
Also: NASA Man-Systems Integration Standards: https://msis.jsc.nasa.gov/Volume1.htm

The Human: Overview

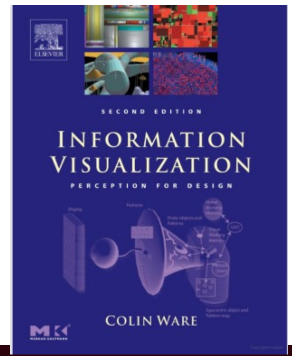
- Human Input
  - Vision, hearing, haptics, olfaction
- Human Output
  - Pointing, steering, speech, typing, …
- Human Processing
  - Visual search, decision times, learning
- Human Memory
- Human Phenomena & Collaboration
- Human Error
- And UI implications of each

Human Input: Vision

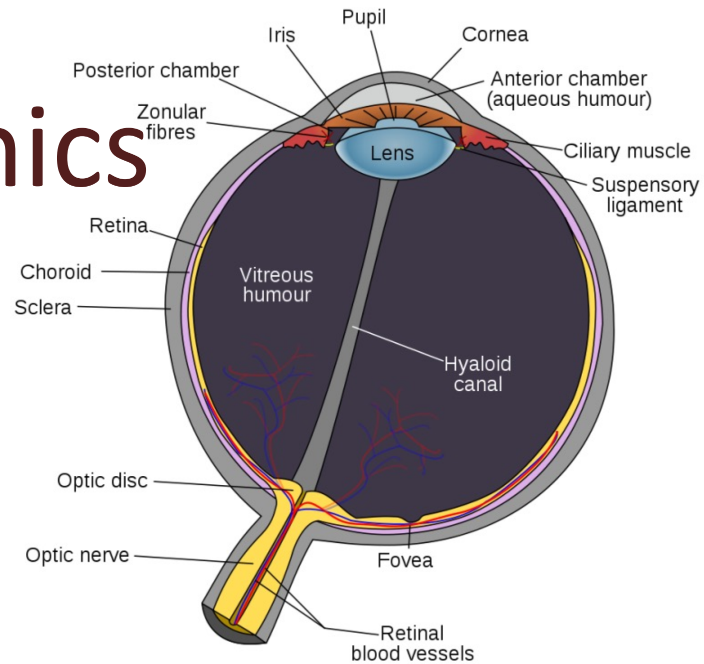
- Mechanics, acuity & movement
- Size and depth
- Colour
- Reading



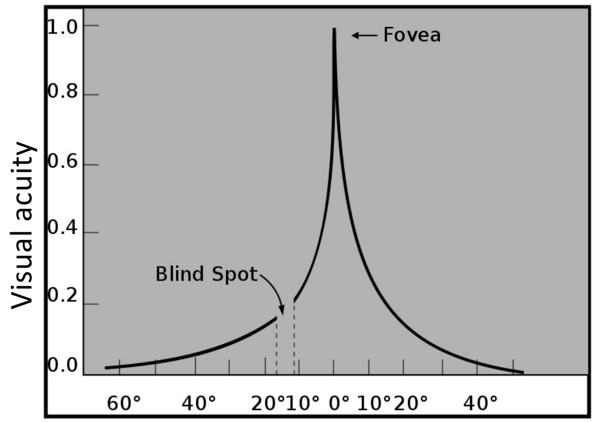
- Colin Ware. Information Visualization: Perception by Design



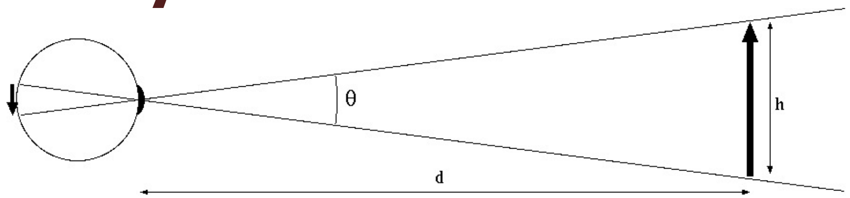
Vision Mechanics



- Photoreceptors cells
  - Rods: low light, monochrome, 100M across retina (not fovea)
  - Cones: normal light, colour, 6M, in fovea
- Fovea: detailed vision of ≈2°
- Retina: non-detailed vision of ≈120°; sensitive to movement



Visual Acuity



- Point acuity: 
  1 minute of arc
- Grating acuity: 
  1-2 minutes of arc
- Letter acuity: **E**
  5 minutes of arc
- Vernier acuity:
  10 seconds of arc

Eye movement

- Fixations: visual processing occurs when the eye is stationary (nearly)
- Saccades: rapid eye movements (900° sec), blind
- Eye movement used as input via eye-tracker
  – "Midas touch" problem
- Smooth-pursuit: for tracking moving objects; up to 100° sec; cannot be induced voluntarily
  – relevant in scrolling, e.g. SDAZ

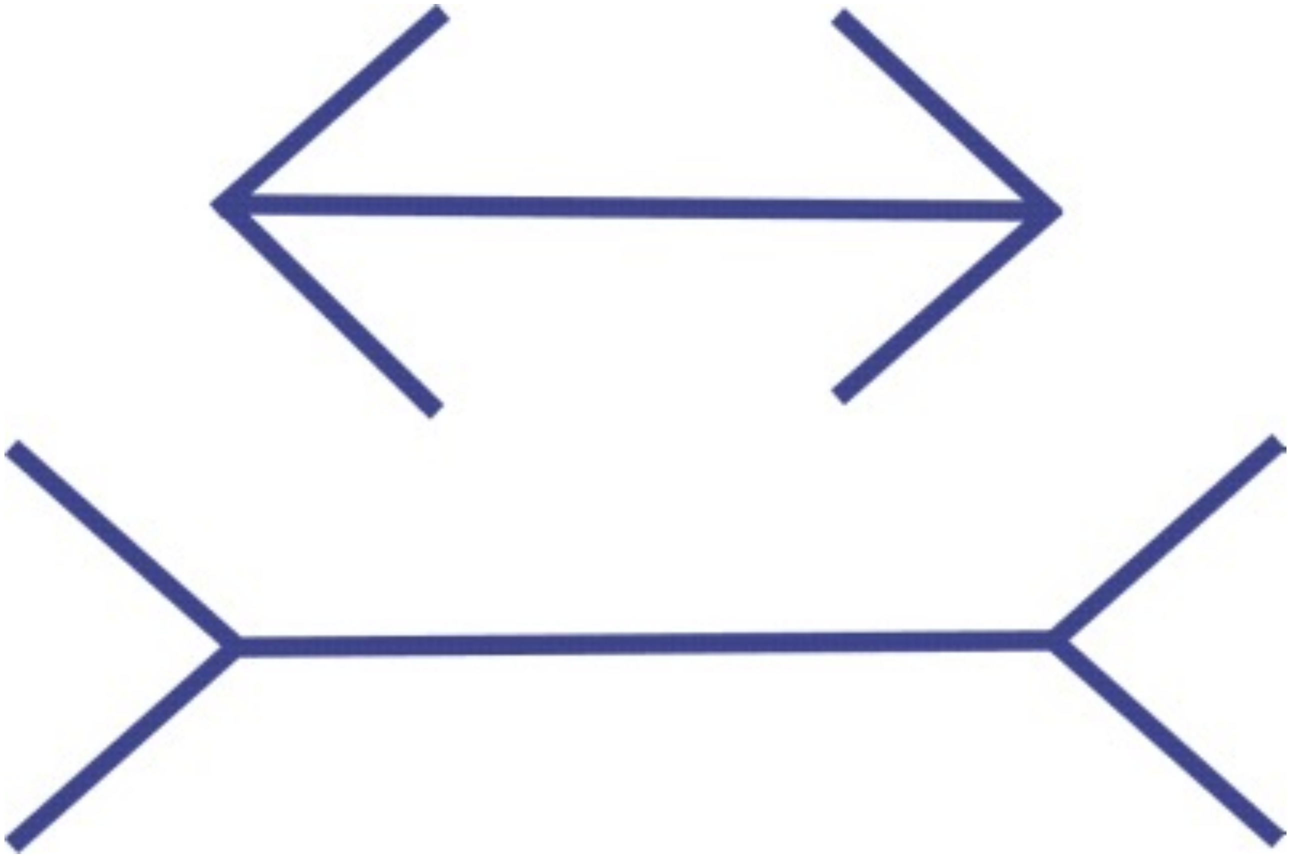
Demo: SDAZ

- Speed-dependent automatic zooming: overcome motion blur…

Size/Depth Cues

- Familiarity
- Linear perspective
- Horizon distance
- Size constancy
- Texture gradient
- Occlusion
- Depth of focus
- Aerial perspective
- Shadows/Shading
- Stereoscopy
  (ineffective beyond 10m; best within 1m)

Muller-Lyer Illusion



Depth-based UIs: 3D

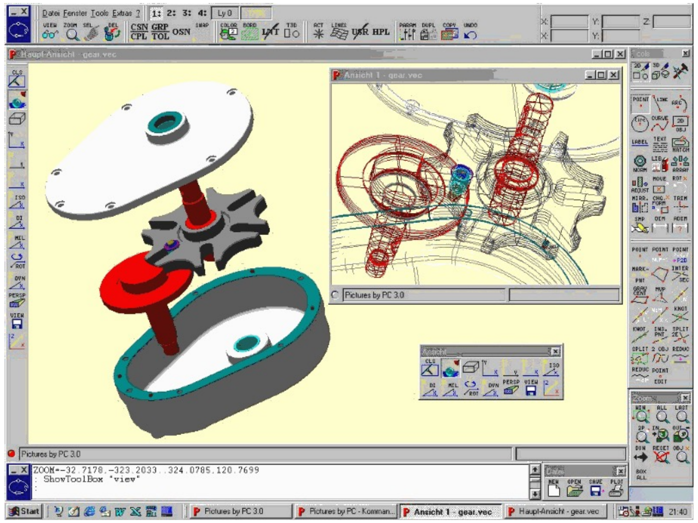
- The real world is 3D
- So all interaction should ideally be 3D, right?

Wrong!

(In my opinion.)

Depth-based UIs: 3D

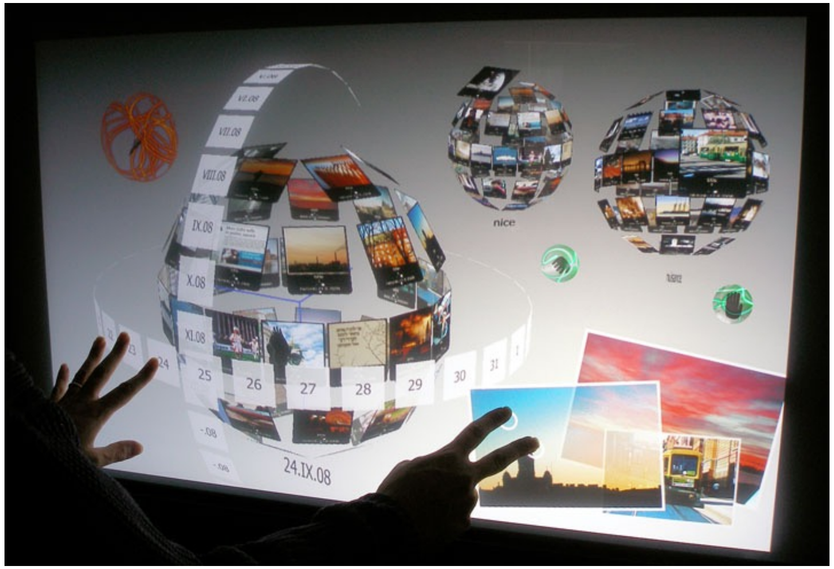
- 3D can be invaluable for interaction with 3D objects or in 3D environments



Depth-based UIs: 3D

- 3D introduces problems for non 3D interactions:
  - Navigation/orientation
  - Occlusion
  - Layout efficiency
  - Layout complexity
  - Motion sickness

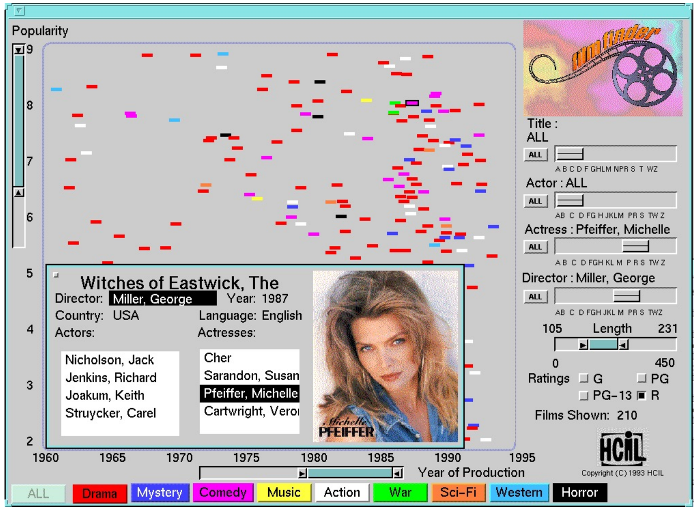
- Use with caution!



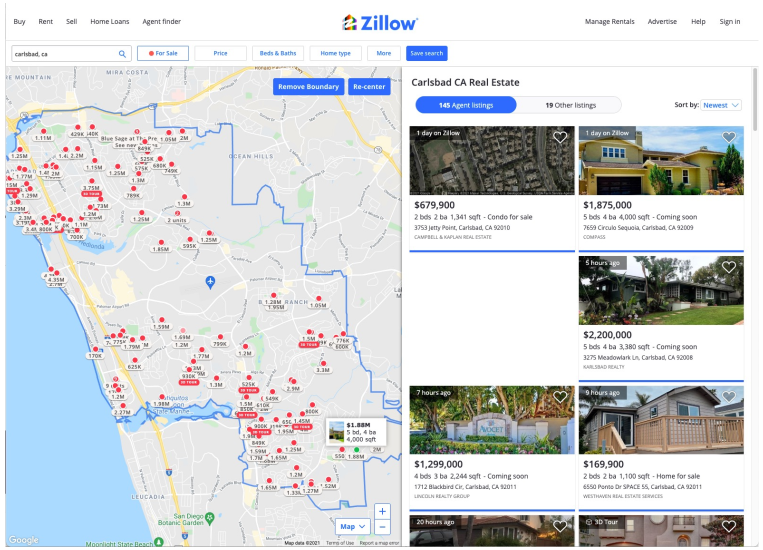
Depth-based UIs: Zooming

- "Visual Information-Seeking Mantra"
  Ben Shneiderman

Overview first, zoom and filter, details on demand



Ahlberg & Shneiderman's FilmFinder (1994) www.cs.umd.edu/hcil/spotfire/



Zillow's zooming web interface www.zillow.com/carlsbad-ca

Colour

- Colour can clarify information and enhance subjective experience
- 8% males, 0.4% females have some form of colour deficiency
  - Protanomaly : red; 1% M, 0.01% F
  - Deuteranomaly: green; 6% M, 0.4% F
  - Tritanomaly: blue, 0.01% M, F
- Sensitivity to blue is lowest (2% cones)

Colour

Protanopic color vision.

Normal trichromatic color vision.

Deuteranopic color vision.

Image checker…

http://www.vischeck.com/vischeck/vischeckImage.php


Chesham
Chalfont & Latimer
Amersham
Chorleywood
Rickmansworth
Watford
Croxley
Moor Park
Northwood
Northwood Hills
Pinner
North Harrow
West Ruislip
Hillingdon
Ruislip
Ruislip Manor
Eastcote
Uxbridge
Ickenham
Rayners Lane
Ruislip Gardens
West Harrow
Harrow-on-the-Hill
South Ruislip
Northolt
Greenford
Perivale
Hanger Lane
South Harrow
Sudbury Hill
Sudbury Town
Alperton
Park Royal
North Ealing
Ealing Broadway
Ealing Common
West Acton
North Acton
East Acton
White City
Wood Lane
Acton Central
South Acton
Acton Town
South Ealing
Northfields
Boston Manor
Osterley
Hounslow East
Hounslow Central
Hounslow West
Hatton Cross
Heathrow Terminals 1, 2, 3
Heathrow Terminal 4
Heathrow Terminal 5
Chiswick Park
Turnham Green
Stamford Brook
Ravenscourt Park
West Kensington
Gunnersbury
Kew Gardens
Richmond
Watford Junction
Watford High Street
Bushey
Carpenders Park
Hatch End
Headstone Lane
Harrow & Wealdstone
Kenton
South Kenton
North Wembley
Wembley Central
Stonebridge Park
Harlesden
Willesden Junction
Northwick Park
Preston Road
Wembley Park
Stanmore
Canons Park
Queensbury
Kingsbury
Neasden
Dollis Hill
Willesden Green
Kilburn
West Hampstead
Finchley Road
Swiss Cottage
St. John's Wood
Brondesbury Park
Kensal Rise
Brondesbury
Kensal Green
Queen's Park
Kilburn High Road
South Hampstead
Kilburn Park
Maida Vale
Warwick Avenue
Royal Oak
Westbourne Park
Ladbroke Grove
Latimer Road
Shepherd's Bush
Shepherd's Bush Market
Goldhawk Road
Kensington (Olympia)
Hammersmith
Barons Court
Holland Park
Notting Hill Gate
Bayswater
Paddington
Edgware Road
Marylebone
Baker Street
Great Portland Street
Euston
Queensway
Lancaster Gate
Marble Arch
Bond Street
Oxford Circus
Regent's Park
High Street Kensington
Hyde Park Corner
Knightsbridge
Gloucester Road
South Kensington
Sloane Square
Earl's Court
West Brompton
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
Imperial Wharf
Clapham Junction
Edgware
Burnt Oak
Colindale
Hendon Central
Brent Cross
Golders Green
Hampstead
Finchley Road & Frognal
Hampstead Heath
Belsize Park
Chalk Farm
Camden Town
Mornington Crescent
Gospel Oak
Kentish Town West
Kentish Town
Camden Road
Mill Hill East
High Barnet
Totteridge & Whetstone
Woodside Park
West Finchley
Finchley Central
East Finchley
Highgate
Archway
Tufnell Park
Crouch Hill
Upper Holloway
King's Cross St. Pancras
Warren Street
Euston Square
Goodge Street
Tottenham Court Road
Green Park
Piccadilly Circus
Leicester Square
Covent Garden
Holborn
Russell Square
Farringdon
Barbican
Chancery Lane
St. Paul's
Moorgate
Angel
Old Street
Liverpool Street
Bank
Mansion House
Cannon Street
Monument
Charing Cross
Blackfriars
Temple
Embankment
Westminster
St. James's Park
Victoria
Pimlico
Vauxhall
Waterloo
Southwark
Lambeth North
Elephant & Castle
Borough
London Bridge
Kennington
Oval
Stockwell
Brixton
Clapham North
Clapham Common
Clapham South
Balham
Tooting Bec
Tooting Broadway
Colliers Wood
South Wimbledon
Morden
Cockfosters
Oakwood
Southgate
Arnos Grove
Bounds Green
Wood Green
Turnpike Lane
Manor House
Harringay Green Lanes
South Tottenham
Seven Sisters
Tottenham Hale
Blackhorse Road
Walthamstow Central
Walthamstow Queen's Road
Leyton Midland Road
Finsbury Park
Arsenal
Holloway Road
Caledonian Road
Highbury & Islington
Caledonian Road & Barnsbury
Canonbury
Dalston Kingsland
Dalston Junction
Hackney Central
Homerton
Hackney Wick
Haggerston
Hoxton
Shoreditch High Street
Bethnal Green
Mile End
Stratford
Pudding Mill Lane
Bow Road
Bow Church
Bromley-by-Bow
West Ham
Aldgate East
Aldgate
Whitechapel
Stepney Green
Devons Road
Langdon Park
All Saints
Shadwell
Limehouse
Westferry
Poplar
East India
Blackwall
Tower Hill
Fenchurch Street
Tower Gateway
Wapping
Rotherhithe
Bermondsey
Canada Water
Surrey Quays
Canary Wharf
West India Quay
Heron Quays
South Quay
Crossharbour
Mudchute
Island Gardens
Cutty Sark for Maritime Greenwich
Greenwich
Deptford Bridge
Elverson Road
Lewisham
North Greenwich for The O2
Canning Town
West Silvertown
Pontoon Dock
London City Airport
King George V
Woolwich Arsenal
Royal Victoria
Custom House for ExCeL
Prince Regent
Royal Albert
Beckton Park
Cyprus
Gallions Reach
Beckton
New Cross Gate
New Cross
Brockley
Honor Oak Park
Forest Hill
Sydenham
Crystal Palace
Penge West
Anerley
Norwood Junction
West Croydon
Epping
Theydon Bois
Debden
Loughton
Buckhurst Hill
Roding Valley
Chigwell
Grange Hill
Hainault
Fairlop
Barkingside
Newbury Park
Redbridge
Woodford
South Woodford
Snaresbrook
Wanstead
Gants Hill
Leytonstone
Leytonstone High Road
Leyton
Wanstead Park
Woodgrange Park
Upminster
Upminster Bridge
Hornchurch
Elm Park
Dagenham East
Dagenham Heathway
Becontree
Upney
Barking
East Ham
Upton Park
Plaistow
River Thames
11/IT/1955/P
Bakerloo
Central
Circle
District
Hammersmith & City
Jubilee
Metropolitan
Northern
Piccadilly
Victoria
Waterloo & City
DLR
London Overground
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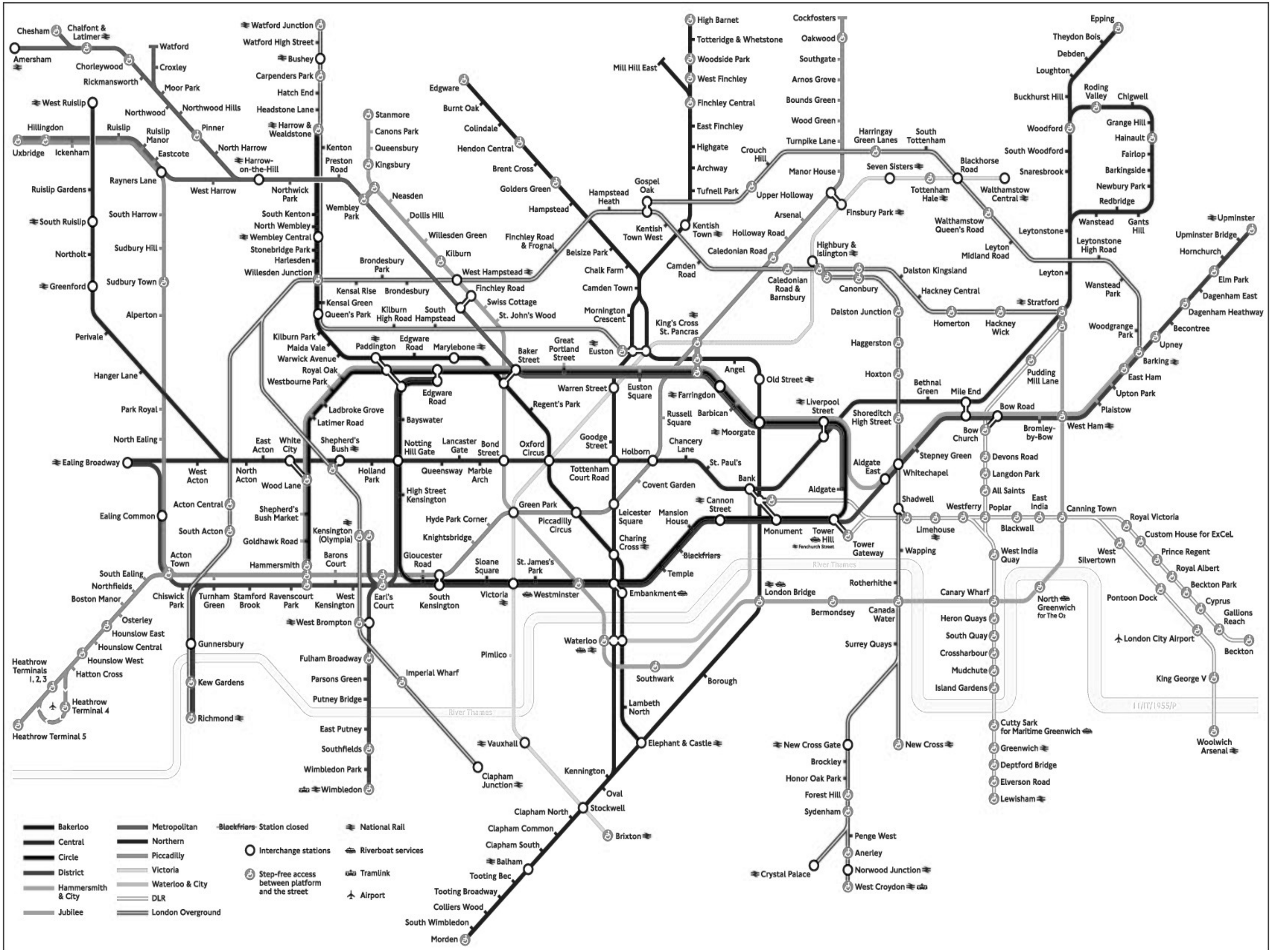
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Amersham
Chorleywood
Rickmansworth
Watford
Croxley
Moor Park
Northwood
Northwood Hills
Pinner
North Harrow
West Ruislip
Hillingdon
Uxbridge
Ickenham
Ruislip
Ruislip Manor
Eastcote
Rayners Lane
West Harrow
Harrow-on-the-Hill
Ruislip Gardens
South Ruislip
Northolt
Greenford
Perivale
Hanger Lane
South Harrow
Sudbury Hill
Sudbury Town
Alperton
Park Royal
North Ealing
Ealing Broadway
Ealing Common
West Acton
North Acton
East Acton
White City
Wood Lane
Acton Central
South Acton
Acton Town
South Ealing
Northfields
Boston Manor
Osterley
Hounslow East
Hounslow Central
Hounslow West
Hatton Cross
Heathrow Terminals 1, 2, 3
Heathrow Terminal 4
Heathrow Terminal 5
Chiswick Park
Turnham Green
Stamford Brook
Ravenscourt Park
Gunnersbury
Kew Gardens
Richmond
Watford Junction
Watford High Street
Bushey
Carpenders Park
Hatch End
Headstone Lane
Harrow & Wealdstone
Kenton
South Kenton
North Wembley
Wembley Central
Stonebridge Park
Harlesden
Willesden Junction
Kensal Green
Queen's Park
Kilburn Park
Maida Vale
Warwick Avenue
Preston Road
Northwick Park
Wembley Park
Stanmore
Canons Park
Queensbury
Kingsbury
Neasden
Dollis Hill
Willesden Green
Kilburn
West Hampstead
Finchley Road
Swiss Cottage
St. John's Wood
Brondesbury Park
Kensal Rise
Brondesbury
Kilburn High Road
South Hampstead
Edgware
Burnt Oak
Colindale
Hendon Central
Brent Cross
Golders Green
Hampstead
Finchley Road & Frognal
Belsize Park
Chalk Farm
Camden Town
Mornington Crescent
Hampstead Heath
Gospel Oak
Kentish Town West
Kentish Town
Camden Road
High Barnet
Totteridge & Whetstone
Woodside Park
West Finchley
Mill Hill East
Finchley Central
East Finchley
Highgate
Archway
Tufnell Park
Crouch Hill
Upper Holloway
Holloway Road
Caledonian Road
Caledonian Road & Barnsbury
Arsenal
Finsbury Park
Highbury & Islington
Canonbury
Cockfosters
Oakwood
Southgate
Arnos Grove
Bounds Green
Wood Green
Turnpike Lane
Manor House
Harringay Green Lanes
South Tottenham
Seven Sisters
Tottenham Hale
Blackhorse Road
Walthamstow Central
Walthamstow Queen's Road
Leyton Midland Road
Dalston Kingsland
Hackney Central
Dalston Junction
Homerton
Hackney Wick
Stratford
Haggerston
Hoxton
Epping
Theydon Bois
Debden
Loughton
Buckhurst Hill
Roding Valley
Chigwell
Grange Hill
Hainault
Fairlop
Barkingside
Newbury Park
Redbridge
Woodford
South Woodford
Snaresbrook
Wanstead
Gants Hill
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Wanstead Park
Woodgrange Park
Upminster
Upminster Bridge
Hornchurch
Elm Park
Dagenham East
Dagenham Heathway
Becontree
Upney
Barking
East Ham
Upton Park
Plaistow
West Ham
Paddington
Edgware Road
Marylebone
Baker Street
Great Portland Street
Euston
King's Cross St. Pancras
Royal Oak
Westbourne Park
Ladbroke Grove
Latimer Road
Shepherd's Bush
Holland Park
Notting Hill Gate
Bayswater
Queensway
Lancaster Gate
Marble Arch
Bond Street
Oxford Circus
Regent's Park
Warren Street
Euston Square
Goodge Street
Tottenham Court Road
Holborn
Russell Square
Angel
Old Street
Farringdon
Barbican
Moorgate
Chancery Lane
St. Paul's
Liverpool Street
Shoreditch High Street
Bethnal Green
Mile End
Bow Road
Bow Church
Bromley-by-Bow
Pudding Mill Lane
Aldgate East
Aldgate
Whitechapel
Stepney Green
Devons Road
Langdon Park
All Saints
Bank
Monument
Cannon Street
Mansion House
Tower Hill
Fenchurch Street
Tower Gateway
Shadwell
Limehouse
Westferry
Poplar
East India
Blackwall
Canning Town
Covent Garden
Leicester Square
Piccadilly Circus
Green Park
Hyde Park Corner
Knightsbridge
High Street Kensington
Shepherd's Bush Market
Goldhawk Road
Hammersmith
Kensington (Olympia)
Barons Court
West Kensington
Earl's Court
Gloucester Road
South Kensington
Sloane Square
Victoria
St. James's Park
Westminster
Charing Cross
Embankment
Temple
Blackfriars
London Bridge
Bermondsey
Canada Water
Rotherhithe
Wapping
Surrey Quays
New Cross Gate
New Cross
Brockley
Honor Oak Park
Forest Hill
Sydenham
Penge West
Anerley
Crystal Palace
Norwood Junction
West Croydon
Canary Wharf
Heron Quays
South Quay
Crossharbour
Mudchute
Island Gardens
Cutty Sark for Maritime Greenwich
Greenwich
Deptford Bridge
Elverson Road
Lewisham
West India Quay
North Greenwich for The O2
Royal Victoria
Custom House for ExCeL
Prince Regent
Royal Albert
Beckton Park
Cyprus
Gallions Reach
Beckton
West Silvertown
Pontoon Dock
London City Airport
King George V
Woolwich Arsenal
West Brompton
Fulham Broadway
Parsons Green
Putney Bridge
East Putney
Southfields
Wimbledon Park
Wimbledon
Imperial Wharf
Clapham Junction
Pimlico
Vauxhall
Waterloo
Southwark
Borough
Lambeth North
Elephant & Castle
Kennington
Oval
Stockwell
Brixton
Clapham North
Clapham Common
Clapham South
Balham
Tooting Bec
Tooting Broadway
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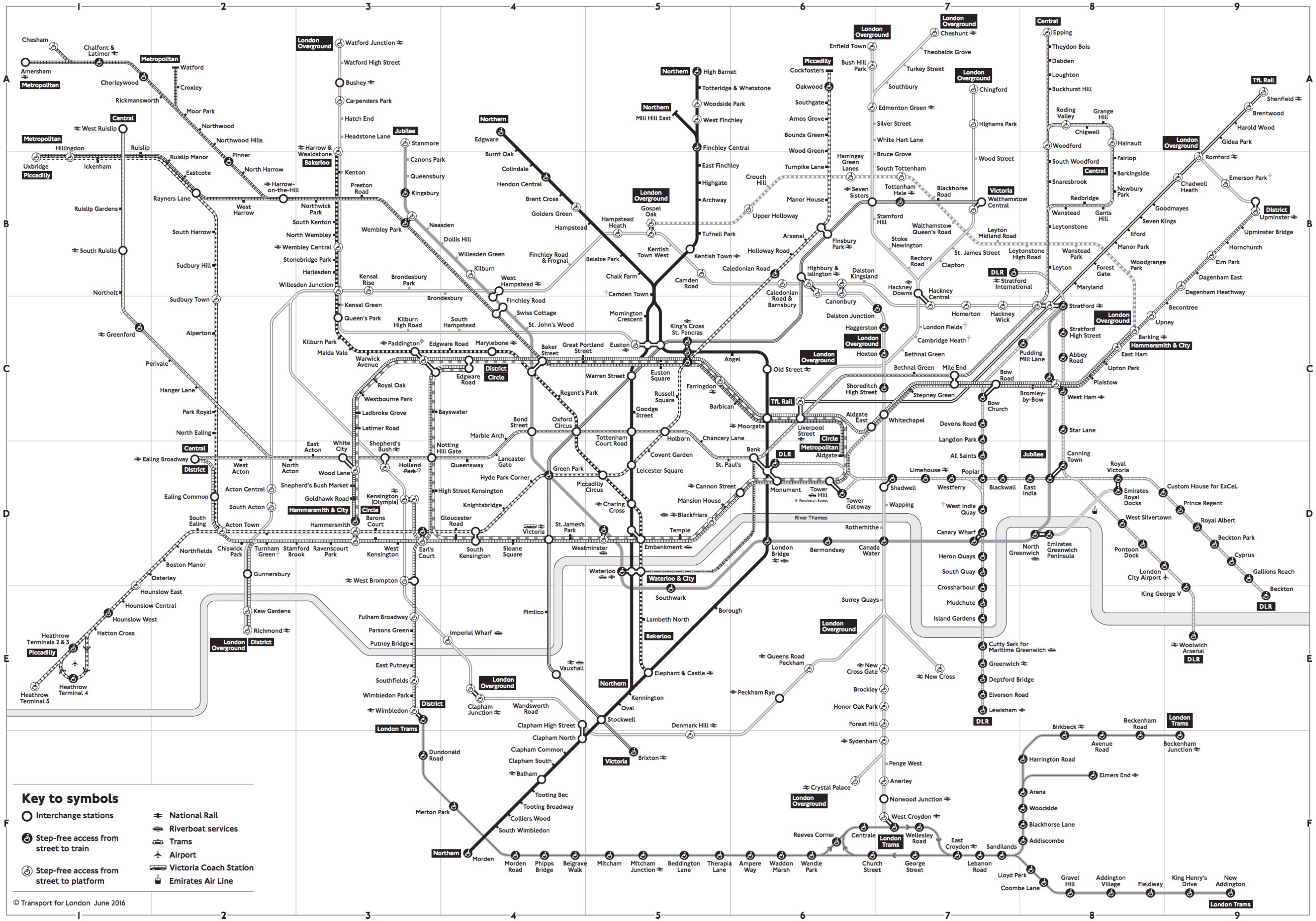
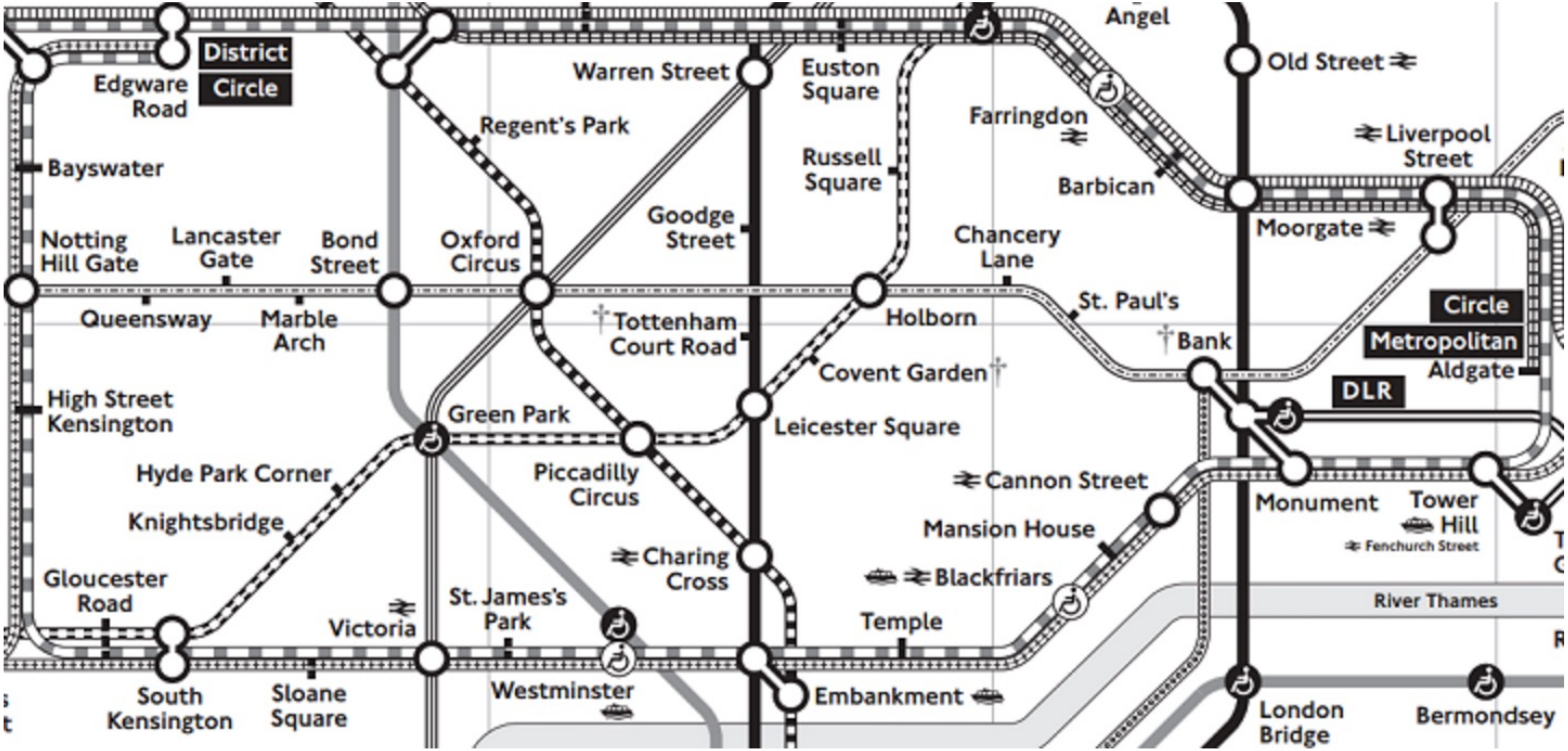

Key to symbols
Interchange stations
Step-free access from street to train
Step-free access from street to platform
National Rail
Riverboat services
Trams
Airport
Victoria Coach Station
Emirates Air Line
© Transport for London June 2016


District
Circle
Edgware Road
Bayswater
Notting Hill Gate
Lancaster Gate
Bond Street
Oxford Circus
Regent's Park
Warren Street
Euston Square
Russell Square
Goodge Street
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Cannon Street
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Fenchurch Street
Charing Cross
Blackfriars
Gloucester Road
Victoria
St. James's Park
Temple
River Thames
South Kensington
Sloane Square
Westminster
Embankment
London Bridge
Bermondsey

Reading

- Saccades, fixations (94% time), regressions
- ≈ 250 words/min (first time)
- Reading speed impaired by ALL CAPS, probably due to reduced character legibility

Human Input: Auditory

- Part of eyes-free interaction
- Pitch: ≈ 20Hz to 15 KHz; good to poor distinction
- Many parameters: amplitude, timbre, direction
- Filtering capabilities (e.g., cocktail party effect)
- Problems with signal interference and noise!

Human Input: Haptic

- Haptics =
  - Proprioception: sense of limb location +
  - Kinaesthesia: particularly limb movement +
  - Tactition: skin sensations
- Potentially powerful: eg Braille



- [redacted]

Human Input: Olfactory!

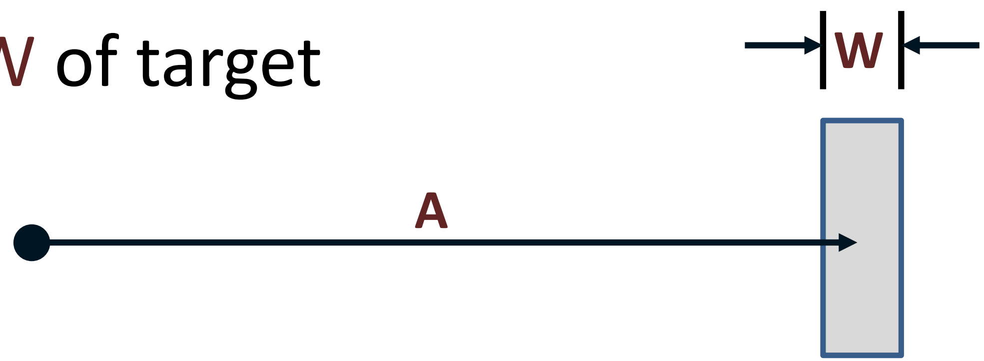
Human Output

- Motor response times depend on stimuli:
  - Visual ≈ 200 ms, audio ≈ 150 ms, haptics ≈ 700 ms
  - Faster for combined signals

- Muscle actions:
  - Isotonic: contraction yields movement (e.g., mouse)
  - Isometric: contraction with no movement

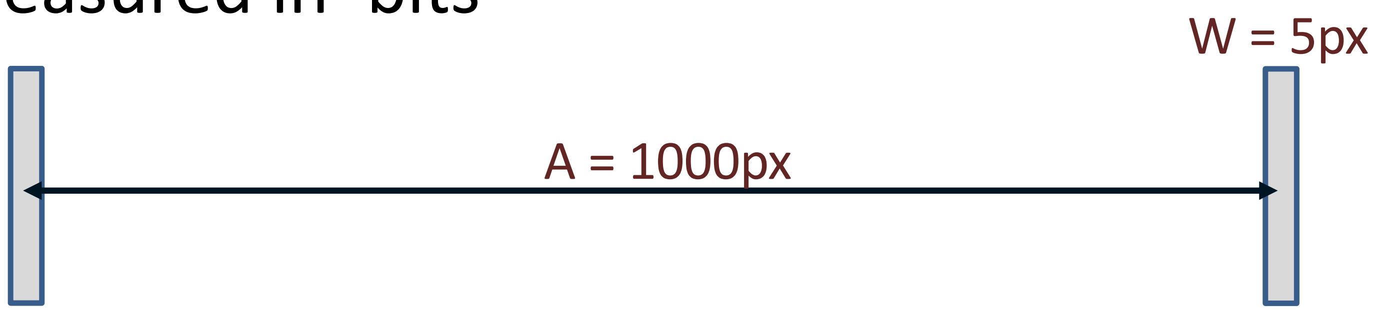
Human Output: Pointing
Fitts' Law

- A model of rapid, aimed human movement:
- Predictive of tasks; descriptive of devices
- Derived from Shannon's theory of capacity of information channels:
  - 'Signal': amplitude A of movement (or D for distance)
  - 'Noise': width W of target



Human Output: Pointing
Fitts' Law

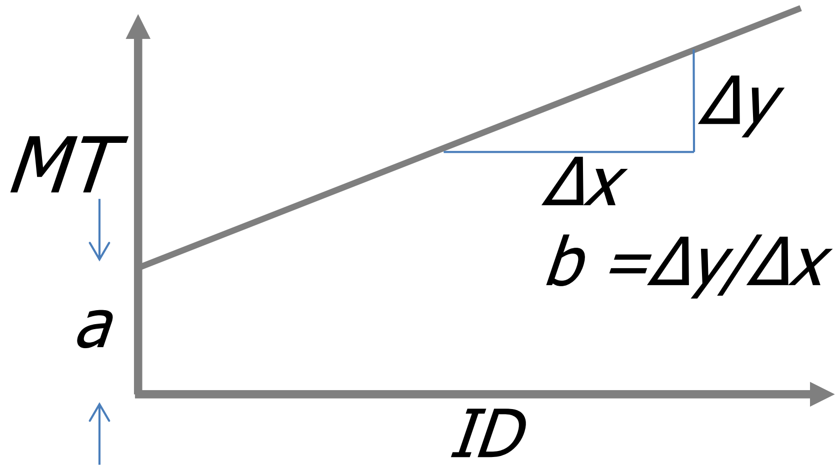
- 'Index of difficulty' (ID) measures difficulty of rapid aimed movement:
  - $ID = log_2 (A/W + 1)$
  - Measured in 'bits'



  - ID = $log_2 (1000/5 + 1) = 7.651$ *bits*

Human Output: Pointing
Fitts' Law

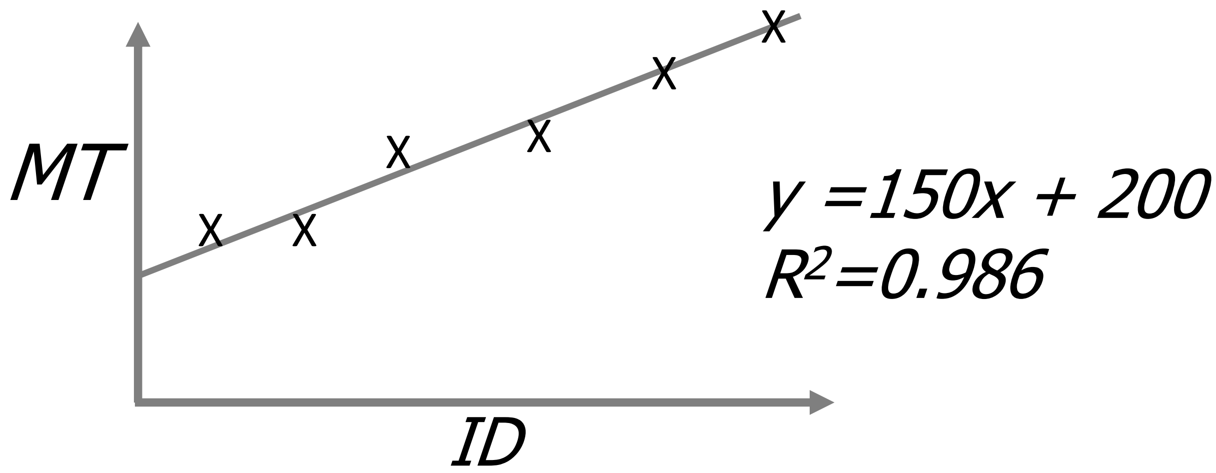
- Fitts' Law: movement time (*MT*) is linear with *ID*
  - $MT = a + b\ ID$ or $MT = a + b \log_2 (A/W + 1)$



  - Reciprocal of slope (*1/b*) also called 'throughput' or 'bandwidth' of device; in bits/second

Human Output: Pointing
Fitts' Law

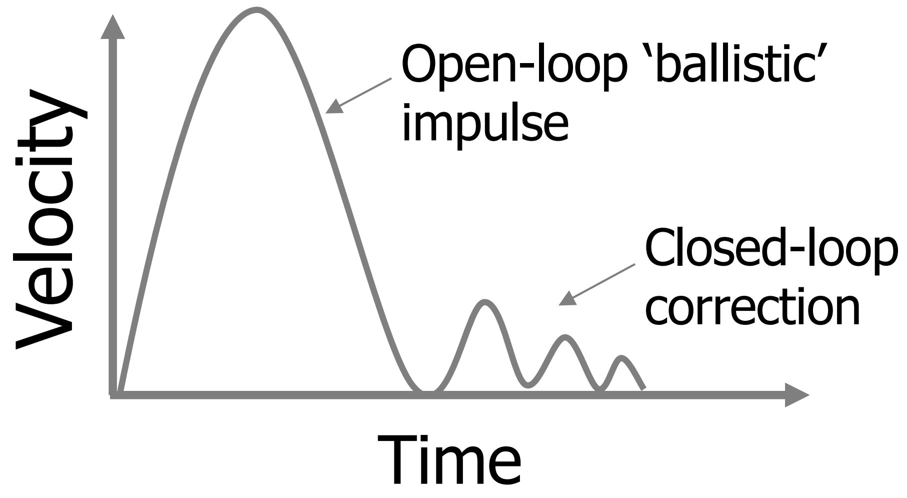
- *a* and *b* empirically determined (regression)



- For a mouse:
  - *a* typically 200-500 ms
  - *b typically* 100-300 ms/bit

Human Output: Pointing
Fitts' Law

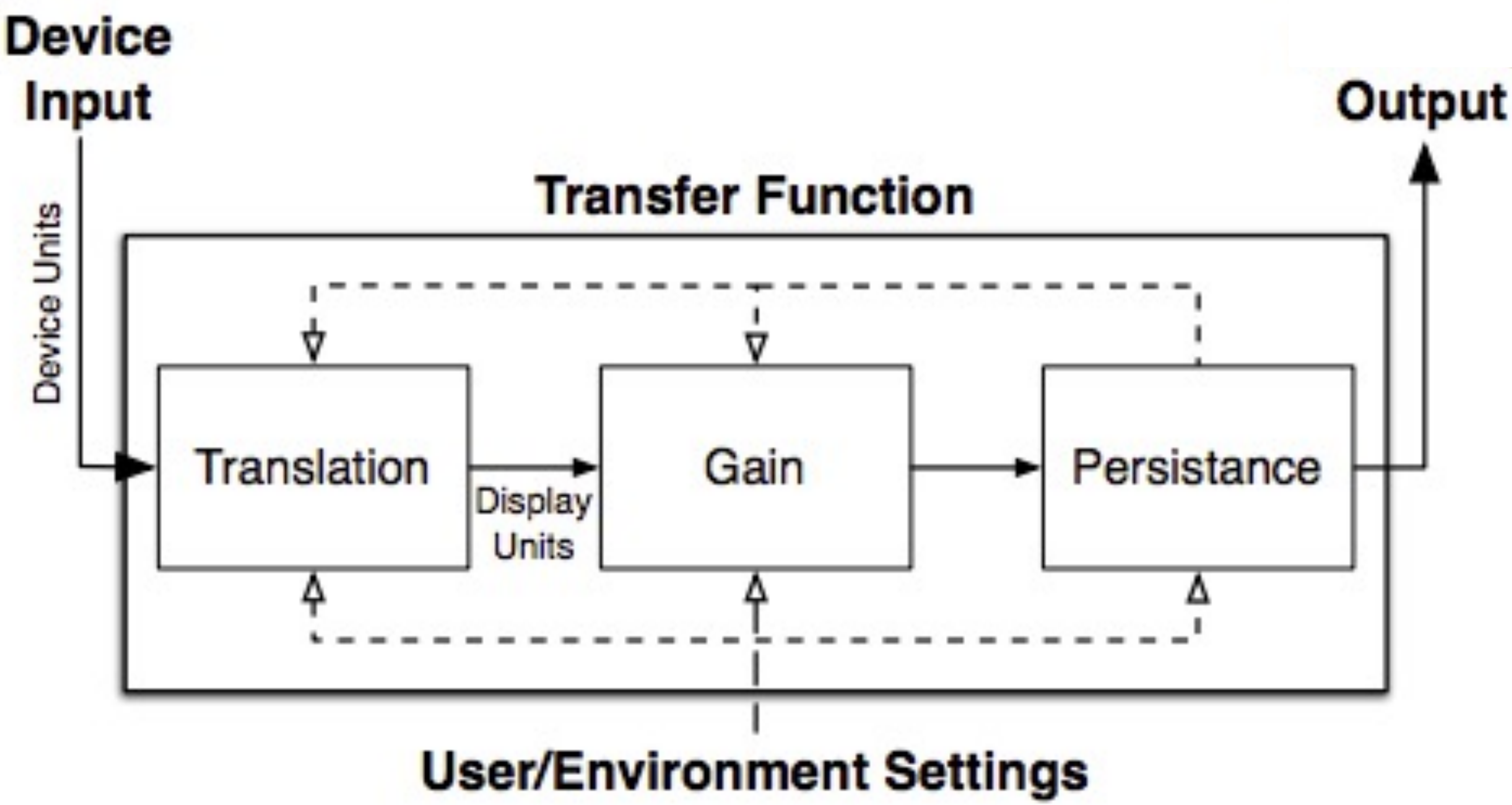
- Accurate and extensively validated for many types of aimed pointing
  - Consider velocity profile



Input Devices: Pointing & Scrolling

- Human Output received as System Input
- Direct vs Indirect
- Absolute vs Relative (Hybrid?)
- Control: position (zero-order), rate (first-order), acceleration (second-order)
- Isotonic (force with movement) vs Isometric (force without movement)
- Control-Display Gain and Transfer Functions

Input Devices: Transfer Functions



Input Devices: Scrolling Gain Example

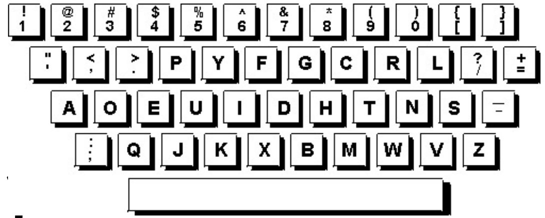
DLD gain. Cockburn et al. 2012

Input Devices:
Touch Scrolling Transfer Function

Input Techniques: Bimanual input and ‘magic lenses’

T3 Design.
Kurtenbach et al., 1997!

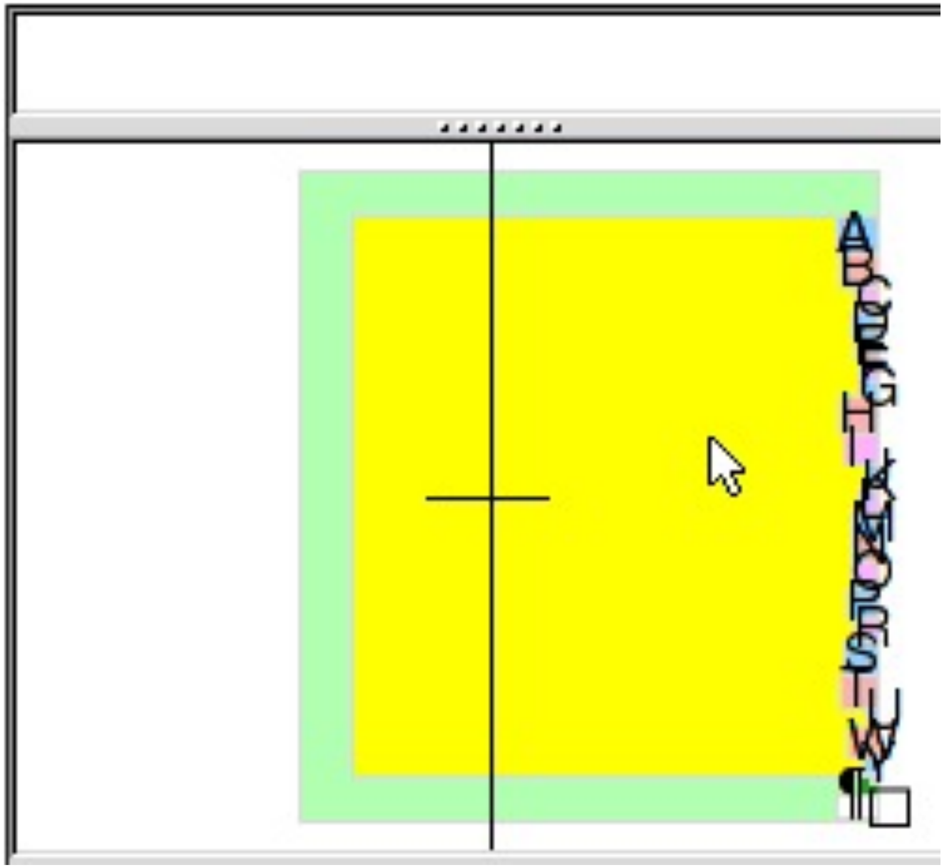
Text Input



- Alternative keyboards (e.g., Dvorak)
- Chord keys
- Constrained keyboards

- Reactive/predictive systems (e.g., Dasher)
- Gestural input (unistrokes, ShapeWriter/Swipe)
- Hand-writing recognition

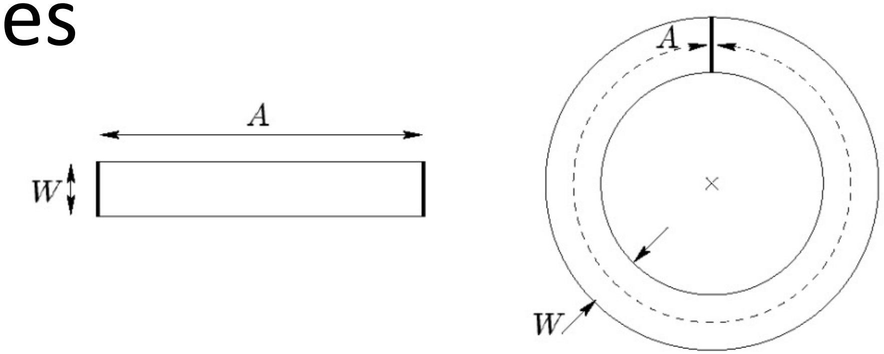
Text Input
Dasher



Text Input
On GoogleGlass?

Human Output: Steering Law

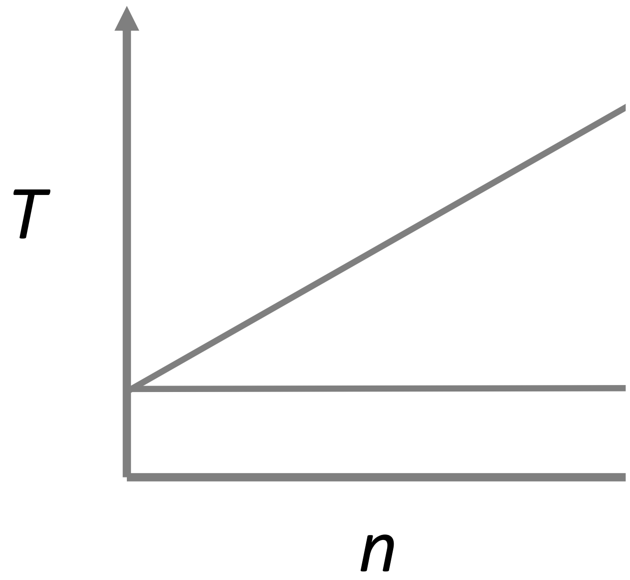
- A model of continuously controlled 'steering'
  - $MT = a + b\ ID$ or $MT = a + b\ (A/W)$
  - *A* is the tunnel length; *W* is tunnel width
  - *(A/W)* still called 'index of difficulty'
- Also works when W varies

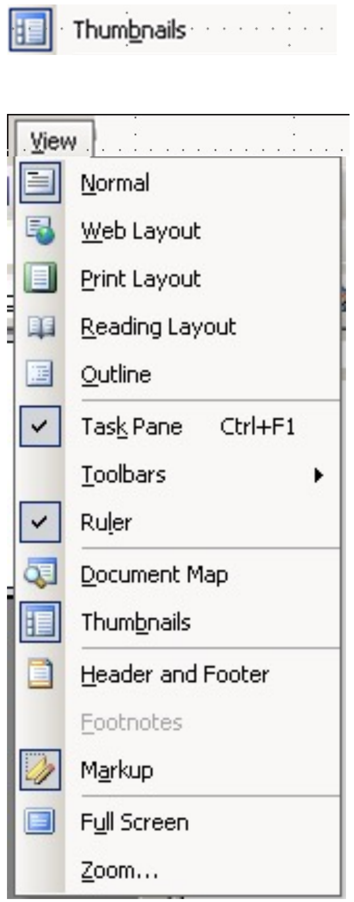


(a) Linear tunnel (b) Circular tunnel

Human Processing: Visual Search Time

- Extensively researched in psychology





Findlater, et al. CHI’09

Human Processing: Visual Search Time

- Extensively researched in psychology
- Visual search time is a linear function of the number of candidate items: O(n) , i.e., $T = a+b\times n$
- BUT, pop-out effects can reduce that to O(1)

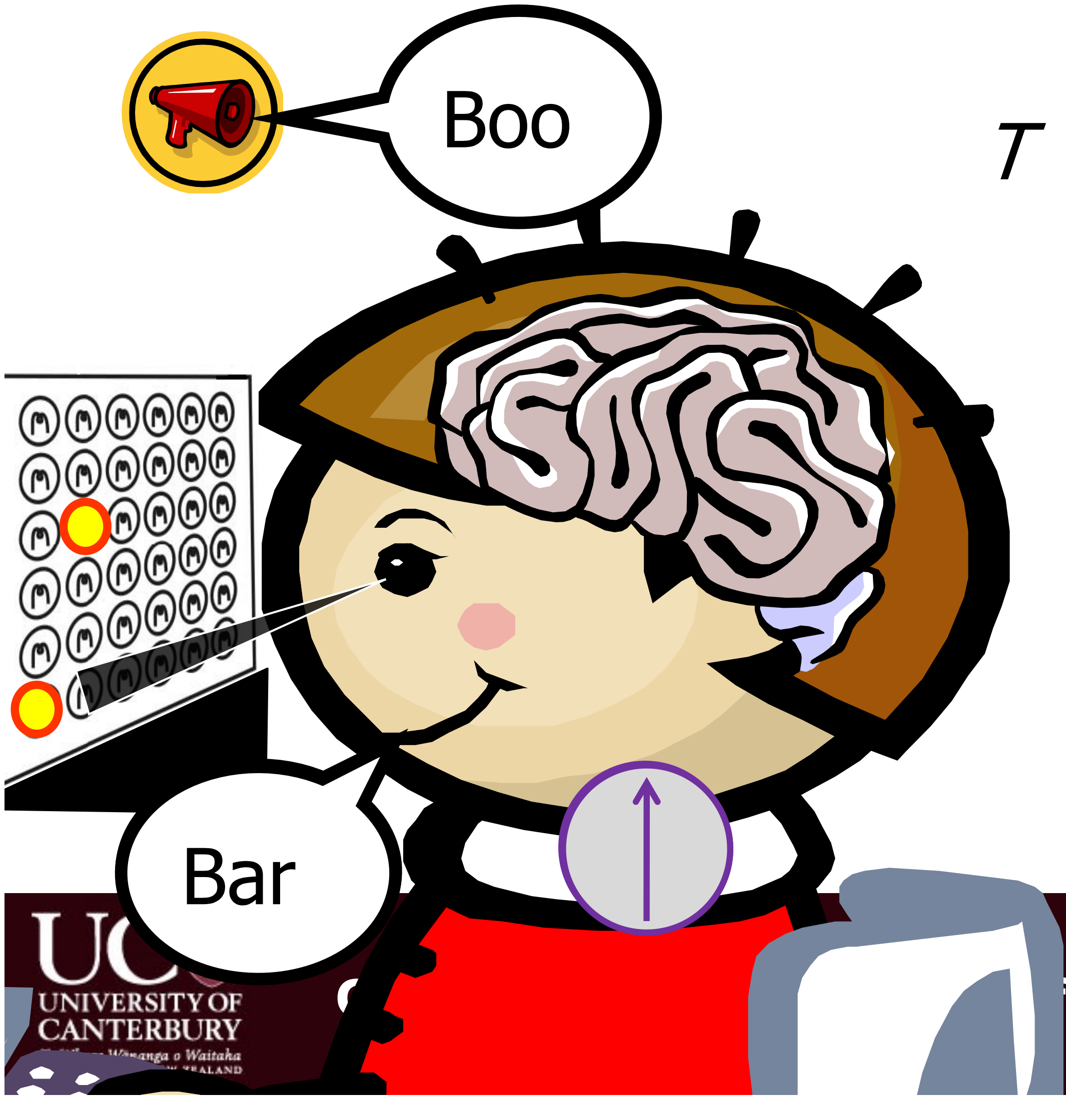
- Visual search is essential when novice, but ideally unnecessary with experience (more soon)

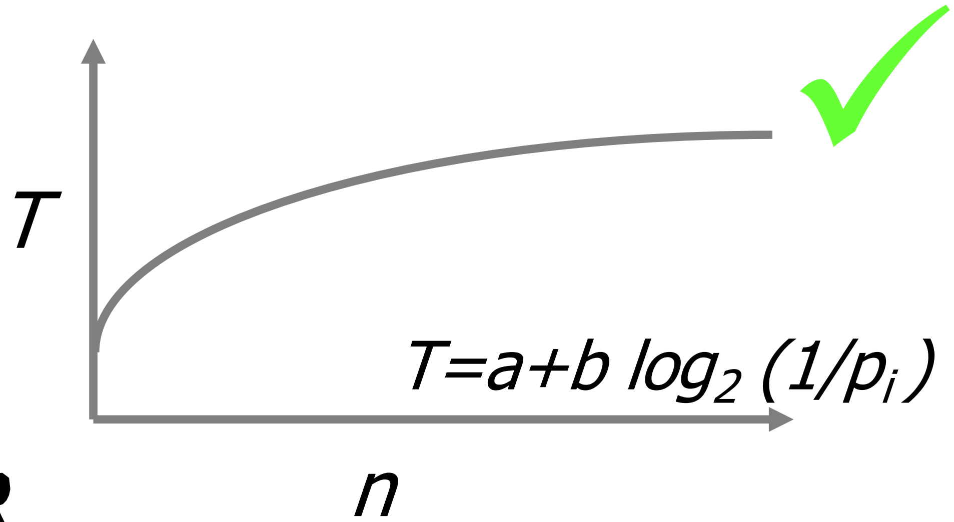
Human Processing: Hick/Hyman Law of Decision Time

- Choice reaction time when optimally prepared
  - $T = a + b \times H$
  - H is ‘information entropy’
  - For item *i,* with probability p_i, $H_i = log_2(1/p_i)$
  - For *n* equally probable items, $H= log_2(n)$

- We make frequent decisions quickly!

Human Processing:
Hick/Hyman Law of Decision Time





In our menu experiments,
a=240ms, b=80ms/bit

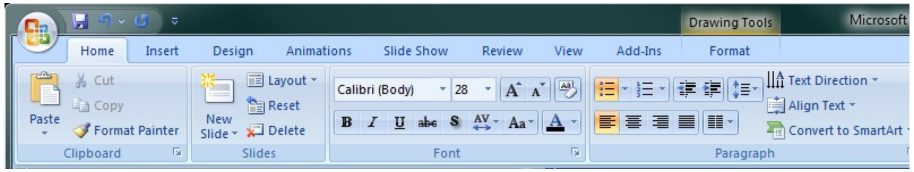
Human Processing: Implications of Hick/Hyman Law

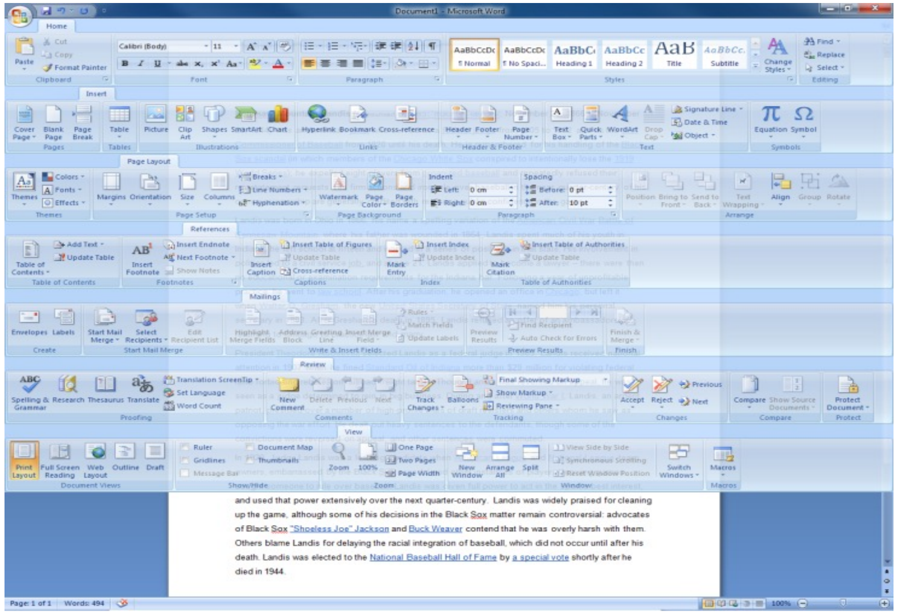
- Decisions are fast: O(log n)
- Applies to name retrieval (commands) and location retrieval
- In GUIs, replace visual search (O(n)) with decision through spatial stability

✓

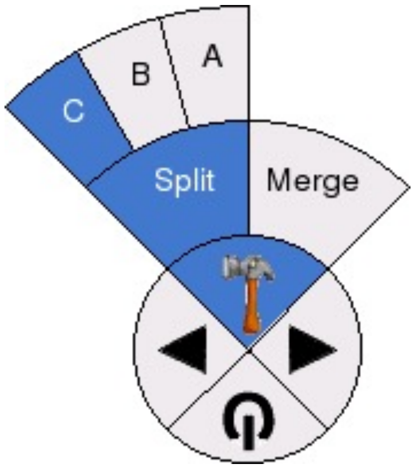
Spatial consistent user interfaces

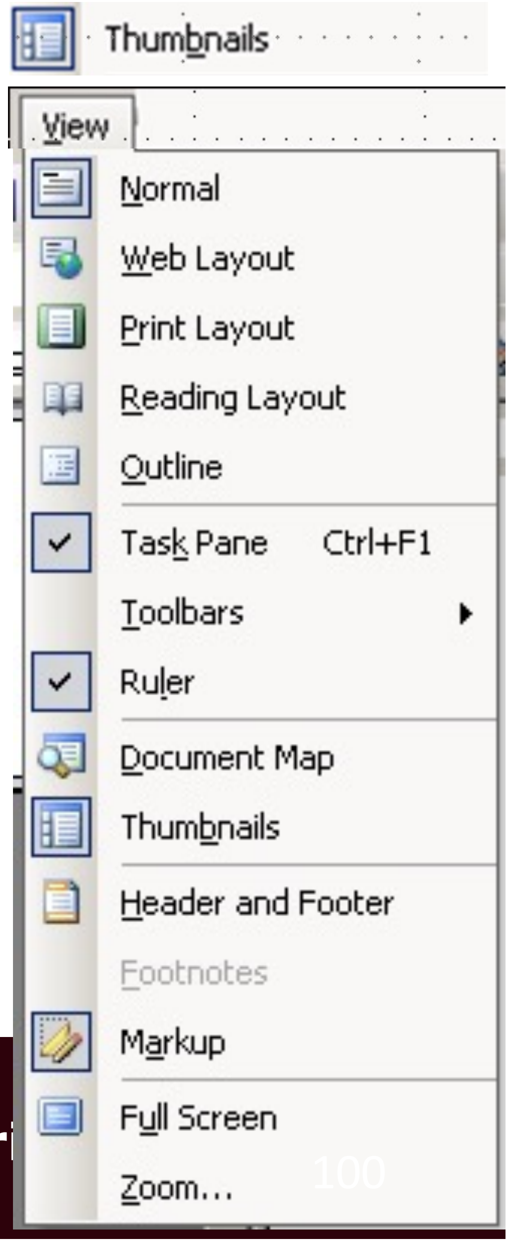
Morphing menus





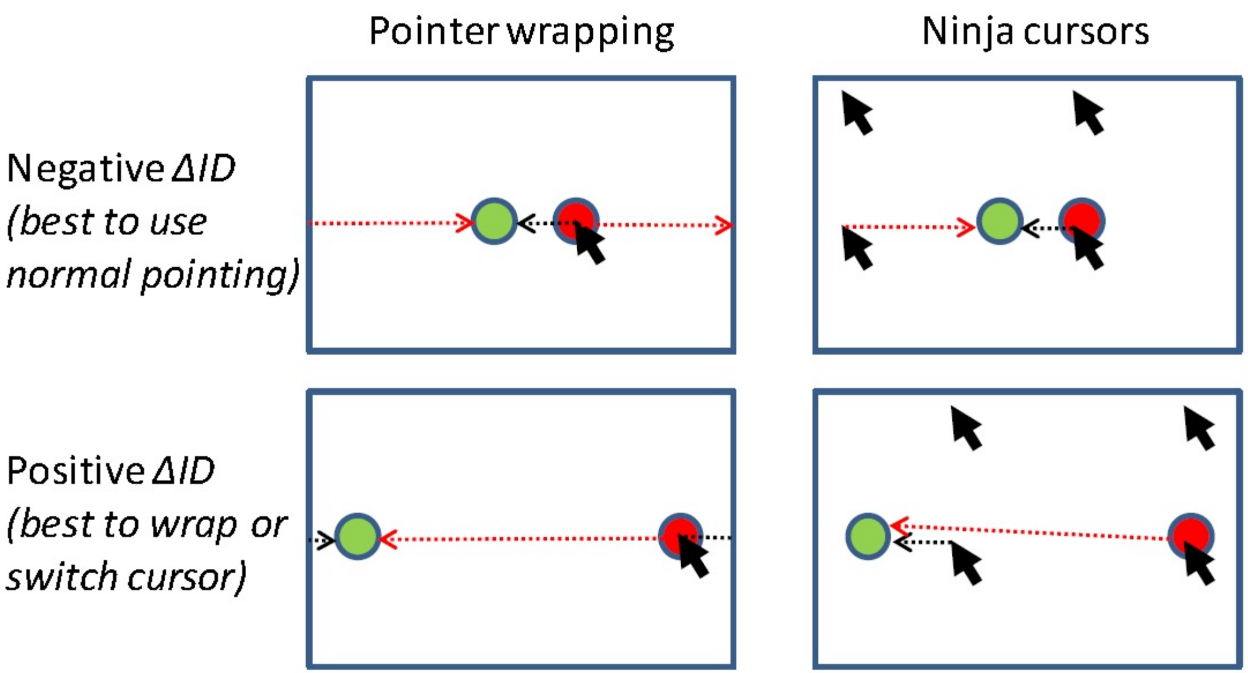
Pie/Marking menus





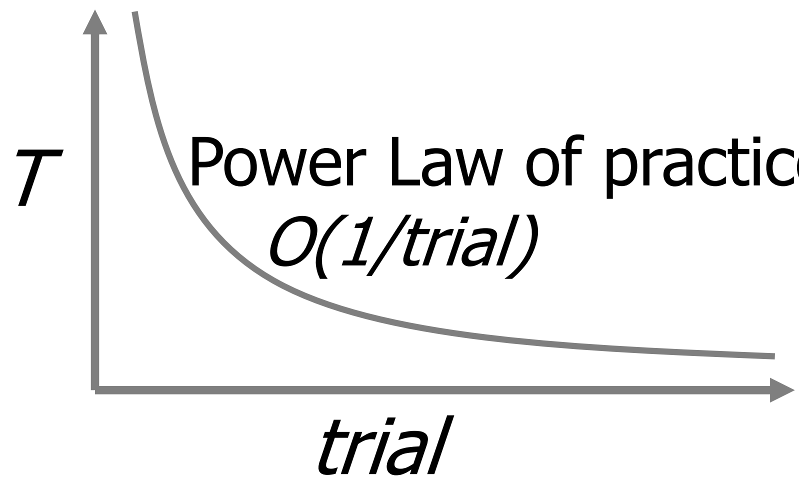
Decision costs in pointing

- Torus pointing and "ninja-cursors"



Human Processing: Power Law of Practice

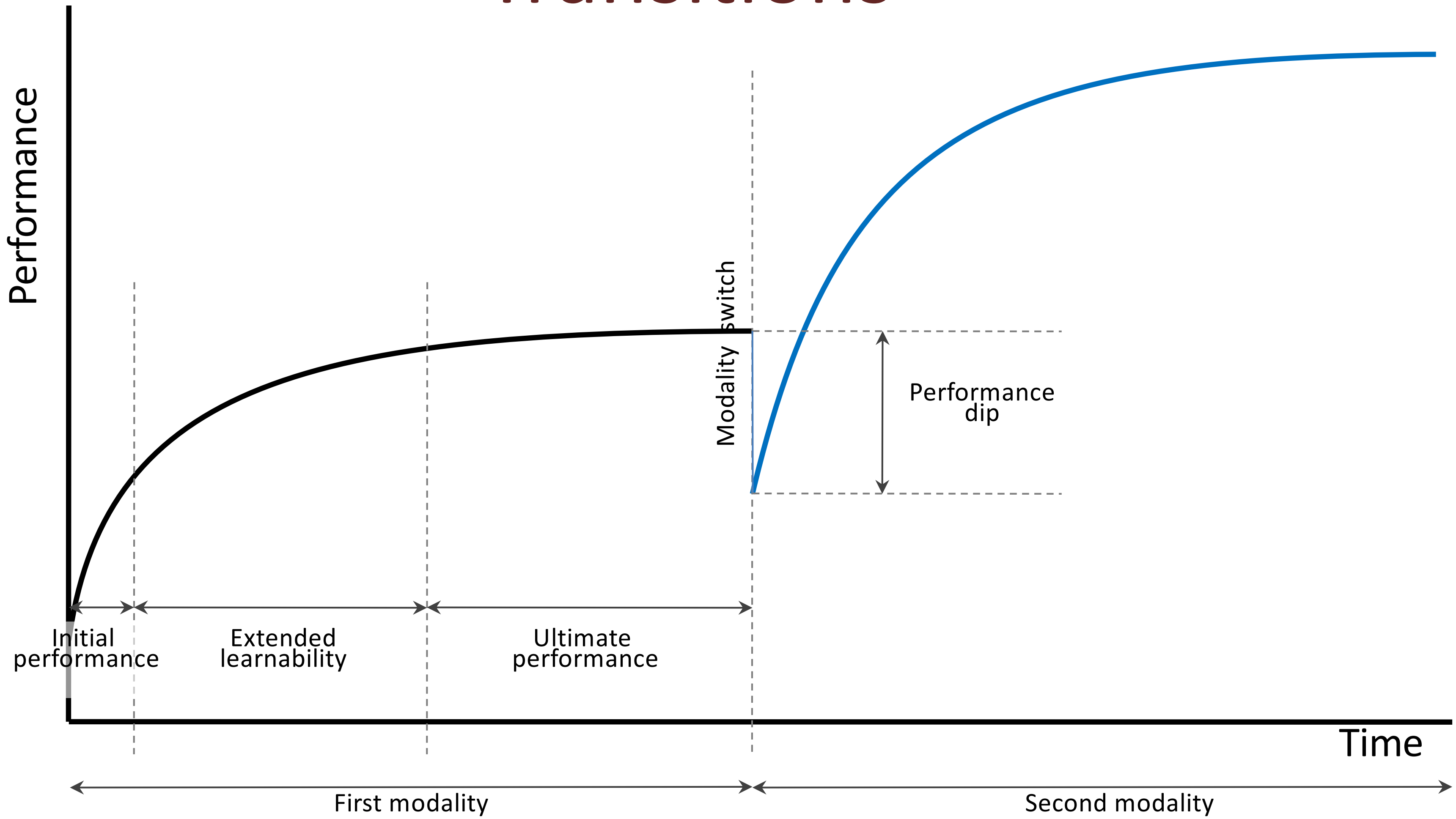
- Performance rapidly speeds up with practice
  - $T_n = Cn^{-\alpha}$ or $\log(T_n) = C - \alpha\log(n)$
  - T_n is time on trial n
  - C is time on trial 1
  - α is learning curve
- Applies to simple and complex tasks



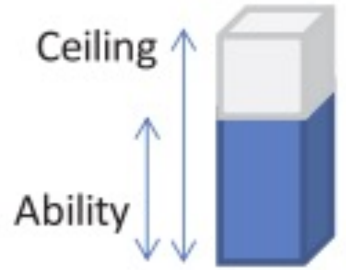
Novice to Expert Transitions

- People use the same tools for years/decades
- Yet shortcut vocabularies are small, and frequency of their use is low
- Many factors:
  - Satisficing (making do rather than optimising)
  - Lack of mnemonics (e.g., Ctrl P for print… paste?)
  - Lack of visibility
- How to support transition to expertise?

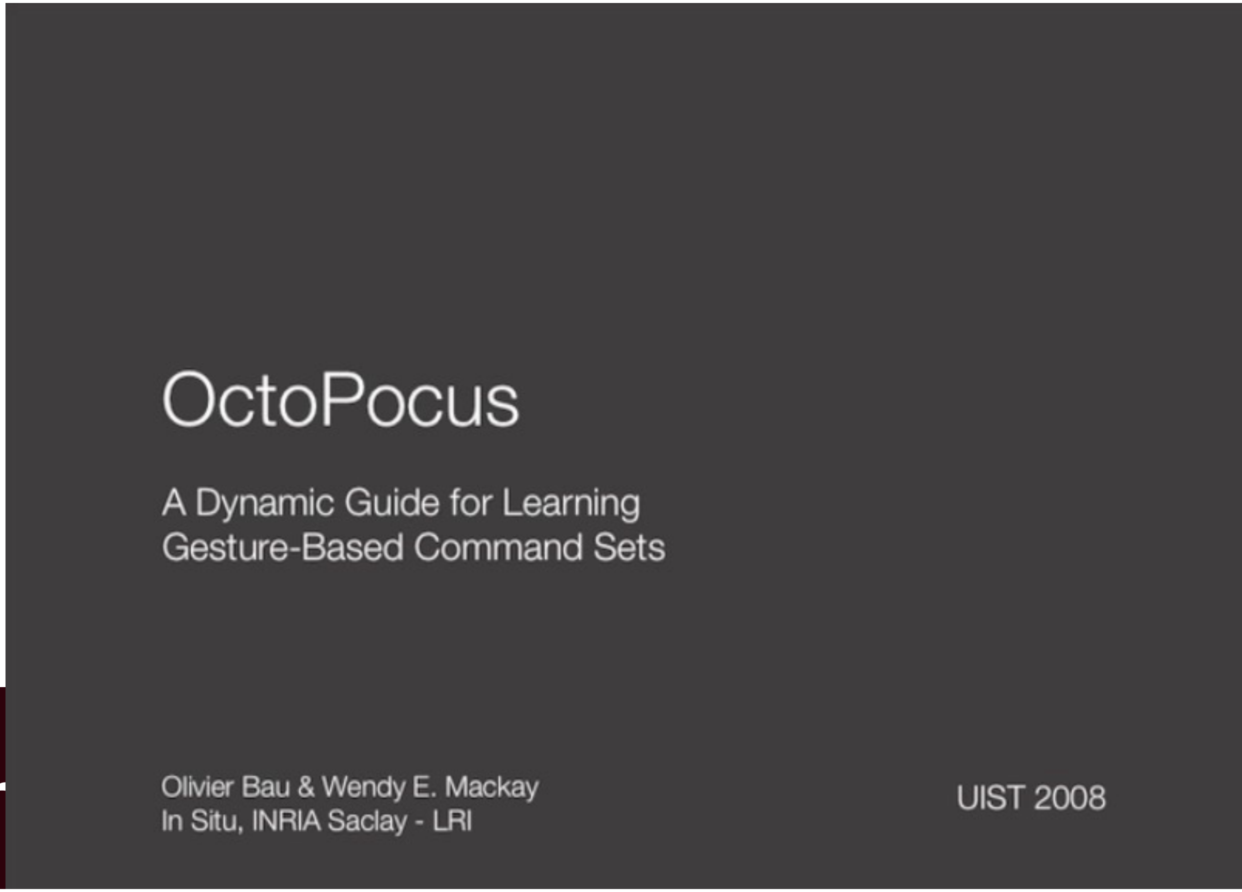
Characterising Novice to Expert Transitions



Domains of Interface Performance Improvement

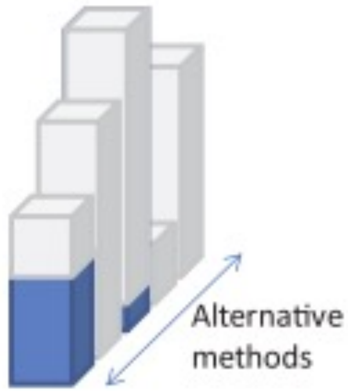


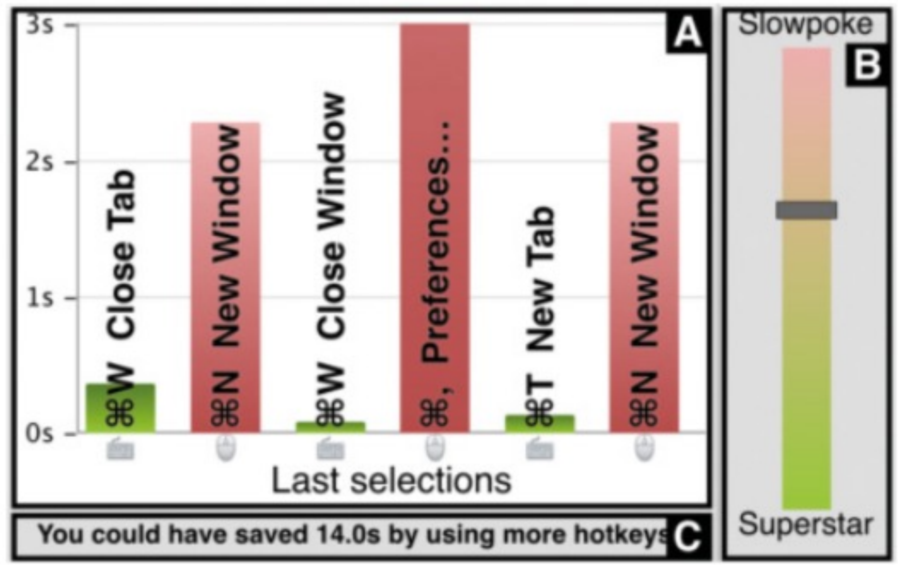
1. Intra-modal improvement
   – E.g. *guidance* techniques



Domains of Interface Performance Improvement

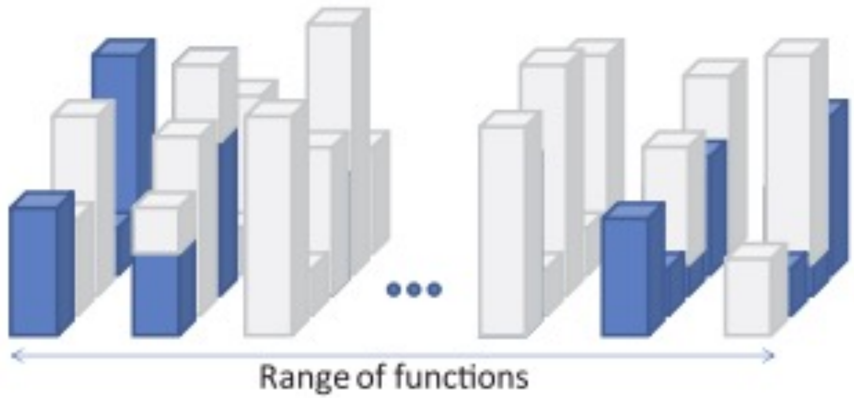
1. Intra-modal improvement
2. Inter-modal improvement
   – E.g., skillometers

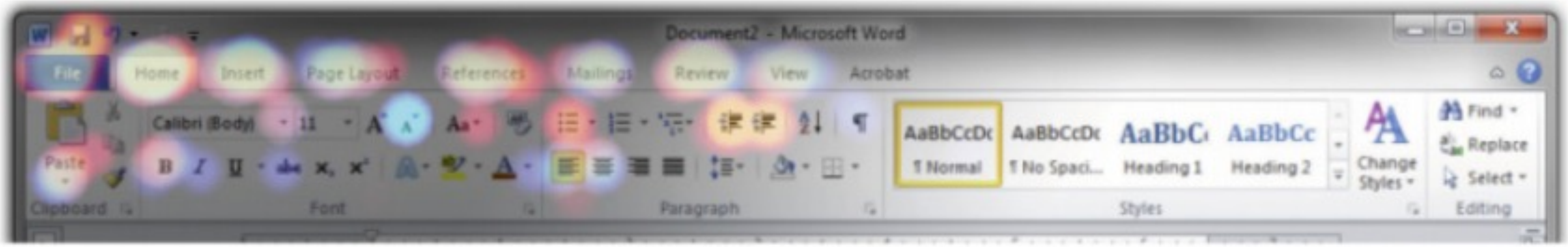




Domains of Interface Performance Improvement

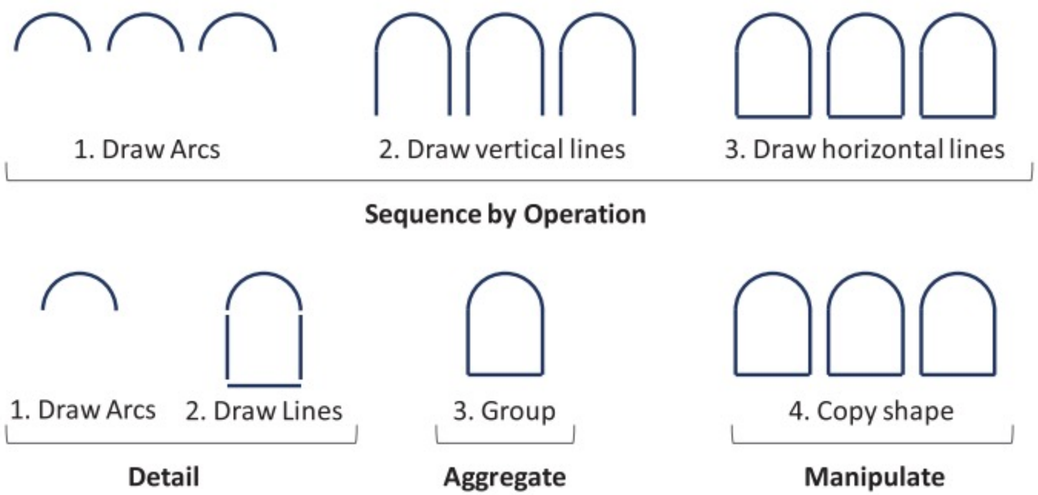
1. Intra-modal improvement
2. Inter-modal improvement
3. Vocabulary extension
   – E.g., community command use



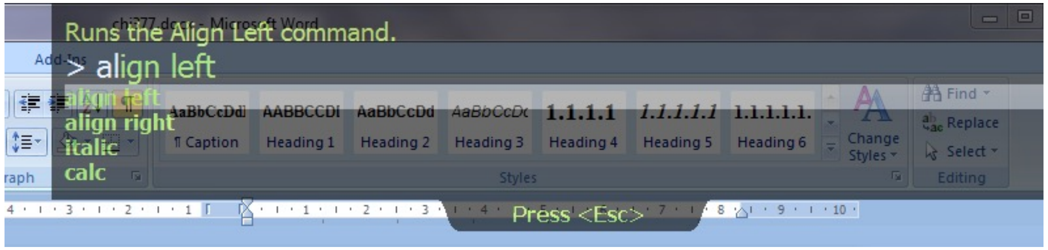


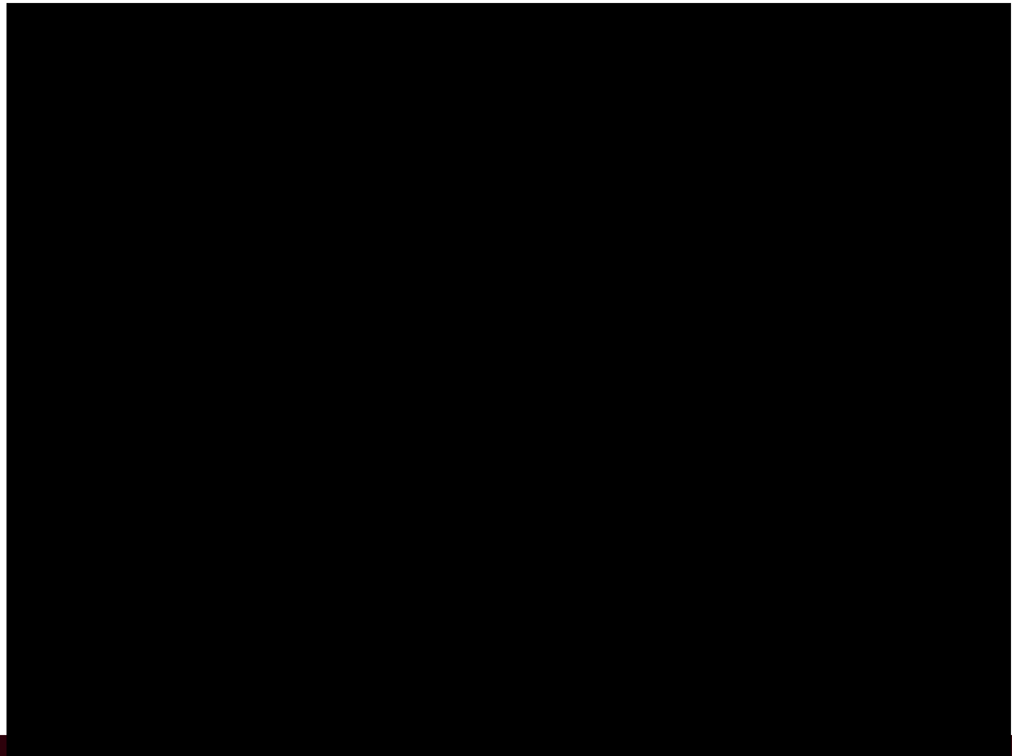
Domains of Interface Performance Improvement

1. Intra-modal improvement
2. Inter-modal improvement
3. Vocabulary extension
4. Task strategy



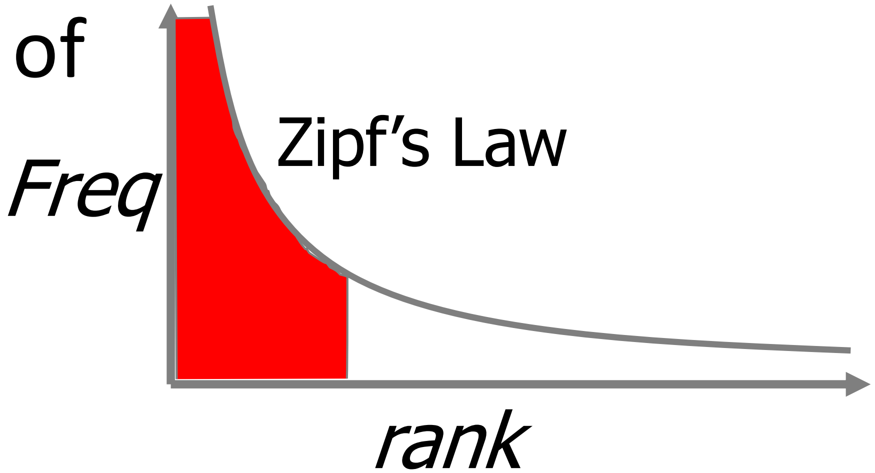
Blur: Supporting Novice to Expert Transitions



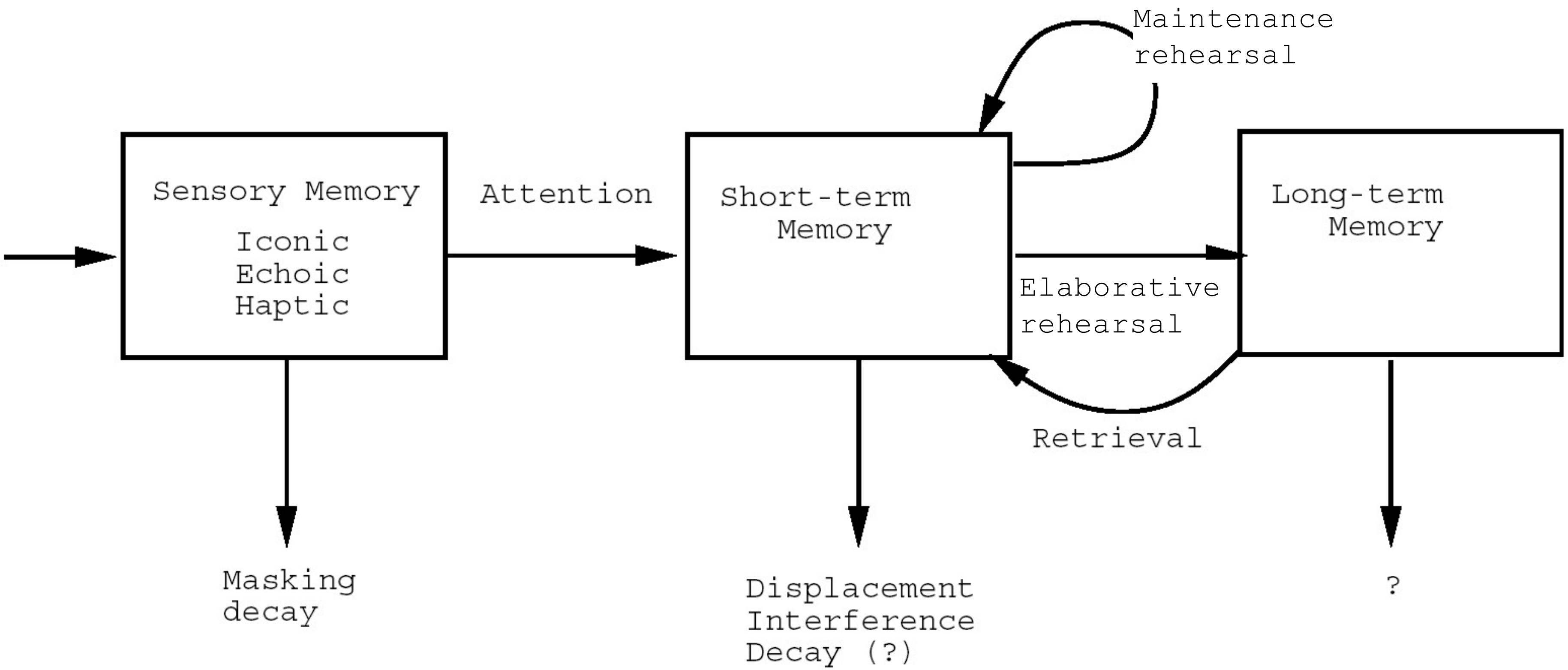


Human Pattern of Behaviour: Zipf's Law, Pareto Principle, 80-20 rule

- Frequency of words (Zipf 1932)
  - $P_n \approx n^{-\alpha}$
  - P_n is scaling factor of frequency of n^{th} ranked word
  - $\alpha \approx 1$
- Also applies to frequency of commands, URLs, apps, windows, ...
- 80% of time using 20%



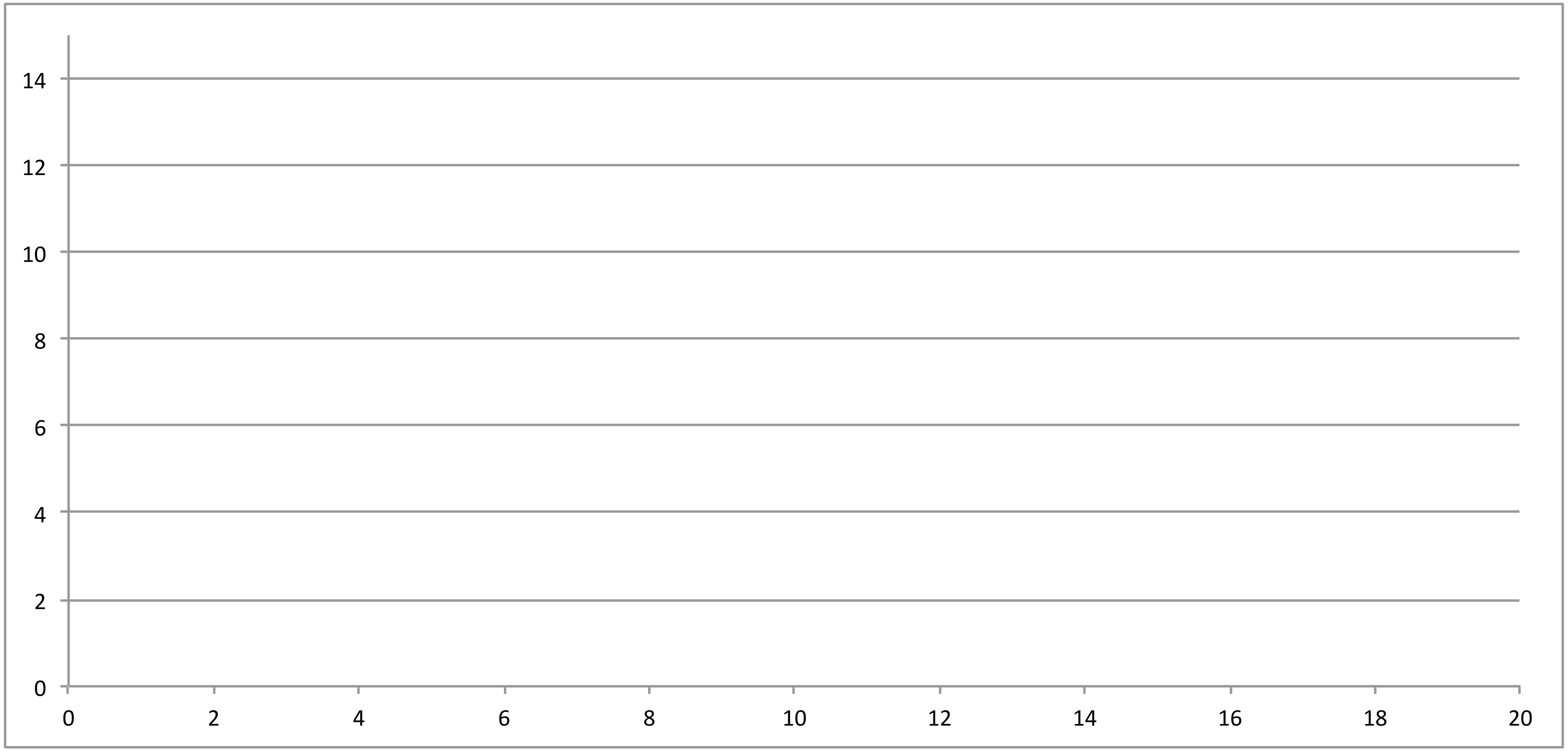
Human Memory: Simplified Model



Short-Term Memory

- Input from sensory or long-term memory
- Capacity up to 7±2 ‘chunks’ (abstractions)
- Chunks used to aid storage and reconstruction
- Fast access (≈70ms); rapid decay (≈200ms)
- Constant update and interference
- Maintenance rehearsal

Test of 7±2



Long-Term Memory

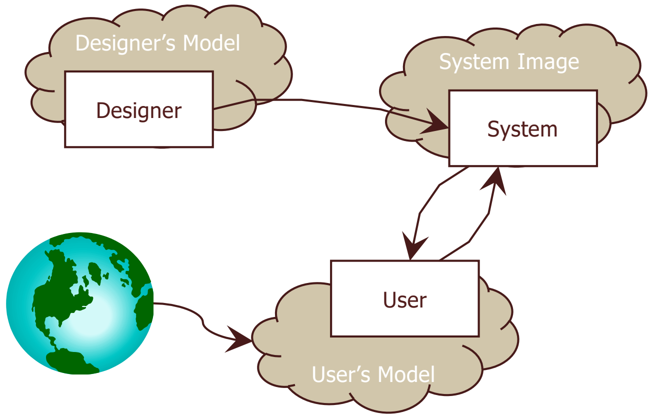
- Input through elaborative rehearsal and extensive repetition
- Slow access (>100ms)
- Decay?

Lessons

- Support recognition; don't demand recall
- Support spatial processing

Human Error: Mistakes

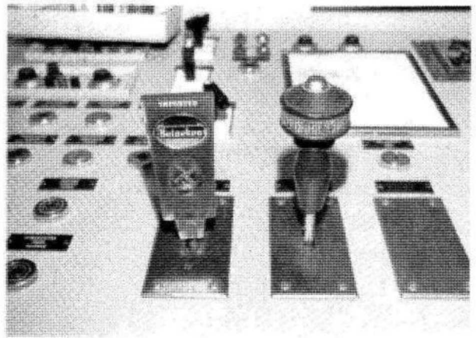
- Errors of conscious decision
- Due to incorrect or incomplete model of system
- Only detected with feedback



Human Error: Slips

Errors of automatic and skilled behaviour

- Capture error
  - Two action sequences with common starting point(s)
  - Captured into wrong path (usually the more frequent one)
- Description error
  - More than one object allowing the same/similar action
  - Execute right action on wrong object
- Data-driven error
  - External data interferes with STM
- Associative activation error



Stroop Effect

(Data-Driven Error)

Red
Blue
Yellow
Green
Orange
Purple
Red
Green
Yellow
Blue
Green

Blue
Red
Green
Orange
Yellow
Red
Green
Purple
Green
Yellow
Blue

Human Error: Slips (continued)

- Loss-of-activation error
  - Goal displaced/decayed from STM completed
- Mode error
  - Right action, wrong system state
- Motor slip
  - Pointing/steering/keying error
- Premature closure error
  - ‘Dangling’ UI actions required after perceived goal completion

Aside: What is a mode?

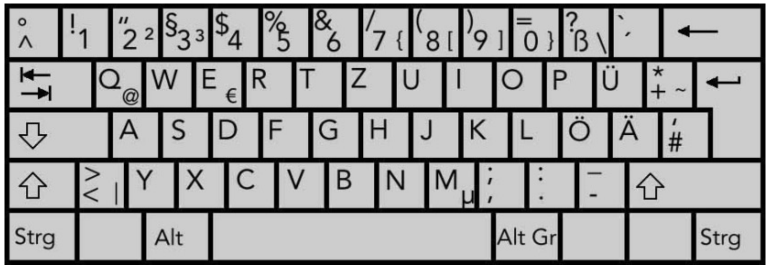
- System **partition**
  - Different set of commands available
  - Different interpretation of same commands/actions
  - Different display method
- Modal dialog
  - Grabs focus for application/desktop and must be dismissed to proceed
- Ensure modes are visible/noticeable

Human Phenomena

But people don’t conform to simple models

- International/cultural differences

Source: w3.org



On or off?

Human Phenomena

- Sapir-Whorf Hypothesis
  - Language influences the way we think
  - More generally, "Law of the instrument" or "Maslow's hammer"
  - Our language/tools influence how we think about design/interaction

Human Phenomena

- Cognitive Dissonance
  - Inconsistent cognitions are uncomfortable
  - Therefore rationalise beliefs
  - Festinger experiments with dull tasks: https://www.youtube.com/watch?v=1kmVy1QPXn0
  - "I spent 5 years learning to use this software"
    - "This software is slow and really hard to use" (I'm a mug)
    - *"I like this software and I can use it well"* (resolves dissonance)

Human Phenomena

- Homeostasis
  - People maintain equilibrium
  - If a system makes things easier, it’ll be used to do more difficult things
  - If a system makes things safer, it’ll be used to do more dangerous things

Human Phenomena

- Satisficing
  - People make do rather than optimise
  - E.g., 'hunt-and-peck' typing for decades because too busy right now to learn touch typing
  - How many keyboard shortcuts do you know and use?

Human Phenomena

- Hawthorne Effect
  - People like being involved
  - Complicates evaluations

Human Phenomena

- Explaining away errors
  - In hindsight, it's often easiest to blame the user

Human Phenomena

- Fixation
  - Tendency to repeatedly reuse the same solution method rather than think of new/better methods

Human Phenomena

- Perception versus reality
  - People's perception often differs from reality
  - E.g., perceived duration varies for filled versus unfilled time

Human Phenomena

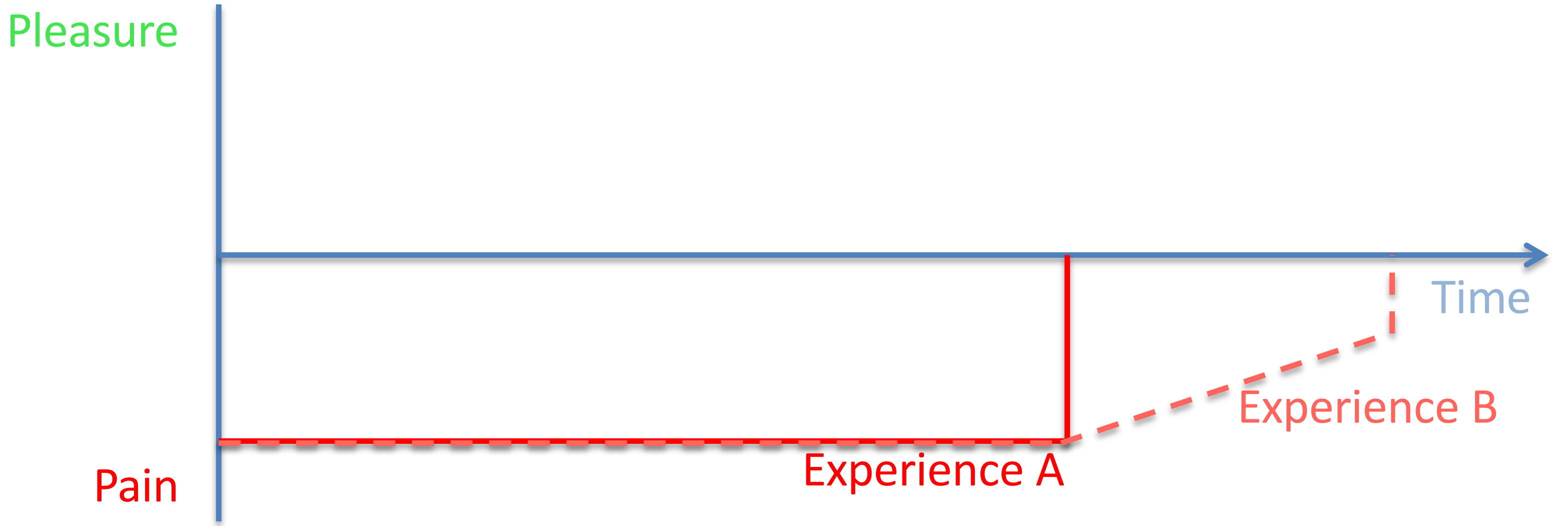
- Peak-End Effects

Human Phenomena

- Peak-End Effects

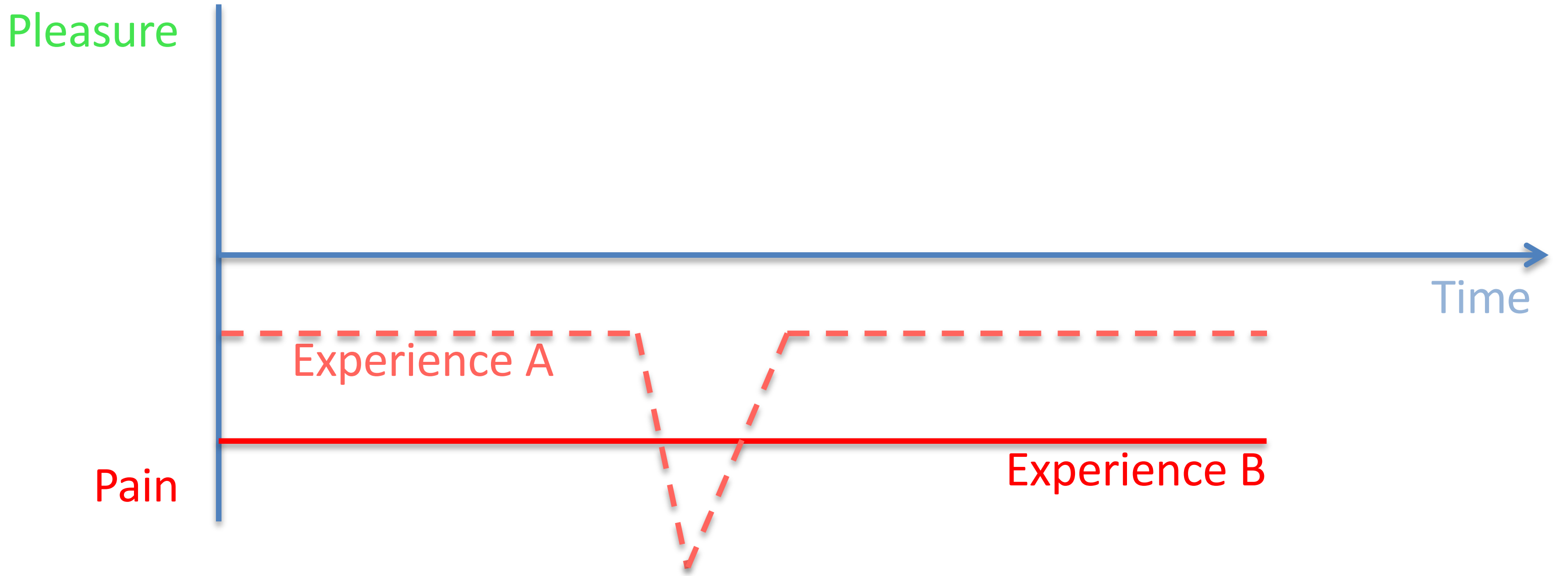
Human Phenomena

- Peak-End Effects



Human Phenomena

- Peak-End Effects



Human Phenomena

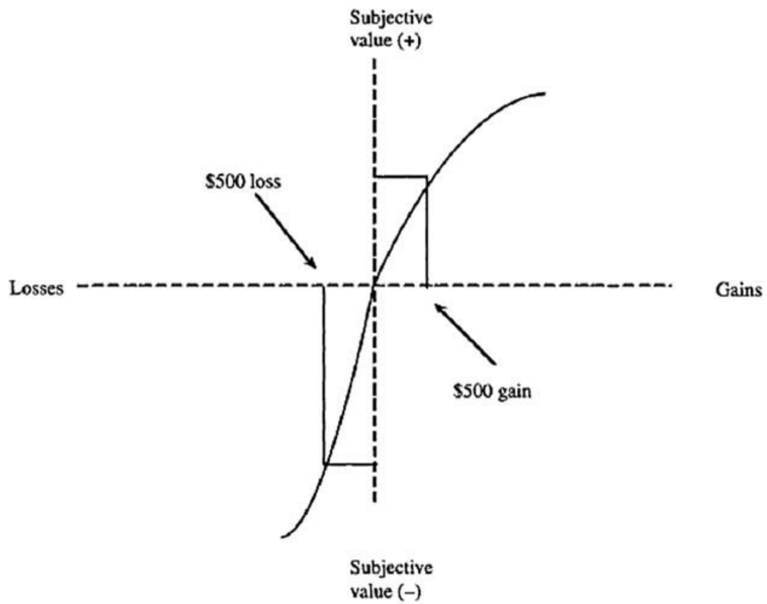
- Peak-End Effects
  – People's retrospective assessment of experience is heavily influenced by moments of peak and end intensity
  – (People prefer more pain to less, if it finishes better)

Human Phenomena

- Negativity bias
  - One coin toss: win $110 on heads; lose $100 on tails will you take it?

Human Phenomena

- Negativity bias
  – One coin toss: win $110 on heads; lose $100 on tails will you take it?
- Bad is stronger than good



Human Phenomena

- Communication convergence:
  - Similarity of pace, gestures, phrases aids affinity, pro-social behaviour, & positive communication outcomes
  - Interfaces could (& should?) measure user pace and adapt effects to match
  - E.g., rate of speech, timeouts, speed of animations, etc.

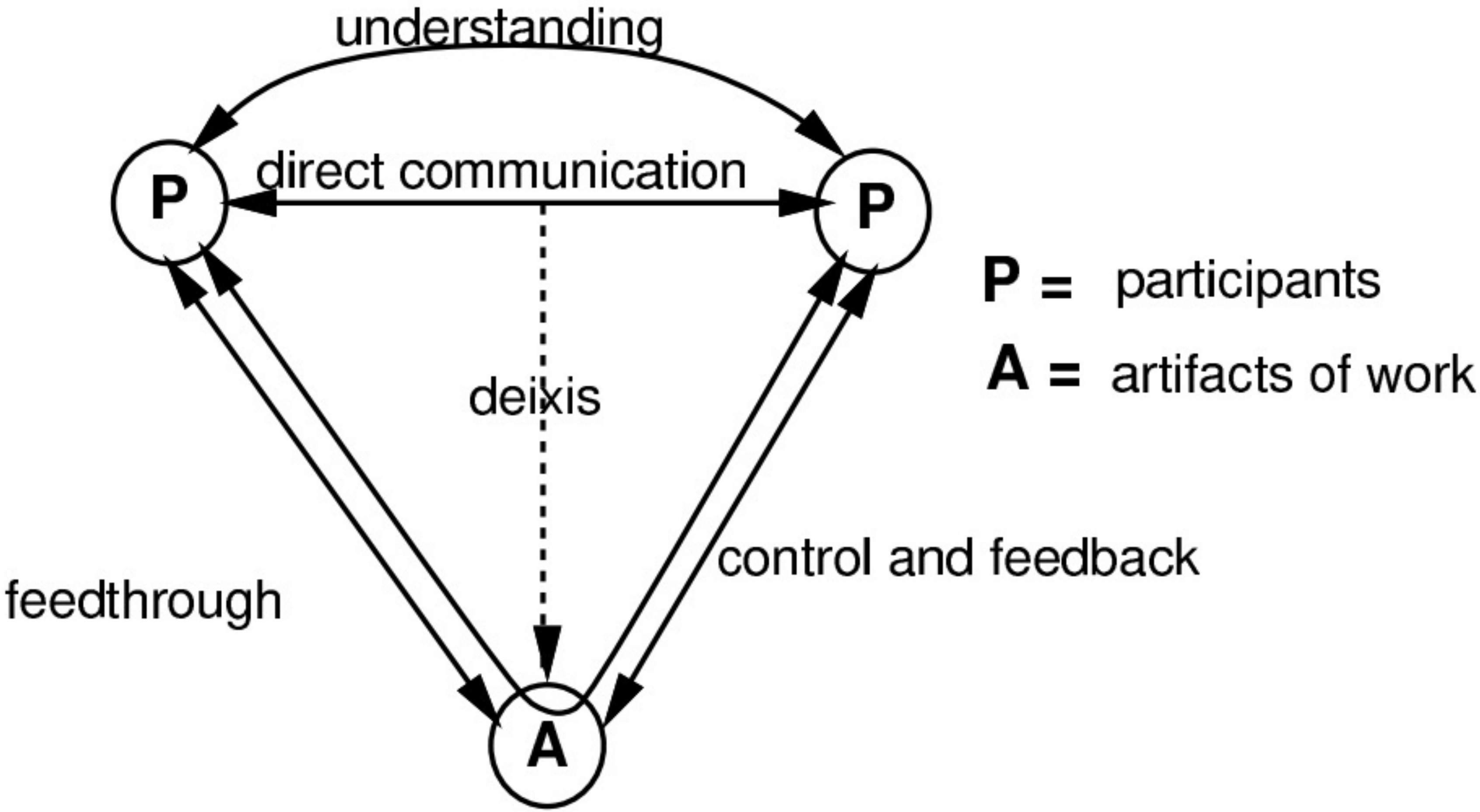
Human Phenomena

- Collaboration
  - Work is inherently collaborative
  - “Computer Supported Cooperative Work: (CSCW) investigates collaboration and how to support it
  - “Groupware” systems support collaborative work
  - Social software (e.g., Facebook) also fits here
  - *Very* difficult to design!

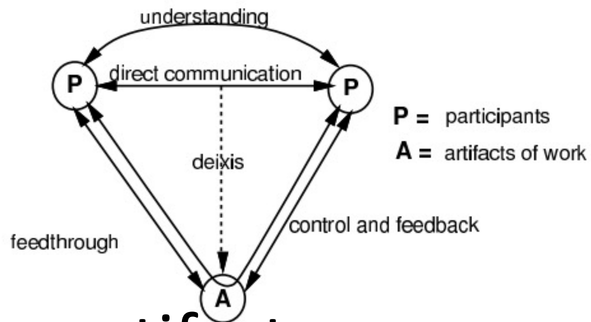
CSCW
Engelbart's "Mother of All Demos" 1968

Video link on "Extra Resources" on Learn

CSCW
Participant-Artifact-Participant Framework



CSCW
Participant-Artifact-Participant Framework



- Classifies:
  - What people do
  - What systems should support
- Feedthrough: communication through an artifact
- Direct communication takes many forms:
  - Obvious: text, speech
  - Subtle "back-channels": nods, 'uh-huh', facial expression, gestures, etc.
- Deixis: communication coupled with contextual reference (e.g., "shift that")
- WYSIWIS design principle

CSCW: Awareness Framework

- **Focus**: the more an object is within your focus, the more aware you are of it
- **Nimbus**: the more an object is in your nimbus, the more aware it is of you

Tom Rodden, 1996

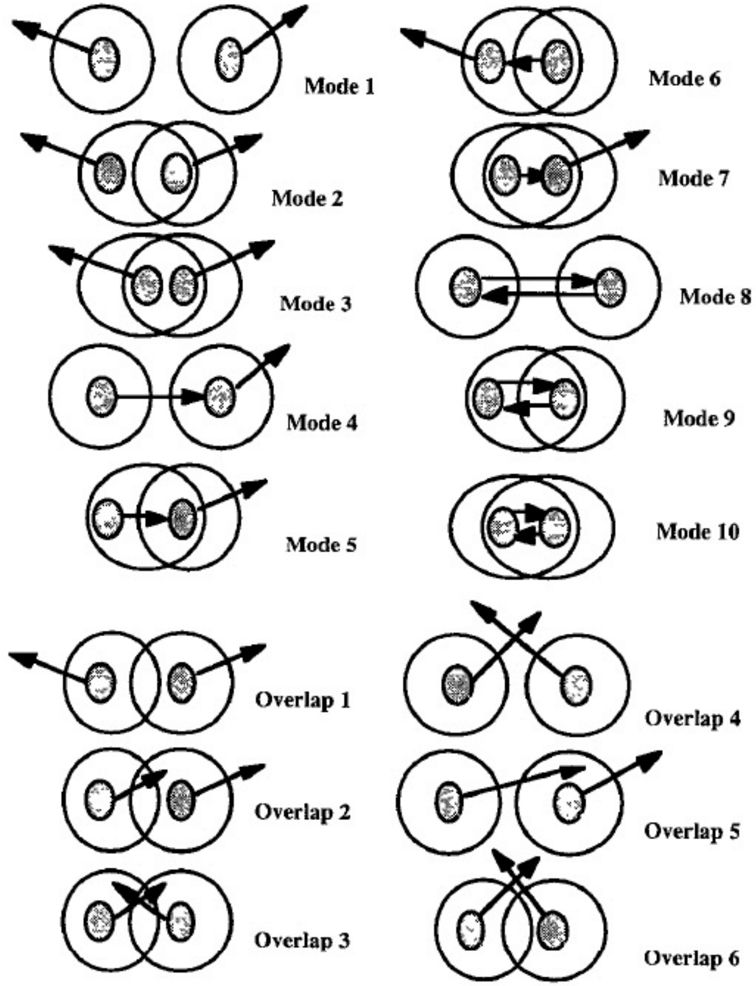
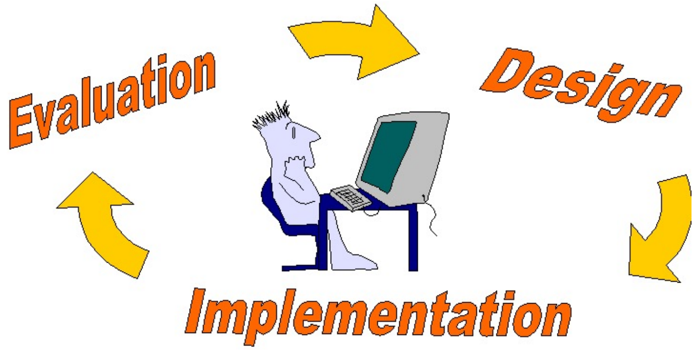
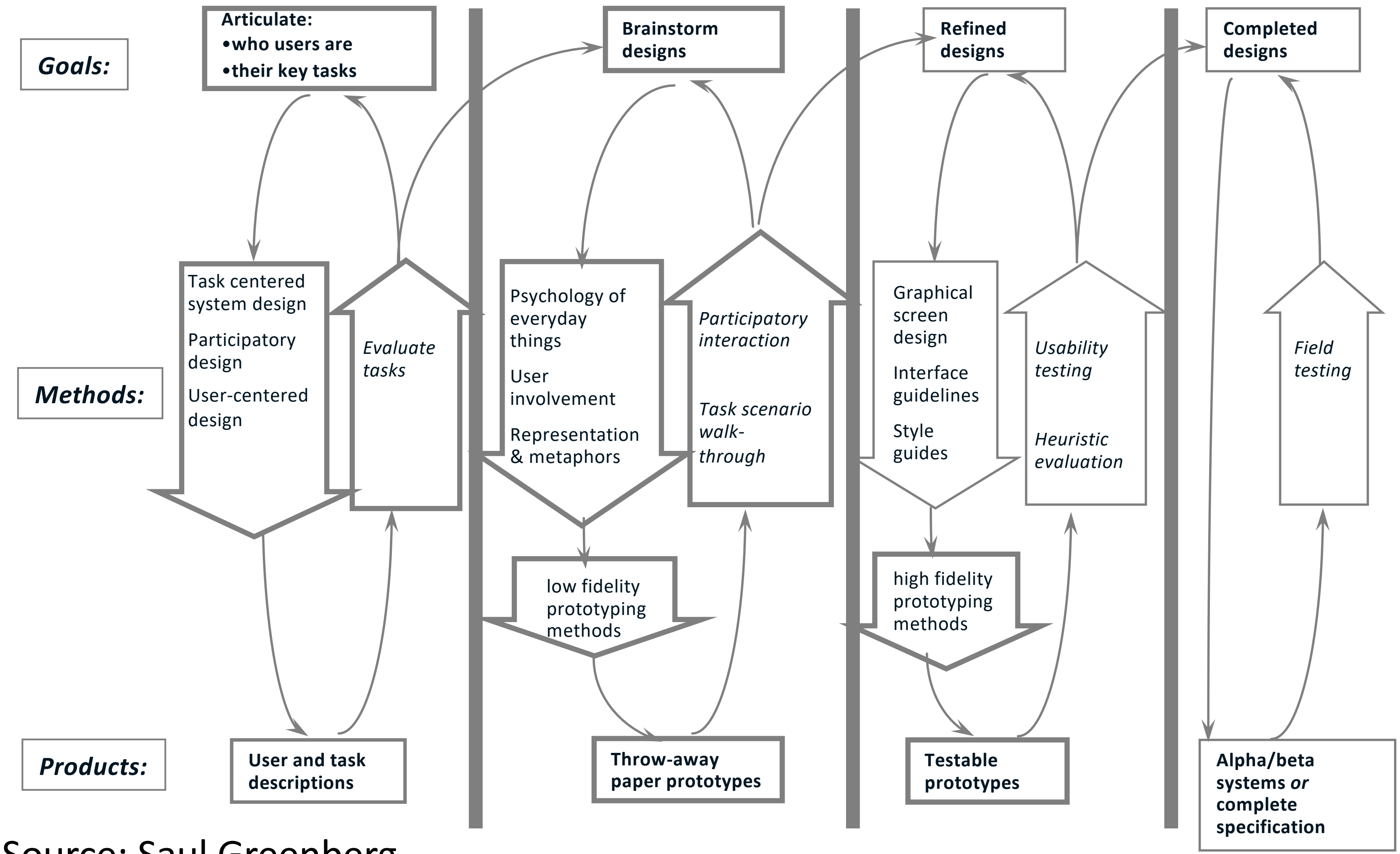


Figure 4 Different Modes of Awareness

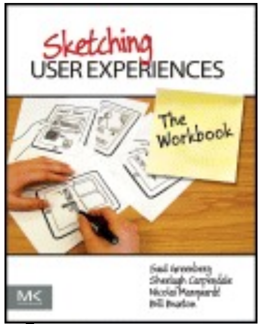
Interface Design



Design Process

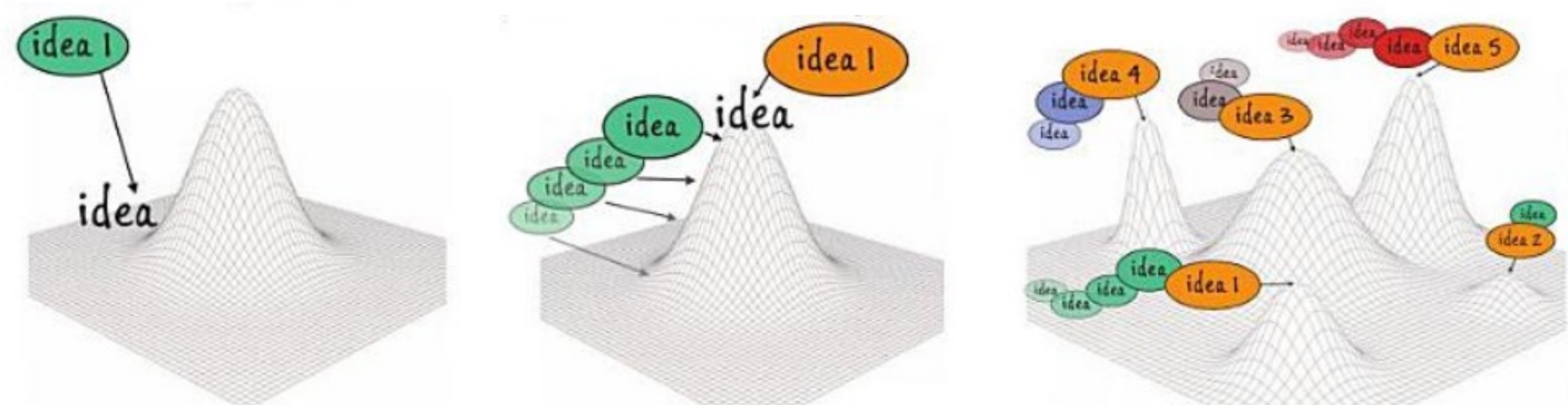


Source: Saul Greenberg



Iterative Design

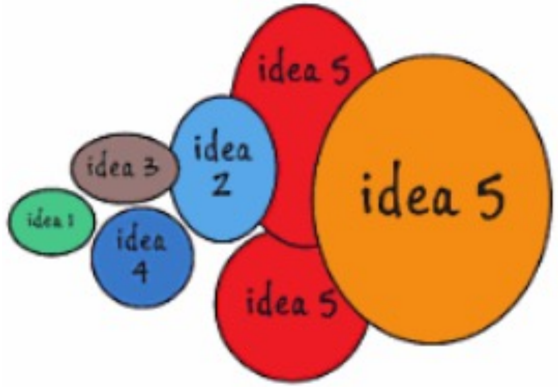
- Designs are iteratively refined based on evaluative feedback
- Beware of tunnel vision, premature commitment, local hill-climbing. Bad early decisions stay bad



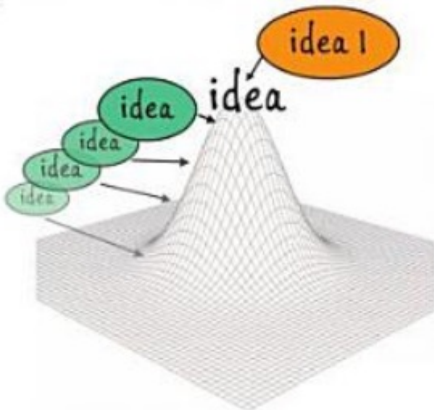
Source: Sketching User Experiences: The Workbook. Greenberg, Buxton, Carpendale
https://sketchbook.cpsc.ucalgary.ca/

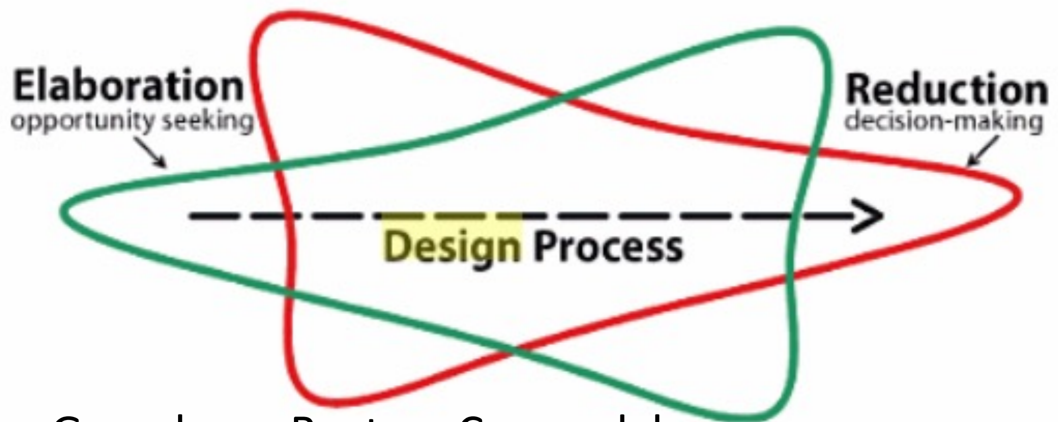
Iterative Design: Elaboration/Reduction Tension

- Elaboration: get the Right Design



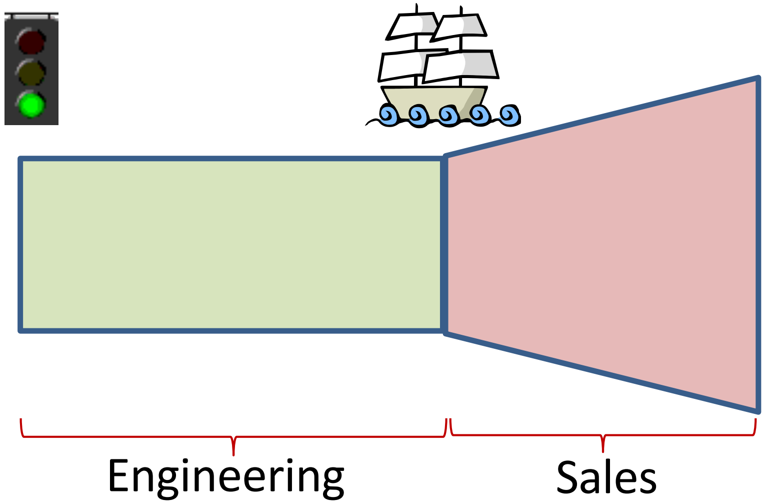
- Reduction: get the Design Right



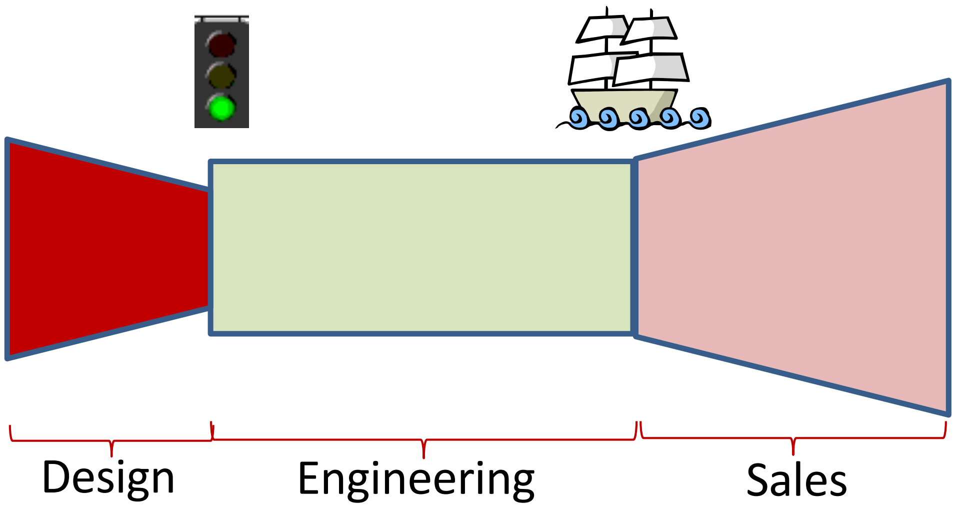


Source: Sketching User Experiences. Greenberg, Buxton, Carpendale

Iterative Design: The Design Funnel

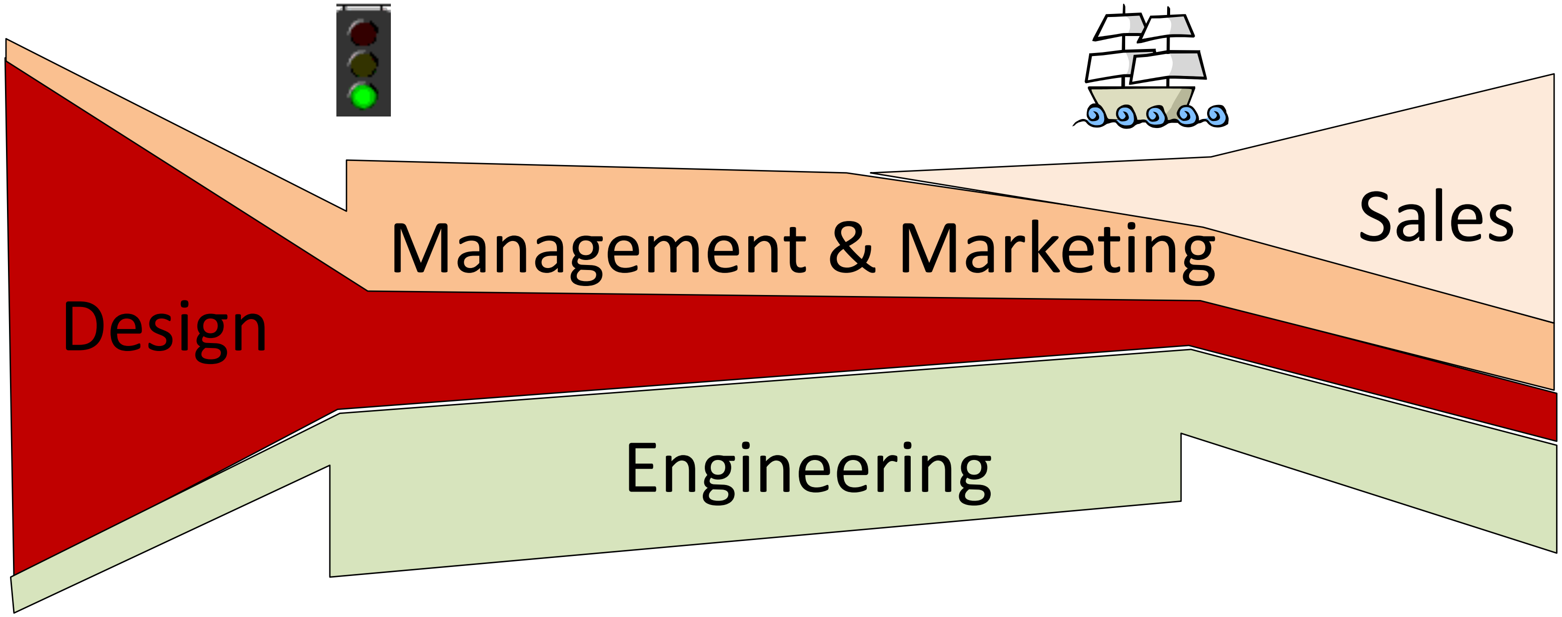


Naive product view



Naive design funnel

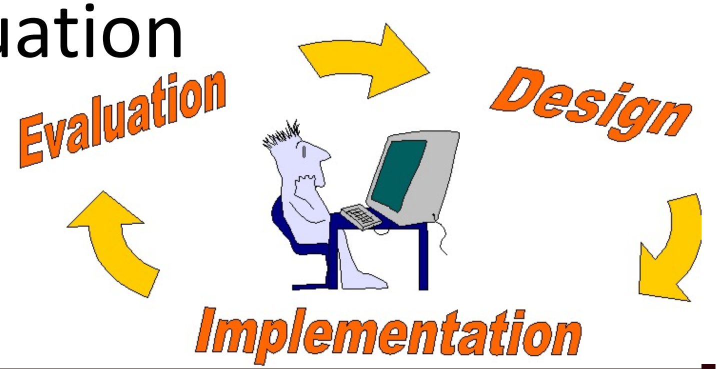
Iterative Design: The Design Funnel



Iterative Design: Supporting *Rapid* Iterations

- Fudd's first law of creativity: to get a good idea, get lots of ideas
- But lots of ideas will take lots of time to build/test
- Time is precious…

- Requires rapid creation and evaluation
- Rapid prototyping



Prototyping

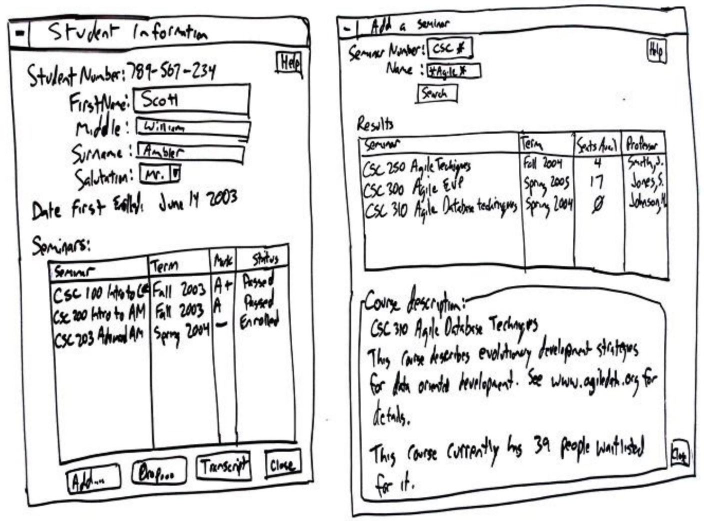
Early design

Brainstorm different representations Choose a representation Rough out interface style Task centered walkthrough and redesign	Low fidelity **paper** prototypes
Fine tune interface, screen design Heuristic evaluation and redesign	Medium fidelity prototypes
Usability testing and redesign	High fidelity prototypes / restricted systems
Limited field testing Alpha/Beta tests	Working systems

Late design

Low fidelity prototypes: sketches

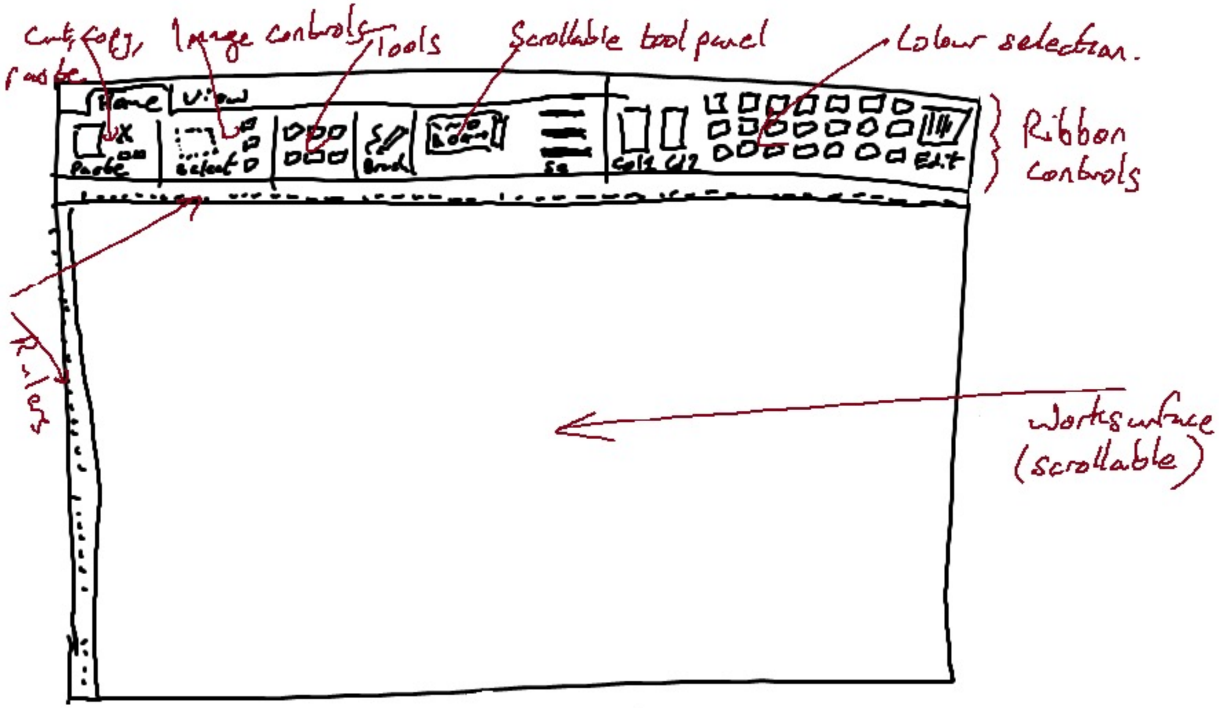
- Outward appearance & structure of intended design
- Necessarily crude/scruffy
  - Focus on high level concepts
  - Fast to develop
  - Fast to change
  - Low change resistance
  - Delays Commitment!
- Annotations/sequence can show UI progression



Source: agilemodeling.com

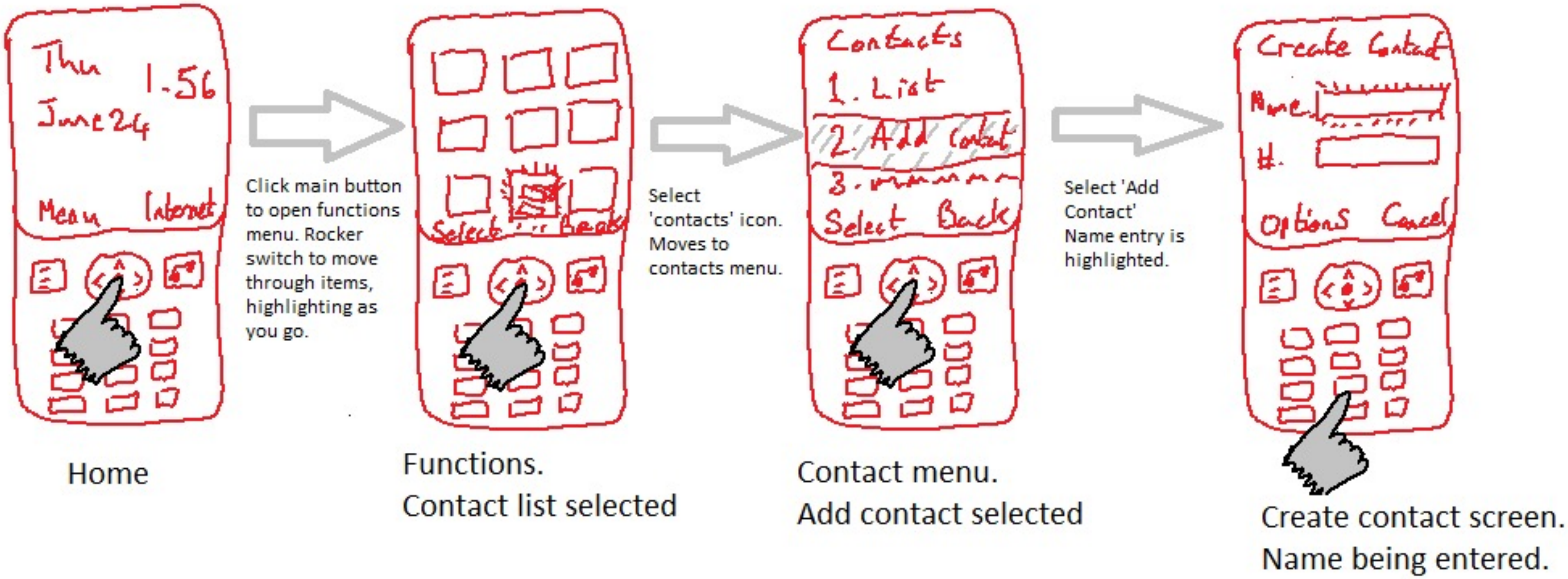
Low fidelity prototypes: sketches

- Use annotations/notes as necessary
- Cross reference to other zoomed in/out sketches



Low fidelity prototypes: sequential sketches /storyboards

- Show state transitions

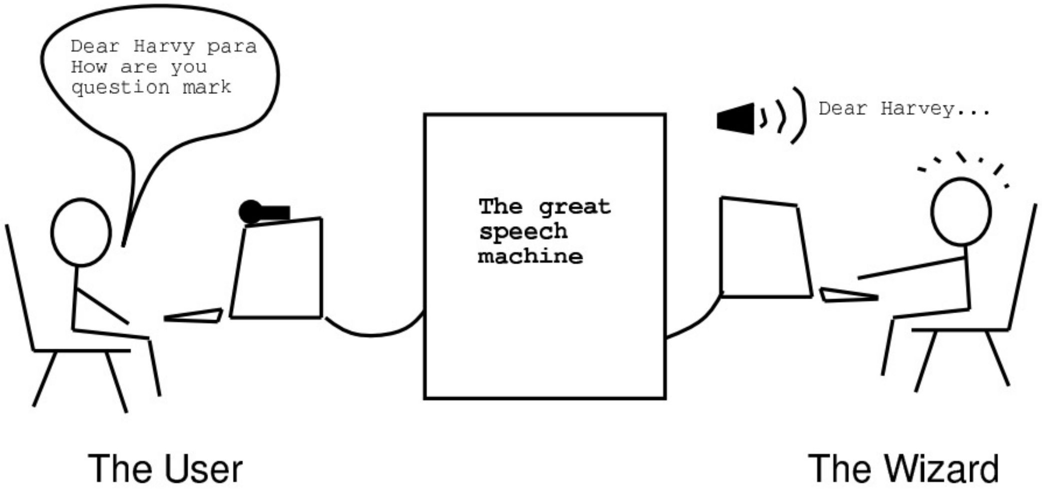


Low fidelity prototypes: tutorials/manuals

- Write the tutorial/manual *before* the system
- Task-centred!
  - Users are not interested in what the system can do
  - They're interested in what they need to do
- Manual/tutorial serves as a UI specification

Medium fidelity prototypes: Wizard of Oz

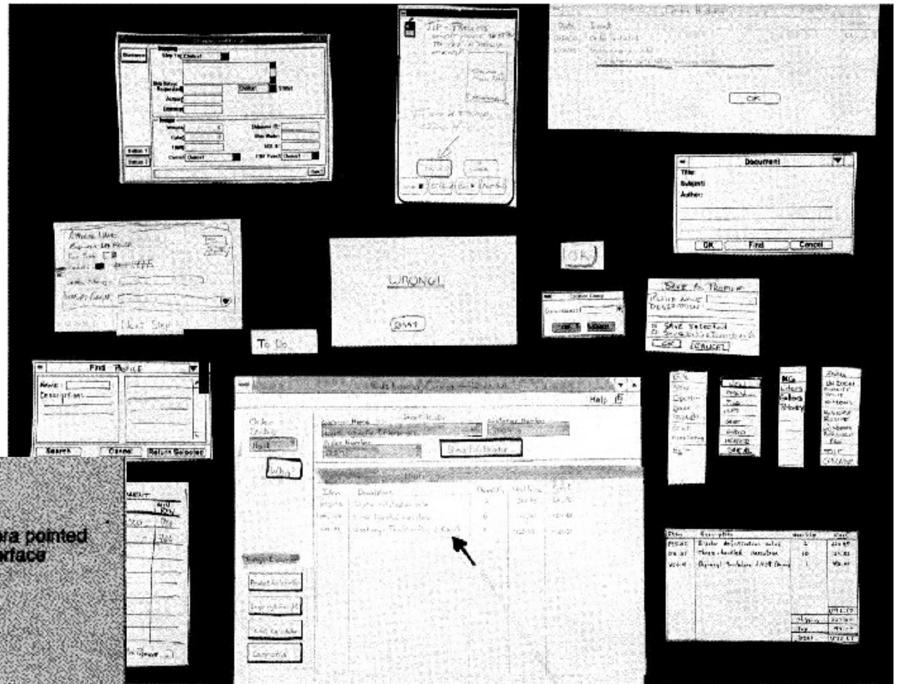
- Functionality is mimicked by a person
- The wizard must know the algorithm (practice!)
- Good for complex/futuristic ideas

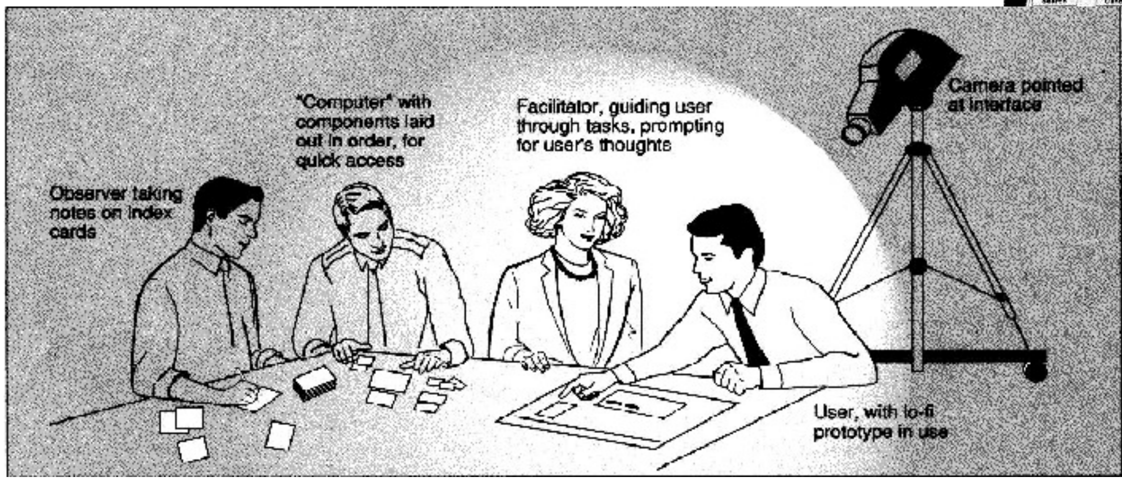


IBM speech editor.
1984

Medium fidelity prototypes: storyboards

- Series of key frames
- State progression is clear
- Walkthrough evaluation





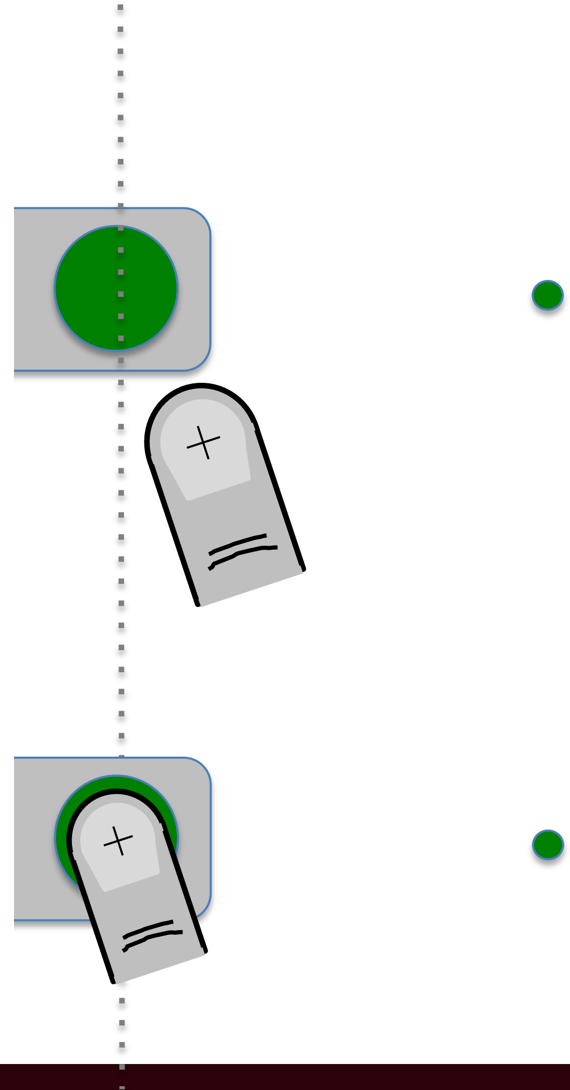
Source: Mark Rettig. "Prototyping for tiny fingers". CACM v37(4). 1994.

Medium fidelity prototypes: Refinement PowerPoint (for example)

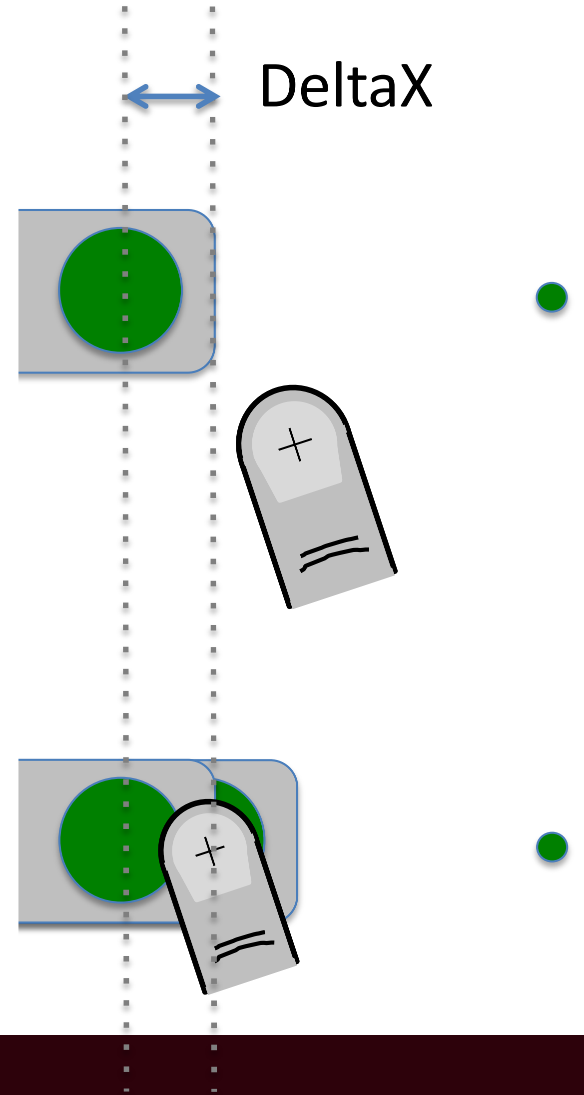
- Facilitates motion paths
- Links between states, etc.

- Lots of “wireframing” tools
  - moqups.com
  - balsamiq.com
  - axure.com, …

Precise Medium Fidelity Prototype

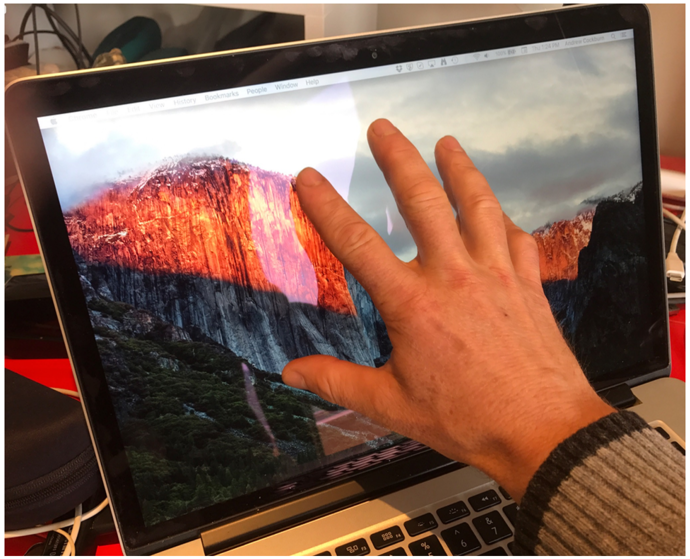


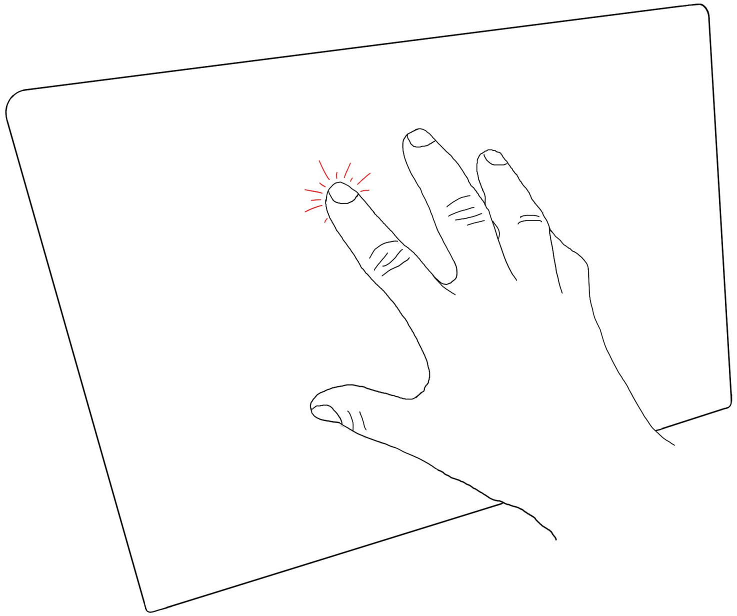
Precise Medium Fidelity Prototype



Medium fidelity prototypes: photo traces

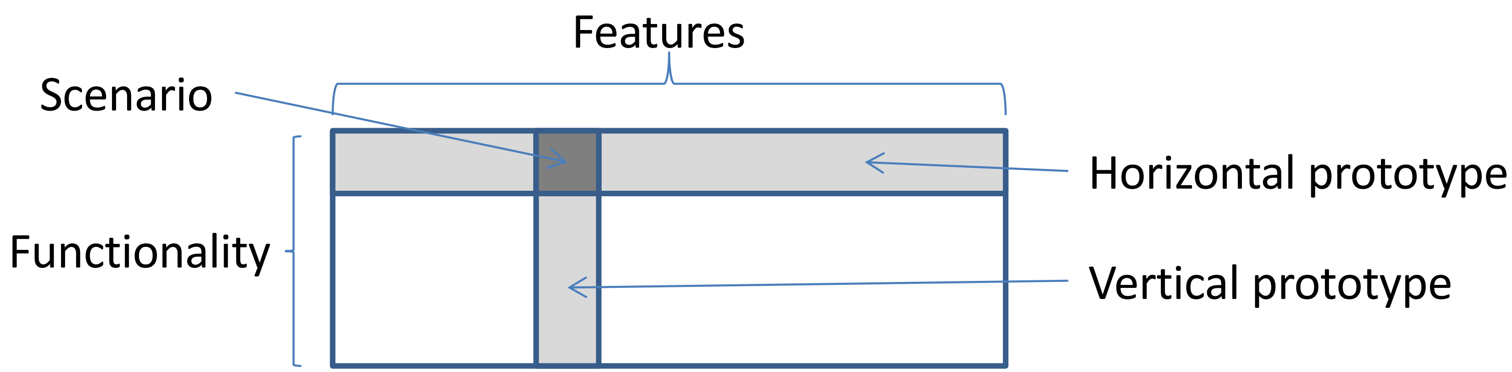
- Overcome sketching inability
- Tidy capture of interaction essence, without exact representation





Medium fidelity prototypes: simulations and animations

- Work well for *second round* evaluation



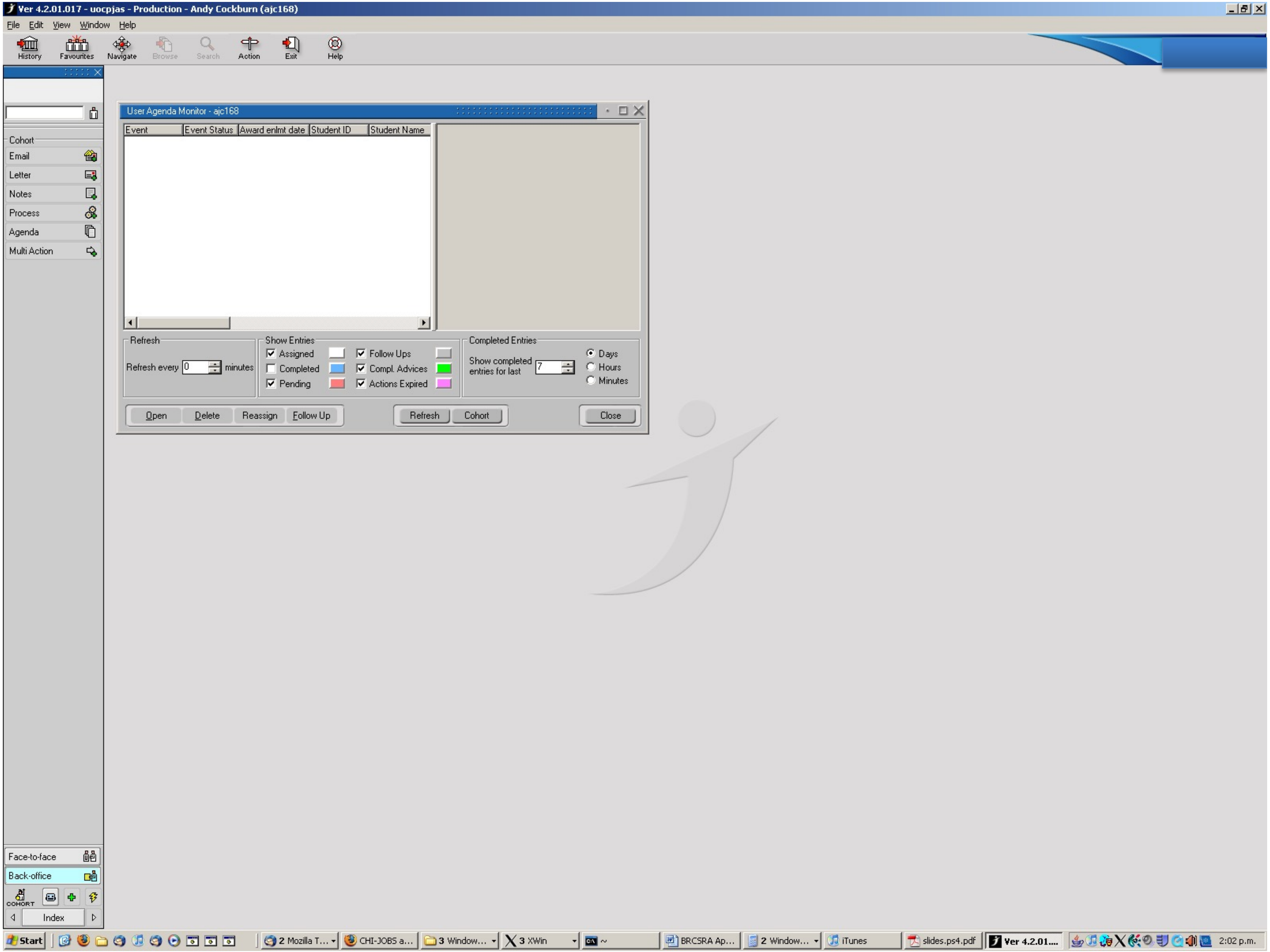
- Beware of:
  - Giving perception of 'nearly completed'
  - Reluctance to change
  - Excessive focus on presentation rather than approach

Interface Design:

Task-Centred System Design (TCSD)

System Centered System Design (How NOT to approach design)

- Focuses on the system's and designer's needs
- What can we easily build?
- What is possible/easy with the tools we have/know?
- What do I (the programmer) find interesting?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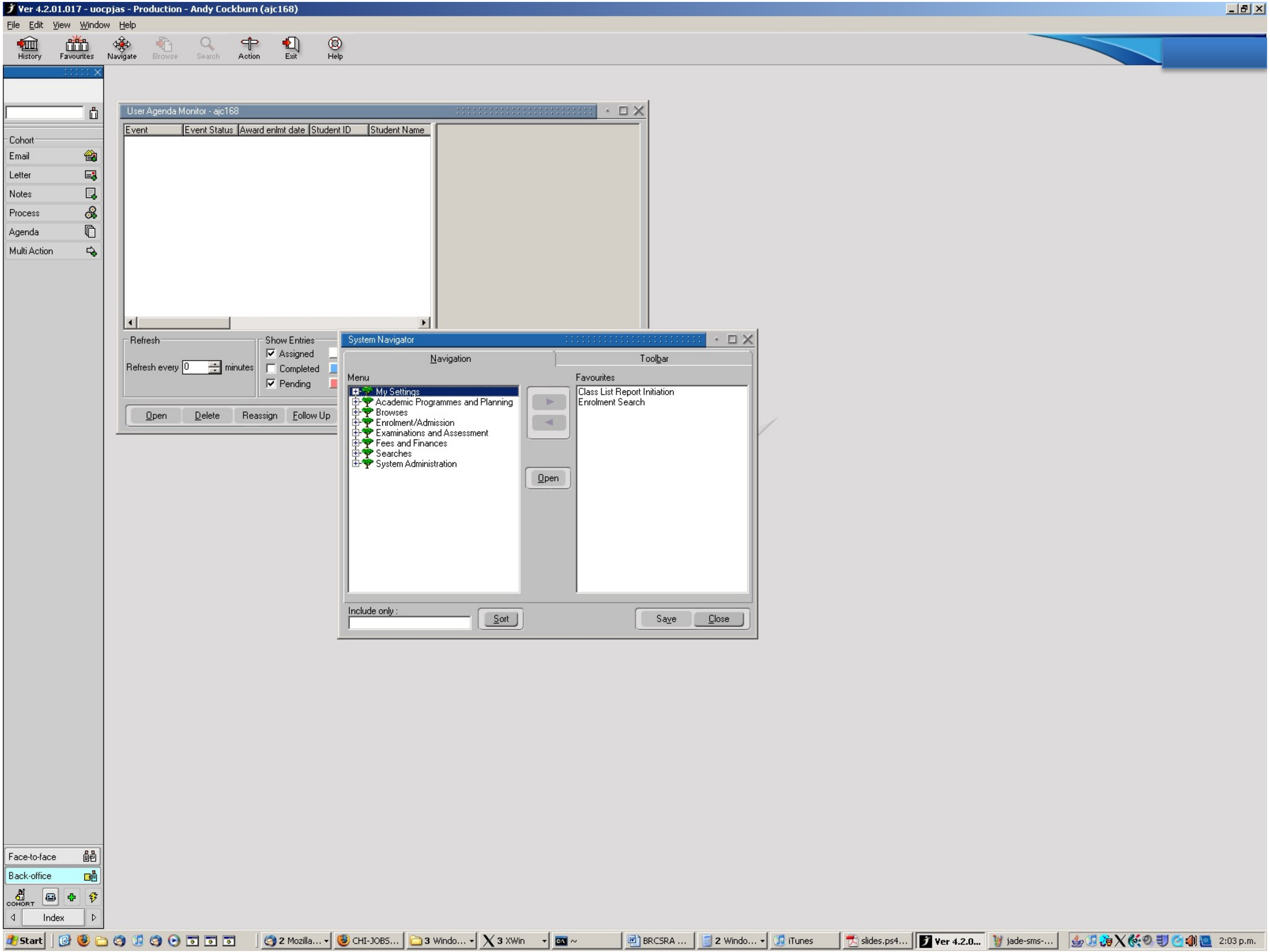
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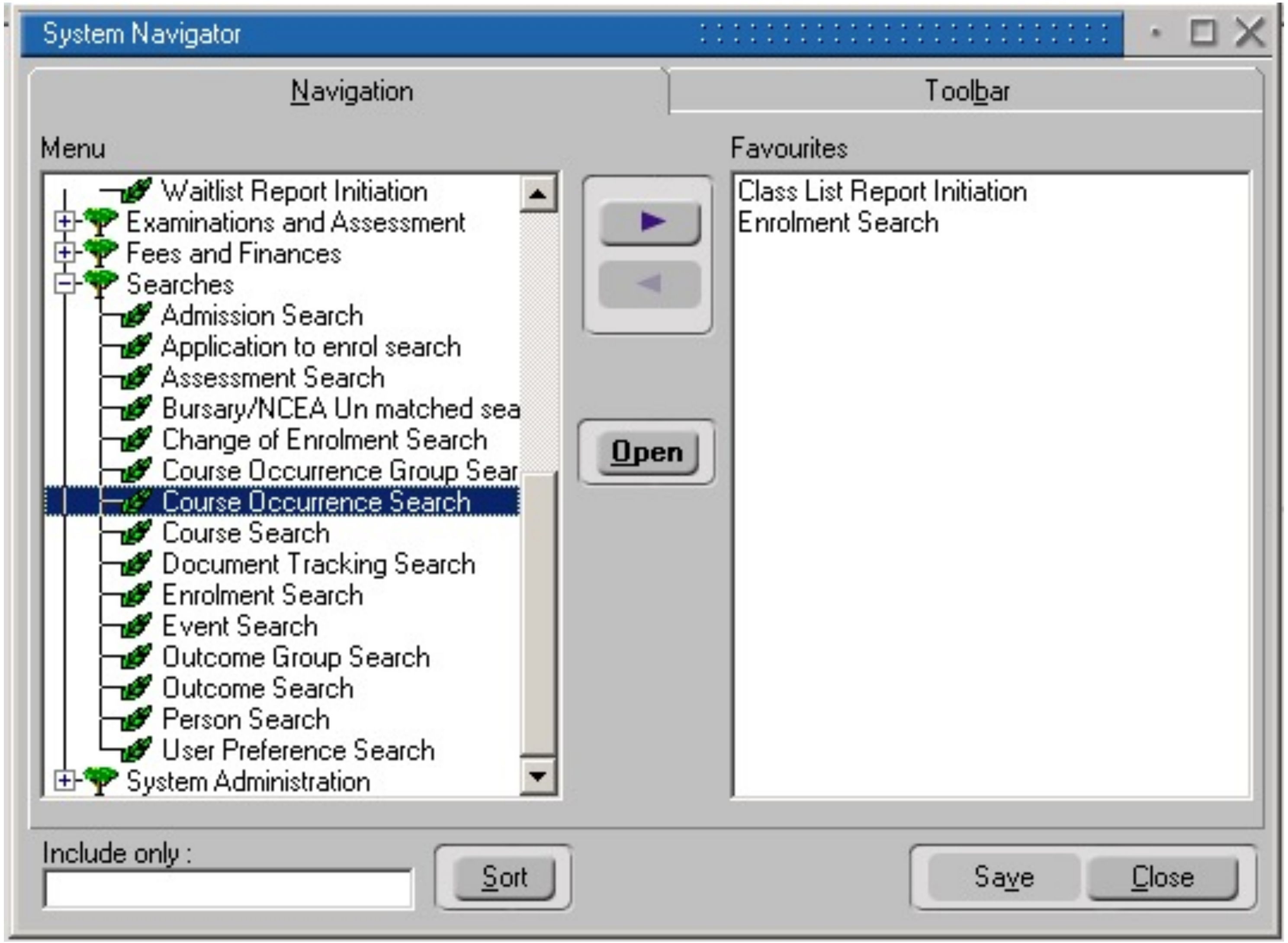
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Document Tracking Search
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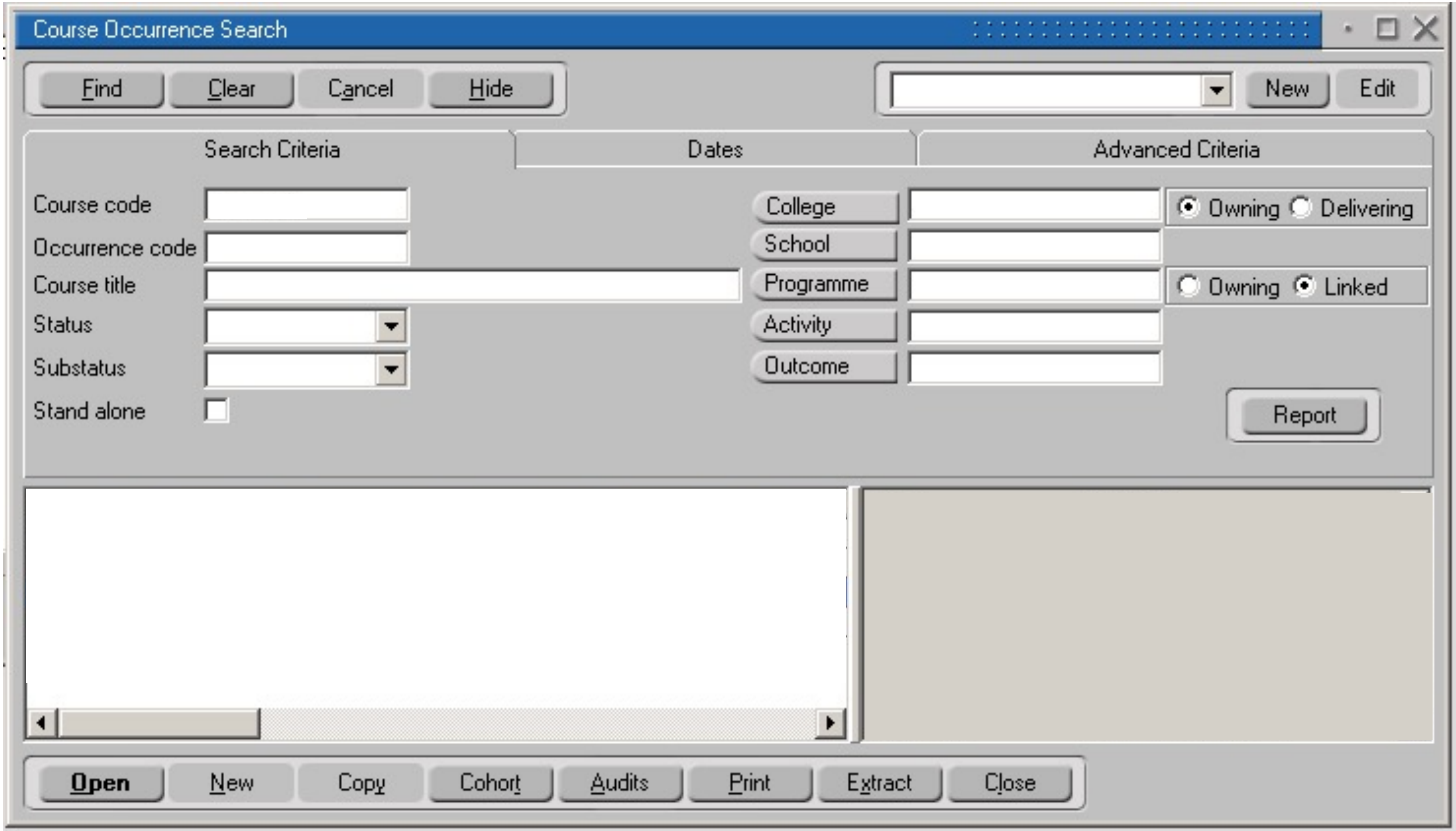
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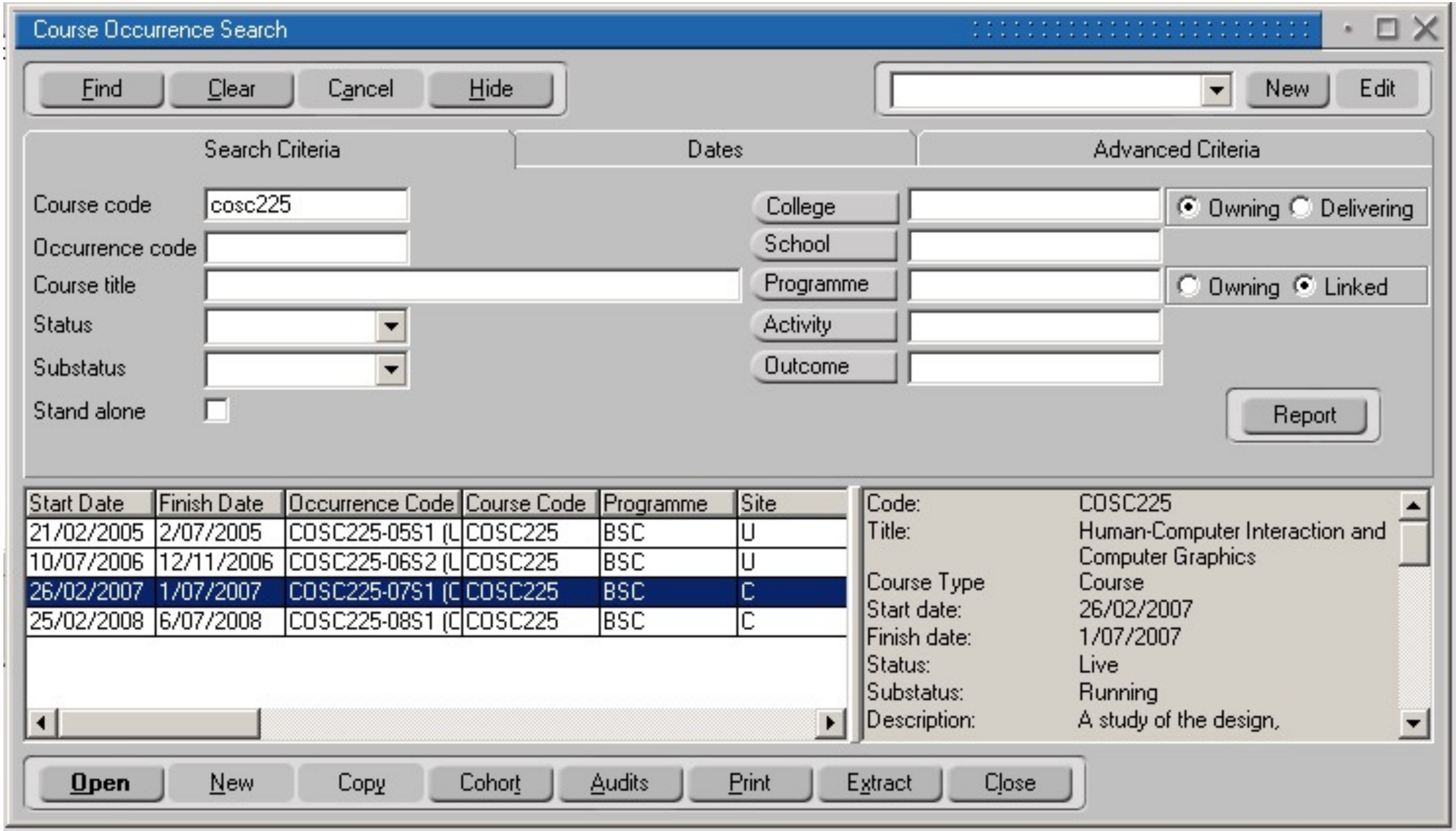
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Course Type Course
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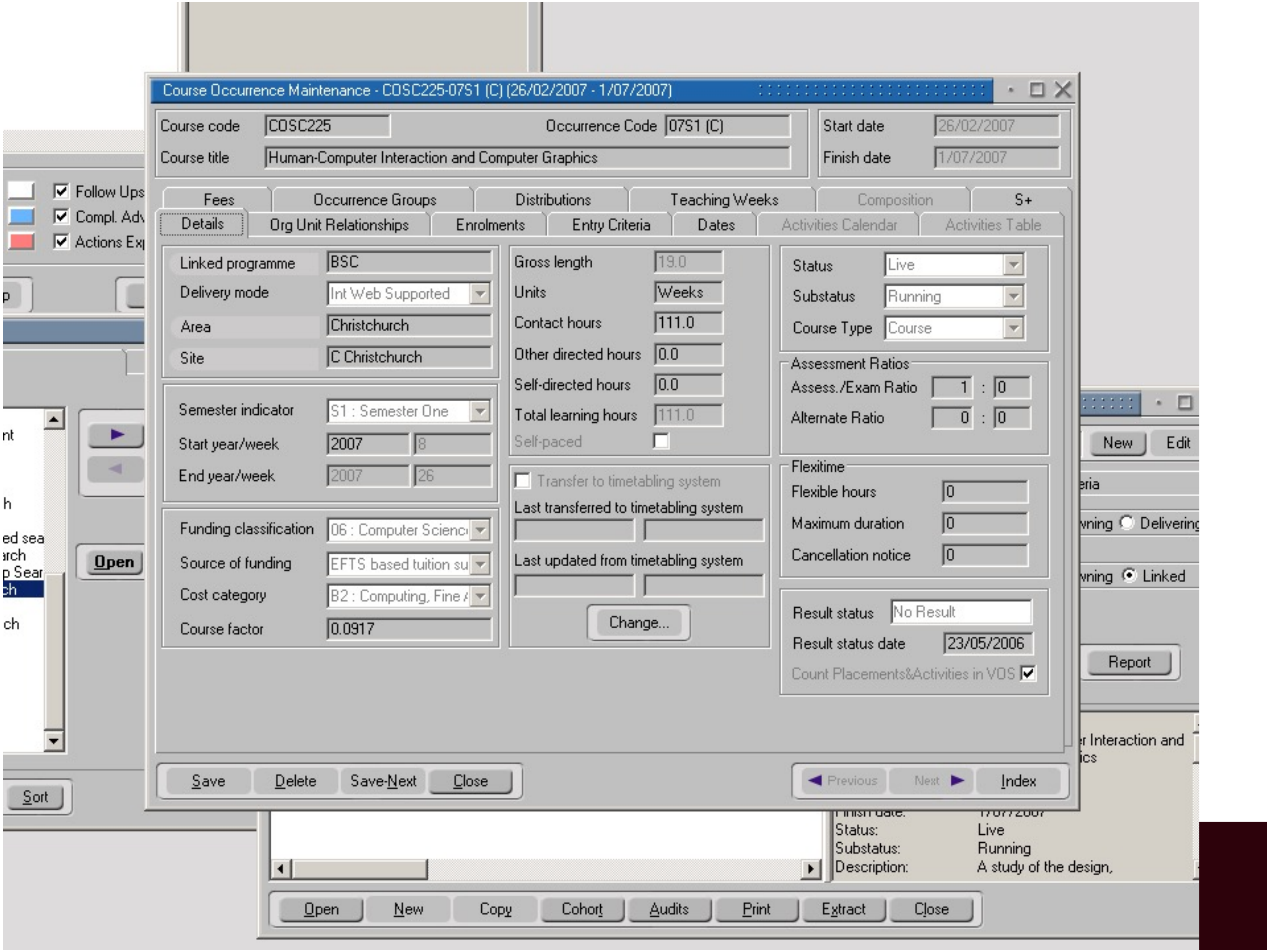
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B2 : Computing, Fine A
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Total learning hours
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Self-paced
Transfer to timetabling system
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Last updated from timetabling system
Change...
Status
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Substatus
Running
Course Type
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Assessment Ratios
Assess./Exam Ratio
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Next
Index
Follow Ups
Compl. Adv
Actions Exp
Open
Sort
New
Edit
Delivering
Linked
Report
Status:
Live
Substatus:
Running
Description:
A study of the design,
Open
New
Copy
Cohort
Audits
Print
Extract
Close

Task-Centred System Design

Lewis and Rieman, 1993

- HCI equivalent of requirements analysis / use cases
- Exactly and specifically who are the users and what will they use the system for?
- Critical difference between:
  - "The User": a pretend person who will adapt to the system
  - "Mary": a real, busy person trying to do her job
- TCSD: a reality-based sanity check for designers

TCSD: 1. User Identification

- Identify categories of end-users, with specific exemplars: typical and extremes
- How: Talk to users!
  - If they won't talk to you, will they use your system?
  - If they really don't exist: worry & describe 'assumed users and tasks'
  - Learn about people in the task chain: who do inputs come from, where do outputs go?

TCSD: 2. Task Identification

1. Record what the user wants to do, but minimize description of how
   - No interface assumptions
   - Can be used to compare alternative designs
2. Record the complete task: input source, output destination
3. Identify users
   - Design success depends on what users know
   - Tested against specific individuals, so name names
4. Uniquely enumerate tasks for identification
5. Identified tasks are circulated for validation (omissions, corrections, clarifications)
6. Identify broad coverage of users and tasks

	Infreq	Freq
Not Important	✗	✓
Important	✓	✓✓✓

TCSD: Phase 1&2 Outcomes

A report on Phase 1&2 would state:

1. User categories (& their priorities if necessary)
   E.g., for UCSMS, undergrads, postgrads, academics, admin, …
2. Specific personas exemplifying each category
   E.g., “Tom is a first year undergrad entering university directly from school…”
3. Task categories and their priorities (perhaps, ‘must’, ‘should’, ‘could’, …)
   E.g., “Course/program enrollment”, “New course creation”, …
4. Concrete representative task scenarios (with name of owner)
   Enumerated, specific, used for UI validation
   “CE42: Tom wants to enroll in COSC224, but to do so he needs a waiver of prerequisite based on his B grade pass in CCS124 at Waikato…”
5. Explicitly identify any groups or tasks that will not be supported (and why)

TCSD: Phase 3, Design

- Use the tasks categories & scenarios to generate and evaluate designs
- Strive for natural workflow (natural to the user)
- Consider task category and its scenarios:
  - For each design for each task scenario:
    - How would the user complete the task?

TCSD: Phase 4, Walk-through evaluation

Interface design debugging (one form of 'cognitive walkthrough')

1. Select a task scenario
2. For each step/action:
   - Given what the user knows, what would they do?
   - Is the story believable? ('credible stories')
   - If not, it's an interface bug
   - Once identified, record it, assume it's fixed, and move on to next step

TCSD Example Task Scenarios: UCSMS

Course Enrolment CE15: Mary Smith (id 66677788) wants to enroll in EMTH555 if that course will be sufficient for her to complete her degree requirements. If not, she will enroll in EMTH666 and EMTH777.

Course Enrolment CE43 & ID2: John Smith arrives at student services. He tried to enroll in COSC368 using the on-line system, but was refused 'due to lack of a prerequisite course'. He has a letter from the Head of Department saying that he can enroll in the course, but the letter also states that he must take MATH115 this year. He has been standing in line for the desk for 20 minutes and has forgotten his Canterbury card. He can't remember his student ID or usercode.

Cautions on TCSD

- Tasks and task scenarios often embody process
- Hard to record identified tasks and write task scenarios that are independent of interface or workflow prescription
- This may hinder identification of alternative (better) ways to achieve tasks
- Can be hard to find people 'responsible' for new tasks in a system (therefore hard to validate them)

User Centred System Design

- Golden rule of interface design:
  "Know The User"
- Design should be based around user's needs, abilities, context, work, tasks
- Users continually involved in design: requirements analysis, storyboards, prototypes, …

User Centred System Design
Participatory Design

- Problem:
  – Intuitions can be wrong
  – Interviews lack precision/context, and can mislead
  – Designers cannot know user's needs sufficiently well to answer all questions likely to arise during design

- Solution:
  – Designers need access to a pool of representative end users
  – Not managers, union-reps; real users
  – These users are full members of the design process

Participatory Design: Pros and Cons

✓ users are excellent at reacting to suggested system designs
  – designs must be concrete and visible

✓ users bring in important “folk” knowledge of work context
  – knowledge may be otherwise inaccessible to design team

✓ greater buy-in for the system often results

✗ hard to get a good pool of end users
  – expensive, reluctance ...

✗ users are not expert designers
  – don’t expect them to come up with design ideas from scratch

✗ the user is not always right
  – don’t expect them to know what they want

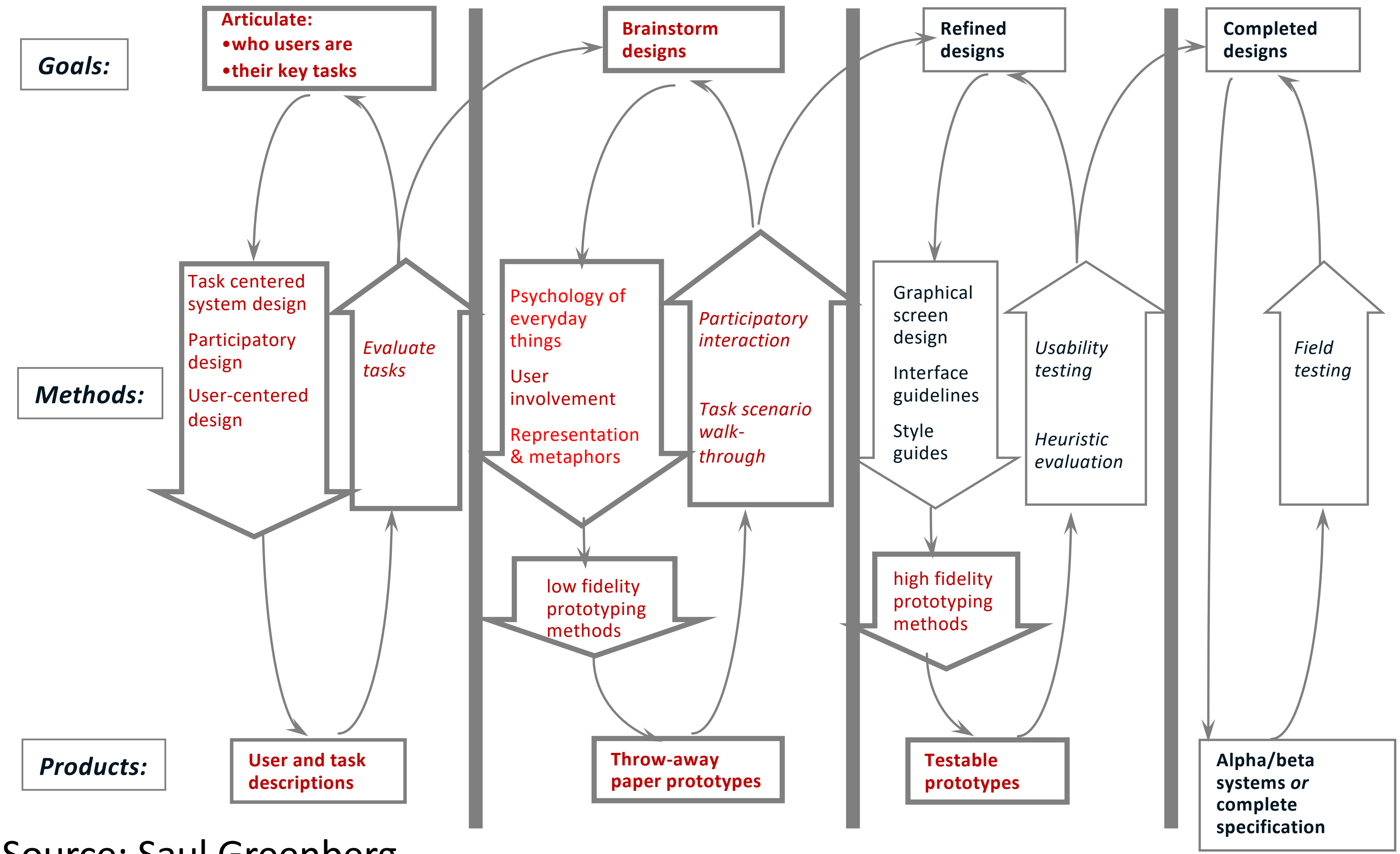
UCSD/Participative Design: Involving the user

- Talk to users!
- Interviews
  - discover user's culture, requirements, expectations, etc.
  - contextual inquiry: interview *while* doing their job
- Explain designs
  - get input at all design stages
  - important to have visuals/demos: Prototypes
- Walk-throughs
  - No one knows better 'what the user would do'

Schedule (long)

Week	Beginning	LECTURES	LABS
1	19-July	Introduction to HCI	Lab 1: Python/TkInter refresher
2	26-July	Models of interaction	Lab 2: Python/TkInter: Keyboard GUI
3	2-Aug	The Human – senses	Lab 3: Python/TkInter: Canvas & Fitts law GUI
4	9-Aug	The Human – performance and phenomena	Lab 4: Fitts' law experiment and analysis
5	16-Aug	Interface Design – Iteration	Lab 5: Sketching Designs
6	23-Aug	Interface Design – Task Centred System Design	Assignment help
	30-Aug		
	6-Sept		
7	13-Sept	Interface Design – Heuristics	Lab 6: Visual search, decision, skill development
8	20-Sept	Interface Design – Heuristics II	Lab 7: Performance prediction
9	27-Sept	Interface Design – Graphical design	Lab 8: Heuristic evaluation
10	4-Oct	Interface Evaluation & Empirical Methods	Lab 9: Experimental data analysis
11	11-Oct	Interface Evaluation & Empirical Methods 2	Assignment help
12	18-Oct	Overflow and UI Intellectual Property	

Design Process



Source: Saul Greenberg

Usability Heuristics

Usability Heuristics:
(Principles, Guidelines, Styleguides, etc.)

- Encapsulate best practice in ‘rules of thumb’
- Identify common pitfalls
- Simple, easy to use, ‘thinking hats’

- Formative: guide design decisions
- Summative: evaluate systems
- Extensively used

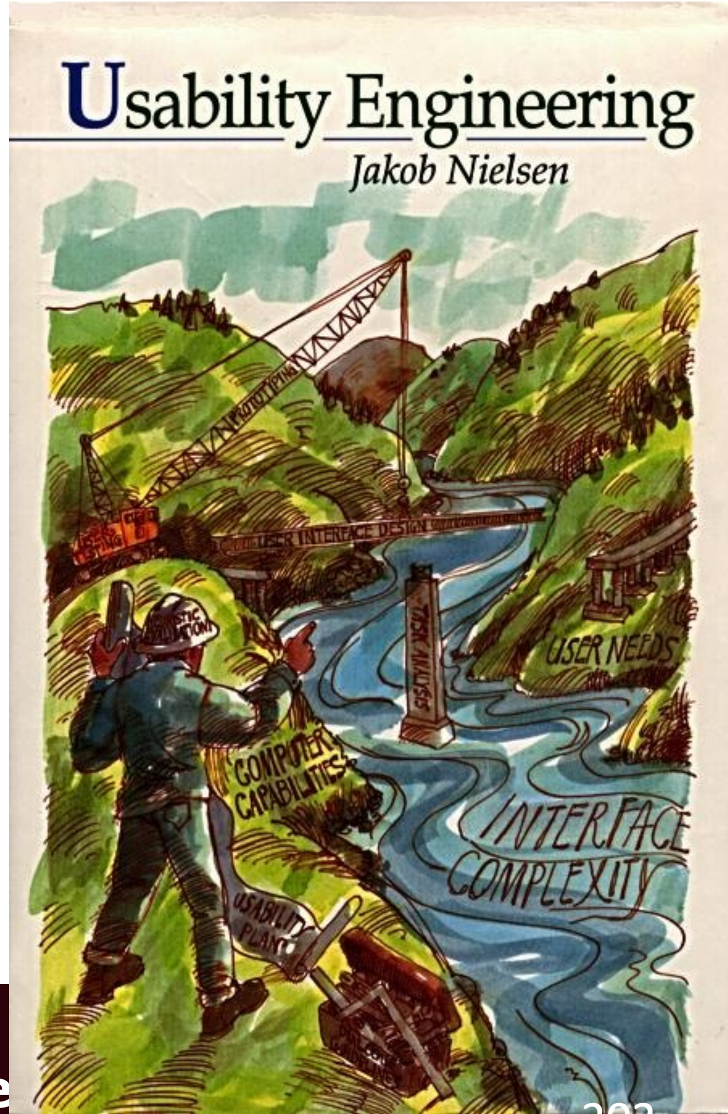
Usability Heuristics:
(Principles, Guidelines, Styleguides, etc.)

- Advantages
  - Minimalist
    - A few guidelines cover most problems
    - Easily remembered and applied
  - Discount usability engineering
    - Cheap and fast
    - Can be done by experts and novices (e.g., end users)
- Disadvantages
  - Heuristics are very general ‘motherhoods’
  - There are subtleties in their application

E.g., Nielsen's Ten

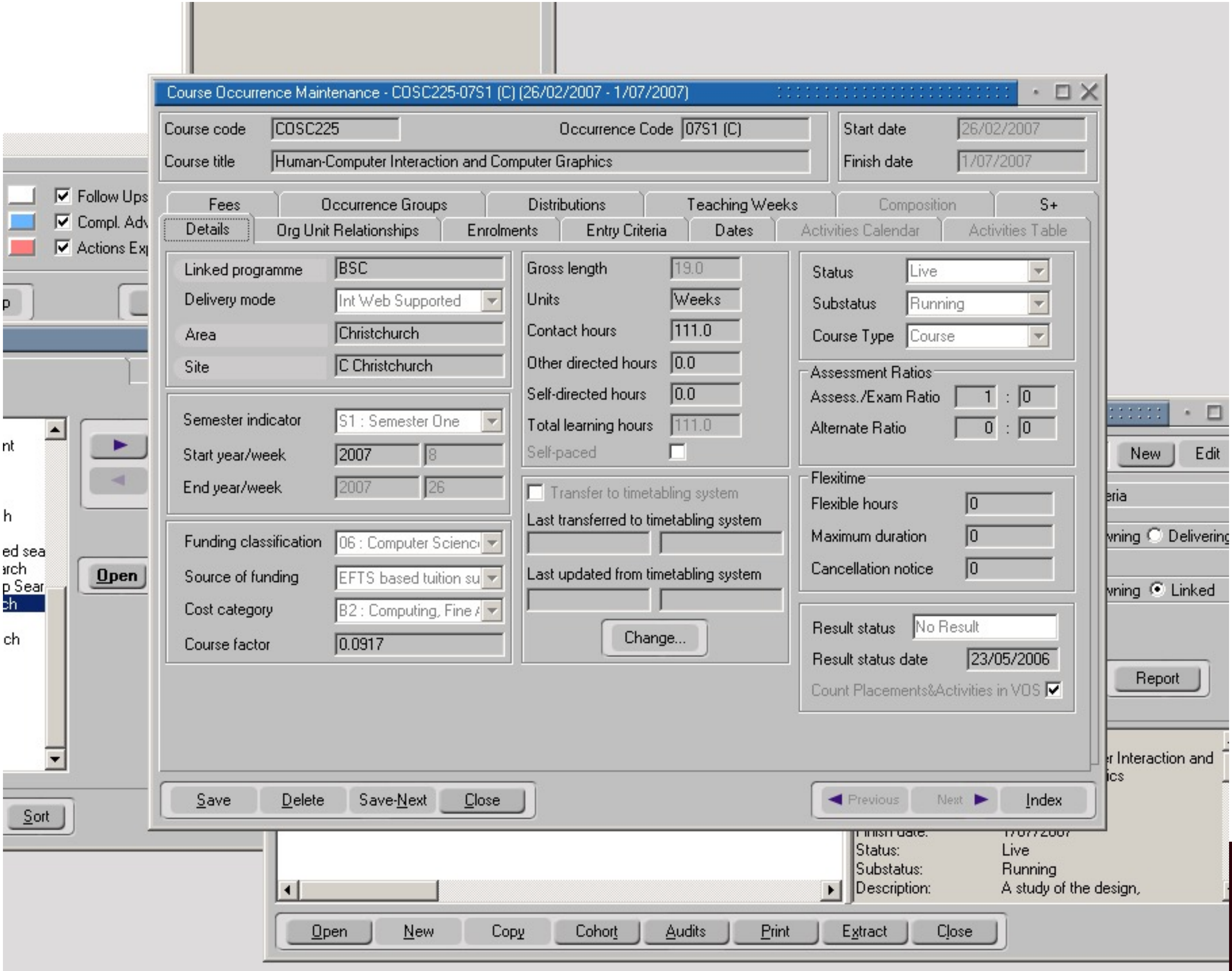
(original set)

1. Simple and natural dialogue
2. Speak the user's language
3. Minimise user memory load
4. Consistency
5. Feedback
6. Clearly marked exits
7. Shortcuts
8. Good error messages
9. Prevent errors
10. Help and documentation



1. Simple and Natural Dialogue

- Managing complexity: as simple as possible (but no simpler)
- Organisation of the interface:
  - Presentation: simple and natural?
  - Navigation: simple and natural?
- Graphic design
  - Organise, Economise, Communicate
  - Employ a graphic designer
- Use windows frugally
- Less is more


Course Occurrence Maintenance - COSC225-07S1 (C) (26/02/2007 - 1/07/2007)
Course code COSC225
Occurrence Code 07S1 (C)
Course title Human-Computer Interaction and Computer Graphics
Start date 26/02/2007
Finish date 1/07/2007
Fees
Occurrence Groups
Distributions
Teaching Weeks
Composition
S+
Details
Org Unit Relationships
Enrolments
Entry Criteria
Dates
Activities Calendar
Activities Table
Linked programme BSC
Delivery mode Int Web Supported
Area Christchurch
Site C Christchurch
Semester indicator S1 : Semester One
Start year/week 2007 8
End year/week 2007 26
Funding classification 06 : Computer Scienc
Source of funding EFTS based tuition su
Cost category B2 : Computing, Fine
Course factor 0.0917
Gross length 19.0
Units Weeks
Contact hours 111.0
Other directed hours 0.0
Self-directed hours 0.0
Total learning hours 111.0
Self-paced
Transfer to timetabling system
Last transferred to timetabling system
Last updated from timetabling system
Change...
Status Live
Substatus Running
Course Type Course
Assessment Ratios
Assess./Exam Ratio 1 : 0
Alternate Ratio 0 : 0
Flexitime
Flexible hours 0
Maximum duration 0
Cancellation notice 0
Result status No Result
Result status date 23/05/2006
Count Placements&Activities in VOS
Save
Delete
Save-Next
Close
Previous
Next
Index
Follow Ups
Compl. Adv
Actions Exp
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Sort
New
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Status: Live
Substatus: Running
Description: A study of the design,
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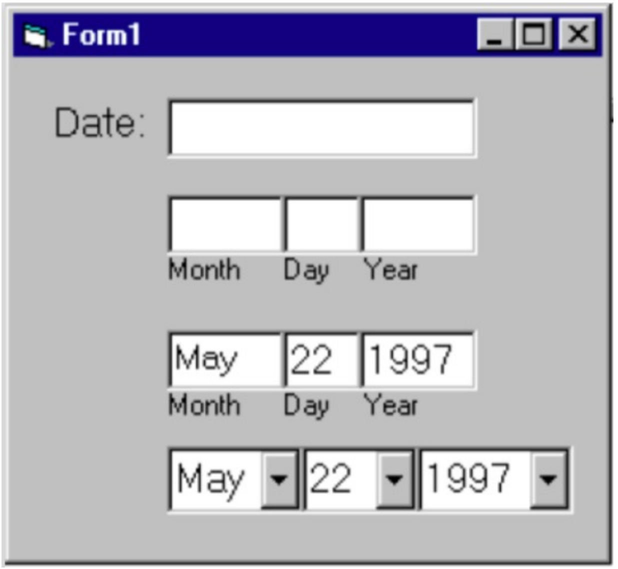
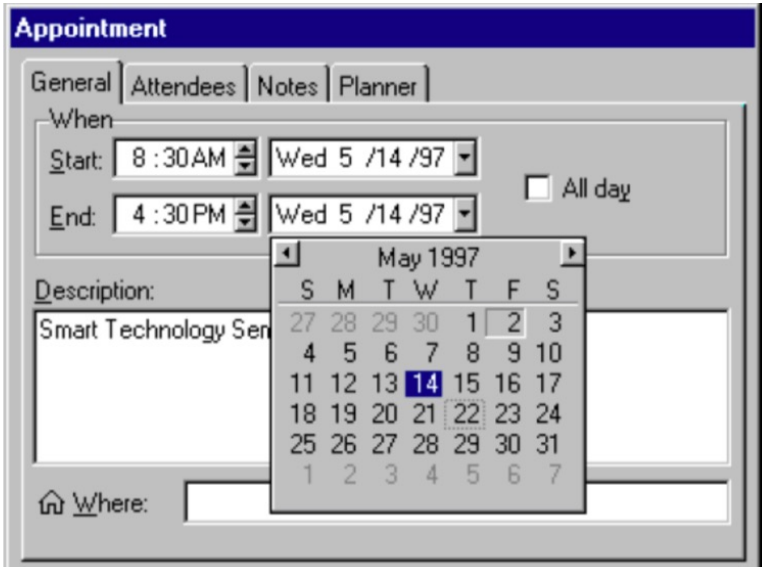
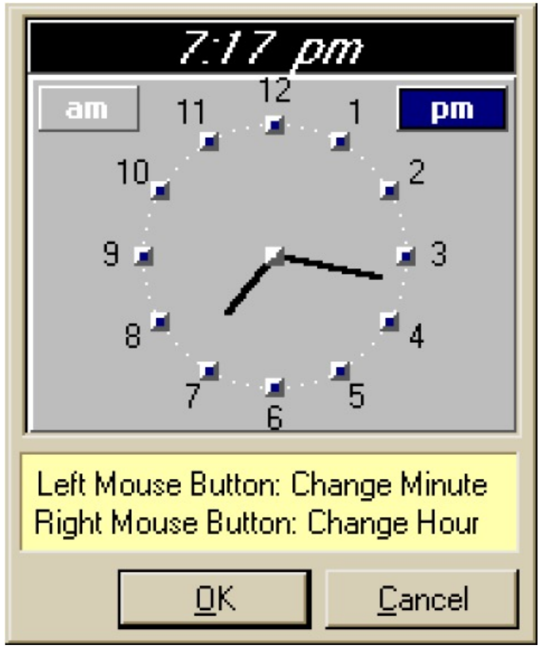
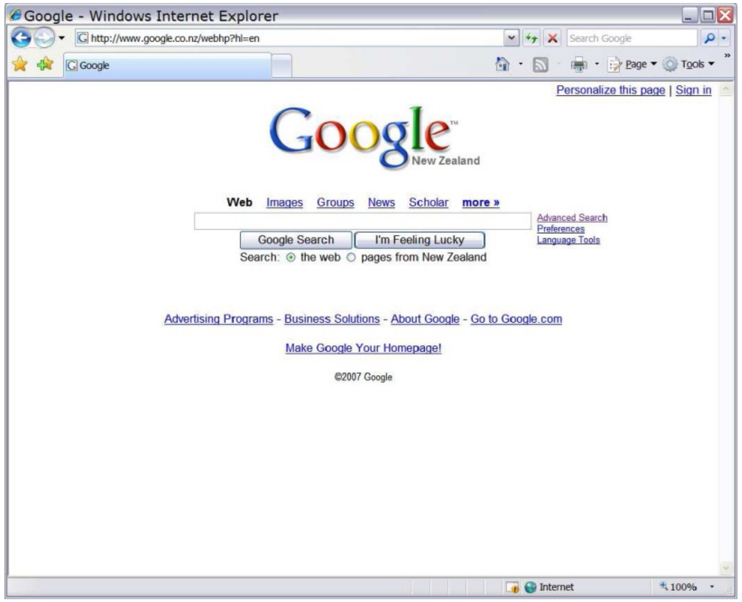
1. Simple and Natural Dialogue

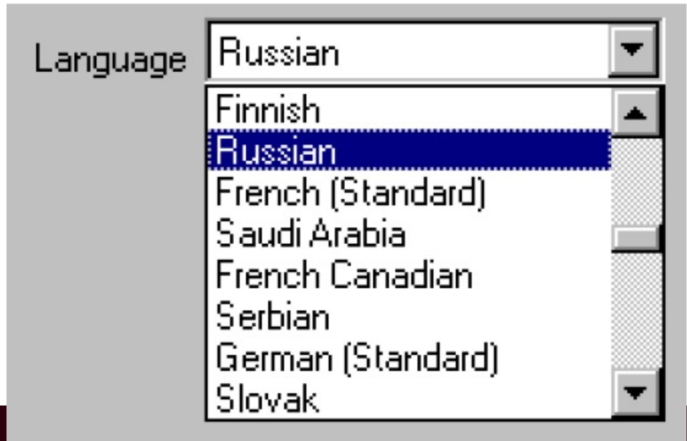






1. Simple and Natural Dialogue



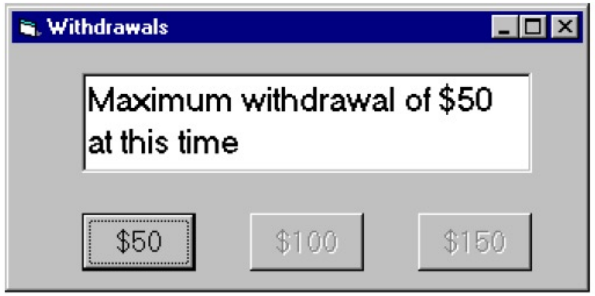


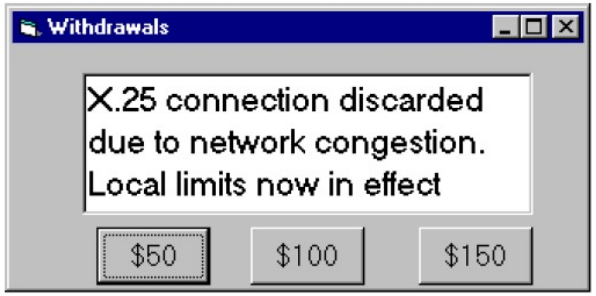
1. Simple and Natural Dialogue

Edward Tufte on the iPhone graphical design

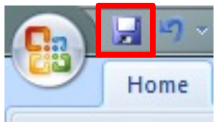
2. Speak the users' language

- Affordance, mappings and metaphors
- Terminology should be based on user's task language





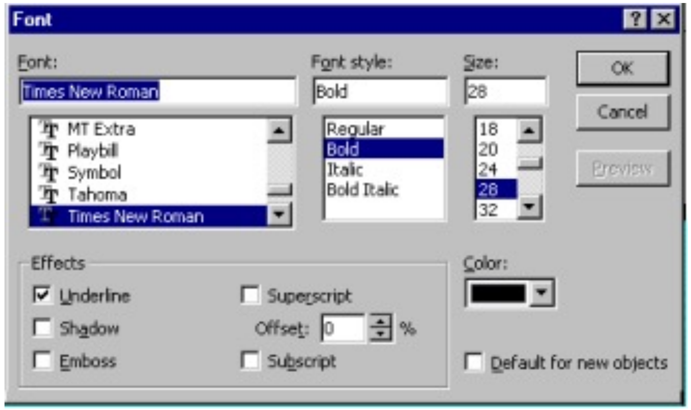
2. Speak the users’ language

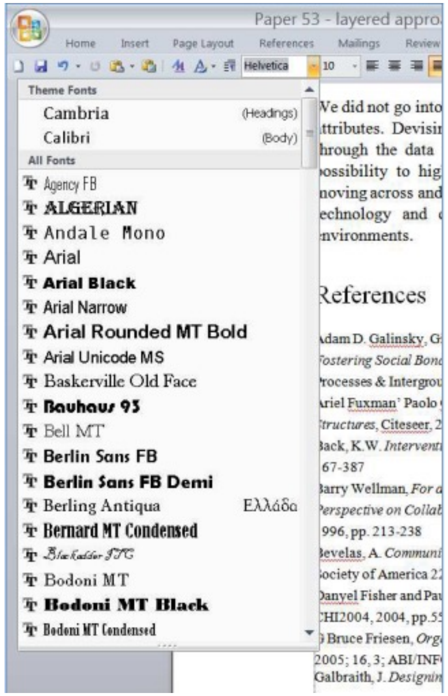
- “Language” is both textual and iconic
  - “Save” (natural language)
  - Ctrl-S (abbreviation)
  - Alt FS (mnemonic for menu action)
  - 

    (toolbar icon)
  - How about Ctrl-x-s (emacs)?

3. Minimise the user's memory load

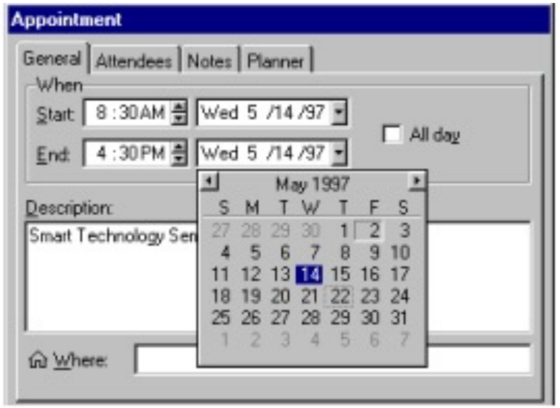
- Promote recognition over recall





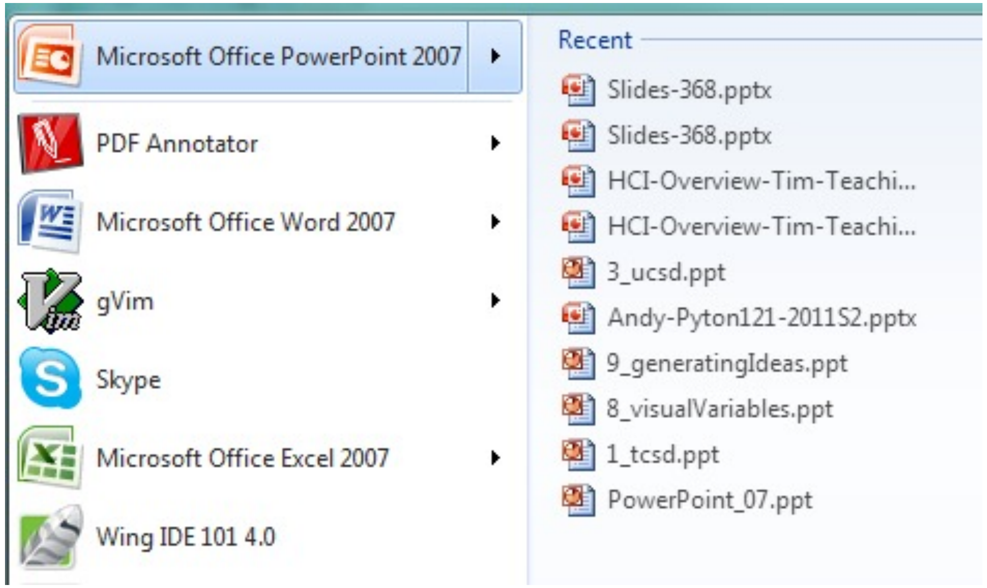
3. Minimise the user's memory load

- Show input formats and provide defaults



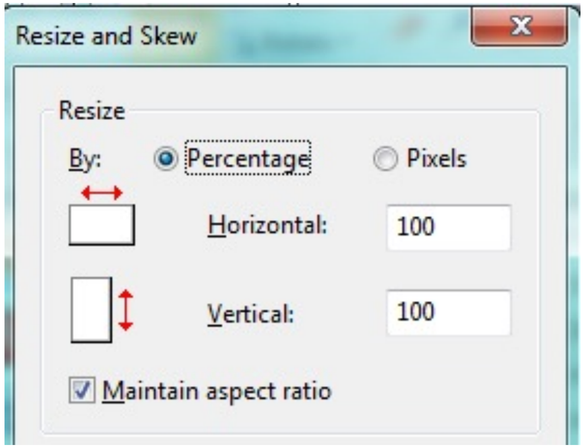
3. Minimise the user's memory load

- Support reuse and revisitation



3. Minimise the user's memory load

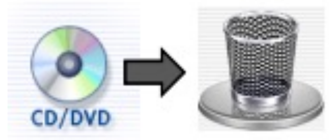
- Support exchange of units



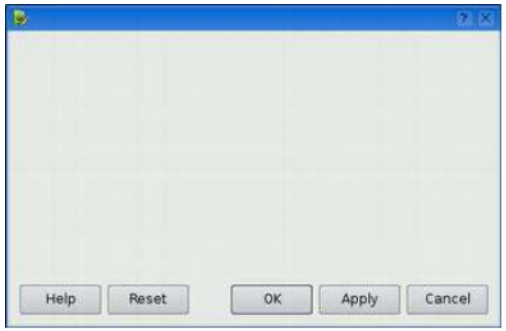
3. Minimise the user's memory load

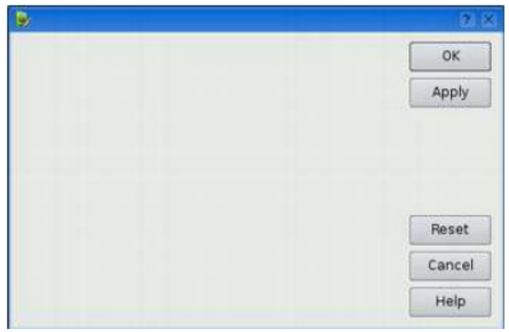
- Support generalisation techniques
  - Same command can be applied to all objects (e.g., cut, copy, paste, drag, drop for characters, words, paragraphs, objects, files...)
  - Same method/modifier can be generalised (e.g., circle is a constrained ellipse; square is a constrained rectangle, etc.)

4. Be Consistent



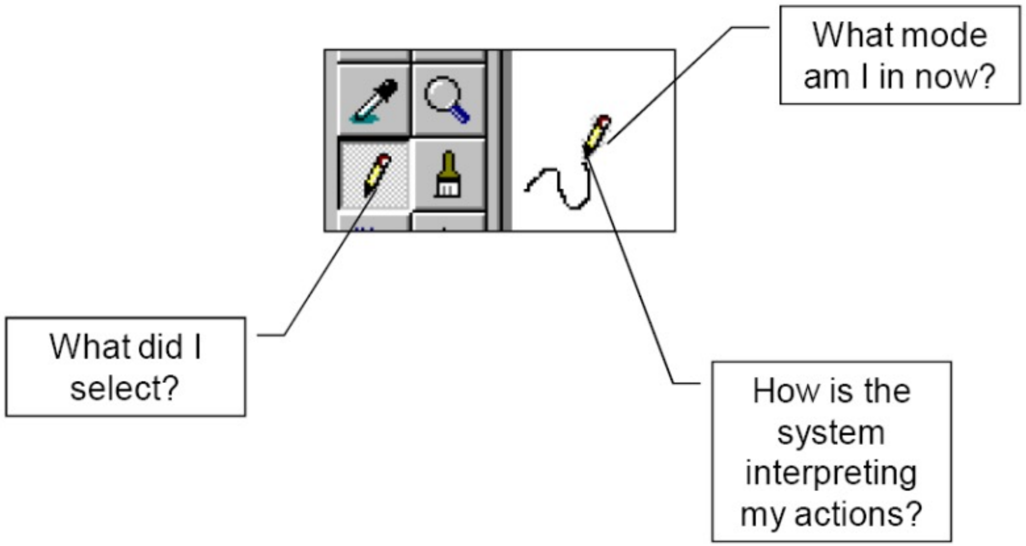
- In graphic design
- In command structure
- In everything!
  - Internal consistency: within the application
  - External consistency: within the platform
  - Beyond computing





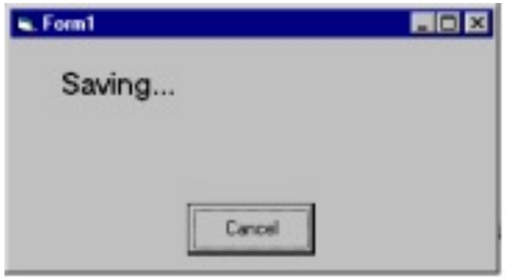
5. Provide Feedback

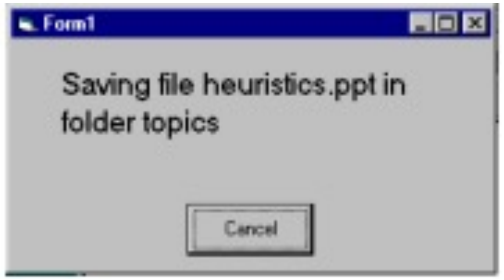
- Continually inform the user about:
  - What the system is doing
  - The system's interpretation of the input



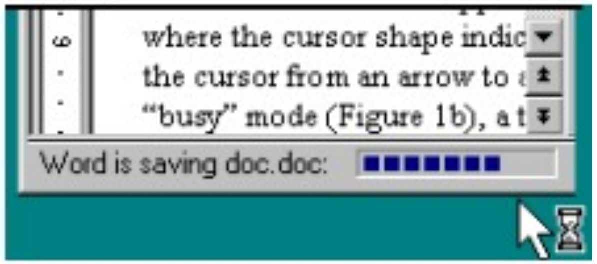
5. Provide Feedback

- Be specific, based on input



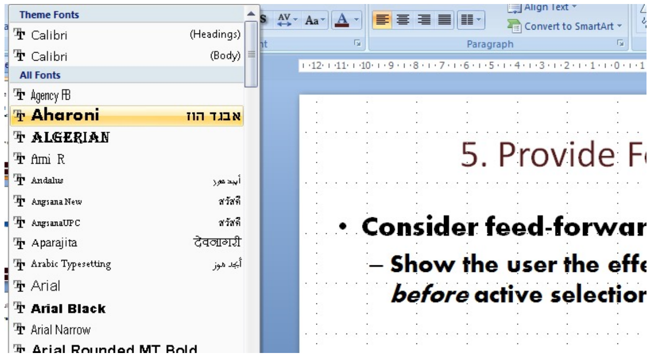


- Consider context of the action (don’t disrupt)



5. Provide Feedback

- Consider feed-forward
  – Show effect of action *before* active selection



  – Offer choices based on partial task completion

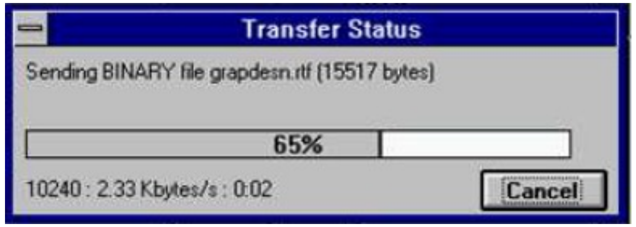
5. Provide Feedback

- Response times:
  - < 0.1s: perceived as ‘instantaneous’
  - < 1s: delay noticed, but flow of thought uninterrupted
  - 10s: limit for keeping attention on the dialogue
  - > 10s: user will want to perform other tasks
- Consider feedback persistence

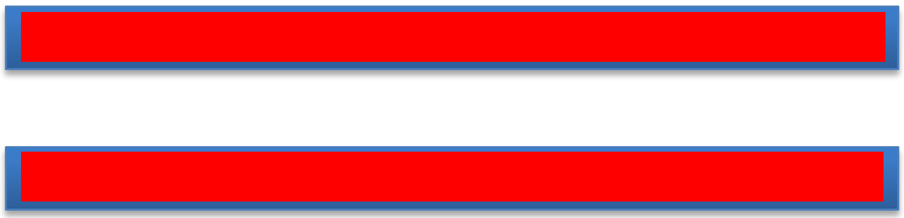
5. Provide Feedback

- Feedback for delays
  - Cursors for short delays

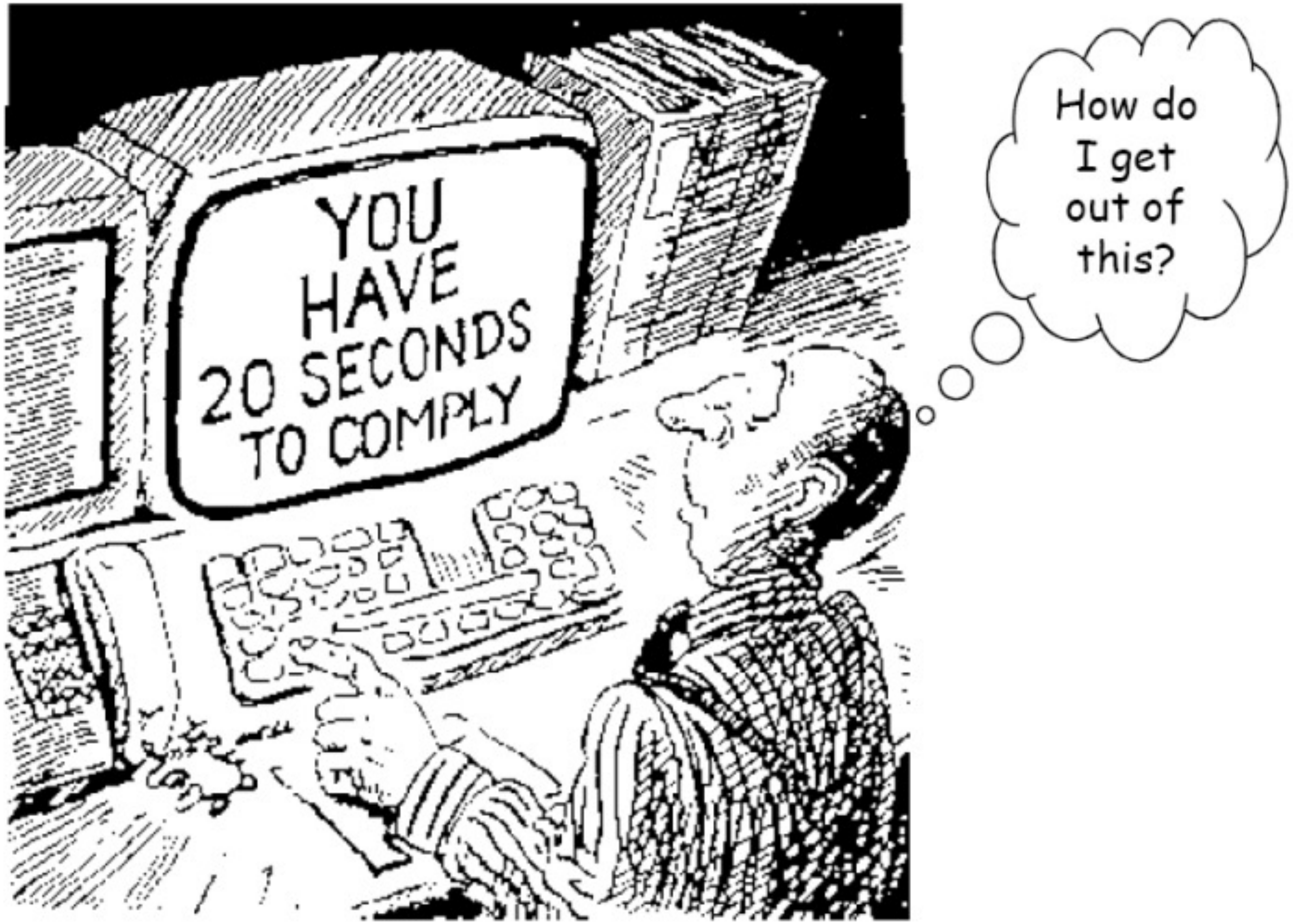
  - Percentage done for longer delays



  - “Working” dialogues for unknown delays



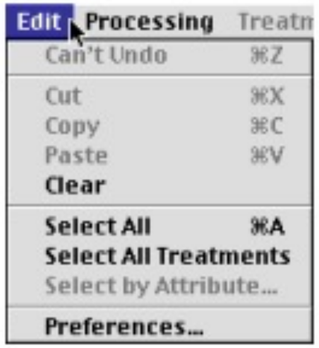
6. Provide clearly marked exits

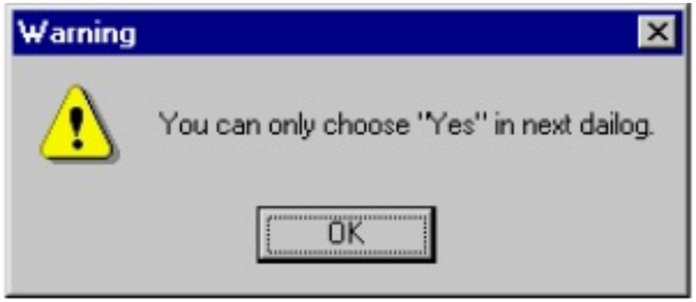


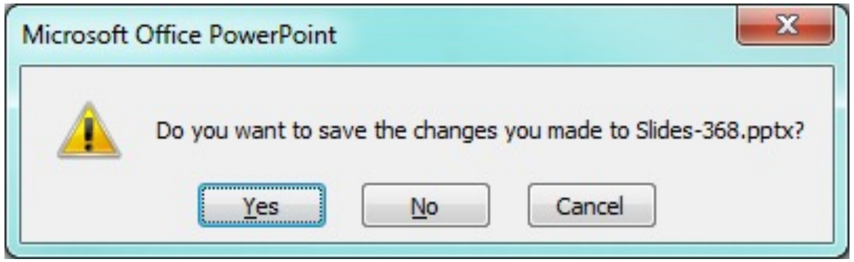
6. Provide clearly marked exits

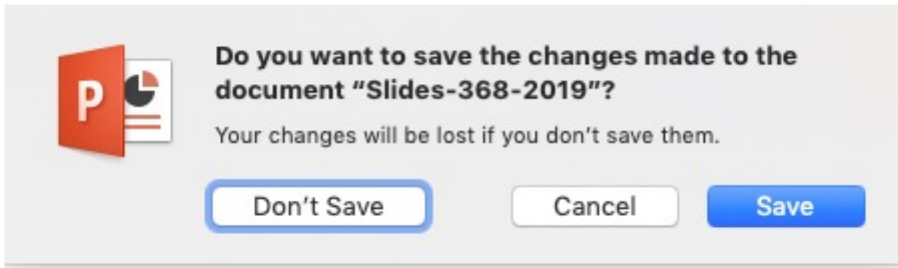
- Avoid 'trapping' the user: offer a way out when possible
- Strategies:
  - Cancel button
  - Universal undo (return to previous state)
  - Interrupt (especially for lengthy operations)
  - Higher precedence for more recent actions
  - Quit
  - Defaults (for restoring a property sheet)

6. Provide clearly marked exits





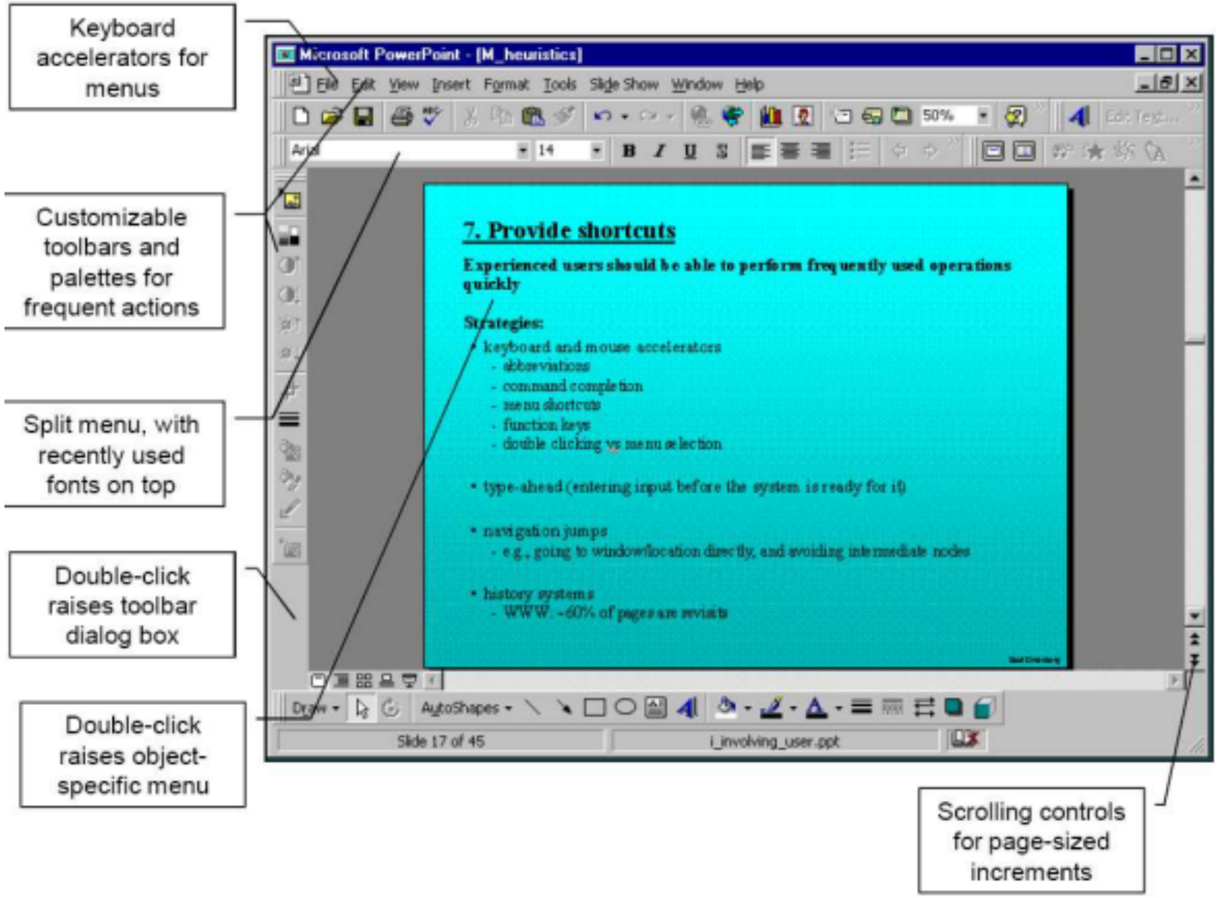




7. Provide shortcuts

- Enable high performance by experienced users
  - Keyboard accelerators
  - Command completion
  - Function keys
  - Double clicking; context menus
  - Type-ahead (most likely prediction is offered)
  - Gestures
  - History

7. Provide shortcuts

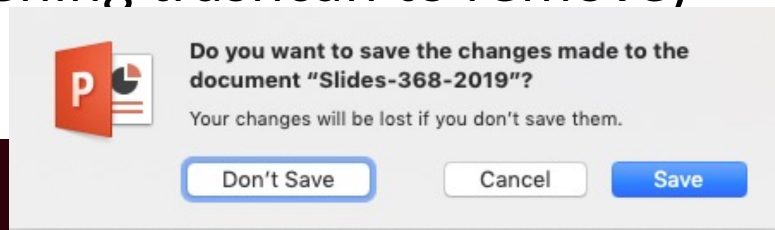


8. Prevent errors and avoid modes

- People will make errors:
  - Mistakes: conscious deliberation leads to incorrect action
  - Slips: unconscious behaviour that gets misdirected
- General rules:
  - Prevent slips before they occur (e.g., syntactic correctness)
  - Allow slips to be detected when they occur (via feedback)
  - Support easy correction (e.g., undo)
  - Commensurate effort (difficult states are hard to irreversibly leave)

8. Prevent errors and avoid modes

- Examples
  - Mode errors:
    - Have as few modes as possible (preferably none)
    - Assure modes are visible (or audible)
    - Spring-loaded modes: ongoing action maintains mode
  - Capture errors:
    - Instead of confirmation, make actions undoable
    - Allow reconsideration (e.g., opening trashcan to remove)
    - Context-sensitive confirmation



8. Prevent errors and avoid modes

- Forcing functions (e.g., syntactic correctness)
  - Prevent continuation of wrongful action
- Warnings
  - Irritating when overused
  - Can be ‘heavy’ (e.g., alertbox) or ‘light’ (beep)
- Do nothing
  - Illegal action ignored
  - User must infer what happened
  - E.g., ignoring letters typed into a number field

8. Prevent errors and avoid modes (iPhone ‘rubber banding’)

- Rubber-banding problem:
  - Potential for confusion/error over gesture scrolling direction – drag document (down for up); drag camera (down for down)
  - No scrollbars for cue (or minimal) or for control
  - Lack of feedback at terminus, confused for “crashed/broken”

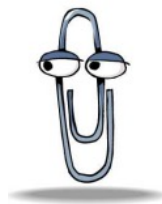
8. Prevent errors and avoid modes (iPhone ‘rubber banding’)

8. Prevent errors and avoid modes (iPhone ‘edge swipe’)

- Edge-swipe problem:
  - Users can swipe/drag between photos
  - Users can swipe/drag within a zoomed photo
  - Users accidentally swipe between photos when they hit the edge of a photo while exploring it
  - How do you prevent the error?

8. Prevent errors and avoid modes

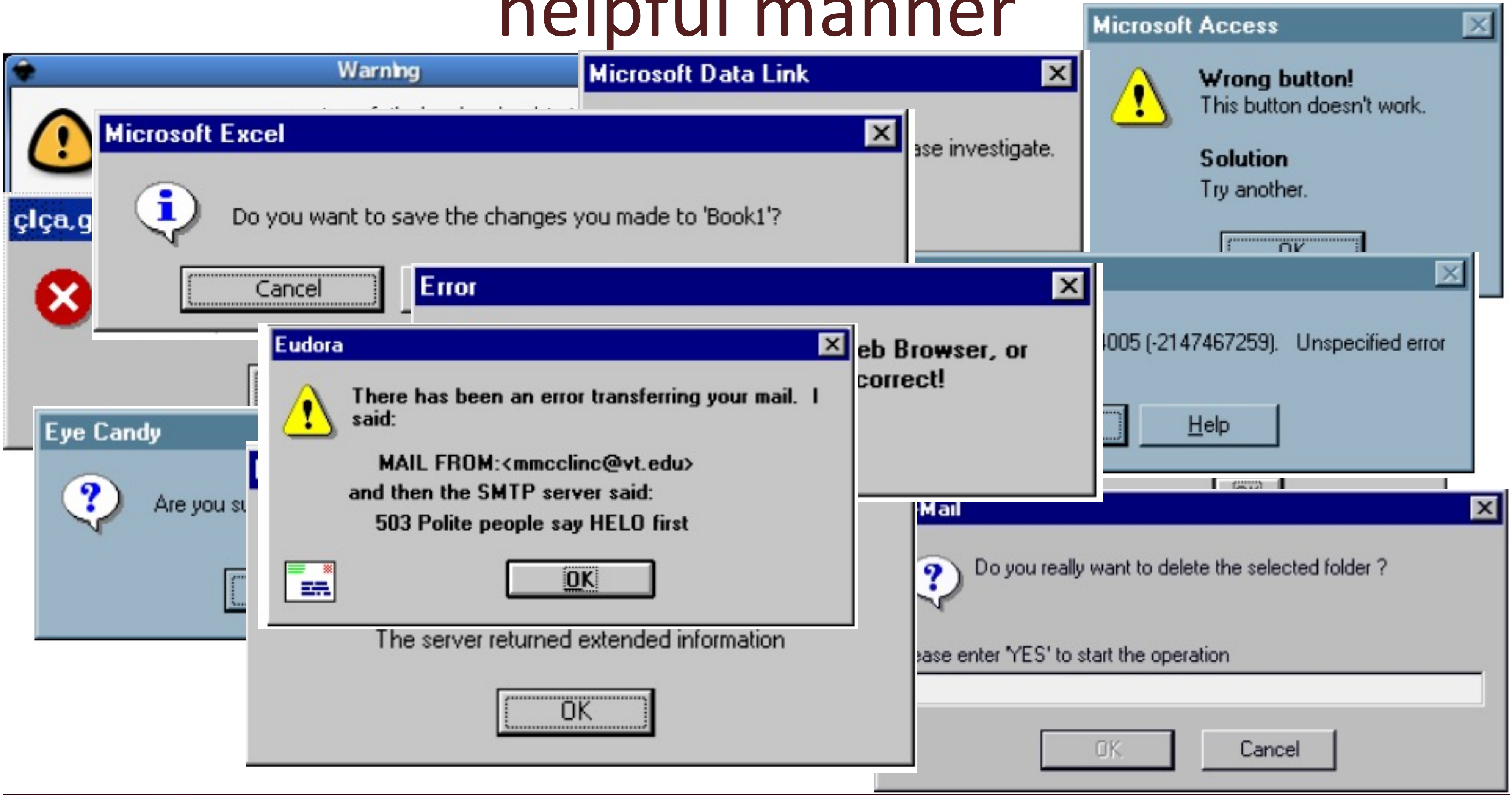
- Self-correct:
  - System guesses action and does it
  - Problems of trust (and negativity bias)
- Let's talk about it:
  - System initiates a dialogue to solve problem
  - E.g., IDE shows syntax error in code on compile error
- Teach me (user instructs system):
  - System asks what was intended
  - Action becomes legal (e.g., dictionary addition)
- Teach you (system instructs user)
  - System guesses intention and instructs user on proper way
  - Clippy! (condescending, boring, tedious, wrong)



9. Deal with errors in a positive and helpful manner

- Bad error message:
  `Error 25`
- Clear language, not codes:
  `Cannot open this document`
- Precise, rephrasing user's input:
  `Cannot open 'chapter5.doc' because the application Microsoft Word is not on your system`
- Constructive help:
  `Cannot open 'chapter5.doc' because the application Microsoft Word is not on your system. Open with WordPad instead?`

9. Deal with errors in a positive and helpful manner



10. Help and documentation

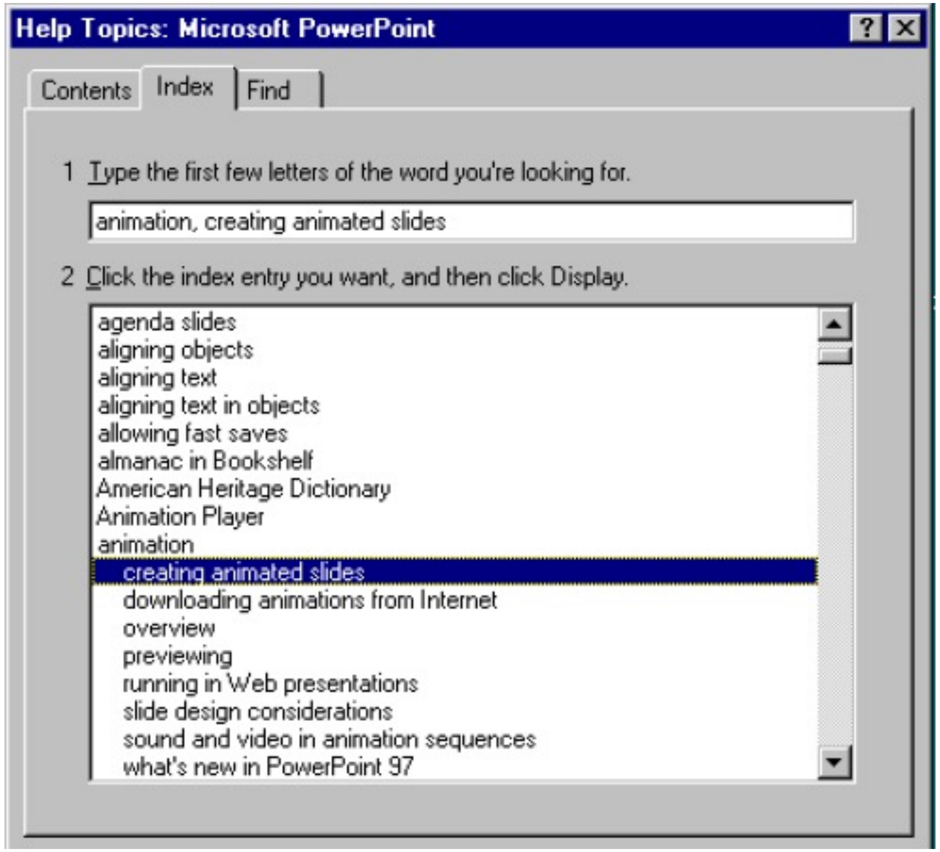
- Documentation is no excuse for interface hacks
- Write the manual before the system
- Task-centred manuals, particularly for beginners and for introduction to new system parts
- Quick reference cards for quick reference to aid novice to expert transition

10. Help and documentation

- Types of help:
  - Tutorials
    - Short introductory guides and overviews
    - Encourage exploration
    - Video walkthrough
    - Simple task walkthrough
  - Reference manuals
    - For lookup by expert (or those wanting to become so)
    - Thematically arranged

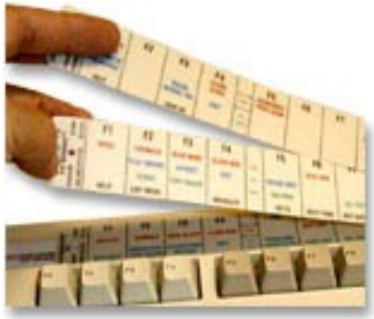
10. Help and documentation

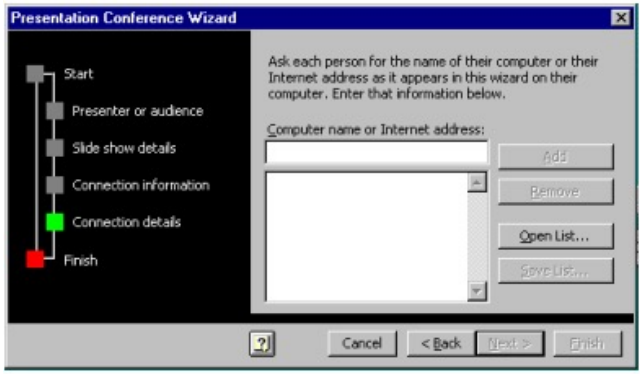
- Types of help (cont.):
  - Online reference:
    - Search/find
    - Table of contents
    - Index



10. Help and documentation

- Types of help (cont.):
  - Reminders:
    - Short reference cards
    - Keyboard templates
    - Tooltips
  - Wizards:
    - Walk user through typical task
    - Dangerous if the user gets stuck
  - Tips
    - Tool for extending user capability
    - Risk that they become boring/tedious



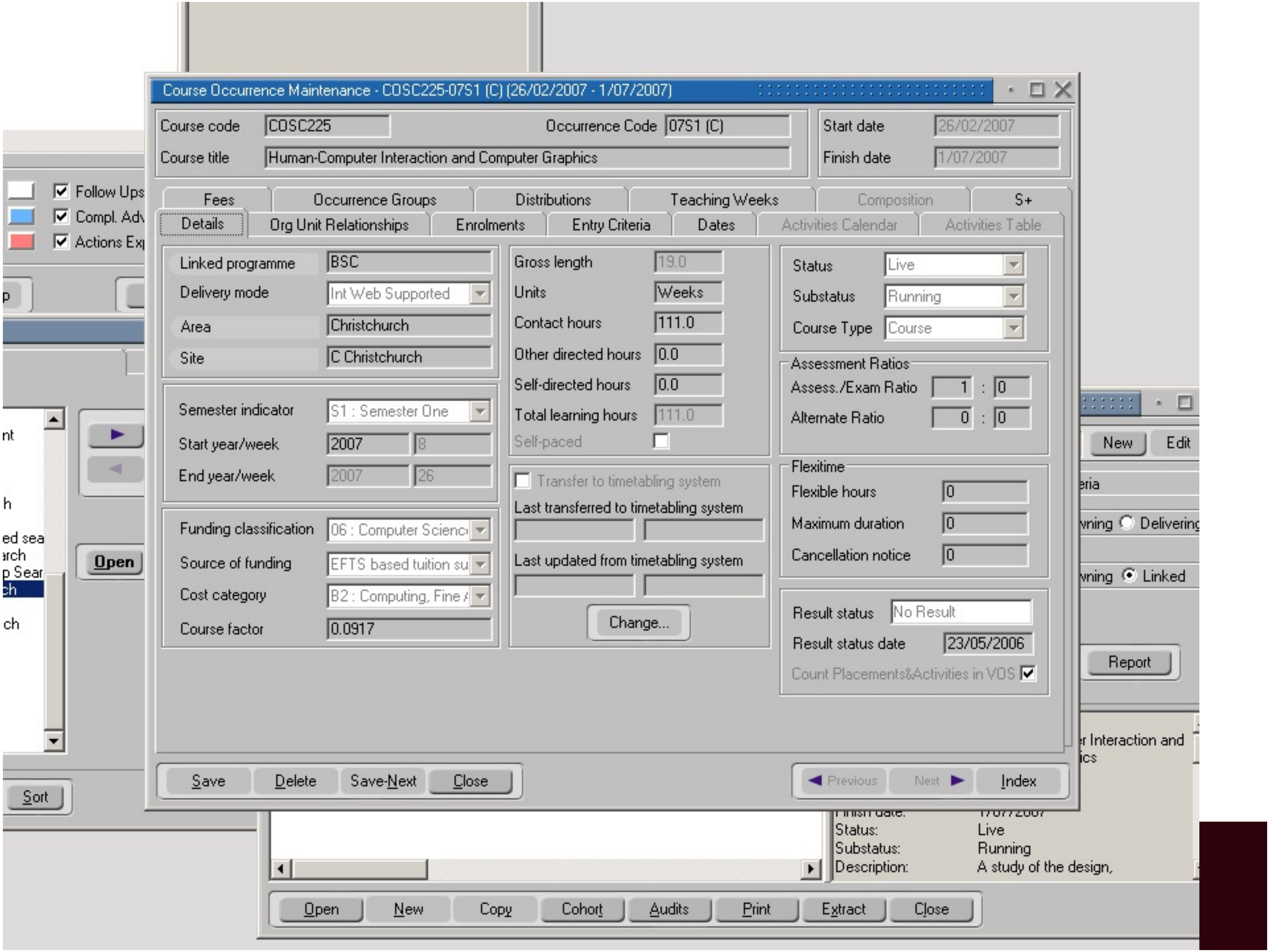


Inspection methods

- Systematic inspection of a user interface
- Goal is to find usability problems
- Inspections typically use inspectors, not real users
- Works for systems at any stage:
  - Paper storyboards, prototypes
  - Working systems
- Heuristic evaluation
  - Most popular inspection technique
  - 3-5 evaluators inspect the interface

How to do a heuristic evaluation

- Each inspector works alone with the interface
- Evaluator traverses interface several times:
  - Has a scenario/task in mind
  - Inspects UI components and workflow
  - Compares them with the heuristics
  - Looks for noncompliance/problems
  - Notes and rates each problem
- Two pass approach
  - First pass: focus on specific UI elements
  - Second pass: focus on higher integration and flow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Activities Calendar
Activities Table
Linked programme
BSC
Delivery mode
Int Web Supported
Area
Christchurch
Site
C Christchurch
Semester indicator
S1 : Semester One
Start year/week
2007
8
End year/week
2007
26
Funding classification
06 : Computer Scienc
Source of funding
EFTS based tuition su
Cost category
B2 : Computing, Fine /
Course factor
0.0917
Gross length
19.0
Units
Weeks
Contact hours
111.0
Other directed hours
0.0
Self-directed hours
0.0
Total learning hours
111.0
Self-paced
Transfer to timetabling system
Last transferred to timetabling system
Last updated from timetabling system
Change...
Status
Live
Substatus
Running
Course Type
Course
Assessment Ratios
Assess./Exam Ratio
1
0
Alternate Ratio
0
0
Flexitime
Flexible hours
0
Maximum duration
0
Cancellation notice
0
Result status
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Result status date
23/05/2006
Count Placements&Activities in VOS
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Delete
Save-Next
Close
Previous
Next
Index
Follow Ups
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Actions Exp
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Sort
New
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Linked
Report
Status:
Live
Substatus:
Running
Description:
A study of the design,
Open
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Audits
Print
Extract
Close

Results synthesis

- Assess overlap in problems reported by inspectors
- Review and compare severity rankings
- Rank problems in order of importance

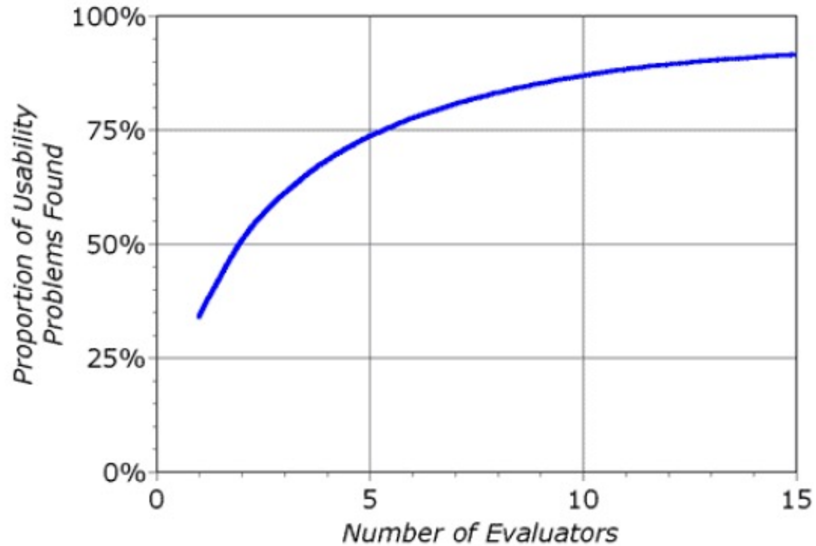
Impact of the problem on those that encounter it	Proportion of users experiencing the problem: Few	Many
Small	Low severity	Medium severity
Large	Medium severity	High severity

Who should evaluate?

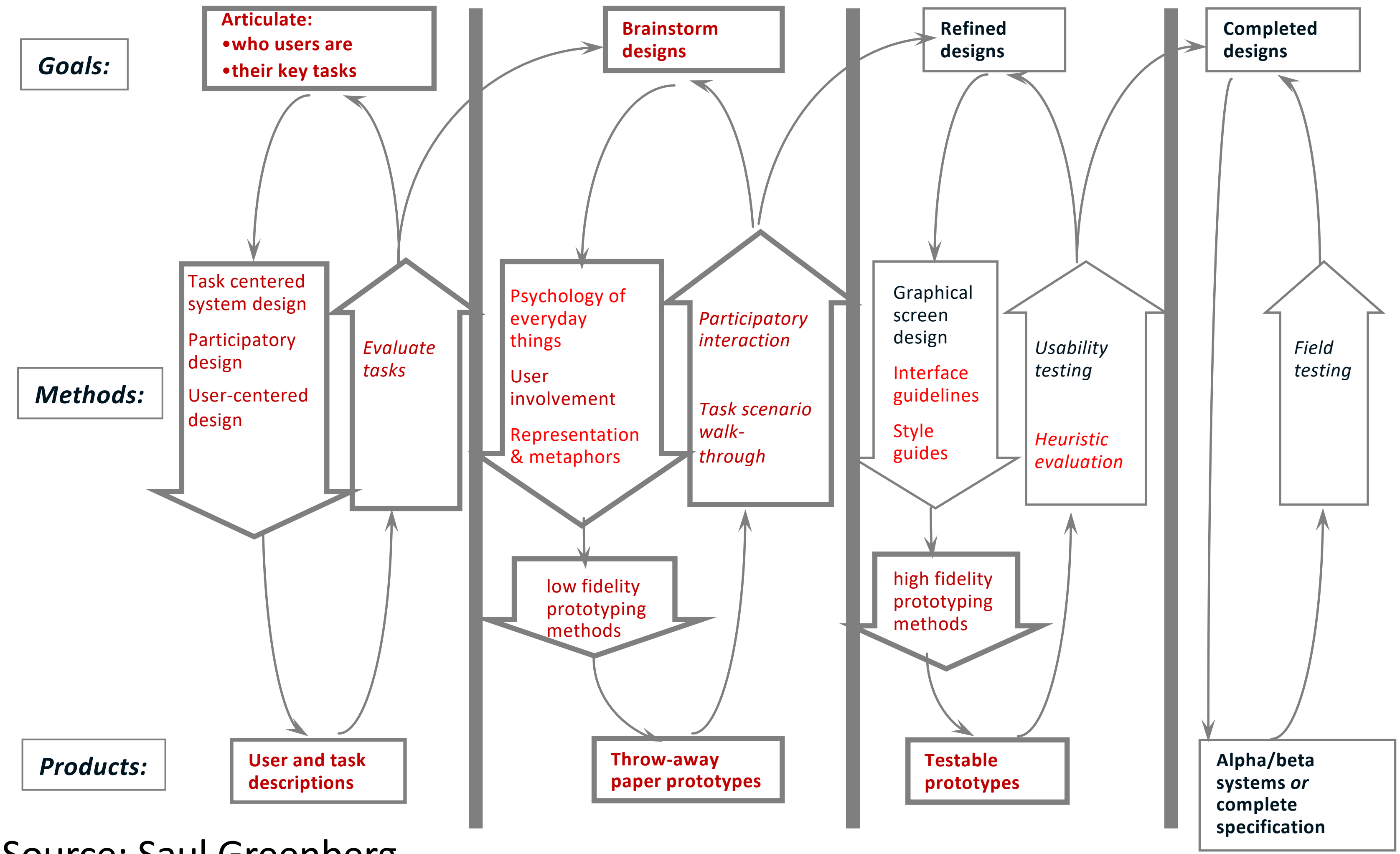
- Different perspectives will catch different problems
- A reasonable team:
  – Developer
  – Designer
  – Usability expert
  – Domain expert
  – User
- Must be trained in the technique

How many evaluators?

- Each inspector finds about 35% of problems
  - But they usually don't find the same ones
- 3 inspectors find ≈60%, 5 find ≈70%,



Design Process



Source: Saul Greenberg

Graphical Screen Design

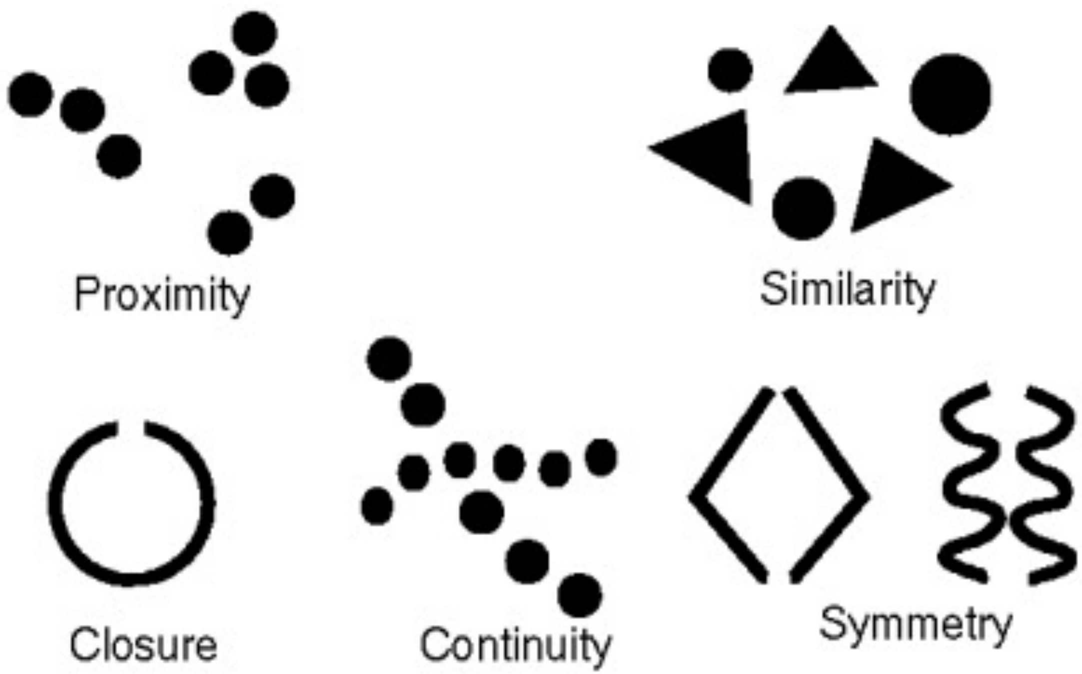
Good screen design draws on:

- Gestalt laws of perceptual organisation
- PARC principles: proximity, alignment, repetition, contrast

- Data representation
- Visual variables
- (Then information visualisation)

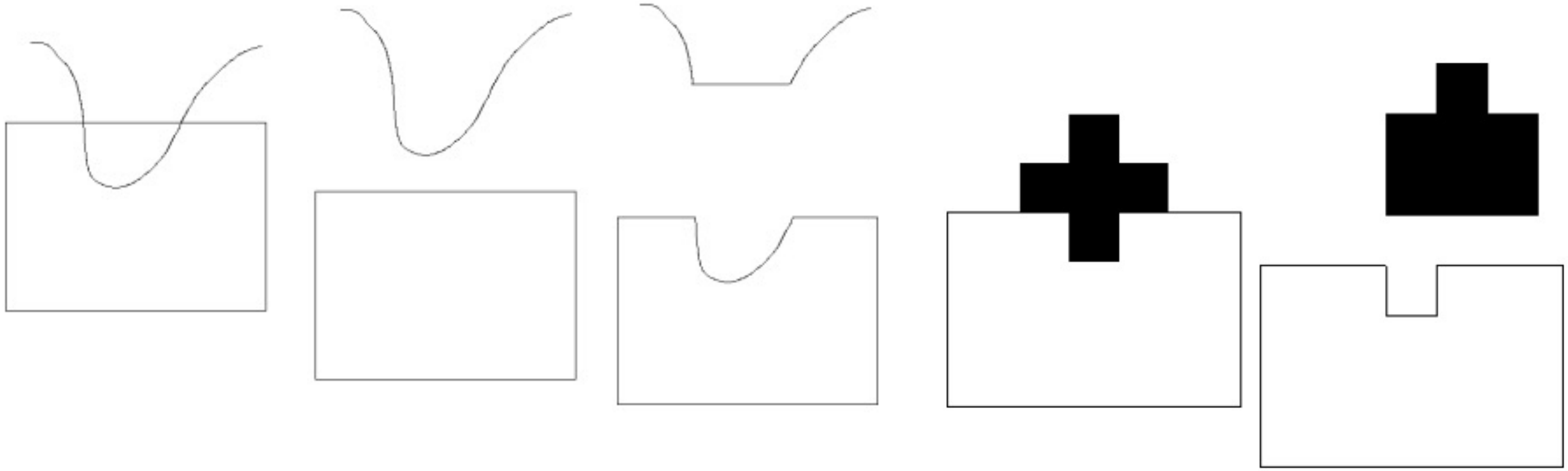
Gestalt Laws of Perceptual Organisation

- How do we see relationships/patterns
- Proximity
- Similarity
- Continuity
- Symmetry
- Closure



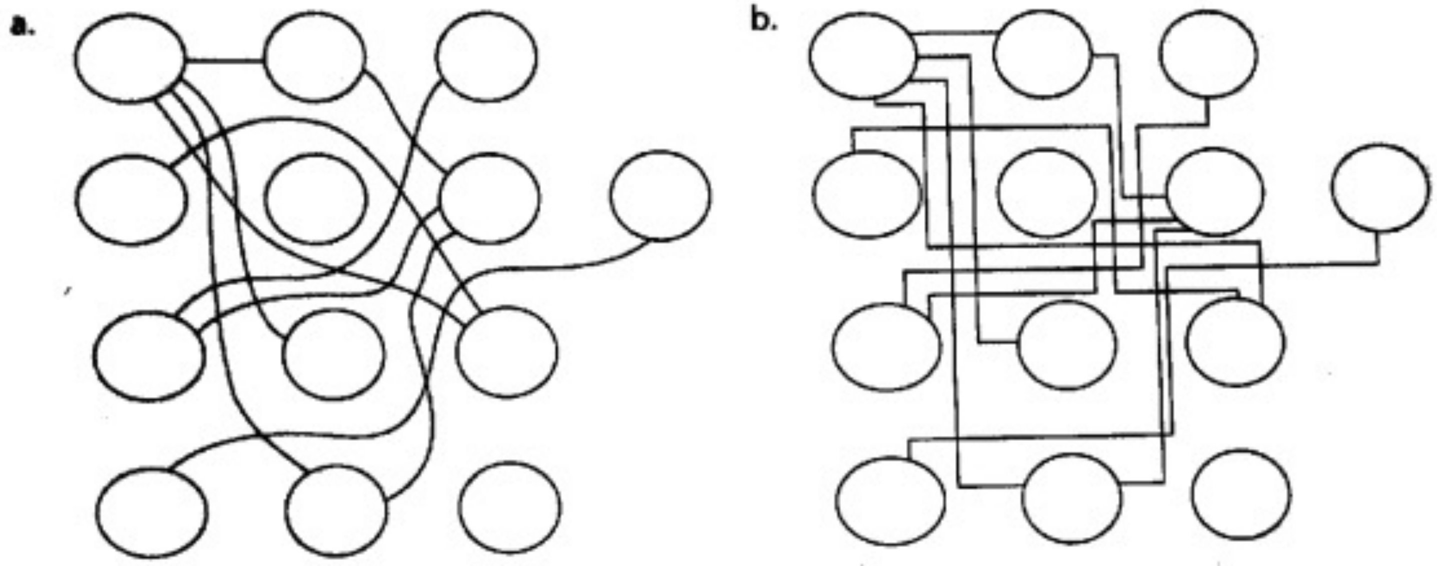
Gestalt Laws of Perceptual Organisation

- E.g., Continuity and symmetry



Gestalt Laws of Perceptual Organisation

- Smooth continuity eases perception (at cost of 'neatness'

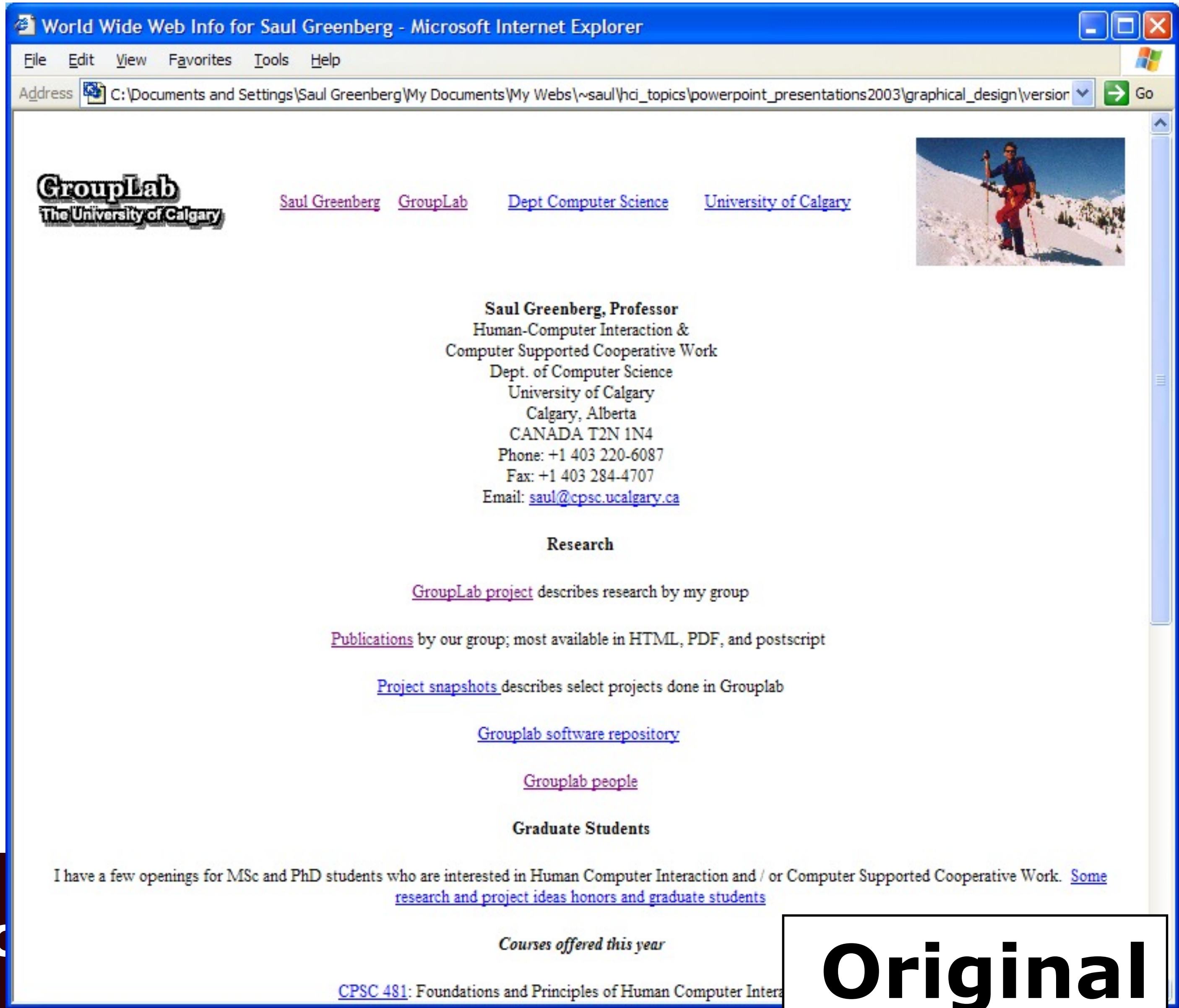


PARC Principles for Graphical Screen

Robin Williams: The non-designer's design book

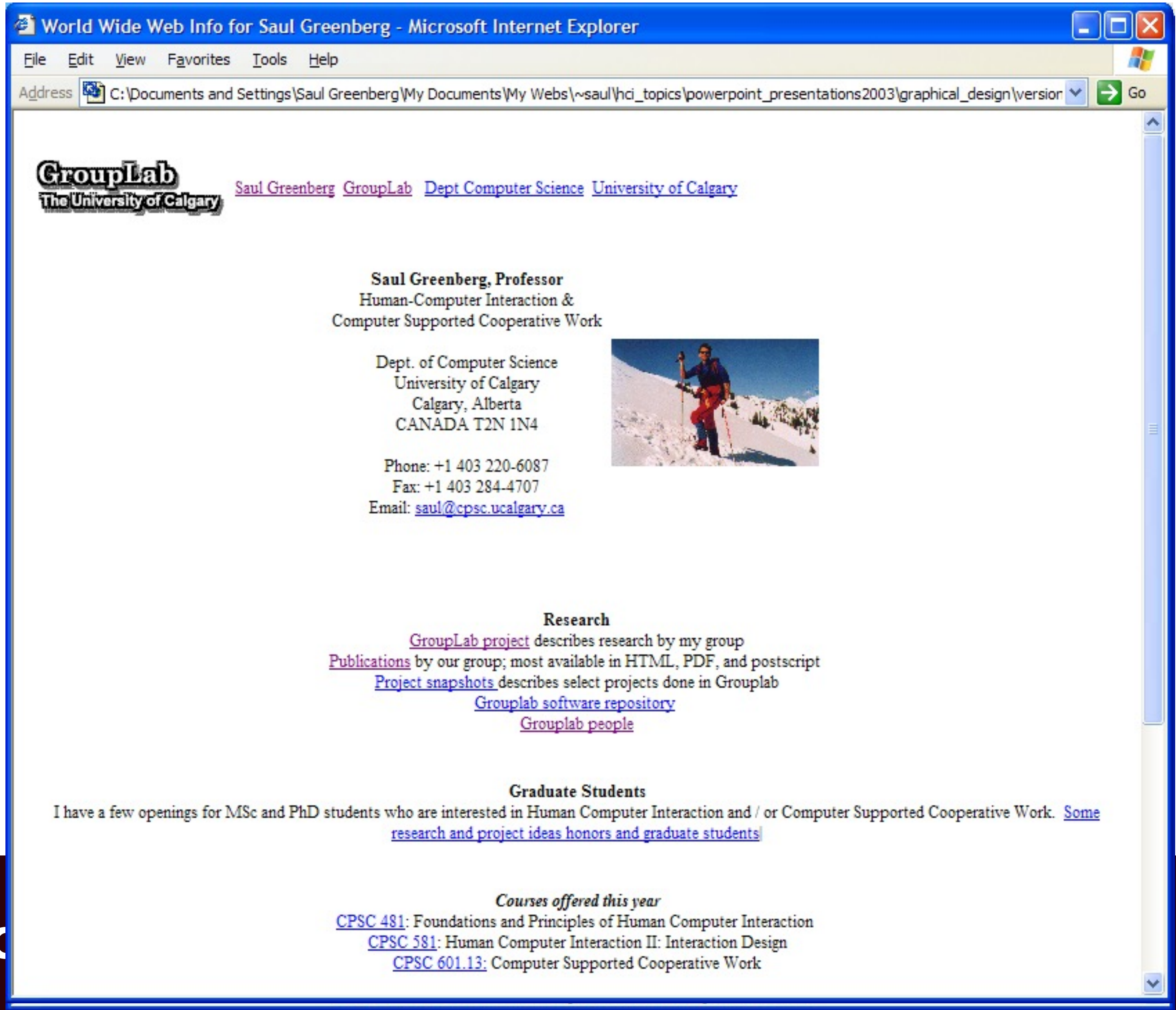
- Proximity
  - Group related elements
  - Separate unrelated ones
- Alignment
  - Visually connect elements
  - Creates a visual flow
- Repetition
  - Repeat designs through the interface
  - Creates unity and consistency
- Contrast
  - Make different things look different
  - Bring out dominant elements, mute lesser ones

Worked example from Saul Greenberg



Original

Proximity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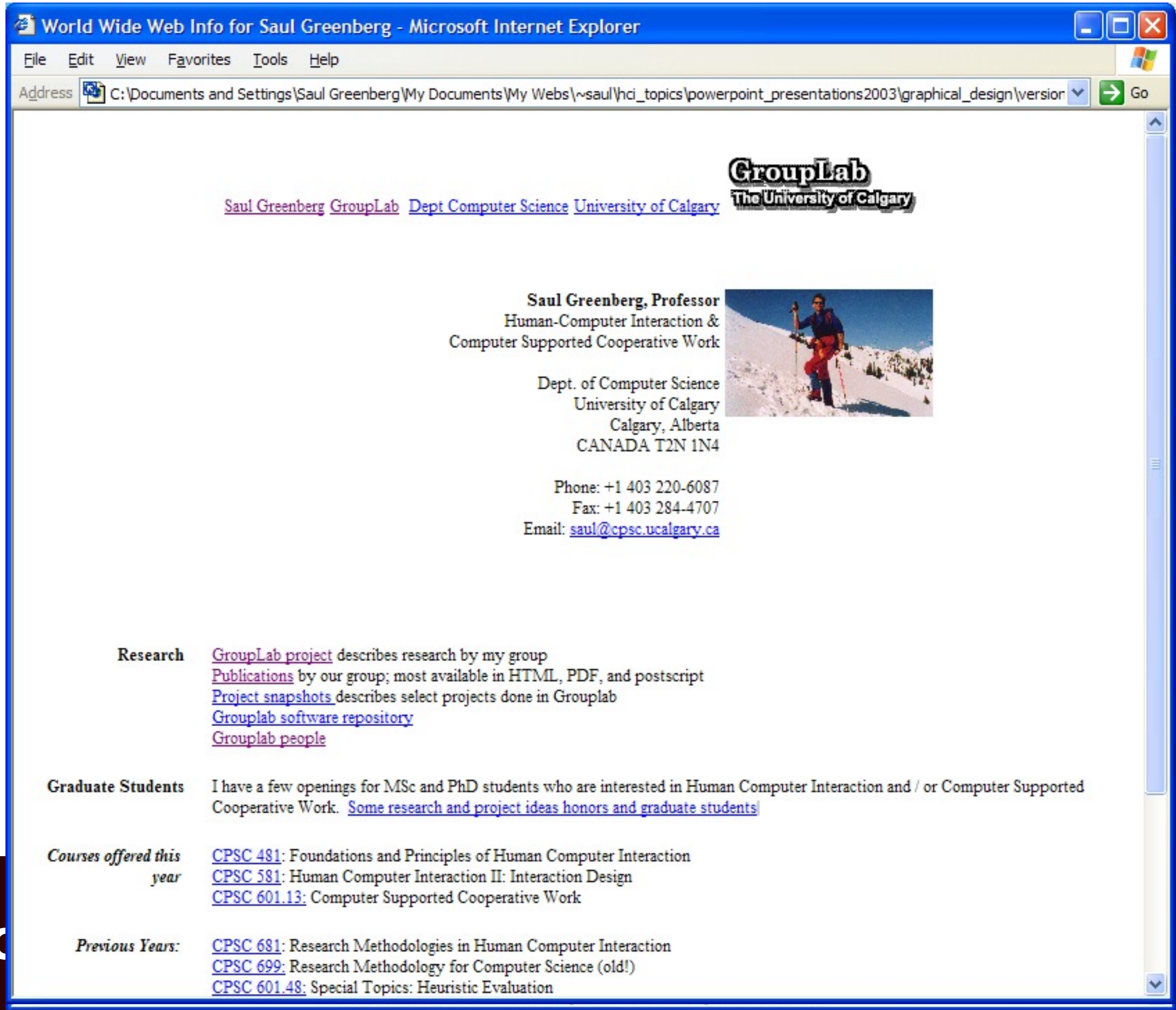
Go
GroupLab
The University of Calgary
Saul Greenberg GroupLab Dept Computer Science University of Calgary
Saul Greenberg, Professor
Human-Computer Interaction &
Computer Supported Cooperative Work
Dept. of Computer Science
University of Calgary
Calgary, Alberta
CANADA T2N 1N4
Phone: +1 403 220-6087
Fax: +1 403 284-4707
Email: saul@cpsc.ucalgary.ca
Research
GroupLab project describes research by my group
Publications by our group; most available in HTML, PDF, and postscript
Project snapshots describes select projects done in Grouplab
Grouplab software repository
Grouplab people
Graduate Students
I have a few openings for MSc and PhD students who are interested in Human Computer Interaction and / or Computer Supported Cooperative Work. Some research and project ideas honors and graduate students
Courses offered this year
CPSC 481: Foundations and Principles of Human Computer Interaction
CPSC 581: Human Computer Interaction II: Interaction Design
CPSC 601.13: Computer Supported Cooperative Work

Alignment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Phone: +1 403 220-6087
Fax: +1 403 284-4707
Email: saul@cpsc.ucalgary.ca
Research
GroupLab project describes research by my group
Publications by our group; most available in HTML, PDF, and postscript
Project snapshots describes select projects done in Grouplab
Grouplab software repository
Grouplab people
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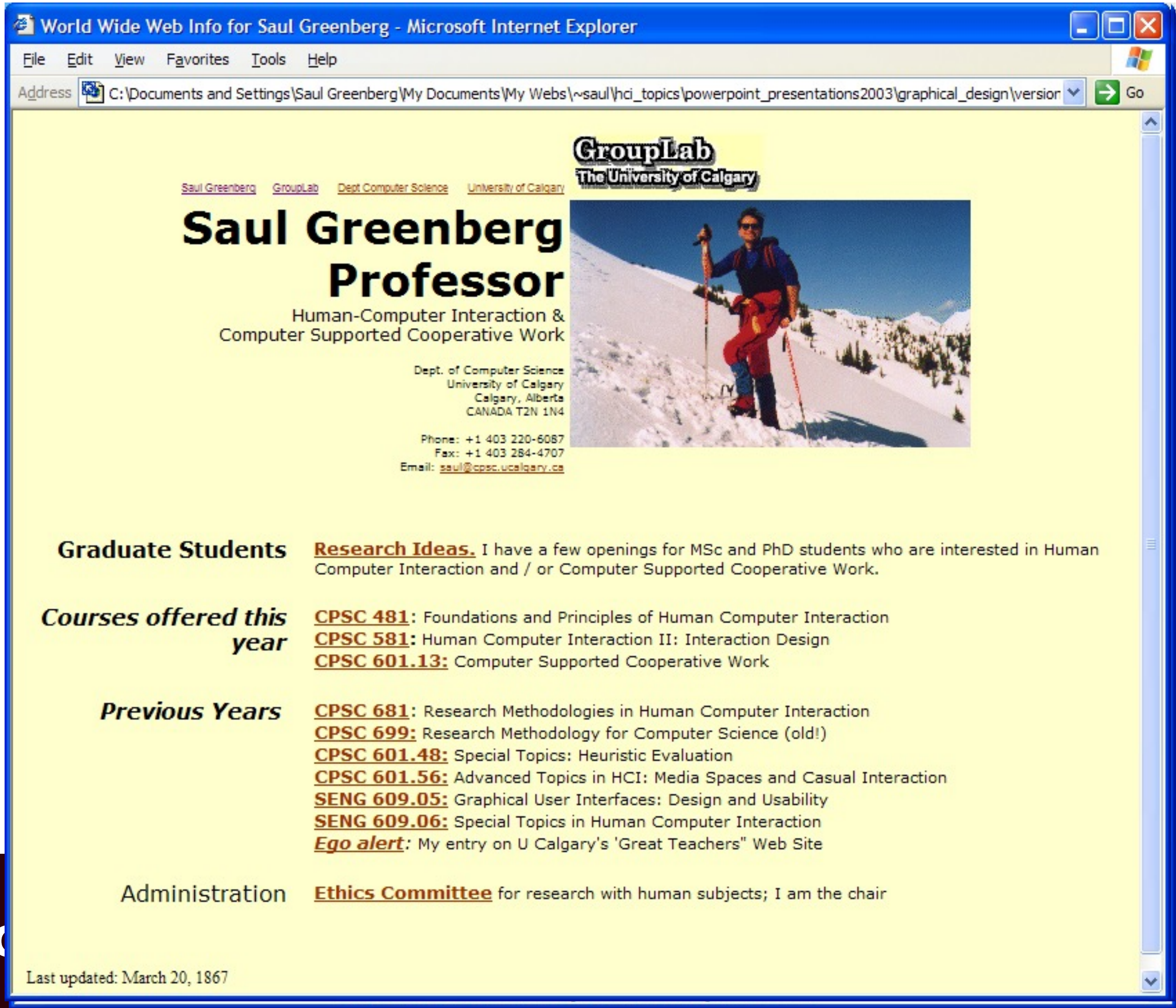
CPSC 699: Research Methodology for Computer Science (old!)
CPSC 601.48: Special Topics: Heuristic Evaluation

Contrast



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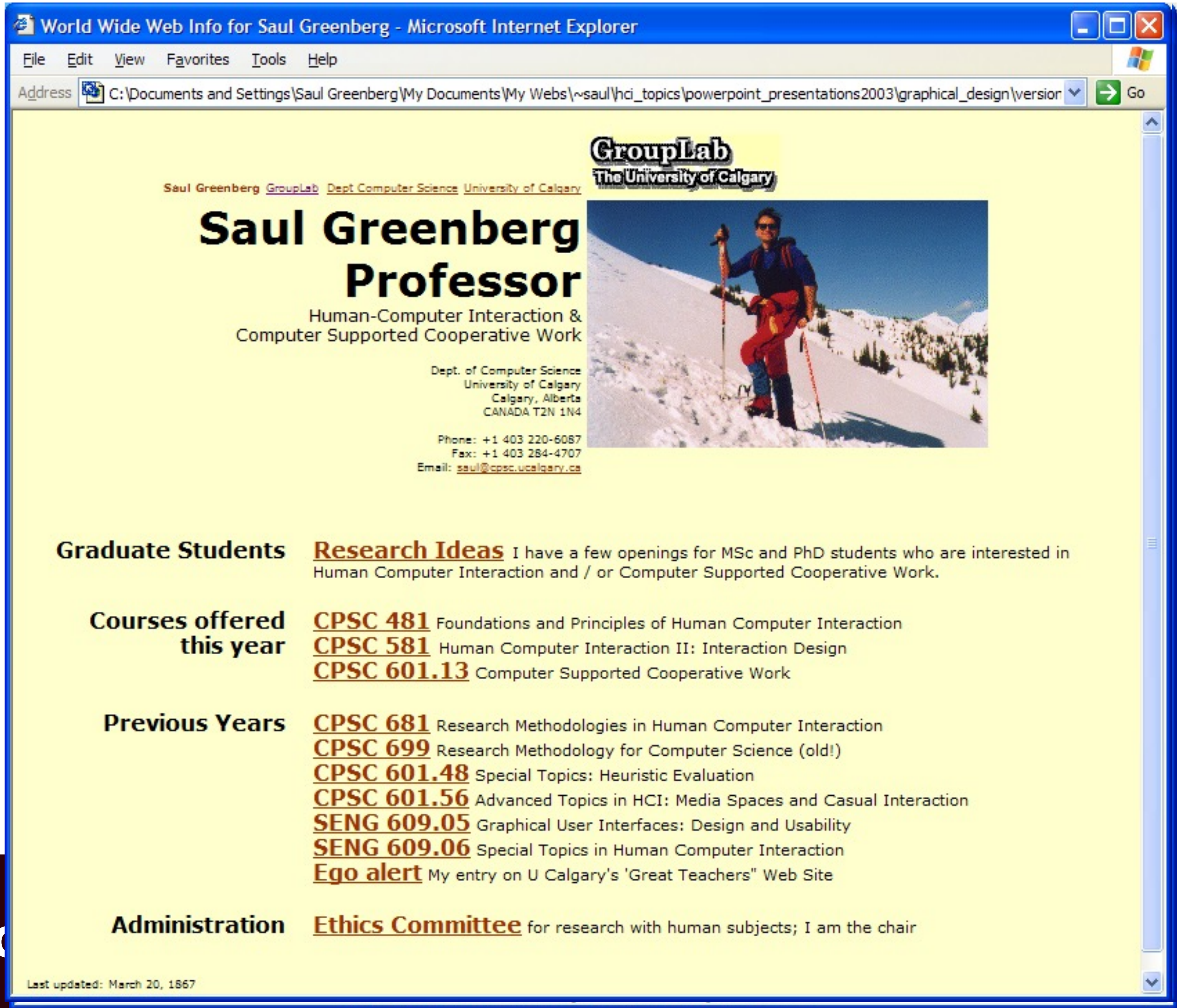
CPSC 601.48: Special Topics: Heuristic Evaluation
CPSC 601.56: Advanced Topics in HCI: Media Spaces and Casual Interaction
SENG 609.05: Graphical User Interfaces: Design and Usability
SENG 609.06: Special Topics in Human Computer Interaction
Ego alert: My entry on U Calgary's 'Great Teachers" Web Site
Administration
Ethics Committee for research with human subjects; I am the chair
Last updated: March 20, 1867

Repetition



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Ego alert My entry on U Calgary's 'Great Teachers" Web Site
Administration
Ethics Committee for research with human subjects; I am the chair
Last updated: March 20, 1867

Good Design Is As Easy as 1-2-3

1. **Learn the principles.**
   They're simpler than you might think.
2. **Recognize when you're not using them.**
   Put it into words – name the problem.
3. **Apply the principles.**
   You'll be amazed.

Contrast

Repetition

Alignment

Proximity

Good design

is as easy as...

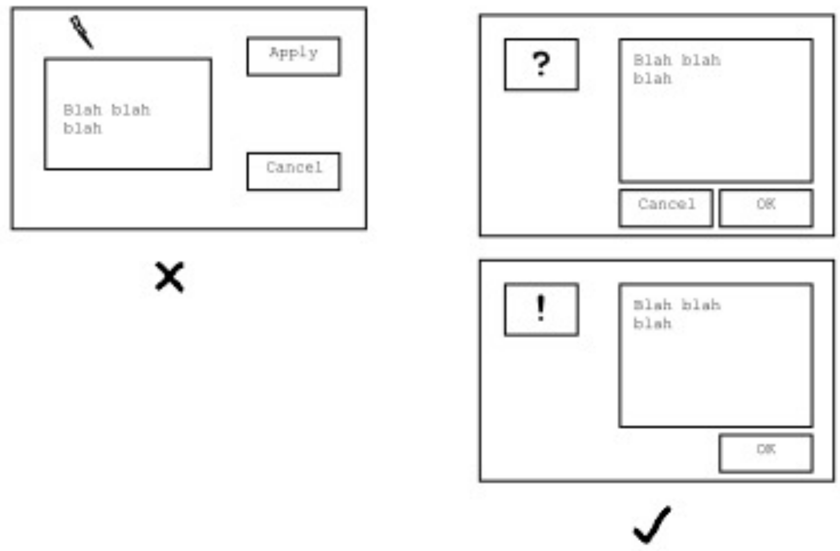
1 **Learn the principles.**
They're simpler than you might think.

2 **Recognize when you're not using them.**
Put it into words – name the problem.

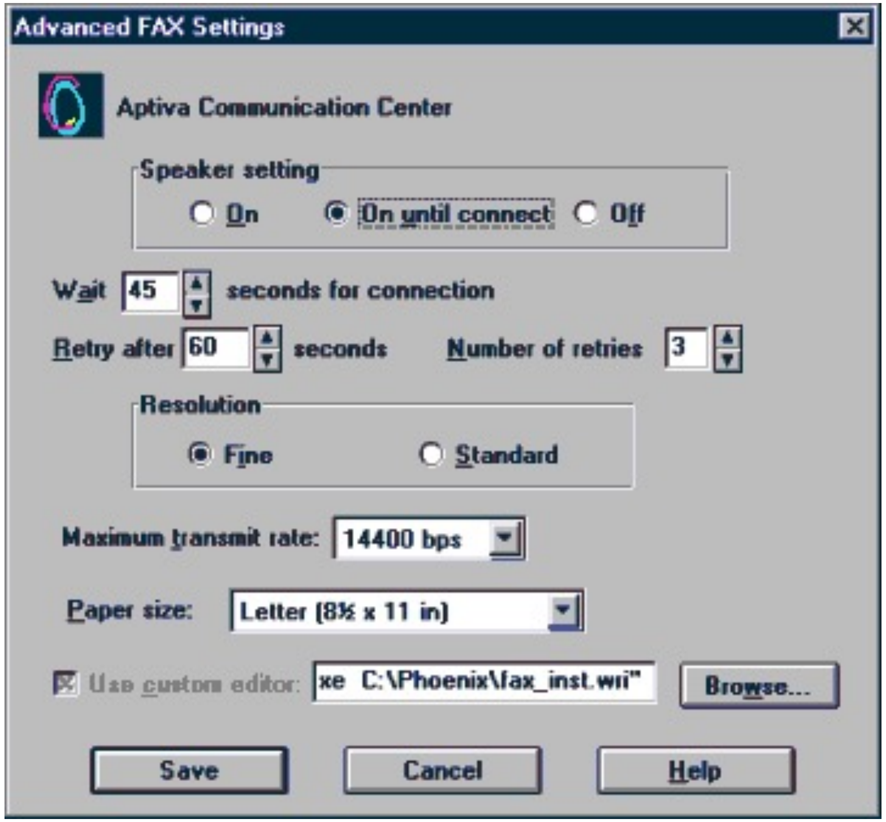
3 **Apply the principles.**
You'll be amazed.

Grids

- Horizontal and vertical alignment to group related components
- Proximity to group (and separate)
- Make <u>light</u> use of explicit structure (boxes and borders)

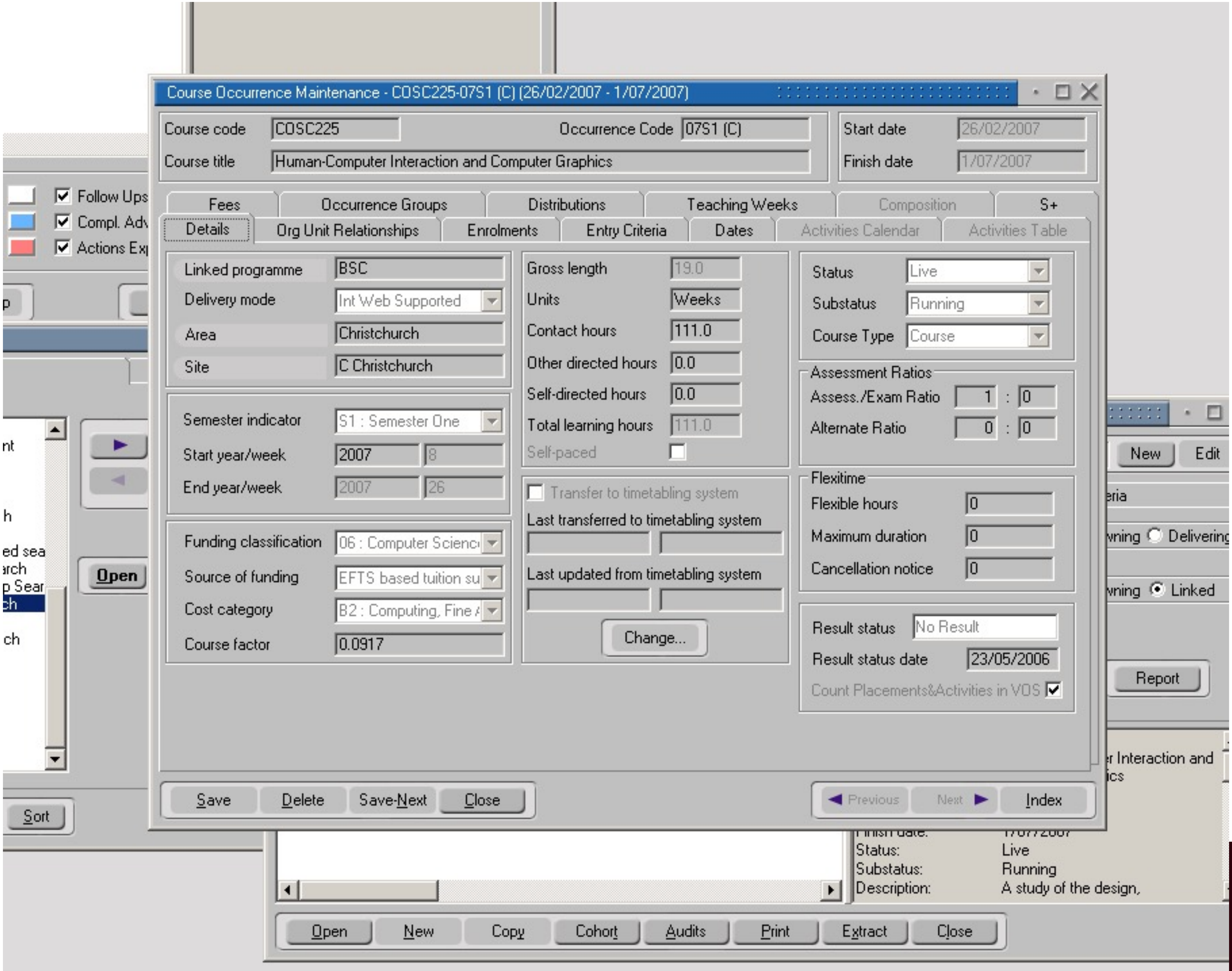


Grids



Weak use of grids. Scruffy

Excessive use of borders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Occurrence Code 07S1 (C)
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Teaching Weeks
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Details
Org Unit Relationships
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Entry Criteria
Dates
Activities Calendar
Activities Table
Linked programme BSC
Delivery mode Int Web Supported
Area Christchurch
Site C Christchurch
Semester indicator S1 : Semester One
Start year/week 2007 8
End year/week 2007 26
Funding classification 06 : Computer Scienc
Source of funding EFTS based tuition su
Cost category B2 : Computing, Fine
Course factor 0.0917
Gross length 19.0
Units Weeks
Contact hours 111.0
Other directed hours 0.0
Self-directed hours 0.0
Total learning hours 111.0
Self-paced
Transfer to timetabling system
Last transferred to timetabling system
Last updated from timetabling system
Change...
Status Live
Substatus Running
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Assessment Ratios
Assess./Exam Ratio 1 : 0
Alternate Ratio 0 : 0
Flexitime
Flexible hours 0
Maximum duration 0
Cancellation notice 0
Result status No Result
Result status date 23/05/2006
Count Placements&Activities in VOS
Save
Delete
Save-Next
Close
Previous
Next
Index
Follow Ups
Compl. Adv
Actions Exp
Open
Sort
New
Edit
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Linked
Report
Status: Live
Substatus: Running
Description: A study of the design,
Open
New
Copy
Cohort
Audits
Print
Extract
Close

Grids (in document tables)

Subject	Initial Model	Task 1		Task 2	
		Correct?	Confidence	Correct?	Confidence
1	List	NO	weak	YES	v weak
2	List	YES	weak	YES	strong
3	Stack	YES	strong	YES	strong
4	List	NO	weak	NO	weak
5	List	NO	strong	YES	weak
6	Tree	NO	weak	YES	weak
7	List	NO	weak	YES	weak
8	List	NO	weak	NO	strong
9	Dequeue	YES	strong	NO	strong
10	List	NO	weak	NO	strong
11	List	NO	weak	NO	strong
Totals		3 of 11 Correct 8 of 11 Incorrect		6 of 11 Correct 5 of 11 Incorrect	

Grids (in document tables)

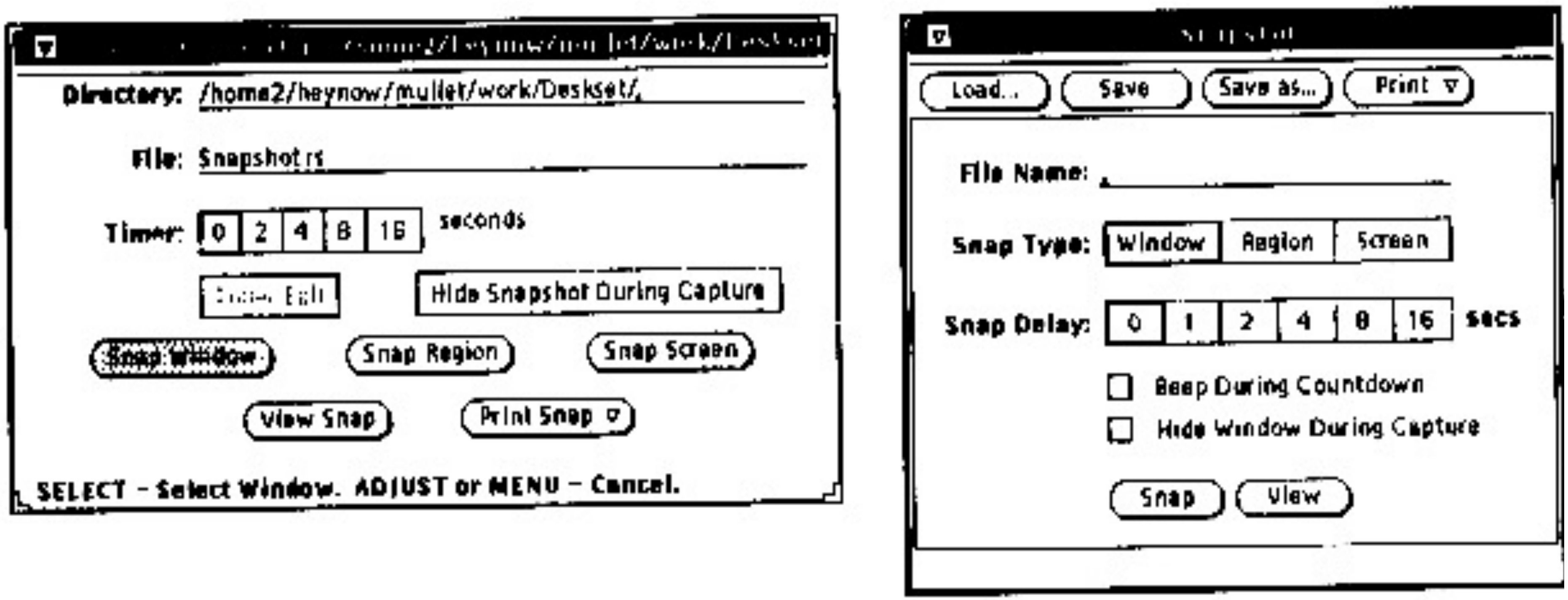
Subject	Initial Model	Task 1		Task 2	
		Correct?	Confidence	Correct?	Confidence
1	List	✗	weak	✔	v weak
2	List	✔	weak	✔	strong
3	Stack	✔	strong	✔	strong
4	List	✗	weak	✗	weak
5	List	✗	strong	✔	weak
6	Tree	✗	weak	✔	weak
7	List	✗	weak	✔	weak
8	List	✗	weak	✗	strong
9	Dequeue	✔	strong	✗	strong
10	List	✗	weak	✗	strong
11	List	✗	weak	✗	strong
Totals		3 Correct 8 Incorrect		6 Correct 5 Incorrect	

Navigational Cues

- Provide an initial focus (top left?)
- Group related items (quietly)
- Visual flow should follow logical flow

✗ ✓

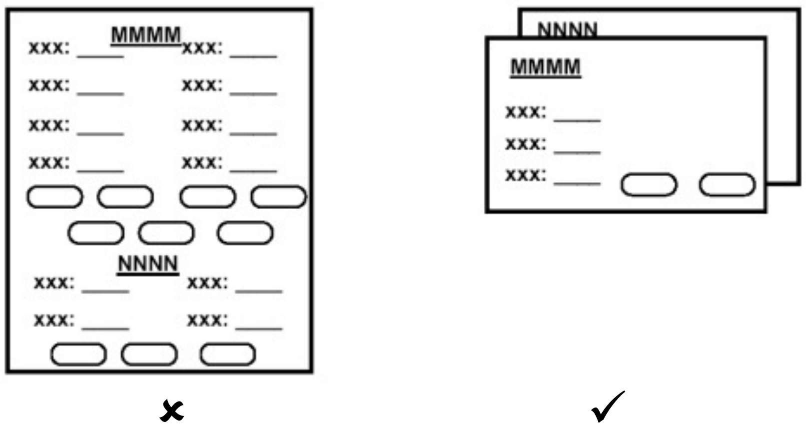
Navigational Cues



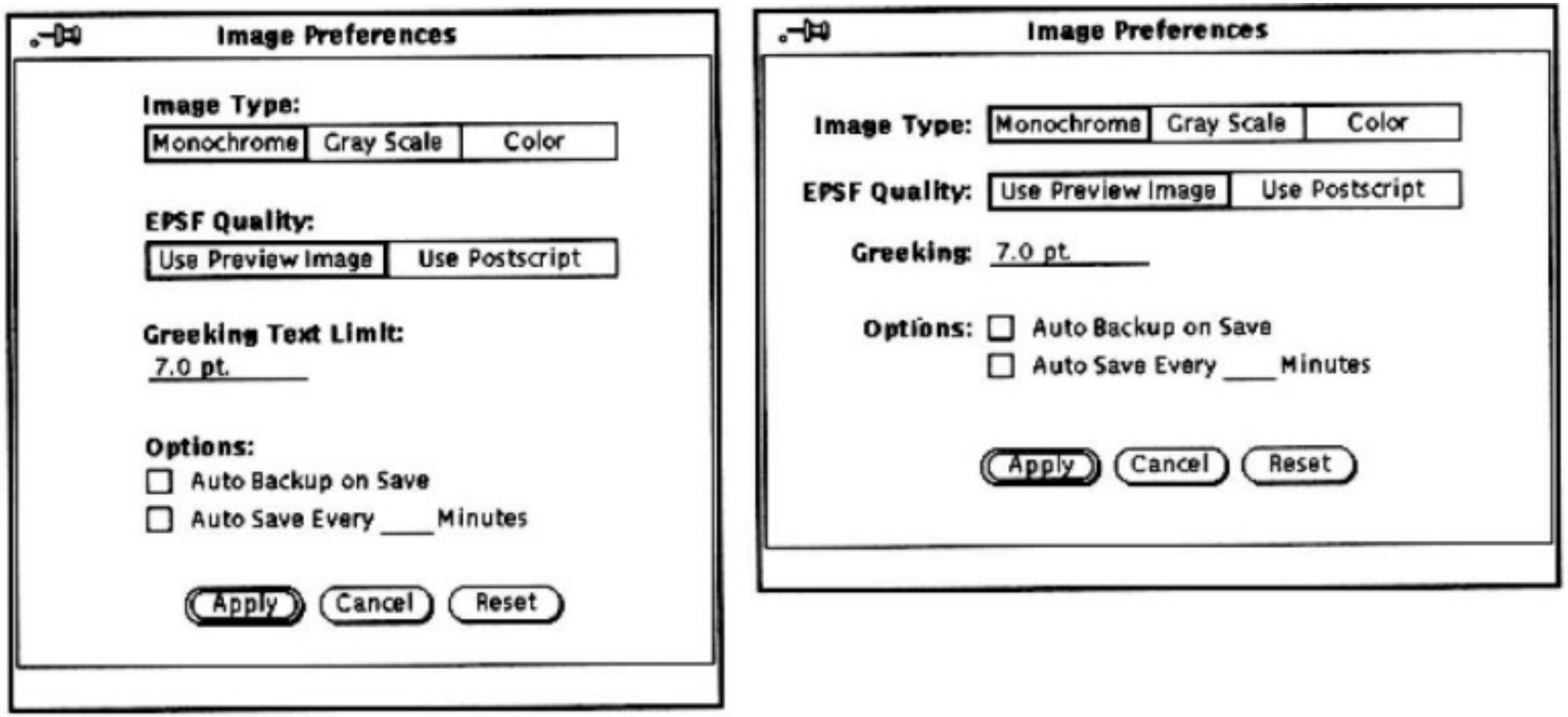
Redesign for navigational flow and alignment

Economy of visual elements

- Minimise the number of controls
- Include only those necessary (relegate others)
- Minimise clutter
- Experiment with white-space



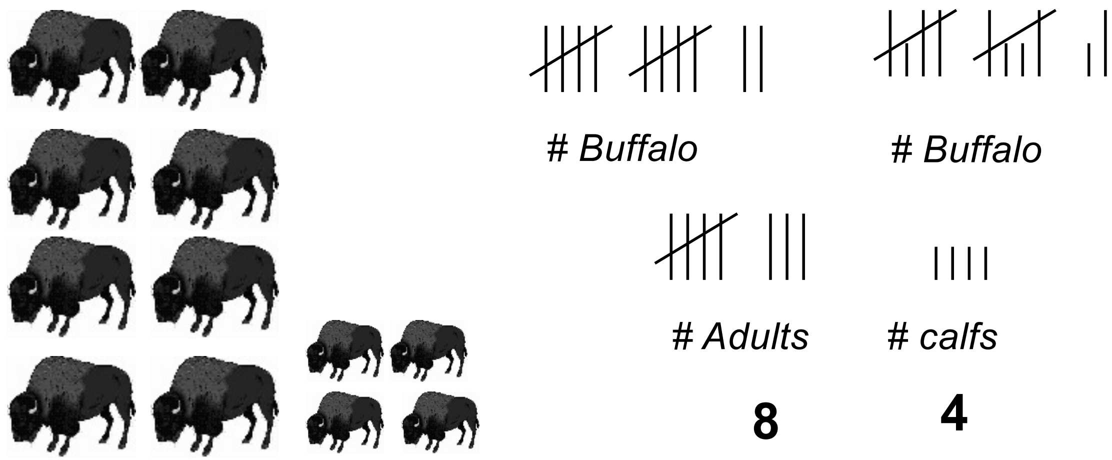
Economy of visual elements



White space experimentation

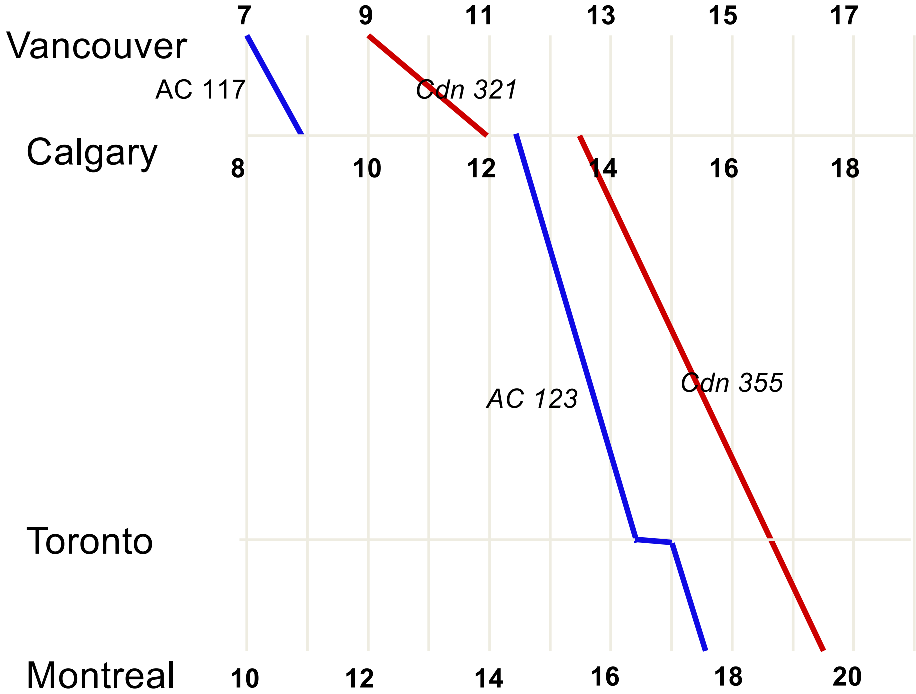
Data representation

- ‘Solving a problem simply means representing it so as to make the solution transparent’ (Simon, 1981)
- Different representations afford different views



Data representation

		depart	arrive
AC 117	Vancouver - Calgary	7:00	9:00
Cdn 321	Vancouver - Calgary	9:00	12:00
Cdn 355	Calgary - Montreal	13:30	19:30
AC 123	Calgary - Toronto	12:30	16:30
AC 123	Toronto - Montreal	16:45	17:30



Data representation

When do I take my pills?

10 - 30% error rate in taking pills

Inderal	-	1 tablet 3 times a day
Lanoxin	-	1 tablet every a.m.
Carafate	-	1 tablet before meals and at bedtime
Zantac	-	1 tablet every 12 hours (twice a day)
Quinag	-	1 tablet 4 times a day
Couma	-	1 tablet a day

	Breakfast	Lunch	Dinner	Bedtime
Lanoxin	O			
Inderal	O	O	O	O
Quinag	O	O	O	O
Carafate	O	O	O	O
Zantac		O		O
Couma				O

Breakfast	Lunch	Dinner	Bedtime
Lanoxin			
Inderal		Inderal	Inderal
Quinag	Quinag	Quinag	Quinag
Carafate	Carafate	Carafate	Carafate
	Zantac		Zantac
			Couma

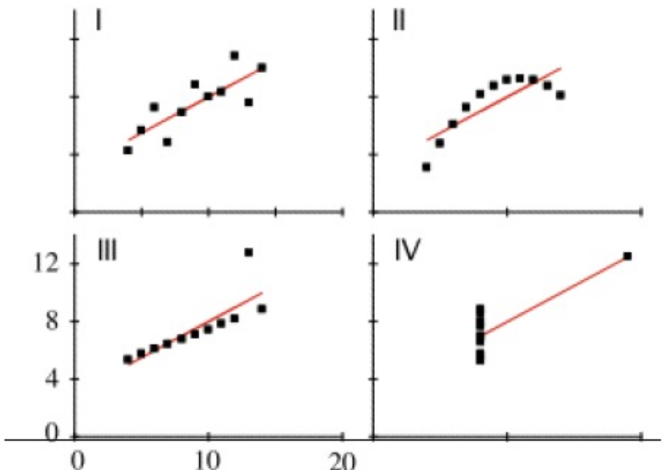
Adapted from Donald Norman

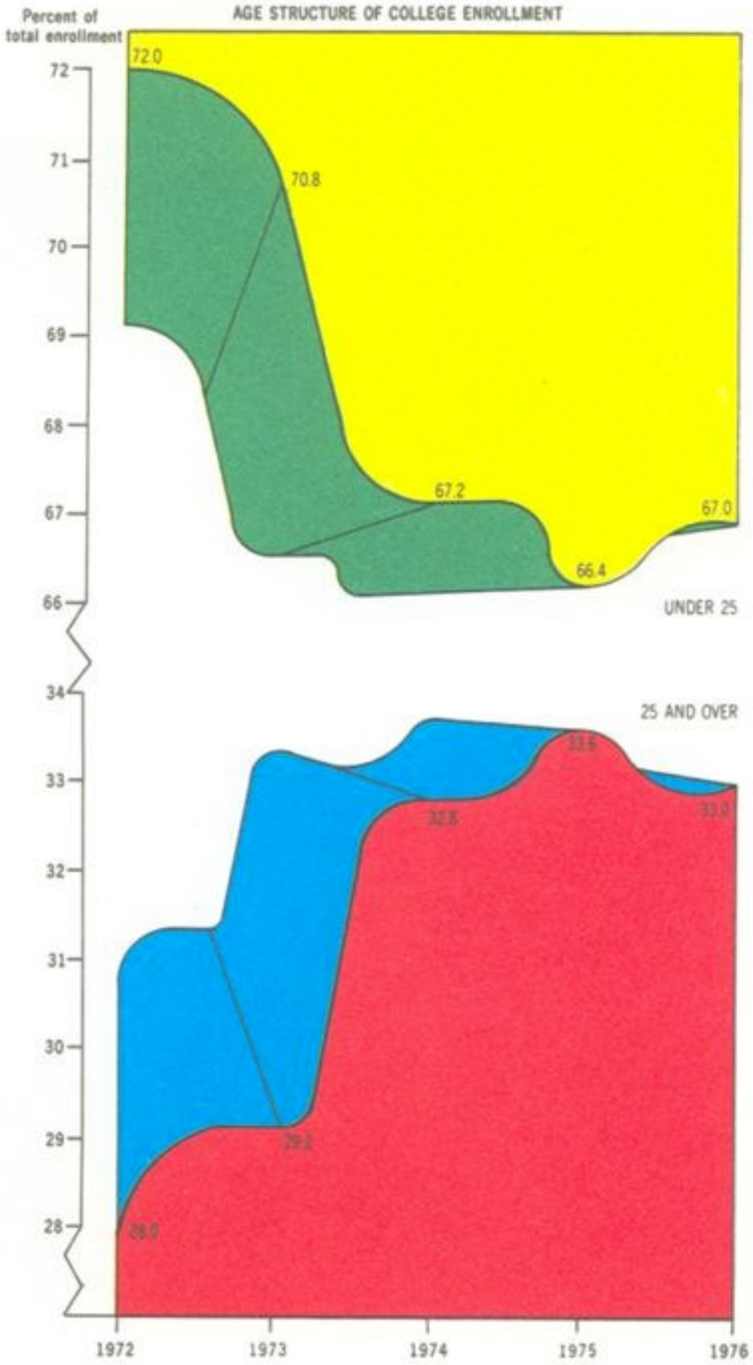
Principles of graphical communication

Edward Tufte: Visual Display of Quantitative Information

- Think: Revelation of the complex
- Show the data
- Suppress the media
- Enhance the information
- Avoid distortions
- Minimise space, time, ink
- Make large data-sets coherent
- Encourage comparisons
- Reveal multiple levels of detail
- Serve a clear purpose

I		II		III		IV	
x	y	x	y	x	y	x	y
10	8.04	10	9.14	10	7.46	8	6.58
8	6.95	8	8.14	8	6.77	8	5.76
13	7.58	13	8.74	13	12.74	8	7.71
9	8.81	9	8.77	9	7.11	8	8.84
11	8.33	11	9.26	11	7.81	8	8.47
14	9.96	14	8.10	14	8.84	8	7.04
6	7.24	6	6.13	6	6.08	8	5.25
4	4.26	4	3.10	4	5.39	19	12.50
12	10.84	12	9.13	12	8.15	8	5.56
7	4.82	7	7.26	7	6.42	8	7.91
5	5.68	5	4.74	5	5.73	8	6.89

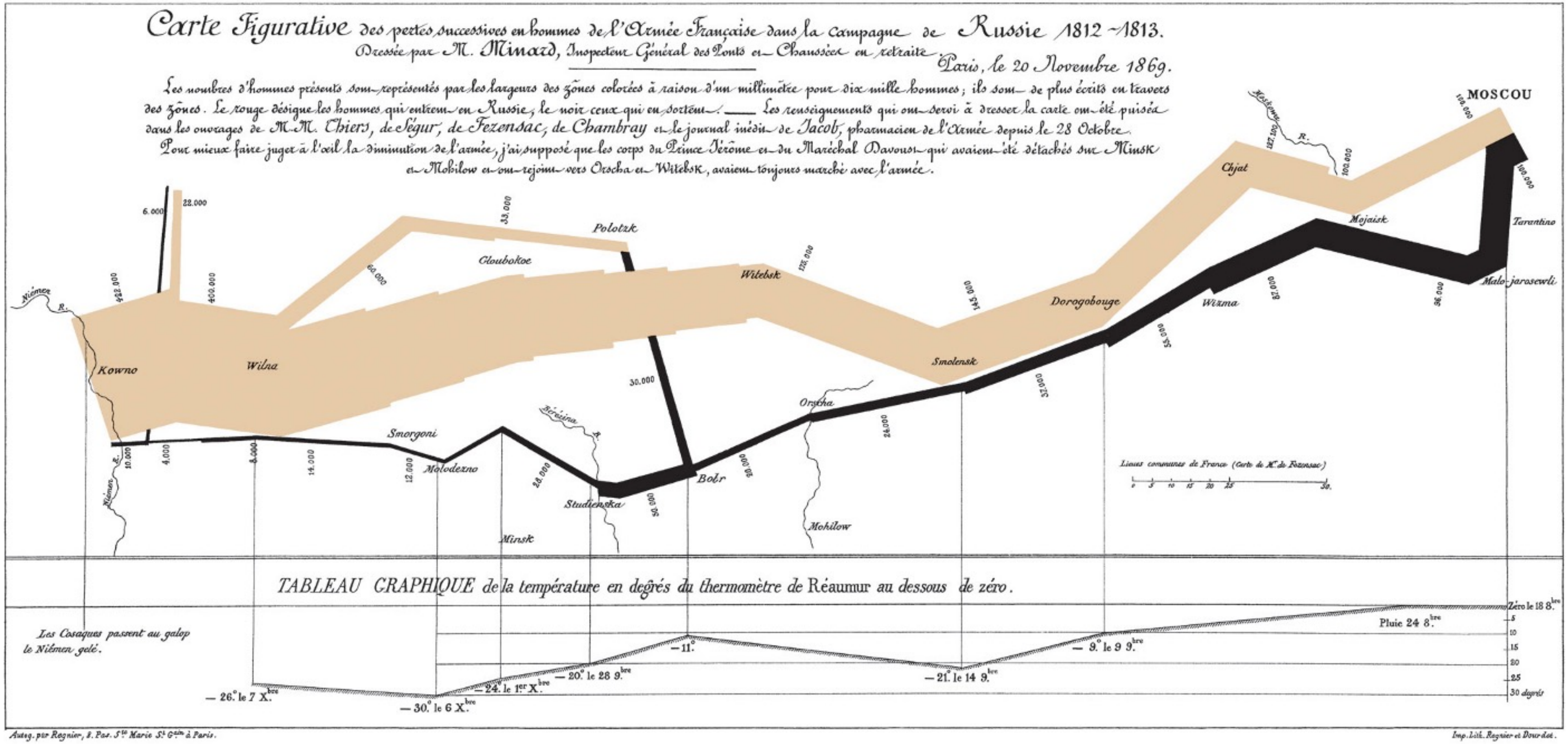




Age structure of college enrollment

Tufte: "this may well be the worst graphic ever to find its way into print"

American Education magazine, 1970s
Tufte (2001) The visual display of quantitative information, p. 118

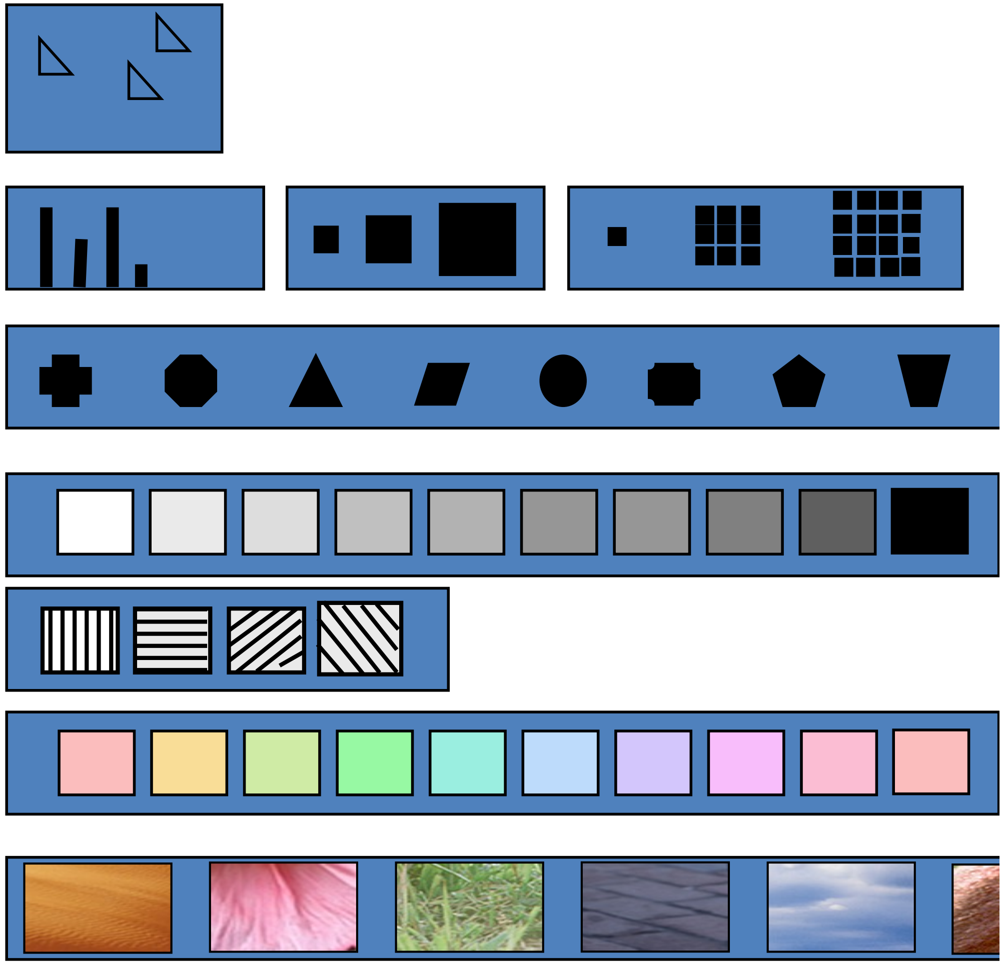


Carte Figurative des pertes successives en hommes de l'Armée Française dans la campagne de Russie 1812-1813.
Dressée par M. Minard, Inspecteur Général des Ponts et Chaussées en retraite.
Paris, le 20 Novembre 1869.
Les nombres d'hommes présents sont représentés par les largeurs des zônes colorées à raison d'un millimètre pour dix mille hommes; ils sont de plus écrits en travers des zônes. Le rouge désigne les hommes qui entrent en Russie, le noir ceux qui en sortent. — Les renseignements qui ont servi à dresser la carte ont été puisés dans les ouvrages de MM. Thiers, de Ségur, de Fezensac, de Chambray et le journal inédit de Jacob, pharmacien de l'Armée depuis le 28 Octobre.
Pour mieux faire juger à l'œil la diminution de l'armée, j'ai supposé que les corps du Prince Jérôme et du Maréchal Davoust qui avaient été détachés sur Minsk et Mobilow et ont rejoint vers Orscha et Witebsk, avaient toujours marché avec l'armée.
MOSCOU
Kowno
Wilna
Gloubokoe
Polotzk
Witebsk
Smolensk
Dorogobouge
Chjat
Mojaisk
Tarantino
Malo-jarosewli
Wizma
Orscha
Mohilow
Bobr
Studienska
Minsk
Smorgoni
Molodezno
TABLEAU GRAPHIQUE de la température en degrés du thermomètre de Réaumur au dessous de zéro.
Les Cosaques passent au galop le Niémen gelé.
— 26° le 7 X.bre
— 30° le 6 X.bre
— 24° le 1er X.bre
— 20° le 28 9.bre
— 11°
— 21° le 14 9.bre
— 9° le 9 9.bre
Pluie 24 8.bre
Zéro le 18 8.bre

Visual Variables – Attributes

Jacques Bertin via Sheelagh Carpendale

- **Position:** changes in the x, y (z) location
- **Size:** change in length, area or repetition
- **Shape:** infinite number of shapes
- **Value:** changes from light to dark
- **Orientation:** changes in alignment
- **Colour:** changes in hue at a given value
- **Texture:** variation in pattern
- **Motion**



Visual Variables – Characteristics

Jacques Bertin via Sheelagh Carpendale

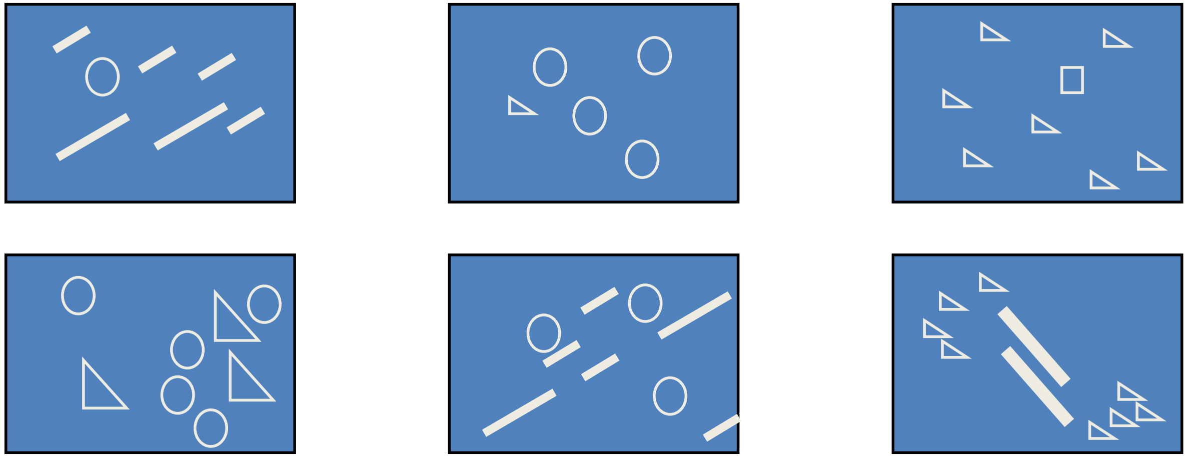
- Different variable attributes may be:
  - **Selective**: supports selection from a group
  - **Associative**: supports perception of groups
  - **Quantitative:** supports numerical extraction
  - **Order:** supports order interpretation
  - **Length:** how many changes are perceptible

Visual Variables – Shape Example

Jacques Bertin via Sheelagh Carpendale

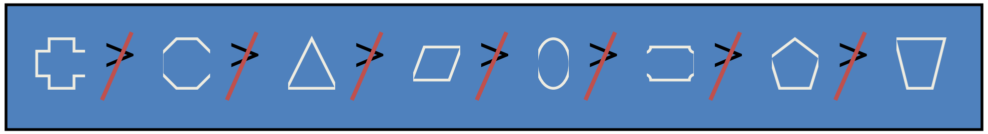
≈ selective

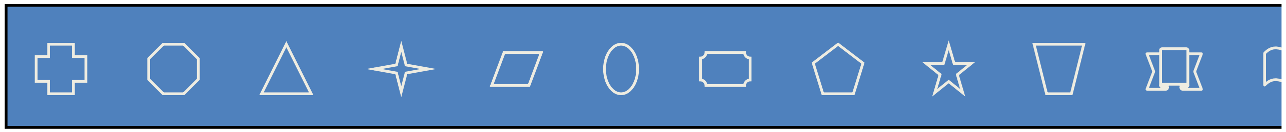
≈ associative



✘quantitative

✘ order

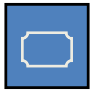


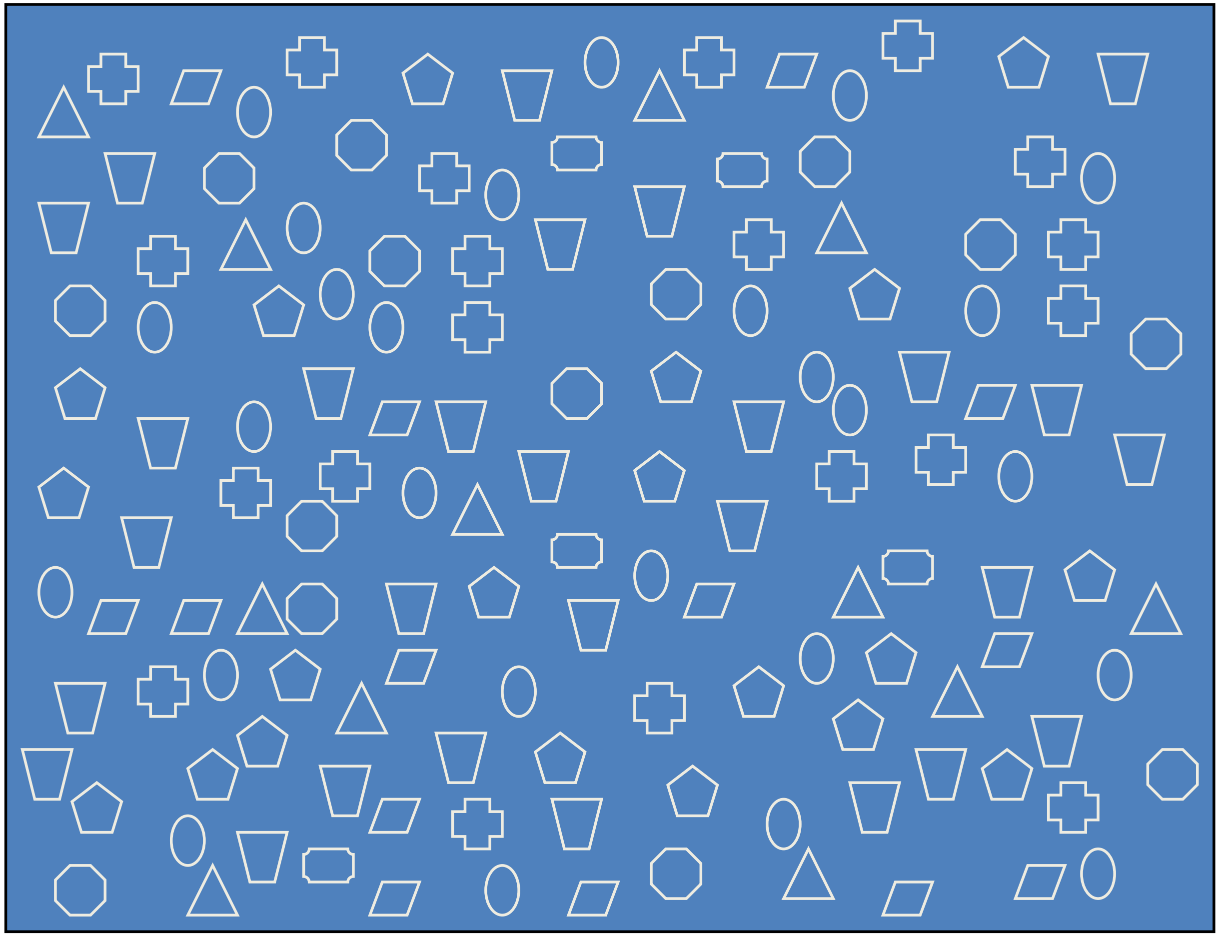


✓length – infinite variation

Visual Variables – Shape Selection Example

Jacques Bertin via Sheelagh Carpendale





Visual Variables

Jacques Bertin via Sheelagh Carpendale

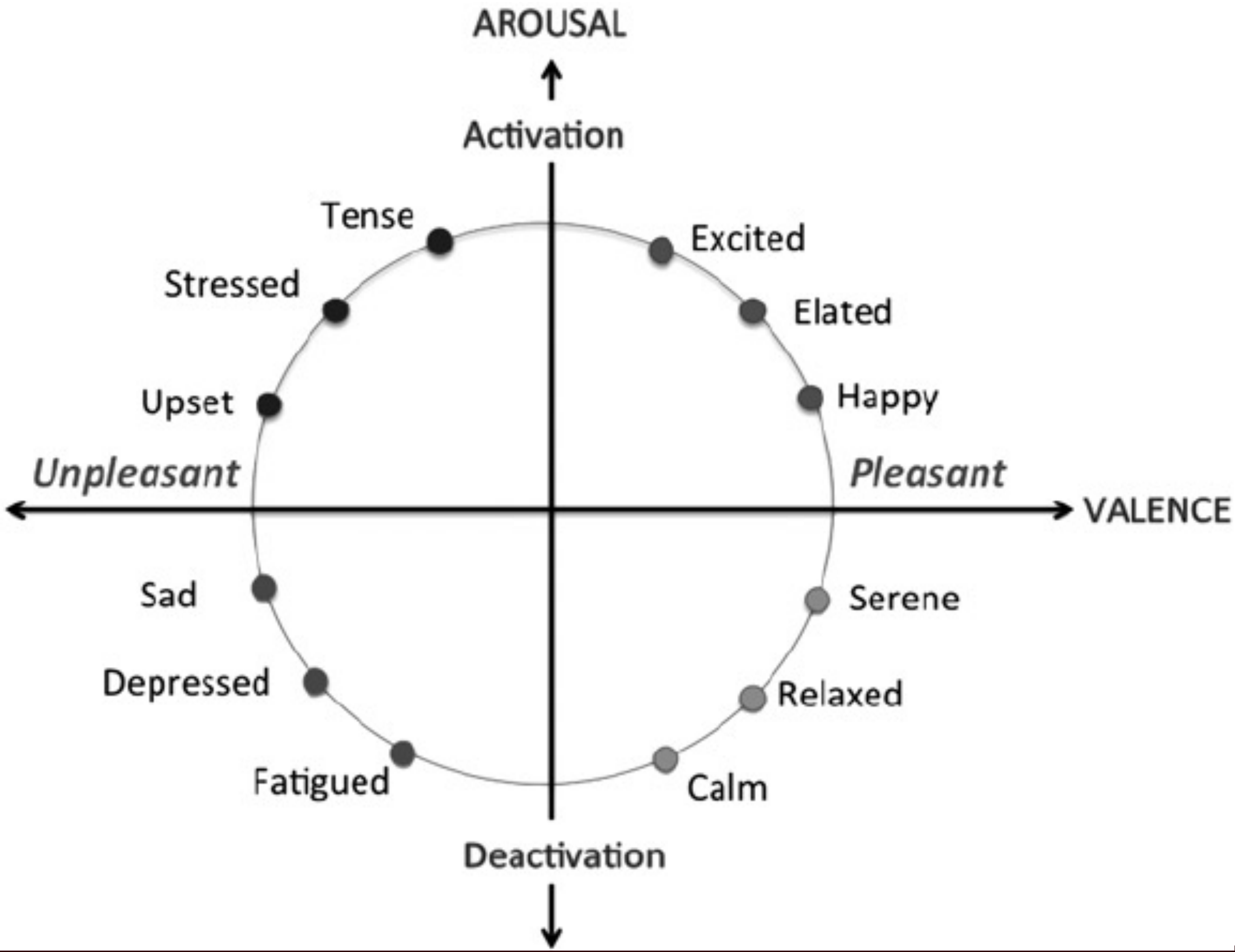
	Selective	Associative	Quantitative	Order	Length
Position	✓	✓	✓	✓	✓
Size	✓	✓	≈	✓	✓
Shape	≈	≈	✗	✗	✓
Value	✓	✓	✗	✓	✓
Orientation	✓	✓	✗	✗	✓
Colour	✓	✓	✗	✗	✓
Texture	✓	✓	✗	✗	✓
Motion	✓	✓	✗	✗	✓

Emotional Effects (briefly)

- Shape, colour, texture, and motion can be used for emotional effects

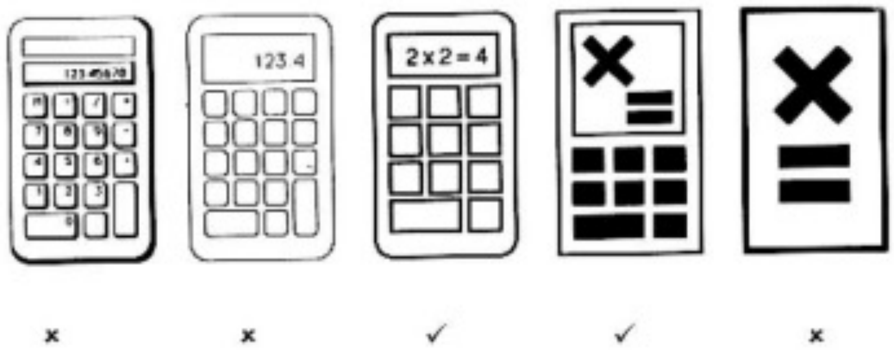
http://mrl.nyu.edu/~perlin/experiments/polly/track.html

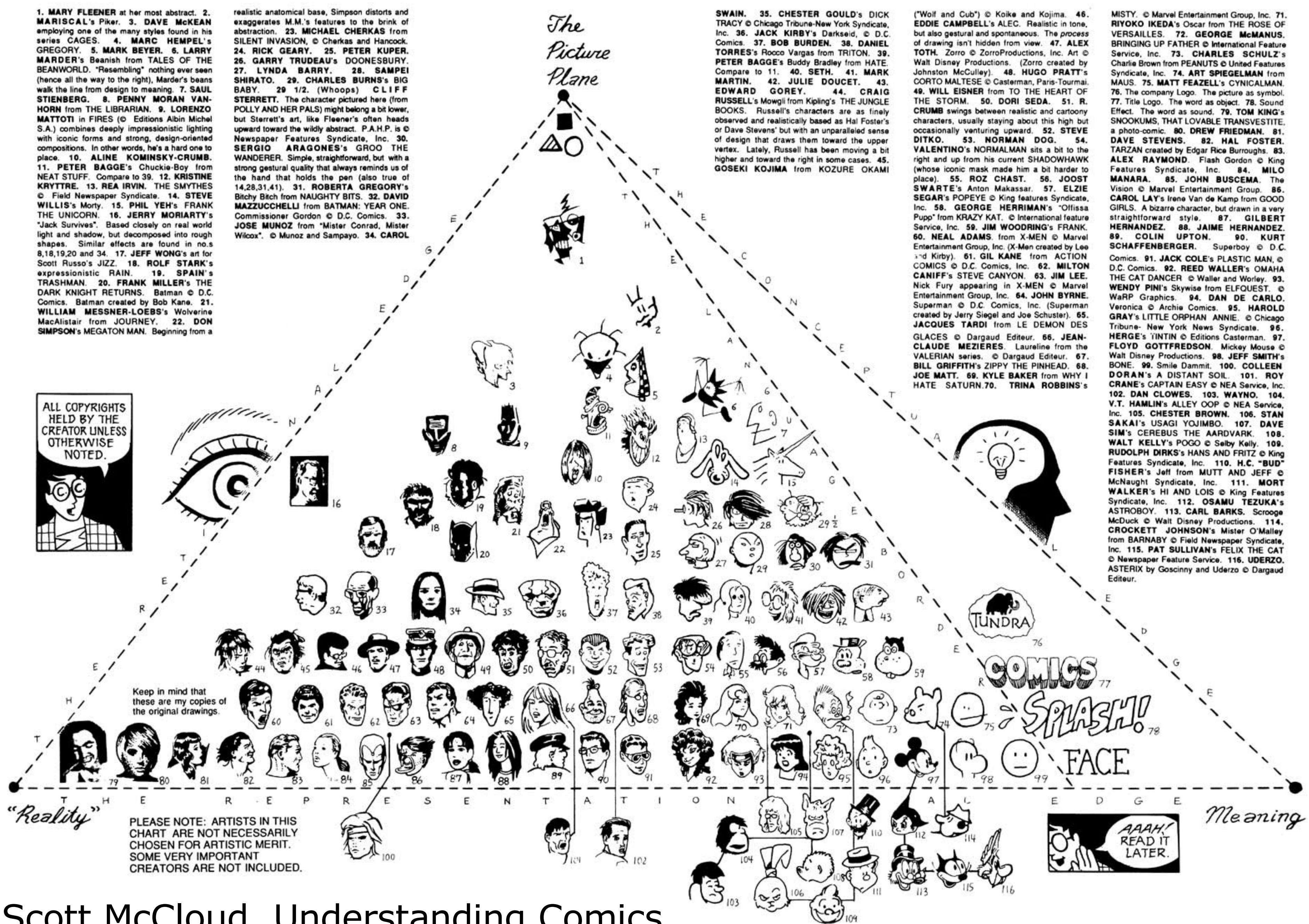
Aside
Emotion: Valence-Arousal Classification



Imagery (in two slides)

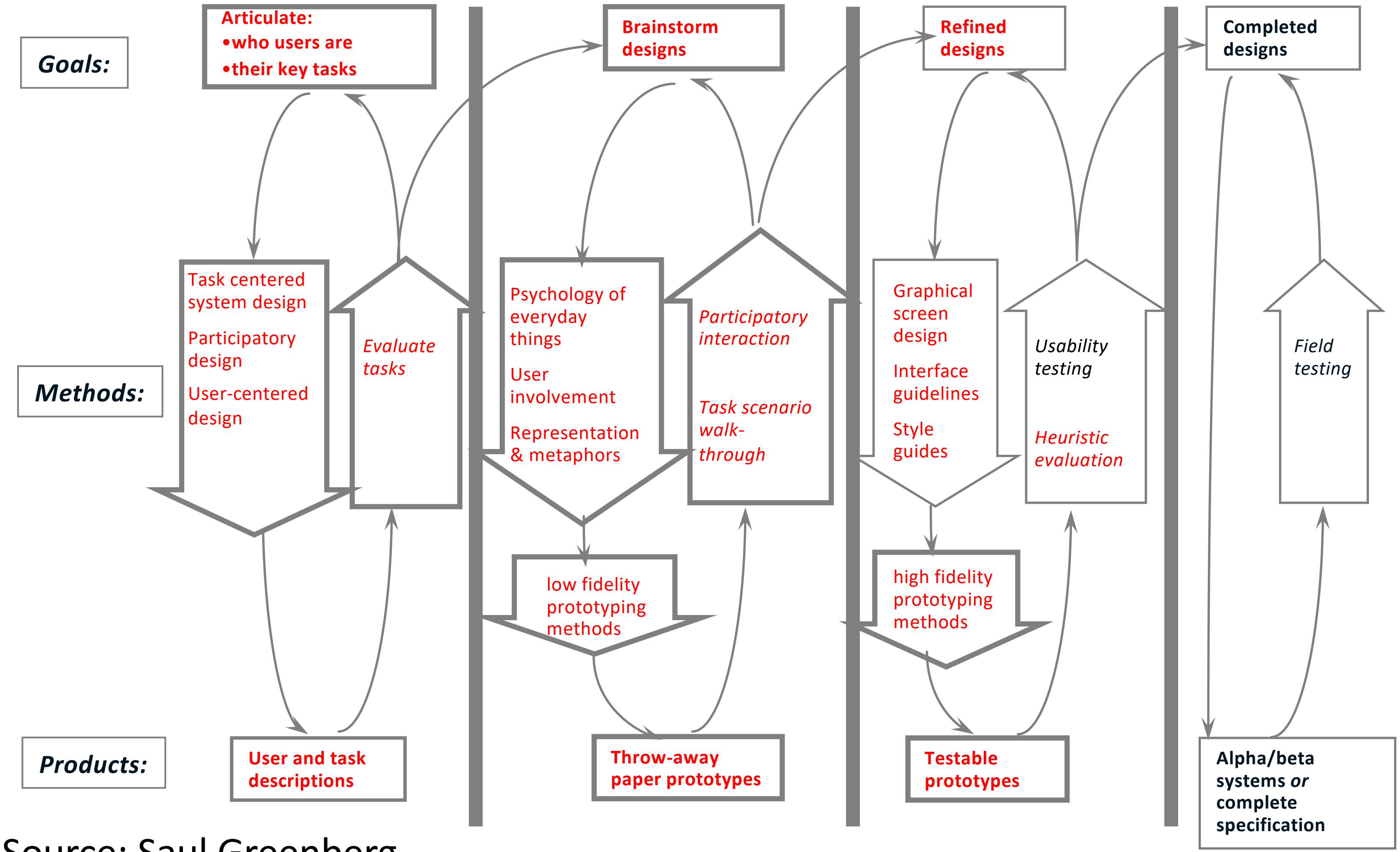
- Consider balance between concrete and abstract representation





Scott McCloud. Understanding Comics

Design Process

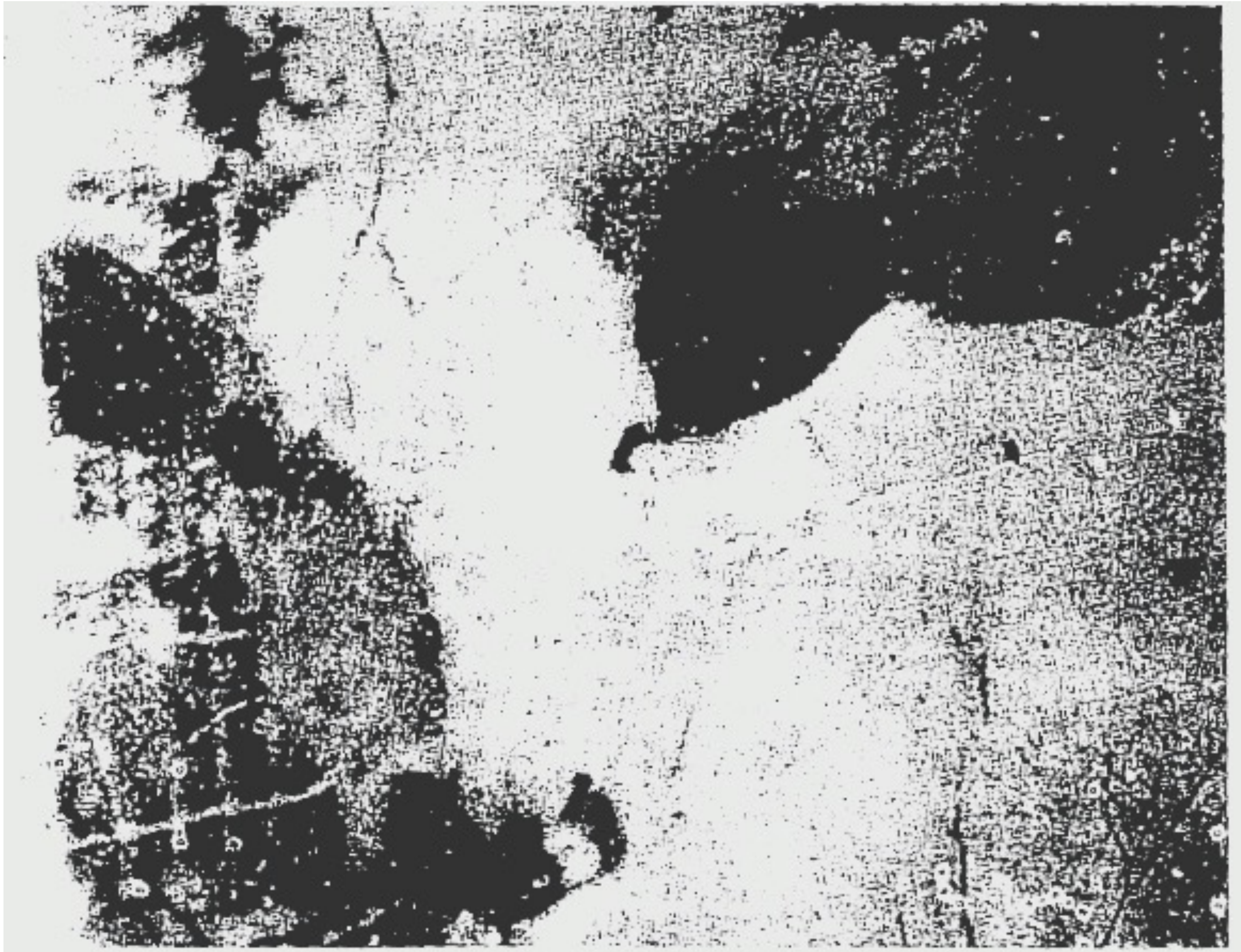


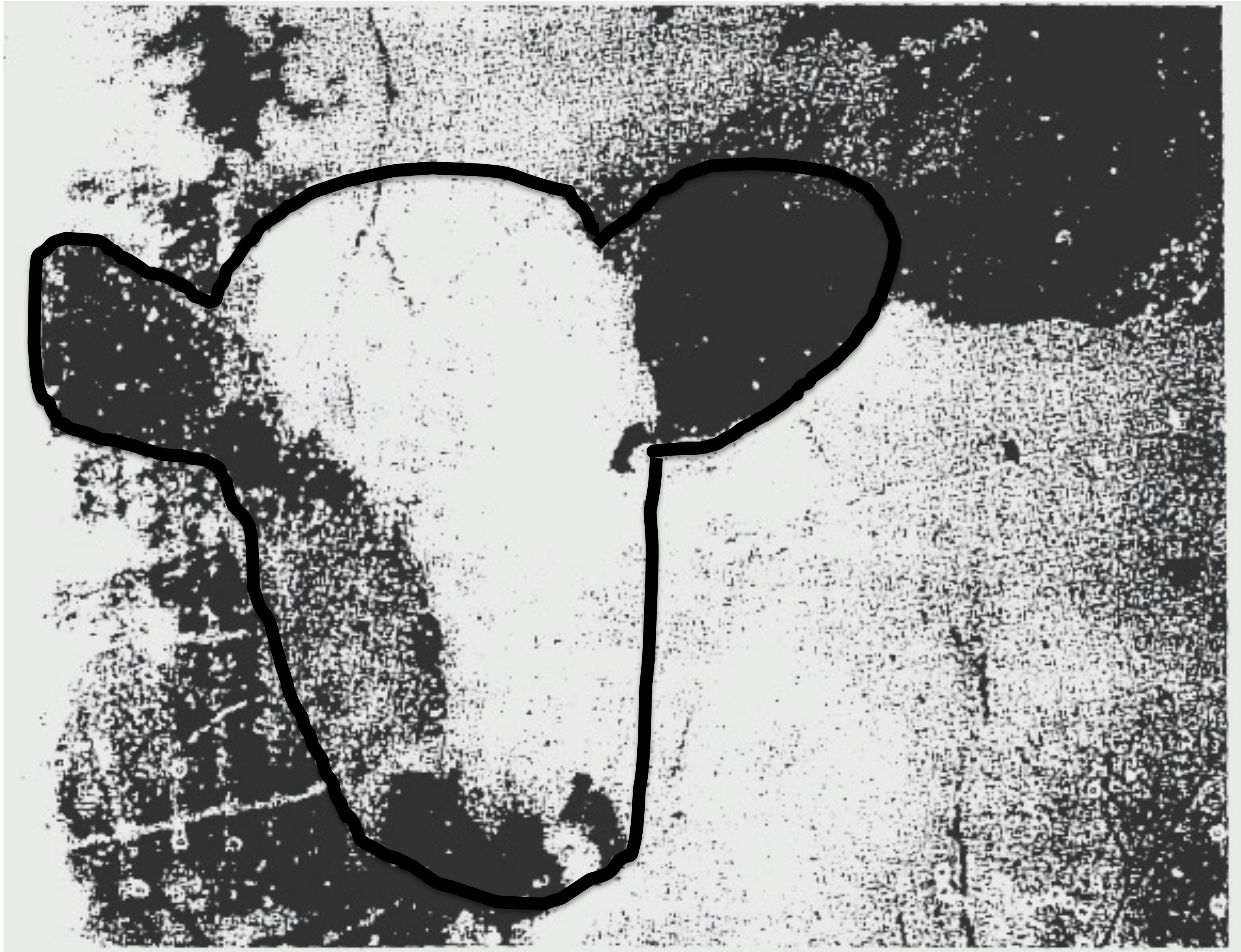
Source: Saul Greenberg

Evaluation

Evaluation

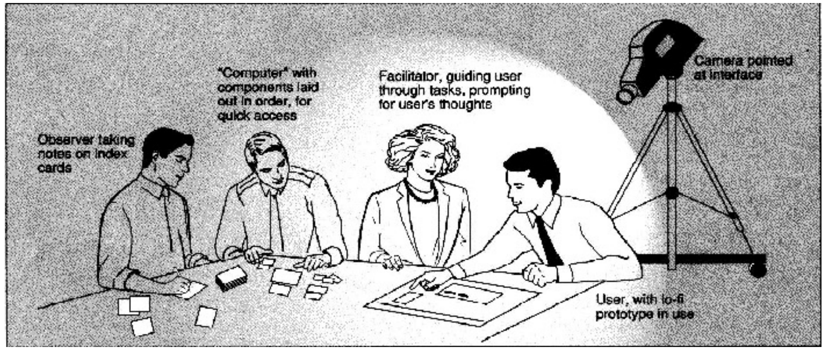
- Designers are blind to their designs
- They are uniquely unqualified to assess usability
- **Problem:** how to detect mismatch between user’s model and designer’s model?
- **Answer**: record realistic interaction
- Requires structure: simple observation is insufficient





“Think Aloud” Evaluation

- Subjects continually prompted to verbalise their thoughts
  - What they are trying to do
  - Why they took an action
  - How they interpret feedback



- One way communication from user (except prompts)
- Gives insights into user’s model
- *Hard* to talk and concentrate; awkward
- Often uncomfortable for subjects

Cooperative Evaluation

- Two subjects (sometimes one a confederate)
- Natural two-way communication
- More natural, more comfortable
- Criticism more likely
- Use Hawthorne effect to advantage

Interviews

- Good for probing particular issues
- Often leads to constructive suggestions
- Prone to post-hoc rationalisation

- Plan a central set of questions
  - Focuses the interview; base consistency
  - Be willing to follow interesting leads

Questionnaires

- Expensive to prepare; cheap to administer
- Doesn't require presence of evaluator
- Quantitative and qualitative
- Only as good as questions asked
  - Know the purpose!
  - Know how you will analyse results
  - Know dissemination method (web, surface mail, etc.)

Questionnaires: Question Types

- Open-ended comments: important insights
- Closed questions: restrict responses
  - Take care with ambiguity
- Ranked
  - Good for forcing comparison
- Likert items: level of agreement

It is easy to recover from mistakes:
Disagree ☐ ☐ ☐ ☐ ☐ Agree

Continuous Evaluation

- Monitoring actual system use
  - Field studies
  - Diary studies
  - Logging and ‘Customer Experience Programs’
  - User feedback and gripe lines

Crowd-Sourced Experiments

- Crowdworkers complete “Human Intelligence Tasks” (HITs) for payment
- Disseminated on the web
- Pay *at least* US minimum wage
- Problems with noisy data and criteria for exclusion
- Include “attention check” questions
- Workers have a HIT approval rating; used as filter
- Amazon Mechanical Turk: www.mturk.com

User performance data collection

- Key loggers, customer experience improvement programs, diary studies, etc.
- Exploratory: collect loads of data and hope something interesting shows up
- Difficult to analyze

- Targeted
  - Frequency of use (e.g., hotkeys, scrollwheel)
  - Characterise activities (e.g., scrolling patterns, web use)
- (Aside: in controlled experiments, log *everything*)

Formal Empirical Evaluation

- Controlled experiments (coming up)
- Strict statistically testable hypothesis: better, worse, no difference
- Measure participants' response to manipulation of experimental conditions
- Repeatable results through rigorous method
- Time-consuming, low-level UI issues, expensive

Ethics

- Testing can be distressing
  - Pressure to perform; errors inevitable
  - Feeling of inadequacy
  - Competition with other subjects

- Golden rule:
  - Subjects should be treated with respect!

https://www.youtube.com/watch?v=iktqSLt1Kes

Ethics – Before the test

- Don't waste the user's time
  - use pilot tests to debug experiments, questionnaires etc
  - have everything ready before the user shows up
- Make users feel comfortable
  - emphasize that it is the system that is being tested, not the user
  - acknowledge that the software may have problems
  - let users know they can stop at any time
- Maintain privacy
  - tell user that individual test results will be completely confidential
- Inform the user
  - explain any monitoring that is being used
  - answer all user's questions (but avoid bias)
- Only use volunteers
  - user must sign an informed consent form

Ethics – During the test

- Don’t waste the user’s time: no unnecessary tasks

- Make users comfortable
  - try to give user an early success experience
  - keep a relaxed atmosphere in the room
  - coffee, breaks, etc
  - hand out test tasks one at a time
  - never indicate displeasure with the user’s performance
  - avoid disruptions
  - stop the test if it becomes too unpleasant

- Maintain privacy
  - do not allow the user’s management to observe the test

Ethics – After the test

- Make the users feel comfortable
  - state that the user has helped you find areas of improvement
- Inform the user
  - answer particular questions about the experiment that could have biased the results
- Maintain privacy
  - never report results in a way that individual users can be identified
  - only show videotapes outside the research group with the user's permission

http://www.canterbury.ac.nz/humanethics/hec/apply.shtml

Controlled Experiments

Controlled experiments

- Characteristics
  - lucid and testable hypothesis
  - quantitative measurement
  - measure of confidence in results (statistics)
  - replicability of experiment
  - control of variables and conditions
  - removal of experimenter bias

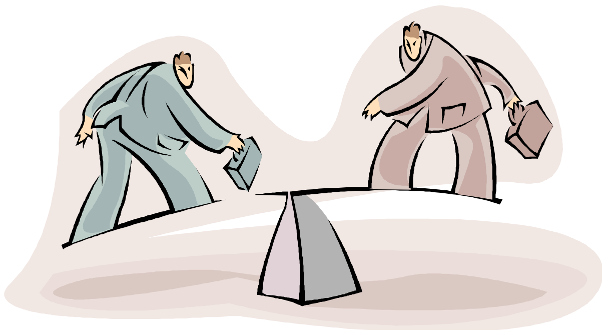
Research Question/Hypothesis

Having invented *gizmo*

- ~~Lets do a user study of *gizmo*!~~
- Is *gizmo* any good?
- Does *gizmo* beat the competition?
- Is *gizmo* faster than the competition?
- Is *gizmo* faster than *de facto* after 10 mins use?
- Is *gizmo* faster and less error prone than *de facto* after 10 mins use?

Research Question Tradeoff: Internal versus External Validity

- External validity: findings are broad/real
  "Is *gizmo* any good?"
- Internal validity: findings are due to conditions
  "Is *gizmo* faster and less error prone than *de facto* after 10 mins use?"



- Tradeoff
- Often addressed with multiple experiments

Research Question

- In HCI, most experimental research questions are comparative
  - Faster, more accurate, preferred (etc.) to baseline(s)
  - Is there a difference?
  - How big (and is this practical)?
  - How likely is it due to chance (statistics)?

Research Question (cont.)

- Hypothesis is lucid and testable
- Normally expressed in negative ("null hypothesis")
  - "no difference" between …
  - Scientists are conservative
- Statistics may lead to rejection of null hypothesis (when $P(D|H_0)$ is low)

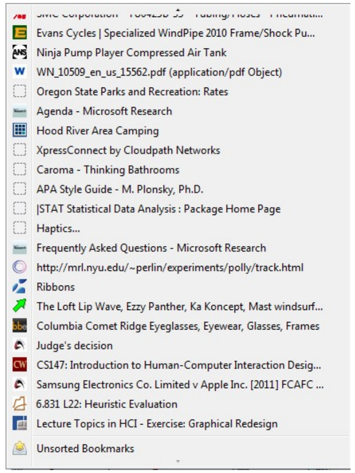
Research Question (cont.)

“There is no difference in user performance (time and error rate) when selecting a single item from a pull-down or pop-up menu”

“There is no difference in user performance (time and error rate) when selecting a single item from a pop-up or a pull down menu of 4 items, regardless of the subject’s previous expertise in using a mouse or using the different menu types”

Research Question (cont.)
Cause of comparative difference?

- A vs B comparisons can be good

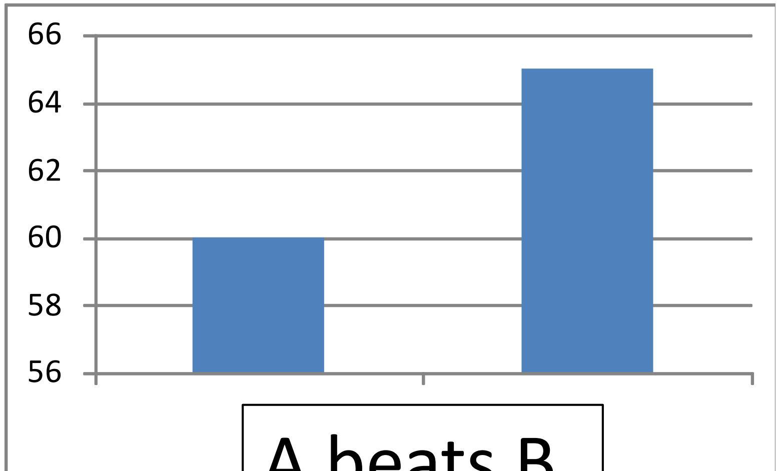


- But how to generalise?
- Know the human factor(s) underlying A/B
- Rephrase the experiment as: HF_A vs HF_B

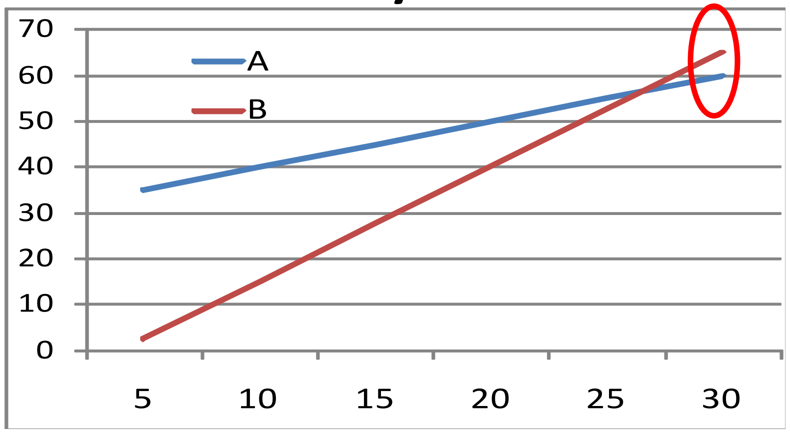
Research Question (cont.)

Point analysis versus depth/theory/model

- A beats B or HF_A beats HF_B… nice
- Generally true, or just the tested condition?
- Identify & include salient secondary factors



A beats B



Oops. Only if n > 25

Experimental Terminology

- Independent variable
- Dependent variable
- Within versus between subjects
- Counterbalancing

Independent variables

- Controlled conditions
- Manipulated independent of behaviour
- May arise from participant classification
  e.g., males/females; gamers/non-gamers
- Discrete values are independent variable *levels*
  e.g., *Friction type* $\in$ *{high, low, variable}*
- 'Independent variable' ≡ 'Factor' with ANOVA

Dependent variables

- Measured
- Values depend on participant's response to manipulation of the independent variable(s)
- Task time, error rate, speed, accuracy, overshoots, etc...

Within Subjects, Between Subjects

- Each independent variable is administered either within subjects or between subjects
- Within subjects: each participant tested on all levels

Friction type	High	Low	Variable
	S1-16	S1-16	S1-16

- Between subjects: each participants tested on one level

Friction type	High	Low	Variable
	S1-16	S17-32	S33-48

Within Subjects, Between Subjects

- Mixing within and between subjects treatment within one factor is flawed (usually)

Friction type	Hig	Low	Variable
	S1	6	S17-32

- (Mixing within subjects factors with between subjects factors is fine... multi-factor analysis, beyond 368)

Within Subjects or Between Subjects?

Within subjects:

+ Participants act as their own control
+ Fewer participants
- Need control for learning/fatigue effects

Within Subjects or Between Subjects?

Between subjects:

- Sometimes necessary (e.g., male/female)

+ No learning/fatigue effect

- Unmoderated variability

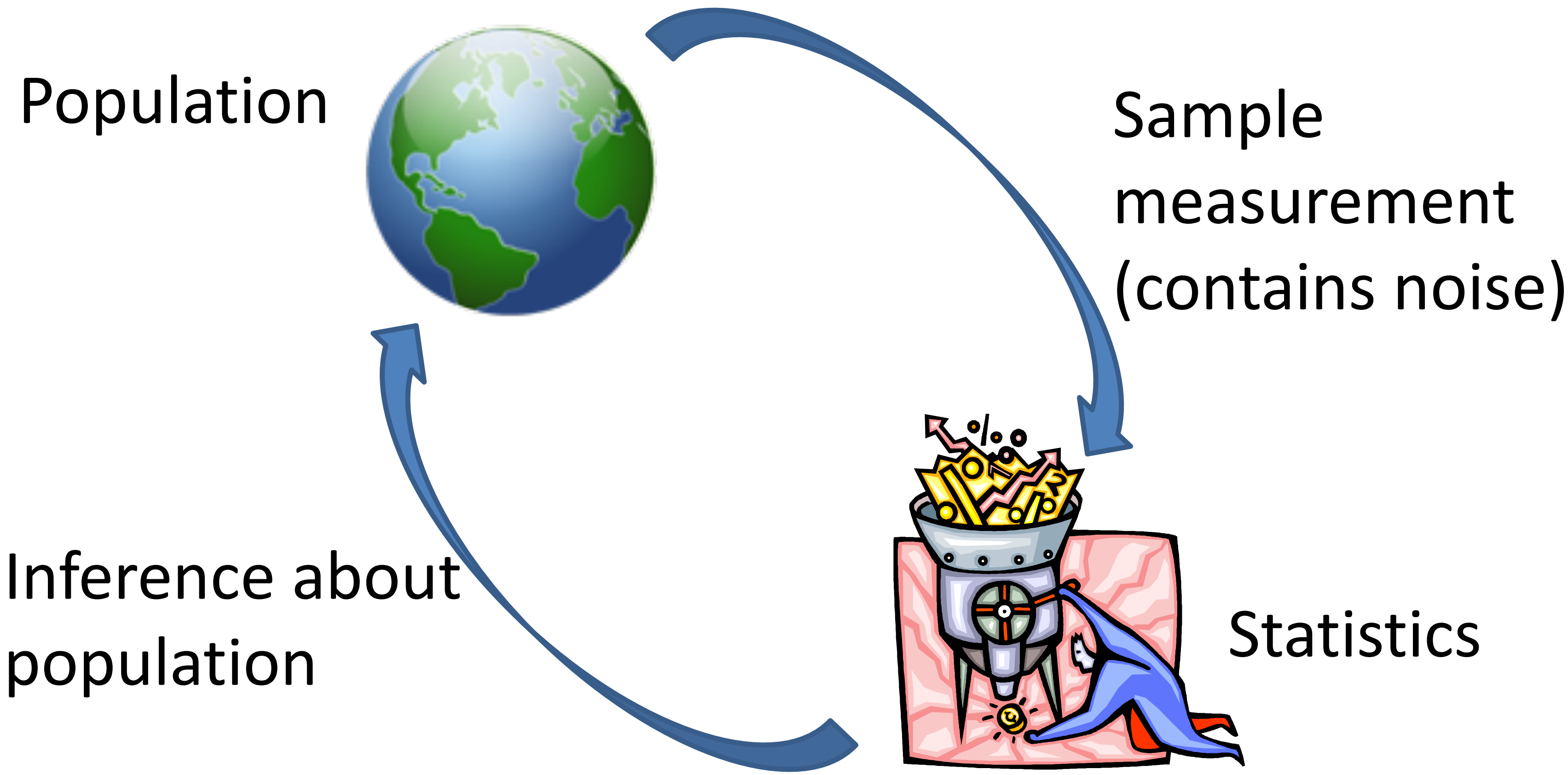
- More participants

Counterbalancing

- Within-subjects factors need control for learning/fatigue effects
- Participants divided into groups
- Different order for each group
- Group becomes a between subjects factor
  (ideally checked for asymmetric skill transfer[1], but often ignored)

[1] Poulton, E. C., & Freeman, P. R. (1966).

Statistics give confidence in answers



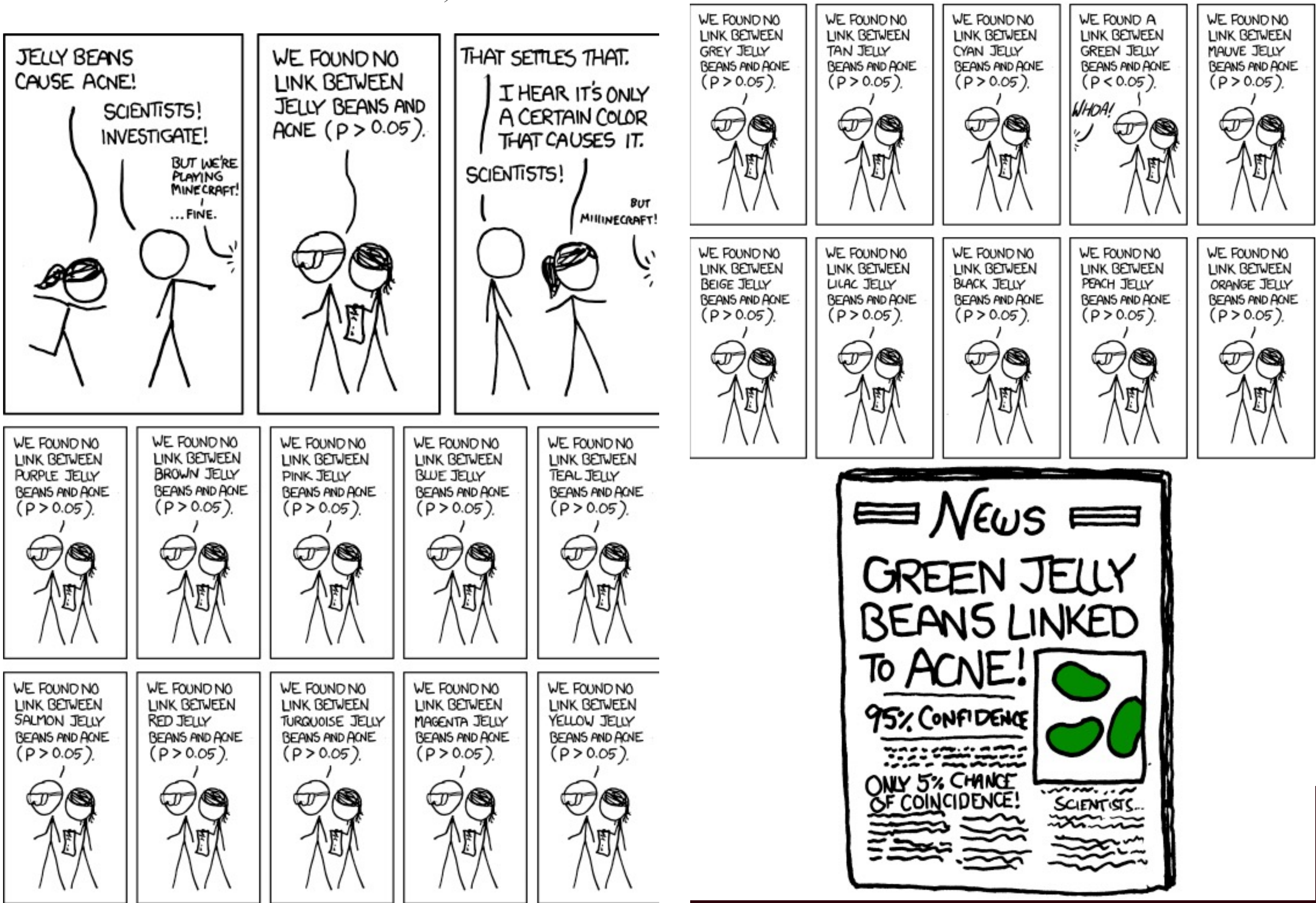
Comparative experiments (most)

- Null Hypothesis Significance Testing (NHST): widely used set of techniques for dichotomous testing
- Test the null hypothesis (H_0) of no difference H_0: $\mu_1 = \mu_2$
- Reject H_0 when $p < \alpha$ (α is normally .05)
  - *p:* Assuming the null hypothesis is true, how likely (*p*) is it that we'd observe data at least as extreme as our sample?
  - $P(D|H_0) < .05$
- Failure to reject does not mean "they are the same"
  - Perhaps they are the same
  - OR your experiment wasn't good enough
- So, reject or <u>fail to reject</u> (*not* reject or accept)

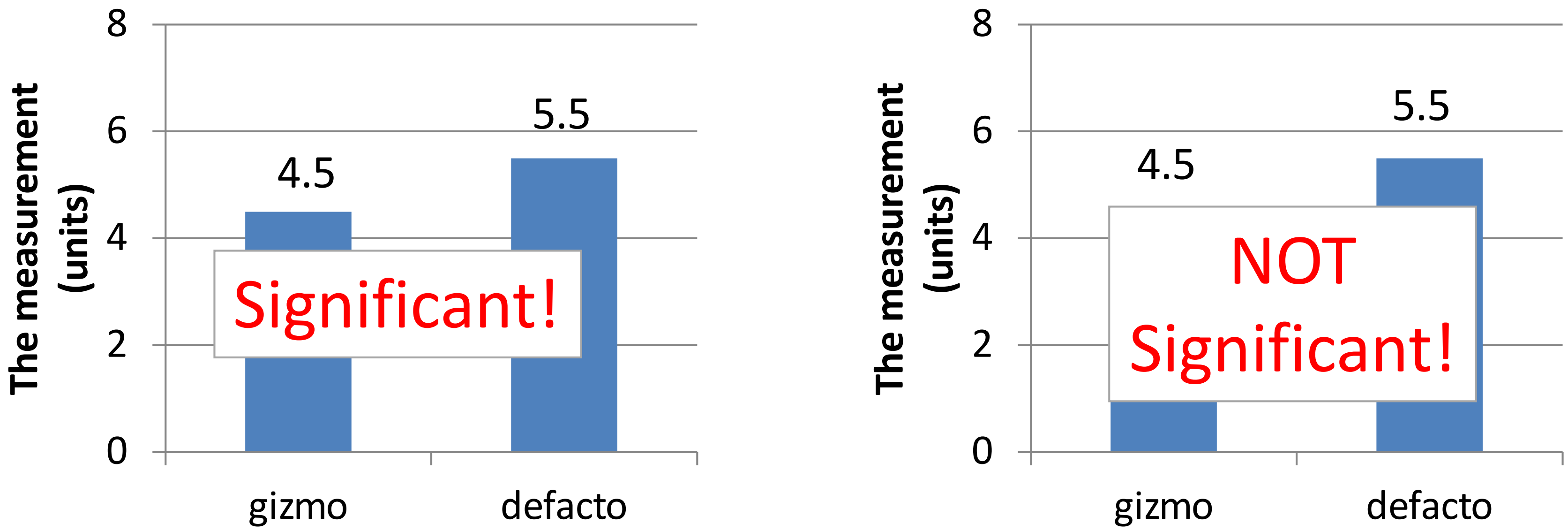
(Aside… The 'file drawer' effect)

- 'Unsuccessful' experiments, which fail to reject the null hypothesis, tend to go unpublished
- They go into 'the file drawer'
- But statistics are about chance; .05 means 1 in 20 chance of erroneously claiming a difference
- E.g., 19 studies correctly claiming "no significant effect" go in the file drawer; 1 incorrectly claiming a "significant effect" gets famous

(http://xkcd.com/1478/, Randall Munroe, Creative Commons Attribution-NonCommercial 2.5 License)



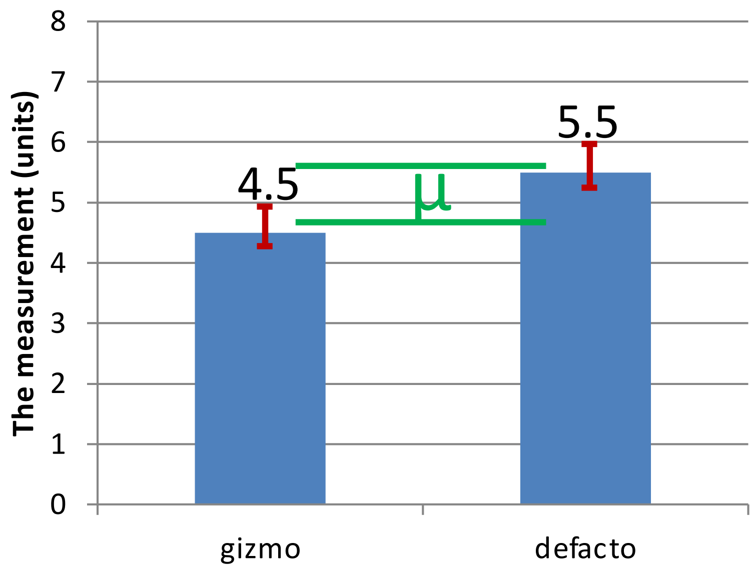
e.g., Gizmo versus de facto



Statistics: Signal to Noise analogy

- Signal: magnitude of the difference
- Noise: random variation

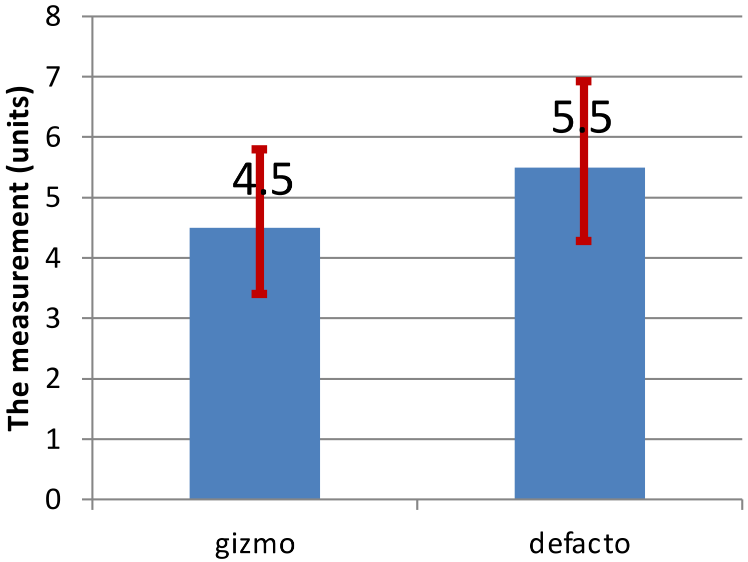
$$\frac{\hat{\mu}}{\hat{\sigma}/\sqrt{n}}$$



Significant!

Statistics: Signal to Noise analogy

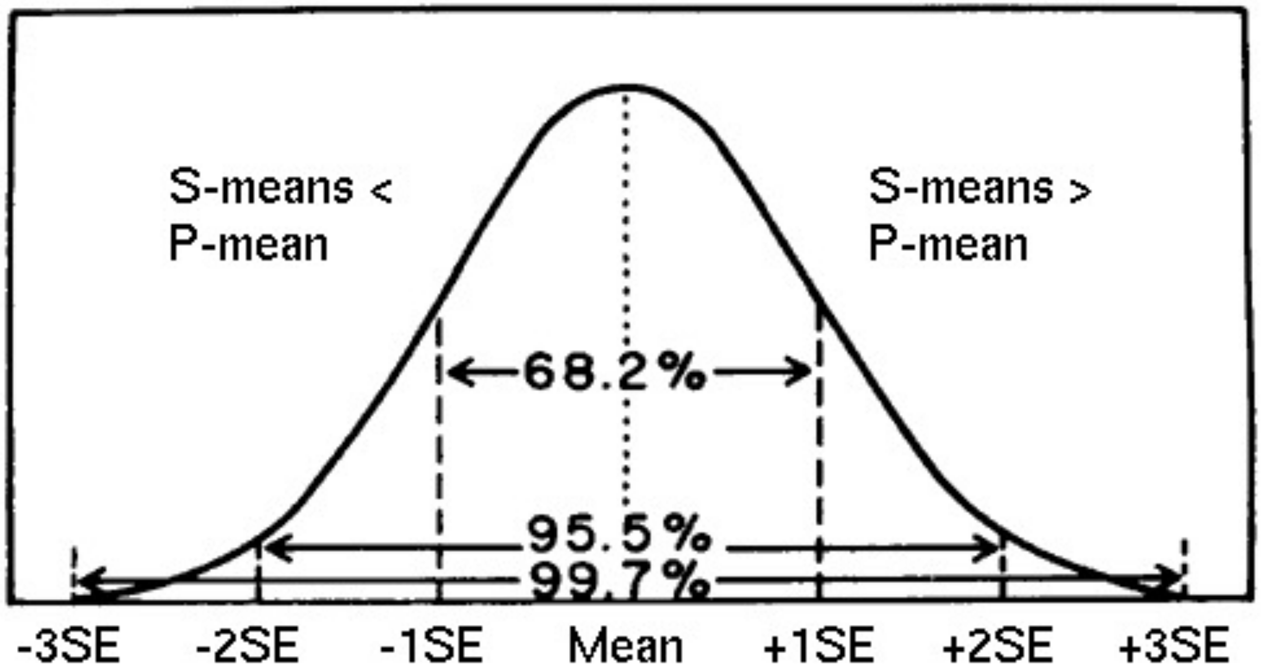
- Signal: magnitude of the difference
- Noise: random variation



NOT Significant!

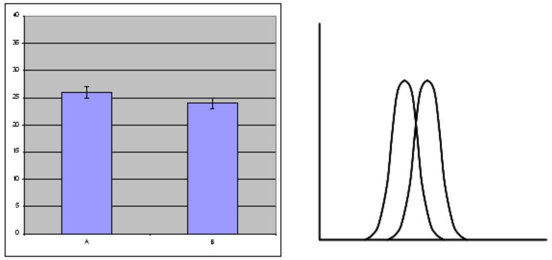
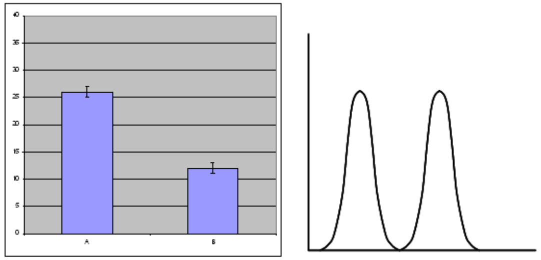
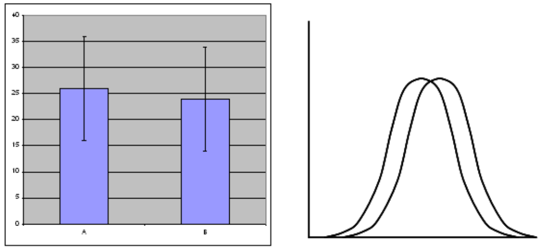
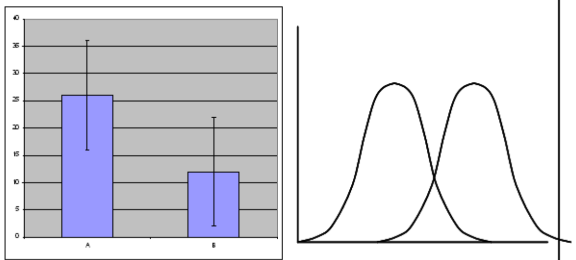
$$\frac{\hat{\mu}}{\hat{\sigma}/\sqrt{n}}$$

Parametric Statistics



$$\frac{\hat{\mu}}{\hat{\sigma}/\sqrt{n}}$$

Parametric Statistics

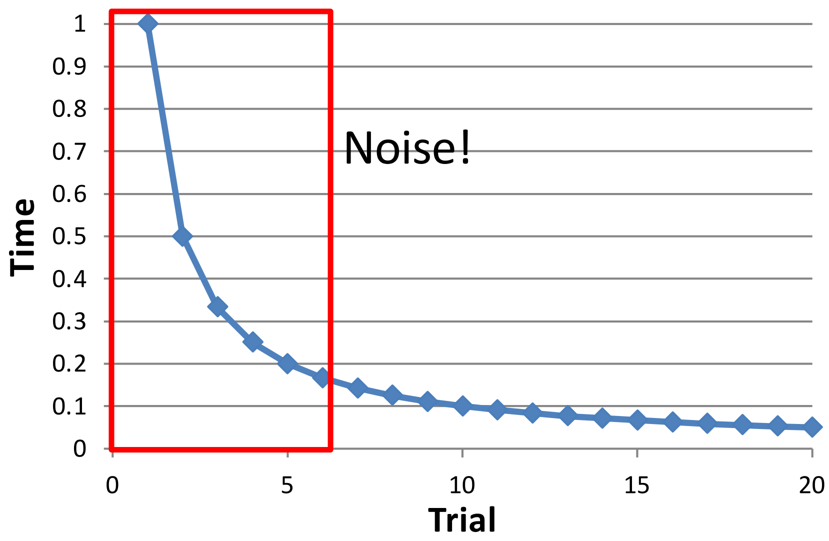
		Signal: Small	Signal: Large
Noise	Small	 e.g. mean max flight speeds of 747s and A380s	 e.g. mean max flight speeds of 747s and Cessnas
	Large	 e.g. mean max speeds of all cars and motorbikes	 e.g. mean max speeds of all cars and bicycles

$$\frac{\hat{\mu}}{\hat{\sigma}/\sqrt{n}}$$

Reducing the denominator

$$\frac{\hat{\mu}}{\hat{\sigma}/\sqrt{n}}$$

- Reduce σ
  - Better training
  - Outlier removal
  - Log transformation
- Increase n
  - Easy, but diminishing returns



Power law of practice

Type I and Type II Errors

		In Reality	
We Conclude		H_0 true (No difference)	H_0 false (Different)
	Reject H_0	Type I error False positive Falsely claim a difference Protected via confidence (α)	Correct decision True positive
	Do not reject H_0	Correct decision True negative	Type II error False negative Fail to identify difference Protected via power ($1-\beta$)

Can use confidence level (α) to change probability of Type I and II errors

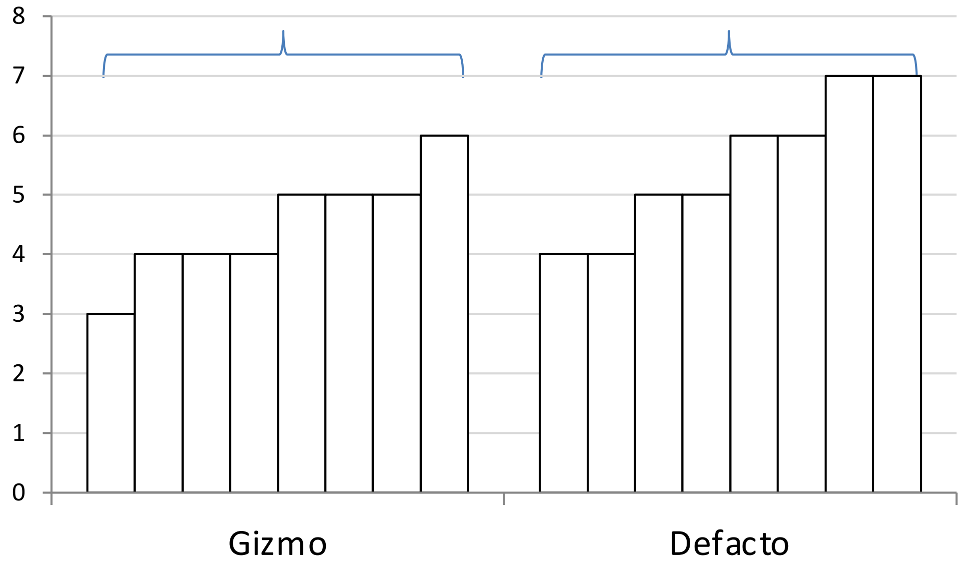
R

- https://www.r-project.org/
- Free, GNU general public license
- Trusted
- Advanced; entire language
- Lots of packages
- Great graphics facilities

- Good books: e.g., “R in Action” by Kabacoff
- Lots of online tutorials and resources (use them!)

For example:
Gizmo versus de facto

Mean 4.5 Mean 5.5




```
> more ttest-data.txt
gizmo    defacto
3        4
4        4
4        5
4        5
5        6
5        6
5        7
6        7
```

8 data points for each condition

T-Tests

- Are two samples from different populations?
- Paired T-Test (≡within subjects)
  - E.g., participants 1-8 use Gizmo *and* de facto
  - Each participant's data is paired
- Unpaired T-Test (≡between subjects)
  - E.g., participants 1-8 use Gizmo, and 9-16 de facto
  - Independent samples

Unpaired T-test: R

T-ratio (signal to noise)
Absolute value: bigger is better

Degrees of freedom (scale of the experiment)

Likelihood of observing this data
(or more extreme) if the null H were true.
Only reject null hypothesis if $p < .05$

```
> more ttest-eg-unpaired.R
#!/usr/bin/env Rscript

data <- read.table("ttest-data.txt", header=TRUE)
t.test(data$gizmo, data$defacto)

> ./ttest-eg-unpaired.R

        Welch Two Sample t-test

data:  gizmo and defacto
t = -1.8708, df = 13.176, p-value = 0.08374
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -2.1531955  0.1531955
sample estimates:
mean of x mean of y
      4.5       5.5
```

"…. no significant difference between mean task time with Gizmo (4.5 s, sd 0.9) and de facto (5.5 s, sd 1.2): $T_{13.2} = 1.87$, $p = .08$."

Paired T-test: R

```
> more ttest-eg-paired.R
#!/usr/bin/env Rscript

data <- read.table("ttest-data.txt", header=TRUE)
t.test(data$gizmo, data$defacto, paired=TRUE)

> ./ttest-eg-paired.R


        Paired t-test

data:  data$gizmo and data$defacto
t = -5.2915, df = 7, p-value = 0.001134
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -1.446872 -0.553128
sample estimates:
mean of the differences
                     -1
```

T-ratio

Degrees of freedom
#Pairs -1

"…. significant difference between mean task time with Gizmo (4.5 s, sd 0.9) and de facto (5.5 s, sd 1.2): $T_7 = 5.29$, p =.001."

Why significant only when paired?

```
> more ttest-data.txt
gizmo    defacto
3        4
4        4
4        5
4        5
5        6
5        6
5        7
6        7
```

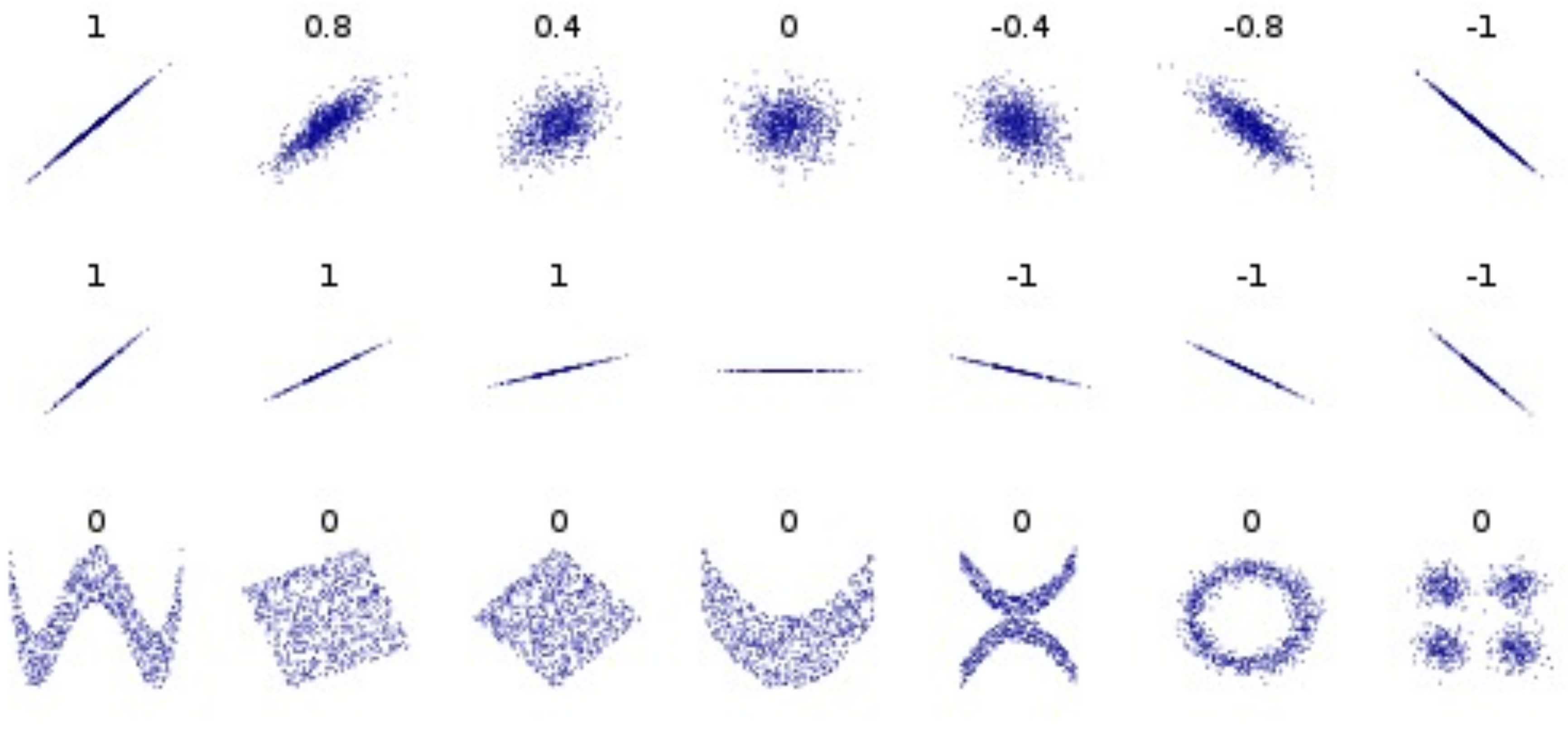
- Lots of extra information through pairing
- Col 1 (Gizmo) < Col 2 (de facto) for all but one

- Within subjects designs: participants act as their own control
- Increases experimental sensitivity

Correlation: Relating datasets

- Strength of relationship between variables
  e.g., typing and menu selection speeds
- Various models possible: linear, power, exponential, logistic…
  - Always, eyeball the data for conformance with the model
- For linear correlation, Pearson's r:
  - Correlation coefficient -1 to 1
  - Both variables are continuous
  - Cohen: 0.1 – 0.3 'small', 0.3 – 0.5 'med'; 0.5 – 1.0 'large'
- Spearman's *rho* for ranked data
- Correlation is *not* causation

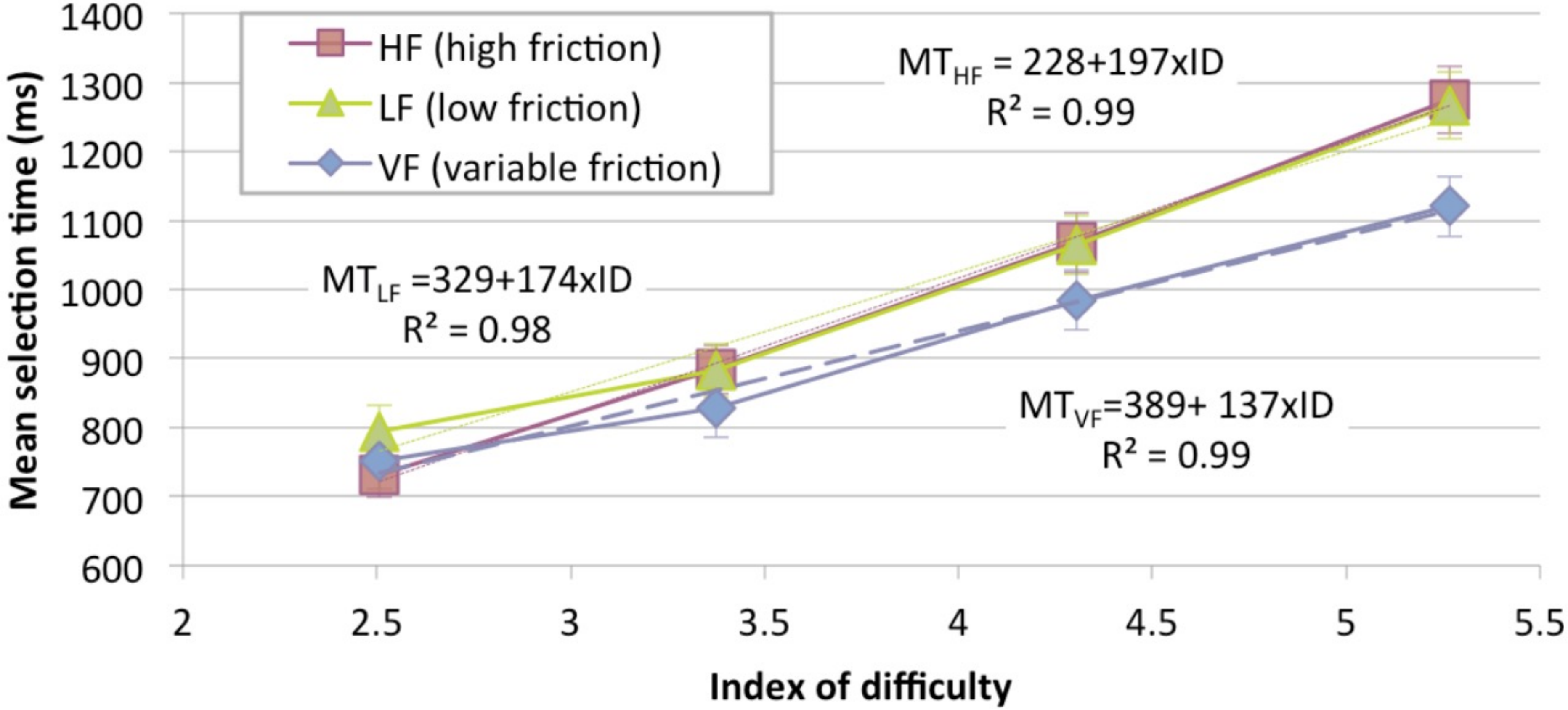
Correlation: Relating datasets



Regression: Relating datasets

- Predicting one value from another
  e.g., calculating pointing time from target distance/width
- Line of best fit
- R^2:
  - Coefficient of determination: 0 to 1
  - Proportion of the variability explained by the model
  - > 0.8 is good for human performance
- Fitts' Law: expect $R^2 > 0.95$
- Easy with Excel's 'Add Trendline'

Regression: Relating datasets



Analysis of Variance (ANOVA) Main statistical workhorse

- Independent variable with more than two levels
  e.g., *Friction type* $\in$ *{high, low, variable}*
- Compare all pairs with T-Tests?
  - # comparisons for *n* levels = $(n^2-n)/2$
  - Increased likelihood of finding a difference by chance (Type 1 error)
- ANOVA: are all conditions from the same population? $H_0: \mu_1=\mu_2=\ldots=\mu_n$

Analysis of Variance (ANOVA)

- Independent variables now called 'factors'
  - One factor $\rightarrow$ 'one way ANOVA'
  - More than one... (COSC411)
  - Each factor *either* within *or* between subjects

Within ✓

Friction type	Low	High	Variable
	S1-15	S1-15	S1-15

Between ✓

Friction type	Low	High	Variable
	S1-15	S16-30	S31-45

Messed up ✗

Friction type	Low	High	Variable
	S1-15	S16-30	S16-30

Analysis of Variance (ANOVA) e.g., one way within subjects

- Data file:
  - One datum per line (usually a trial)
  - At least one trial for every participant in every cell
  - Several trials are fine (replicated trials; averaged)
  - First column: participant identifier
  - Second column: level of the factor
  - Third column: dependent measure

Analysis of Variance (ANOVA) e.g., one way within subjects

```
>  cat oneway-within.txt
sub int time
S1 HF  0.456
S1 LF  1.224
S1 VF  0.775
S1 VF  0.655
S2 VF  1.445
S2 VF  1.224
S2 LF  0.788
S2 HF  1.334
S3 HF  0.443
S3 LF  0.786
...
```

Analysis of Variance (ANOVA)
e.g., one way within subjects with R

```
$ more oneway-within.R
#!/usr/bin/env Rscript

library(ez)
wdata <- read.table("oneway-within.txt", header=TRUE)
ezANOVA(data=wdata, dv=time, within=int, wid=sub)
ezStats(data=wdata, dv=time, within=int, wid=sub)

$ ./oneway-within.R
Warning: Collapsing data to cell means. *IF* the r
    full design, you must use the "within_full" ar
    inaccurate.
$ANOVA
  Effect DFn DFd        F           p p<.05        ges
2    int   2  22 7.529572 0.00322701     * 0.0174203

$`Mauchly's Test for Sphericity`
  Effect         W         p p<.05
2    int 0.8269012 0.3866056

$`Sphericity Corrections`
  Effect       GGe     p[GG] p[GG]<.05                 ]<.05
2    int 0.8524431 0.0054248         *                     *
```

EZ Anova package

Summary statistics

DF between groups (#levels-1),
within groups ((#levels-1)*(#ptcp-1))
F ratio, p value

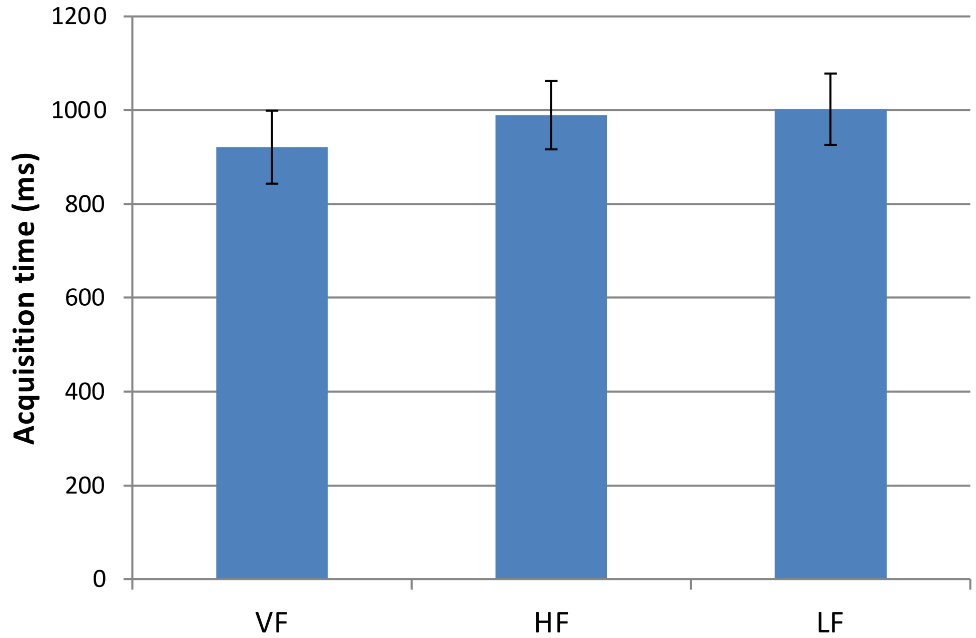
Eta-square
effect size (411)

Important RM-ANOVA
assumption (411)

Analysis of Variance (ANOVA) e.g., one way within subjects with R

```
Warning: Collapsing data to cell means. *IF* the requested effects are a subset of the
    full design, you must use the "within_full" argument, else results may be
    inaccurate.
  int  N      Mean       SD     FLSD
1  HF 12  982.7292 255.4934 43.56331
2  LF 12 1002.2917 263.4246 43.56331
3  VF 12  923.9792 264.1256 43.56331
```

Analysis of Variance (ANOVA) e.g., one way within subjects



"…. significant difference between mean acquisition times, with VF fastest (924ms, sd 264) followed by HF (983ms, sd 255) and LF (1002ms, sd 263): $F_{2,22} = 7.53$, $p = .003$."

Analysis of Variance (ANOVA)
e.g., one way *between* subjects

- Exactly same procedure, except:
- Data file:
  - Each participant has one or more trial datum for exactly one level

```
>  cat onewaybetweeneg.txt
sub cond  time
S1  VF    0.775
S1  VF    0.655
S2  HF    1.445
S2  HF    1.224
S3  LF    1.455
S4  LF    1.25
S5  VF    1.444
S6  HF    1.222
...
```

Analysis of Variance (ANOVA)
e.g., one way *between* subjects with R

```
$ more oneway-between.R
#!/usr/bin/env Rscript

library(ez)
bdata <- read.table("oneway-between.txt", header=TRUE)
ezANOVA(data=bmean_times, dv=mean, between=int, wid=sub)

# or alternatively:
# bfit <- aov(bmean_times$mean ~ bmean_times$int)
# summary(bfit)

➢   ./oneway-between.R

...

$ANOVA
  Effect DFn DFd        F          p p<.05       ges
1    int   2  45 3.810582 0.02959179     * 0.1448308

$`Levene's Test for Homogeneity of Variance`
  DFn DFd      SSn     SSd        F         p p<.05
1   2  45 121150.1 1730129 1.575534 0.2180962
```

Specify treatment

The values you report: $F_{2, 45} = 3.81$, $p = .03$

Analysis of Variance (ANOVA)
e.g., one way *between* subjects with R

```
$ more oneway-between.R
#!/usr/bin/env Rscript

library(ez)
library(plyr)
bdata <- read.table("oneway-between.txt", header=TRUE)
bmean_times <- ddply(bdata, c('sub', 'int'), summarise,
                    mean=mean(time),
                    sd=sd(time),
                    se=sd/sqrt(length(time)))
ezANOVA(data=bmean_times, dv=mean, between=int, wid=sub)

# or alternatively:
# bfit <- aov(bmean_times$mean ~ bmean_times$int)
# summary(bfit)

> ./oneway-between.R
$ANOVA
  Effect DFn DFd        F          p p<.05       ges
1    int   2  45 3.810582 0.02959179     * 0.1448308

$`Levene's Test for Homogeneity of Variance`
  DFn DFd      SSn     SSd        F         p p<.05
1   2  45 121150.1 1730129 1.575534 0.2180962
```

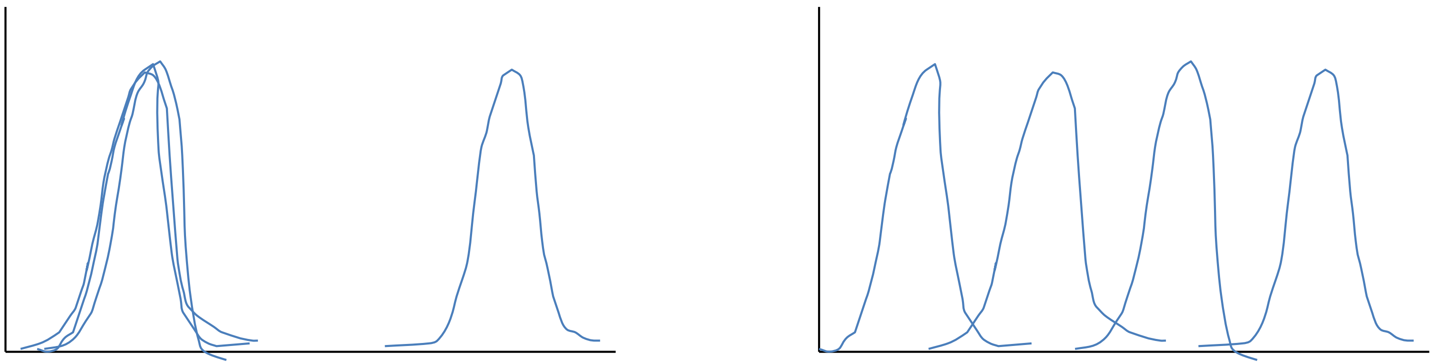
Safest to collapse over replicated trials

Specify treatment

The values you report: $F_{2,\,45} = 3.81$, $p = .03$

What does this tell us?

- We can reject H_0: i.e., we should rarely observe data as extreme as our sample if $\mu_1=\mu_2=\ldots=\mu_n$



- What's different to what?

Posthoc comparisons

- When the 'main effect' for a factor is significant we can do 'posthoc' pairwise comparisons
- They are conservative (reducing type 1 errors)
  – Not uncommon to reject H_0, but find no significant posthoc differences
- Bonferroni correction, Tukey test, …
- (Beyond us for now)

Subjective responses

- User opinions can amplify raw data
- Likert scales (levels of agreement)
- NASA-TLX (in Hancock and Meshkati 1998)
- Rankings
- Preference counts
- User comments

Non-continuous measures
Non-parametric analysis

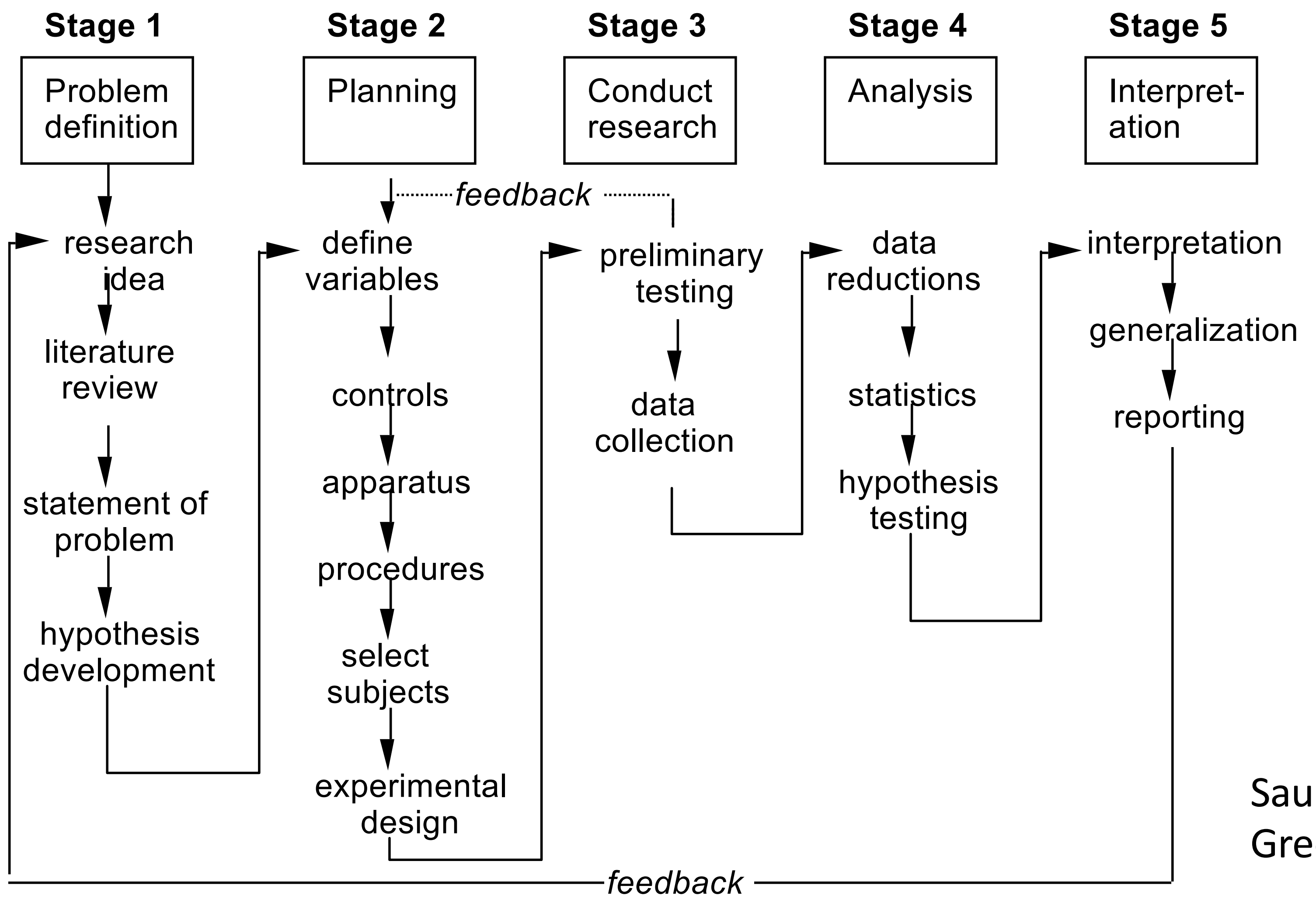
Non-parametric statistics
(In one slide)

- Likert scale responses, ranks, etc.

	Within subjects	Between subjects
2 levels	Wilcoxon Signed Ranks Test	Mann-Whitney U Test
> 2 levels	Friedman Test	Kruskal-Wallace H Test

- Frequencies and proportions
  - Chi-square test
  - Independence of samples (one datum/ptcpt)

Planning Experiments!



Saul Greenberg

What's in the exam?

- Look at past papers.

- Solutions please?
  - Nope; come see me with your attempts

Thanks All!

- Acknowledgements:
  - Saul Greenberg, Scott MacKenzie, Alan Dix