

Visual Analytics

Giuseppe Santucci

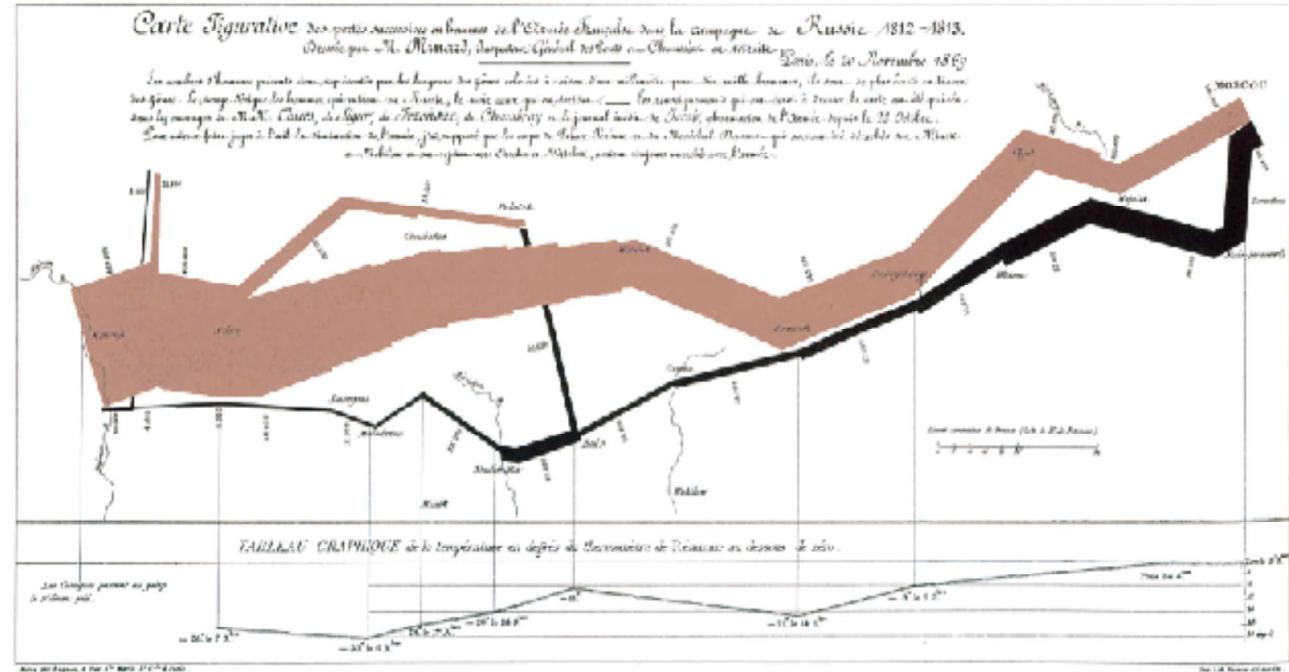
9 – Interaction

Thanks to John Stasko, Robert Spence, Ross Ihaka,
Marti Hearst, Kent Wittemburg

Outline

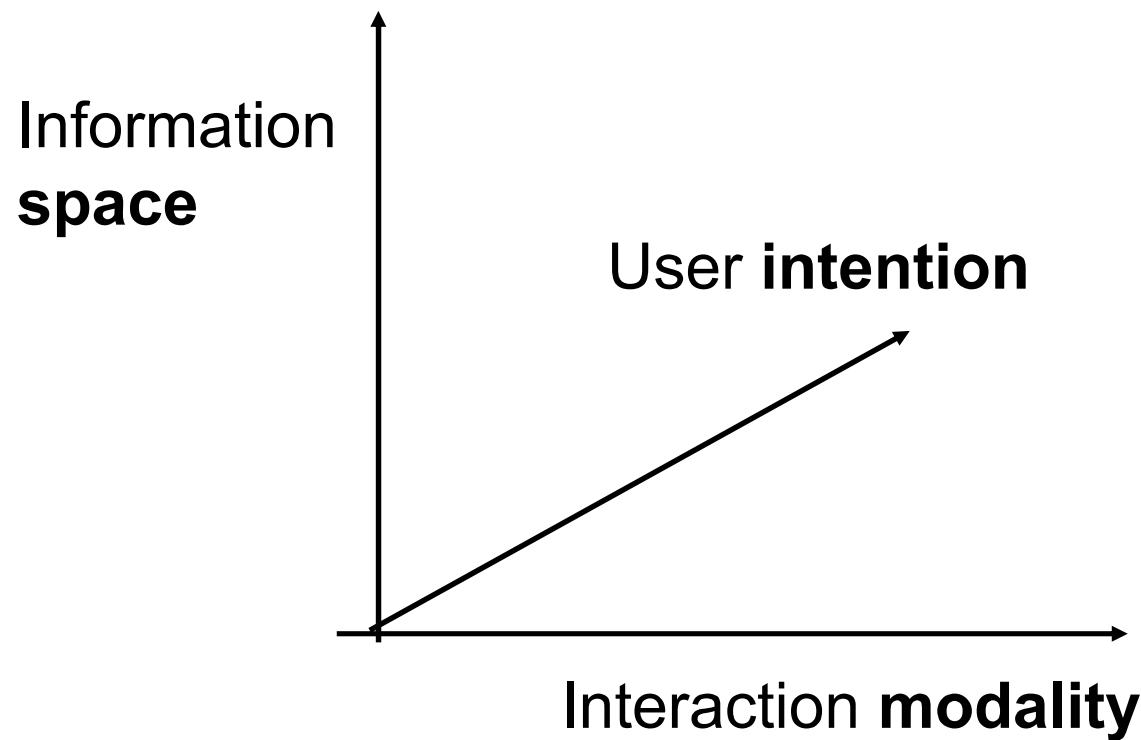
- Interaction and scenarios
- Information space and user interaction
- User intention and interaction framework
- Continuous interaction
- Stepped interaction
- Passive interaction
- Composite interaction
- Interaction dynamics
- The last palette

Interaction



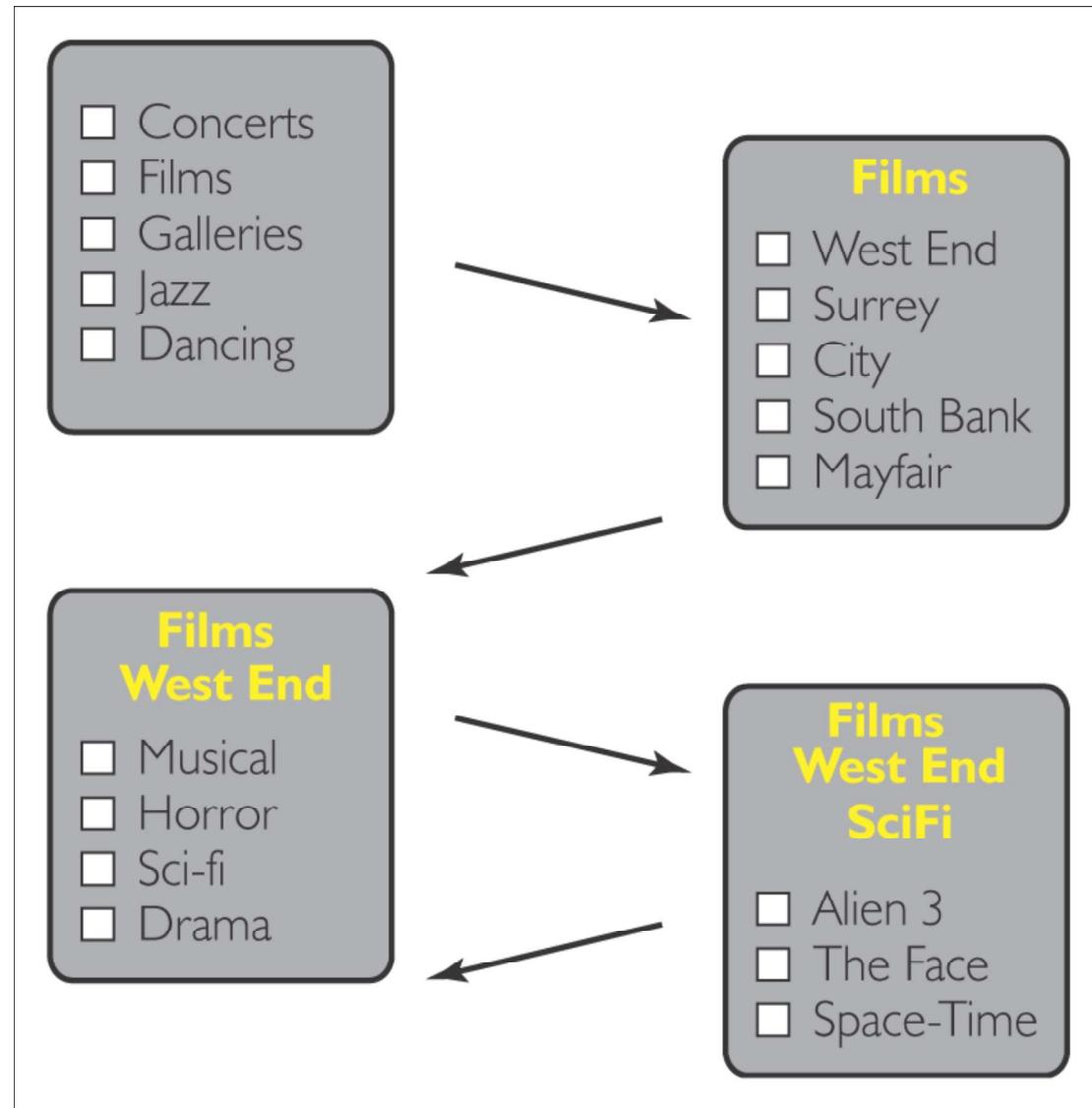
- Static display (all the information pops out)
 - No physical interaction
 - Encoded data immediately viewable: **interaction is NOT a key issue!**

Interaction? A classification attempt



First scenario

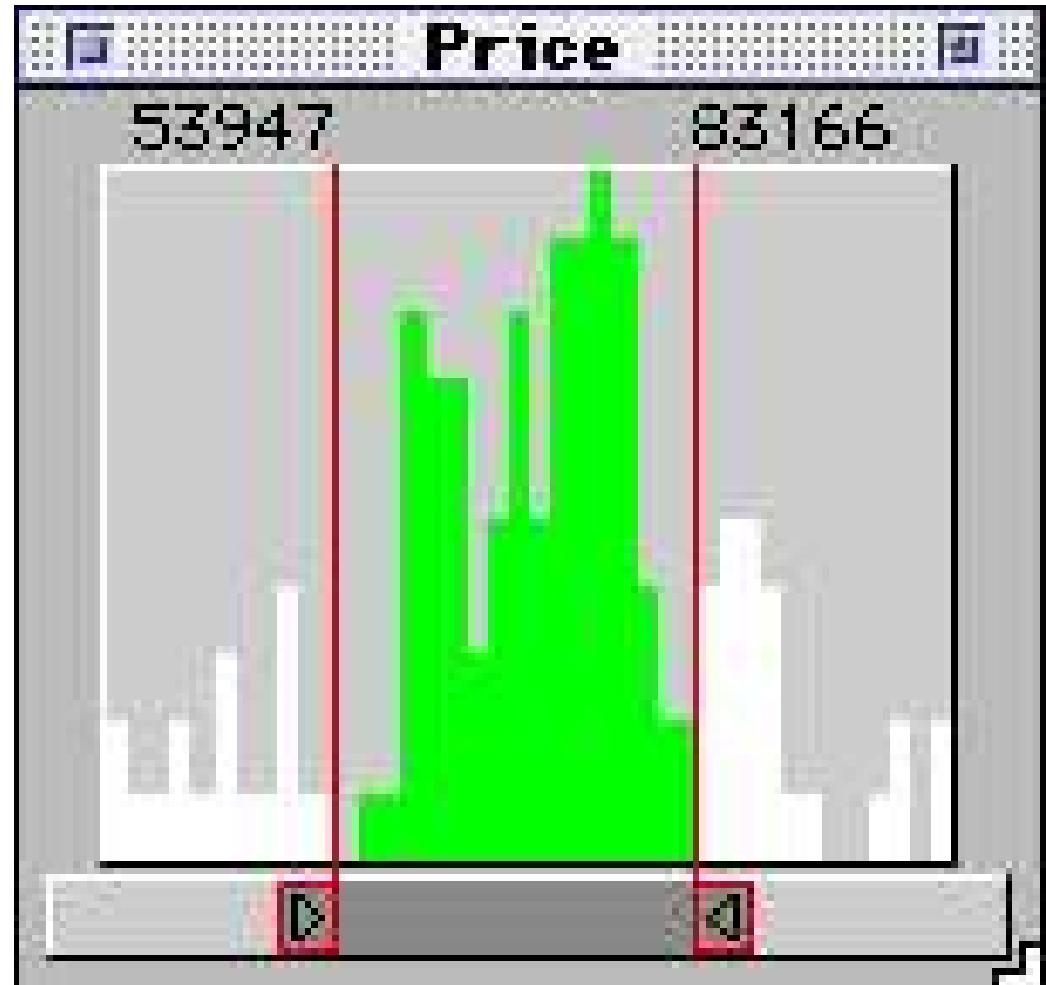
Searching for entertainment



- **Information space:** discrete
- **Interaction:** stepped
- Responsive system (1 sec)

Second scenario

Looking for
a house (using price)



- **Information space:** discrete (price bin size)
- **Interaction:** ~stepped
- Responsive system (0.1 s)

Third scenario

Drinking
a coffee...

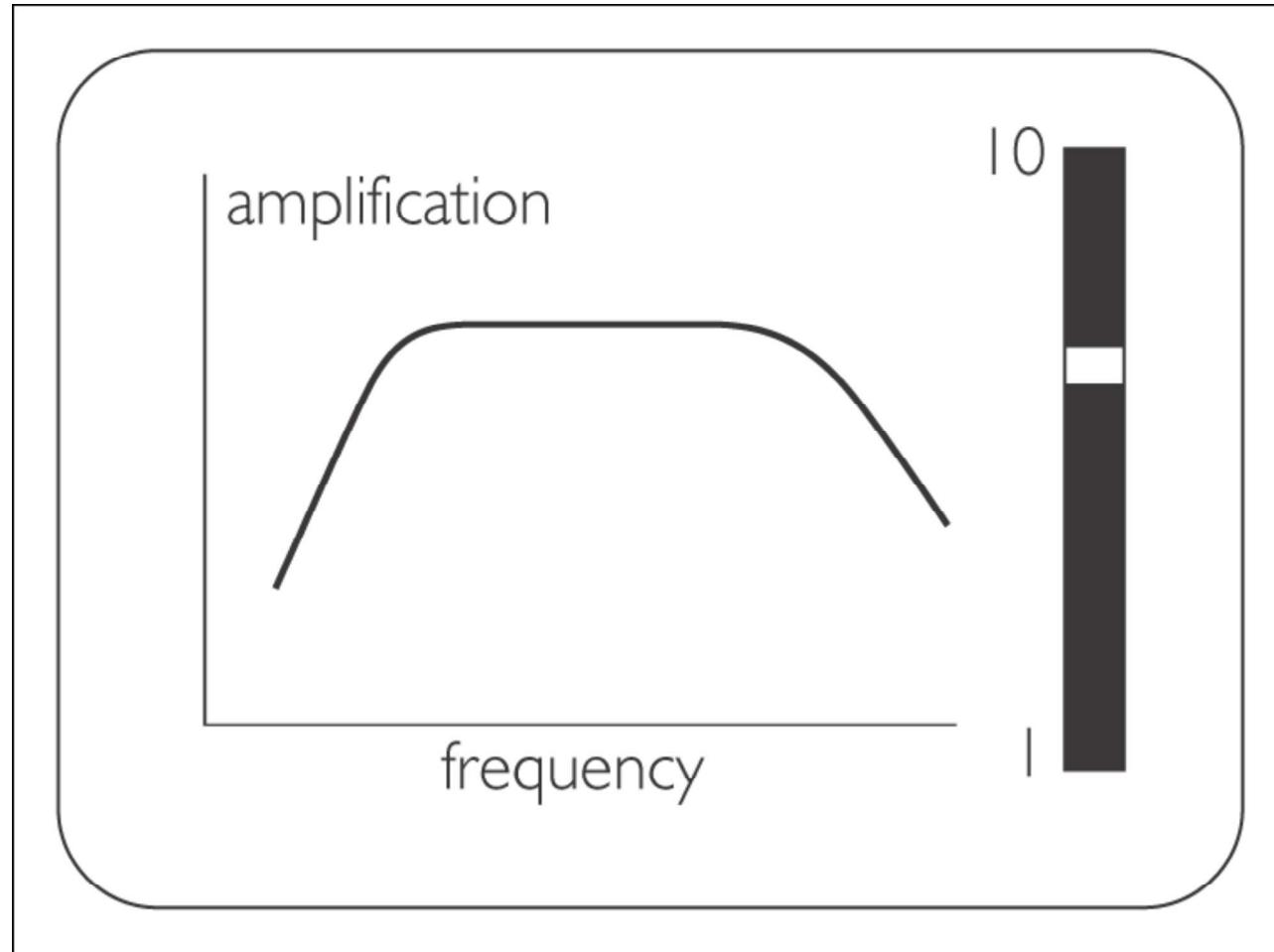


- **Information space:** discrete (moving images)
- **Interaction:** No physical interaction, or passive interaction, unless an image attracts attention and we move to stepped interaction... [video](#) (10)

Fourth scenario

Analyzing an amplifier

- to better understand it
- to optimize a component

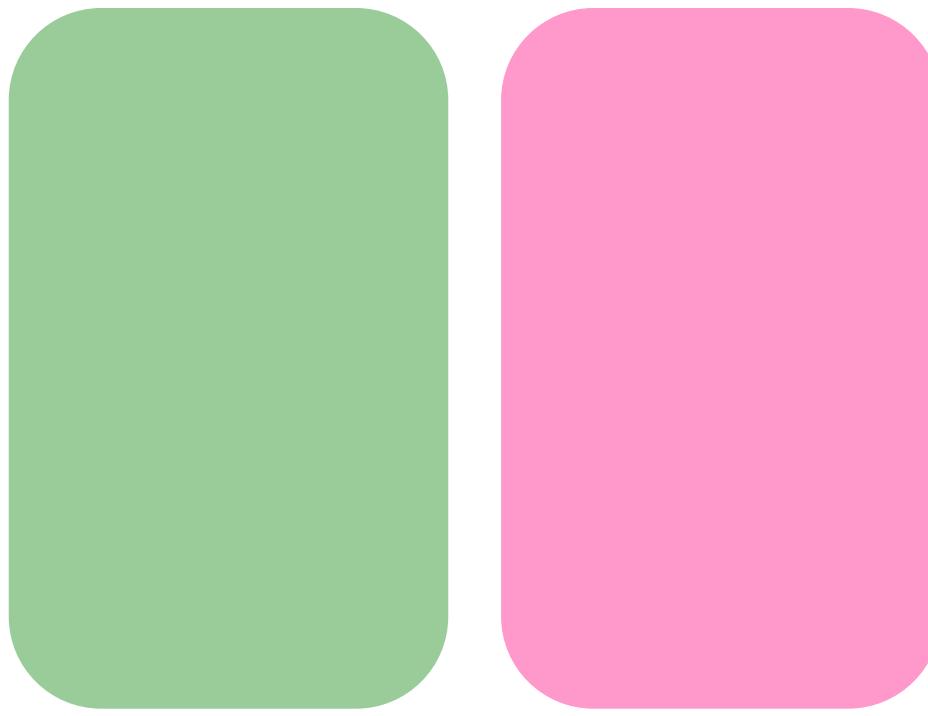


- **Information space:** continuous
- **Interaction:** continuous
- Immediate response (0.1 sec)

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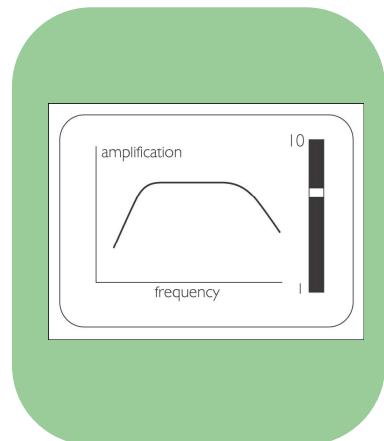
Information space



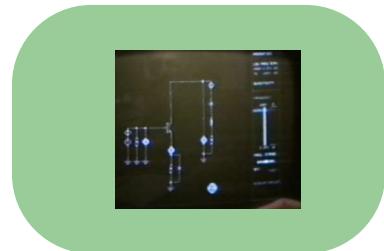
Continuous Discrete
Information spaces

Two classes of information space

Information space & interaction



World Wide Web
Minard's map
Coffee Table



Continuous



Discrete

Information spaces

Continuous

Stepped

Passive

Composite

Interaction modes

Information spaces, interaction modes and examples of their combination

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User intention

- **Learning**
 - Explore the information space
- **Seeking**
 - In depth search
- **Opportunistic analysis**
 - what is there?
- **Involuntary**
 - publicity...

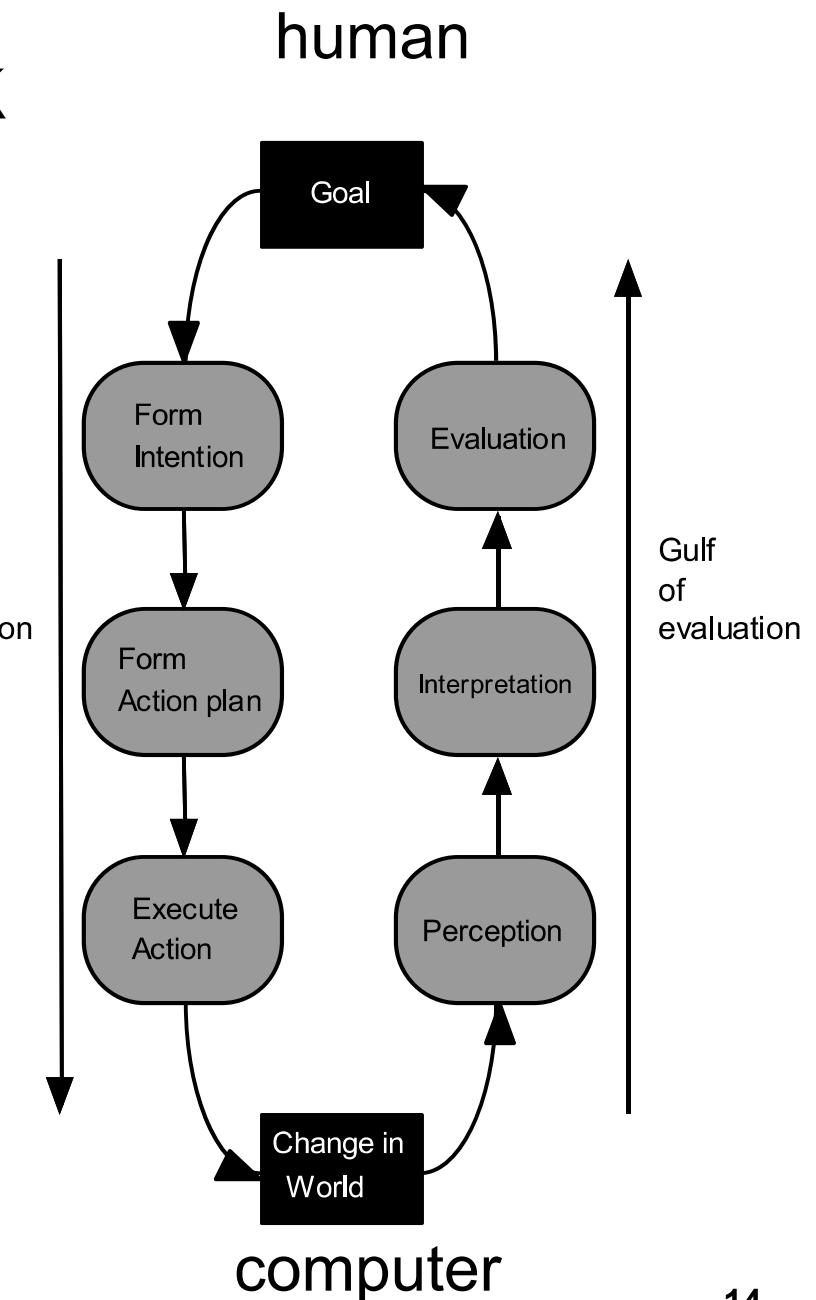
Interaction framework

1. Information space
2. Interaction mode
3. User intent

We need a general framework for interaction:

Norman's Action Cycle (1988)

A visual information application must provide the means to perform all the steps

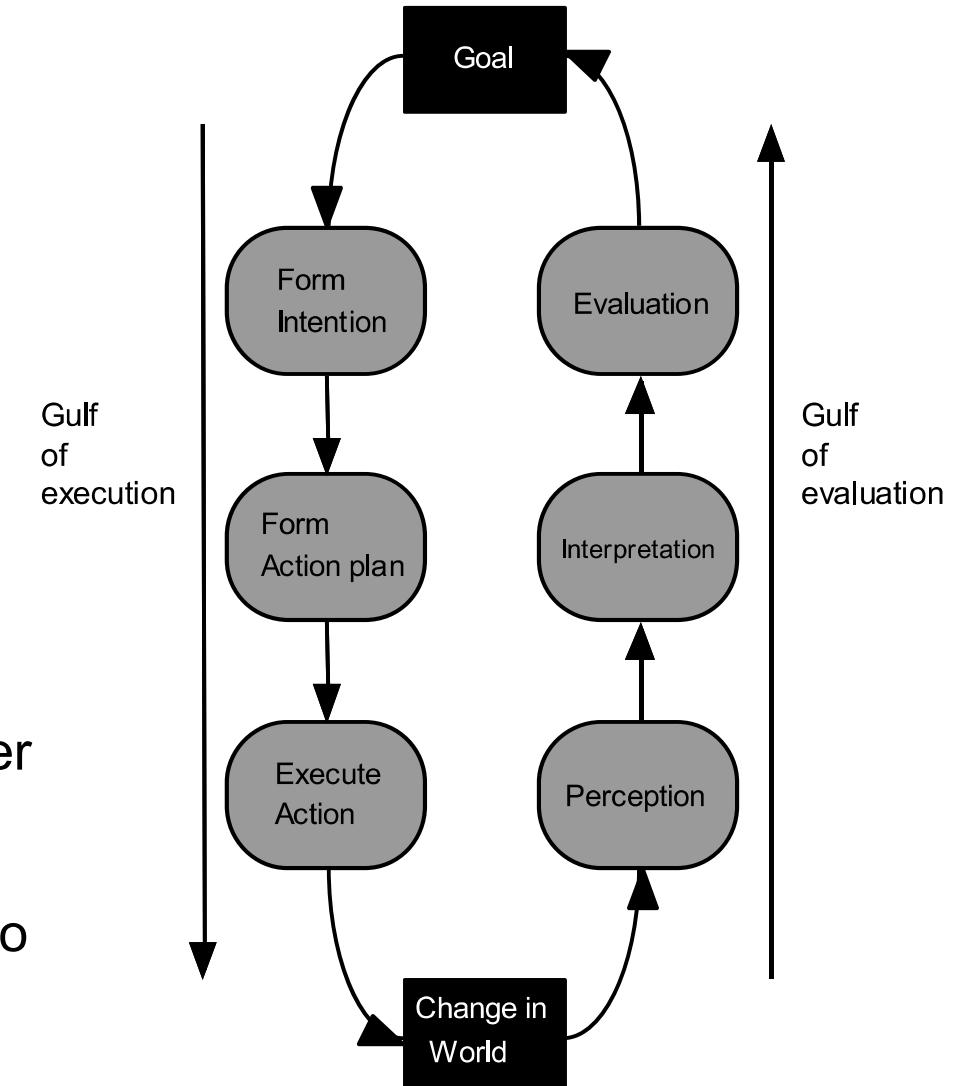


A simple example

A simple example:

- goal: take a pictorial record of an event
- intention: do it by yourself with a camera
- action plan: select scene and exposure parameters
- execute: shutter release
- perception: the click from the camera
- interpretation: done
- evaluation: look at the picture (faster with digital cameras)

In the following we apply these steps to the different kind of interactions

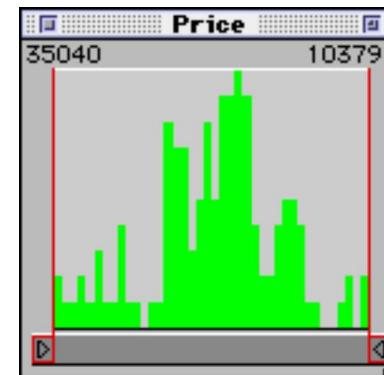


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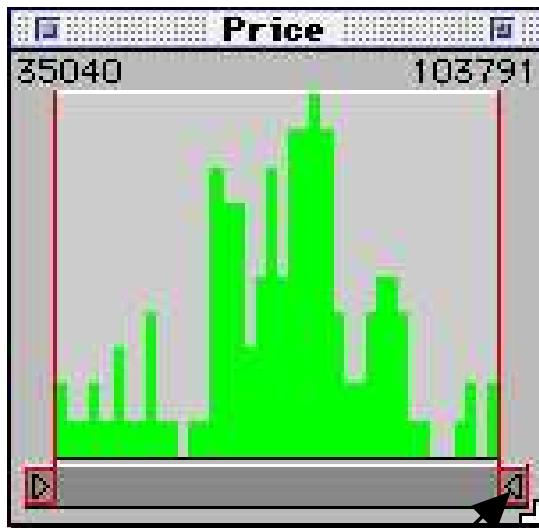
Continuous interaction

- It is no a new concept (early applications in statistics in 1969)
- The increased computational power allows for modeling more complex relations but the principle is the same: the user interacts with a continuous control and the graphic changes
- Let's explore it with an example from attribute explorer

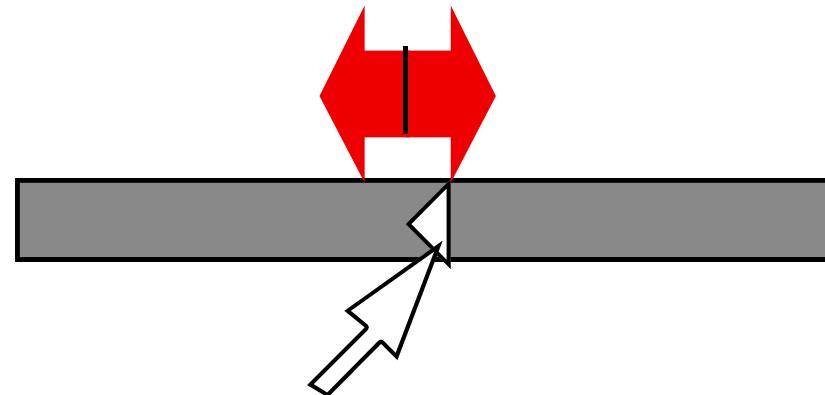


Continuous interaction

- **Intention:** e.g., to understand which kinds of houses exist in a specific price range
- **Forming an action plan:** the application should convey in an intuitive way how to adjust the upper and lower limits of price (easier than setting exposure manually on a compact digital camera...)



Mouse-down only, or
mouse-down and drag?



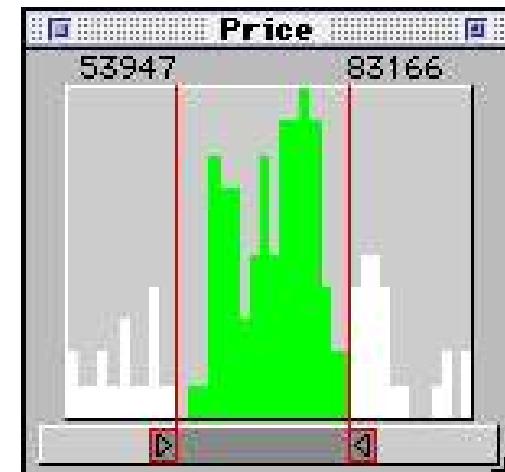
One way of reducing the ambiguity. Mouse-over indicates possible movement

Continuous interaction

- **Execution:** it seems quite straightforward but some tricks can help it (e.g., disregarding y axis mouse movements, or allowing cyclic selections on the same x, y coordinates)

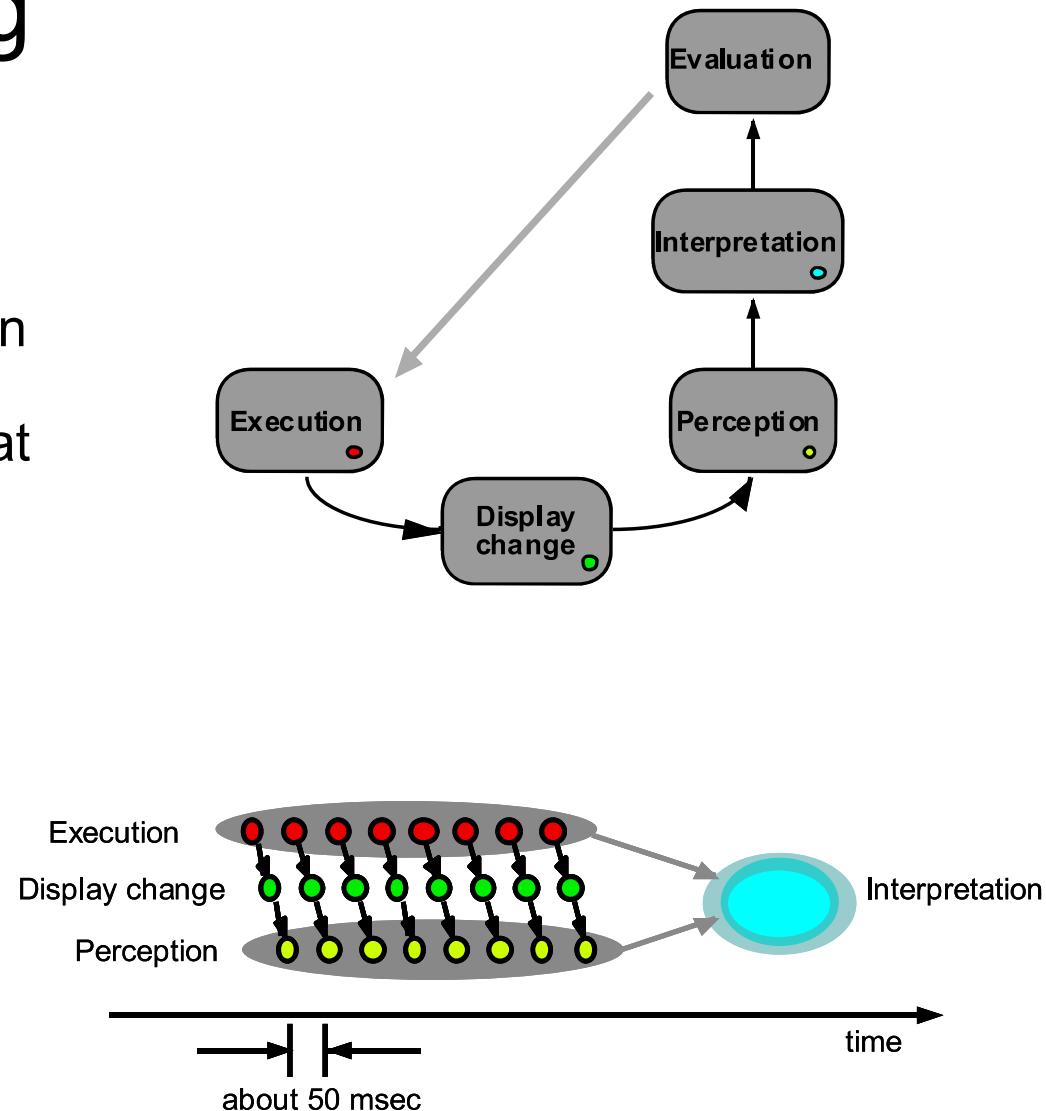
Example: in Powerpoint it is impossible to select the green circle under this writing

- The **change in the world** is the histogram change and it is possible that perception (color?) and evaluation (a counter?) refer to a single limit adjustment



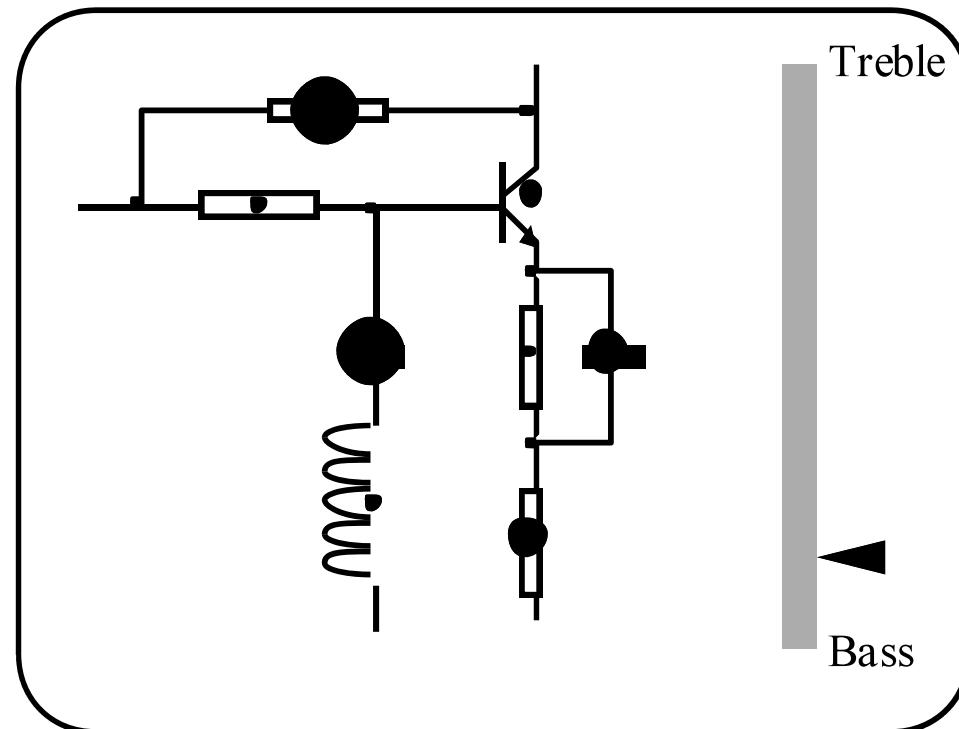
Mental mapping

- A sequence of interactions allows for forming a mental mapping
- As an example the user can increase continuously the upper price limit to see what happens in the other histograms
- Discrete information space + granularity= continuous space
- Be aware of change blindness: animation
- Other helps: some snapshots of relevant values



Continuous interaction

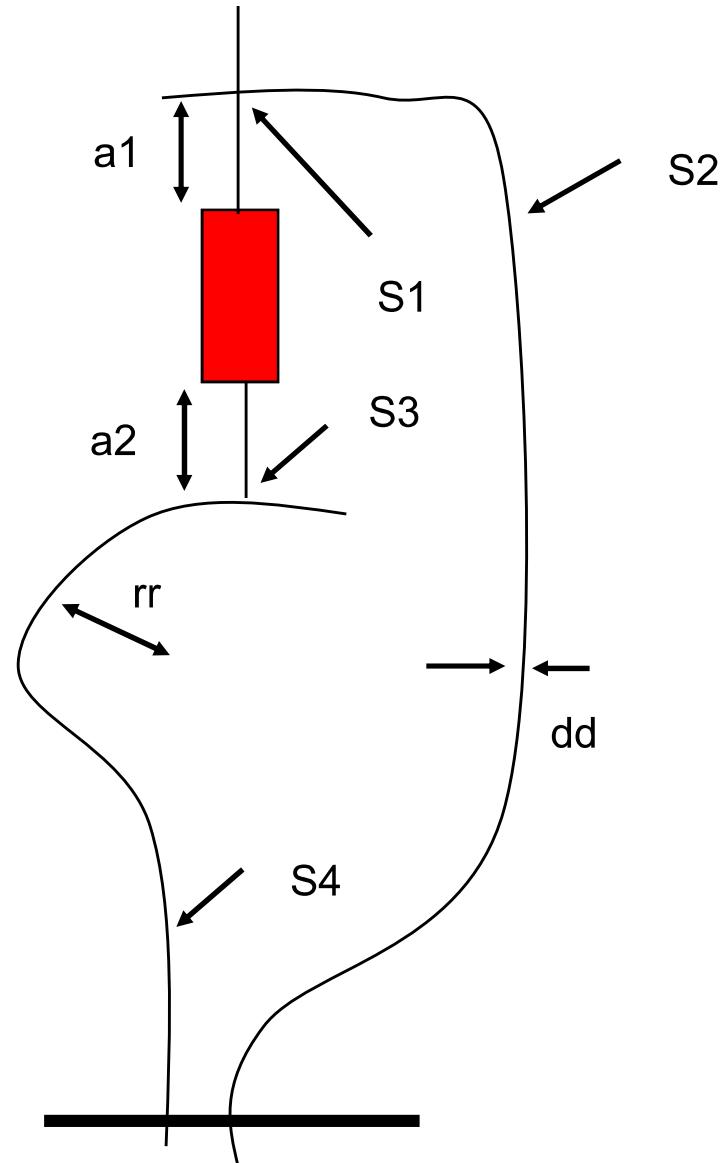
- Continuous interaction can generate pre-attentive like effects
- If two circles suddenly expand together that reveals a correlation
- [video](#) (11)

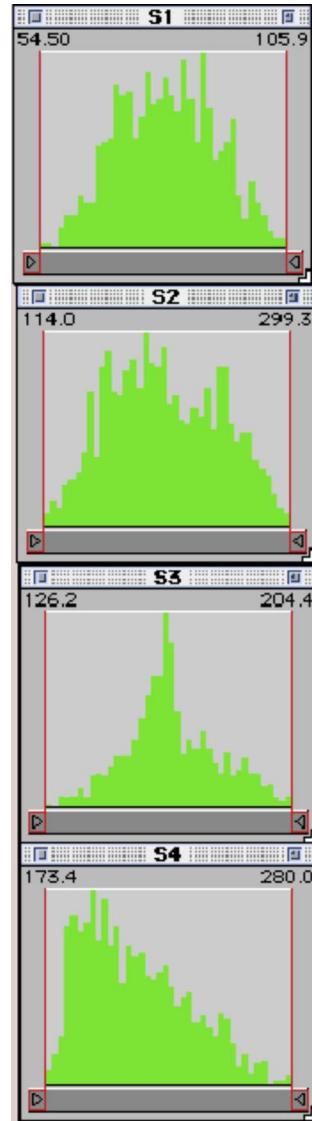


Circles indicate the qualitative effect, on some overall circuit property, of variation in the corresponding component

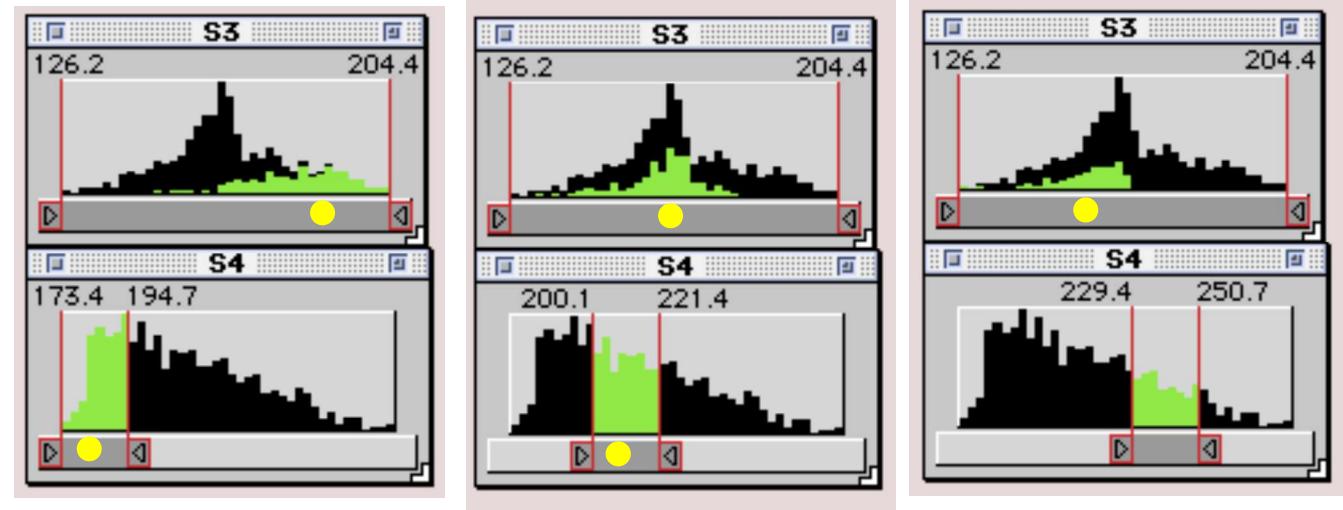
Designing a lamp

- The filament inside a light bulb is sustained by a structure that has four parameters
 - $X1=a1$
 - $X2=a2$
 - $X3=dd$
 - $X4=rr$
- Four stresses ($S1..S4$) are computed for a set of different structures





Histograms interaction



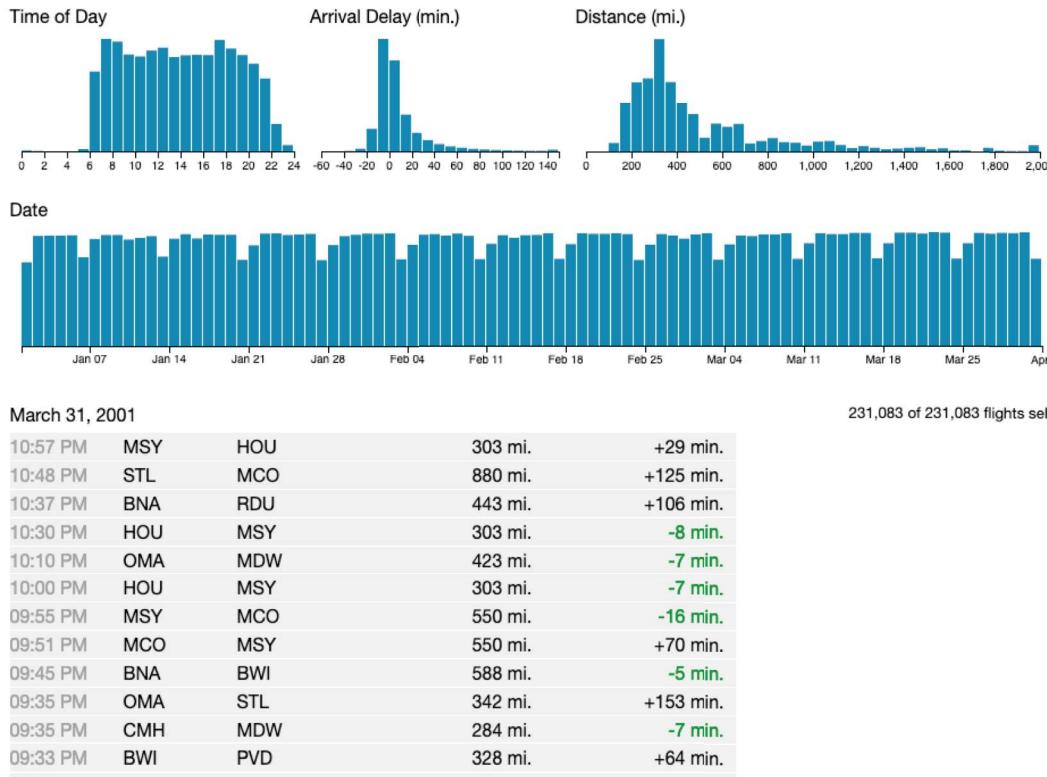
As the range of S4 is moved to higher values, the corresponding values of S3 move to lower values, indicating a trade-off

Yellow circles indicate the average attribute values of objects satisfying all limits

Histograms showing the stresses S1 to S4 calculated for a collection of designs of a structure

[Video12](#)

Some questions to consider: How does time-of-day correlate with [arrival delay](#)? Are [longer](#) or [shorter](#) flights more likely to arrive early? What happened on [January 12](#)? How do flight patterns differ between [weekends](#) and [weekdays](#), or [mornings](#) and [nights](#)? [Fork this example](#) and try your own data!



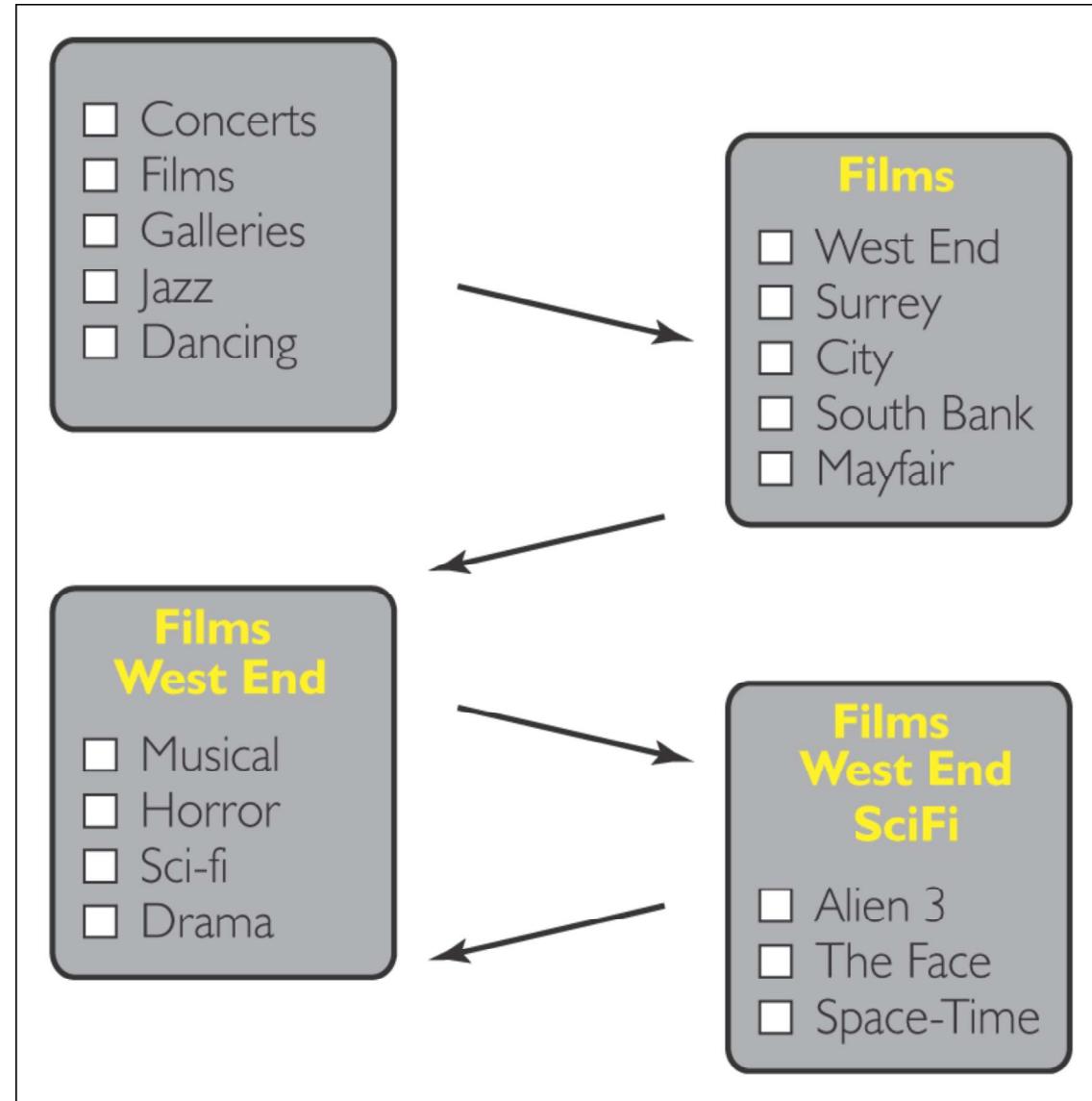
CROSS FILTER !

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Stepped interaction

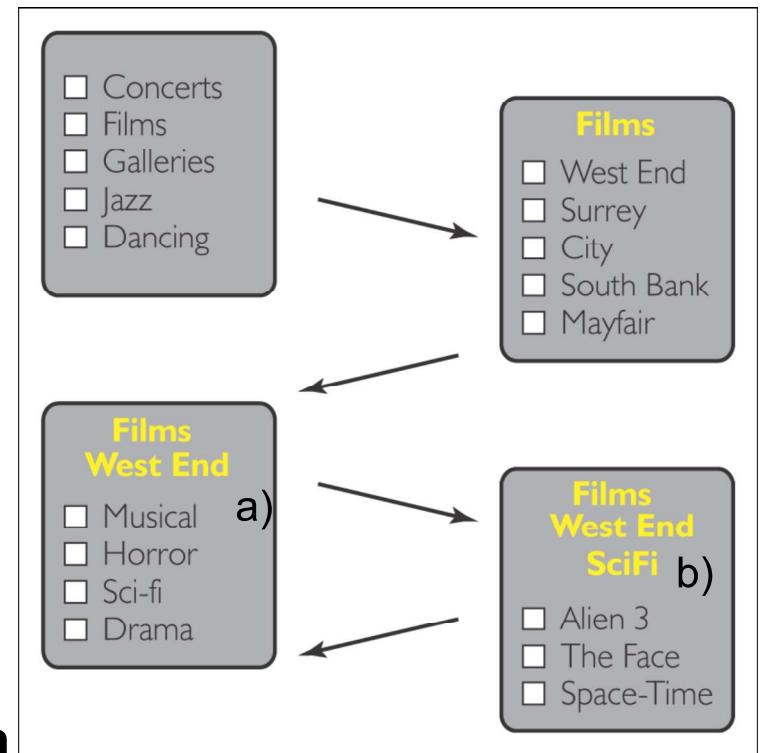
- The system is not exactly responsive
- Speed transition is a key issue
- Exploration refers to **discrete** change of view



Stepped interaction involved in a search for entertainment

Stepped interaction

- Even in this case the challenge is **forming an action plan**
- In each step the user has to decide the best **single** movement
- e.g., if the user does not know that “The Face” is classified as SciFi it might result in bouncing between a) and b) several times
- Most of the effort is, in this case, devoted to **facilitate the navigation**



Stepped interaction

- Like moving in a physical space the following questions may arise:
 - Where am I?
 - Where can I go?
 - How do I get there?
 - What lies beyond?
 - Where can I usefully go?
 - How can I retrieve that interesting spot I saw before?
 - Where have I been?
- Think of the navigation of a complex Web site...

Stepped interaction

- Some useful solutions are exactly the same that are used in physical situations.
- If the navigation is performed to reach a known unique goal the activity resembles a **wayfinding**
- If the movement has the goal of learning the information space structure that resembles a physical **exploration**
- If the goal is to find in the most direct manner a specific target it resembles a **pursuit**
- Again, a Web site can give a precise idea of these activities

Sensitivity

- Navigational cue
 - Where can I go from here?
 - How do I get there?
- Sensitivity S=SM,SI denotes
 - a single movement (SM) and
 - a single interaction (SI)
 - needed to achieve it
- Where to go and how!



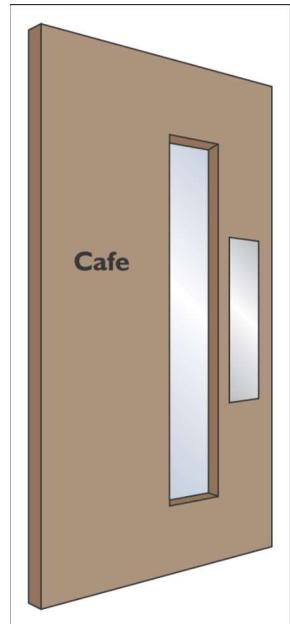
The cloud formed above an island invisible beyond the horizon provides a physical navigational cue

The Minard's [map](#) is...

A navigational cue in the information space

cue = spunto

Sensitivity



The label 'cafe' and the flat plate provide navigational cues by showing where the user can go (the cafe) and how they can get there (push the door)
affordance is high

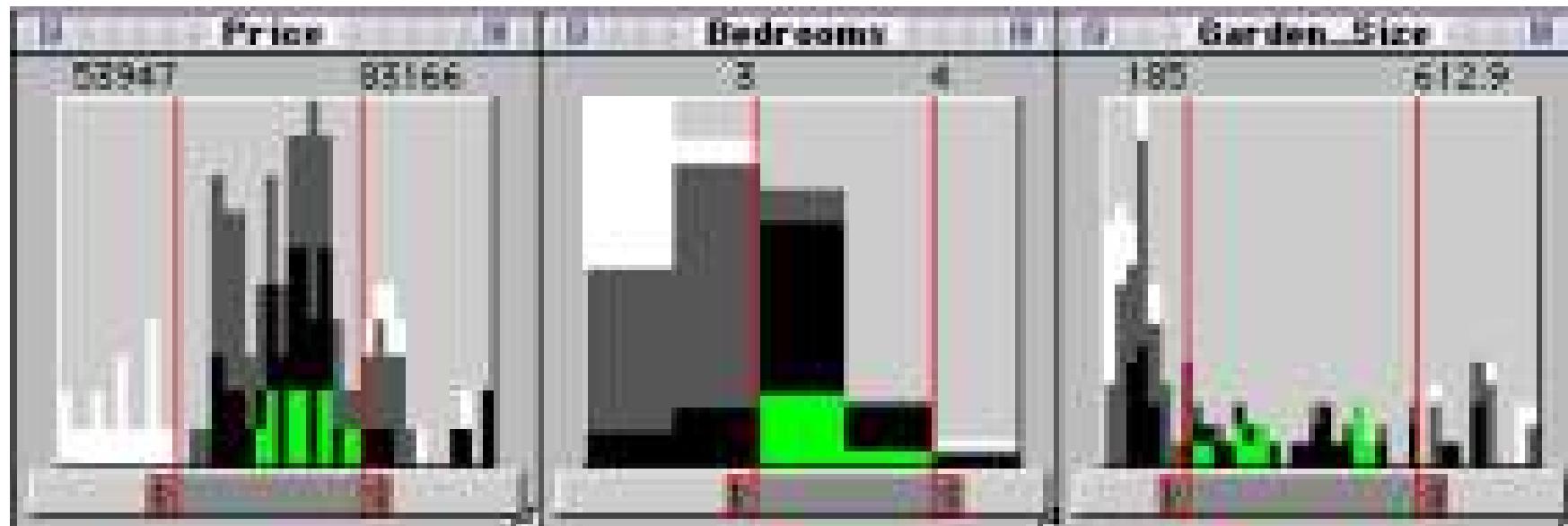
affordance = invito all'uso



Part of a web page. Each label and surrounding grey area indicate that a mouse click on the area (SI) will cause movement (SM) to another page concerned with the selected type of holiday

I do not like it: SI is not standard...
affordance is not high

Sensitivity encoding



Green: satisfying all attribute limits

Black : houses that fail one attribute limit

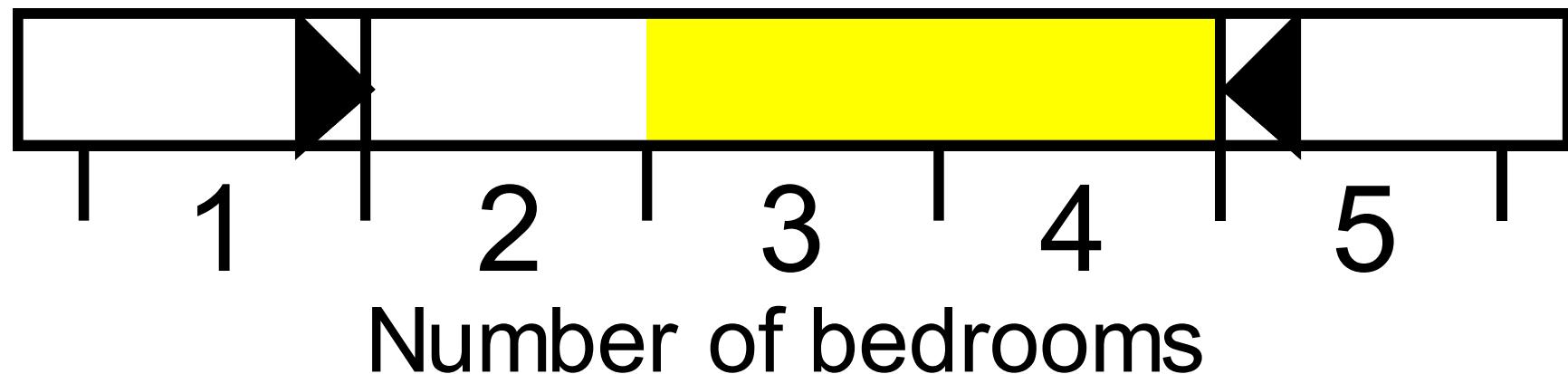
Gray : houses that fail two attribute limits

White: houses that fail three attribute limits

If we want to move towards houses not satisfying just a parameter we need to include black houses...

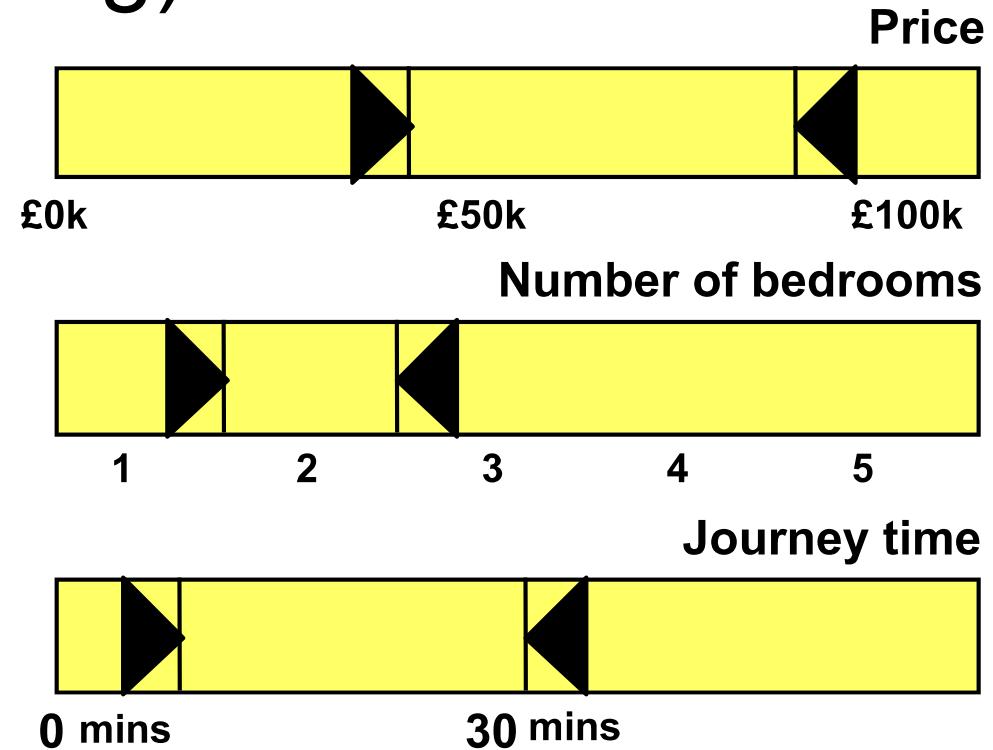
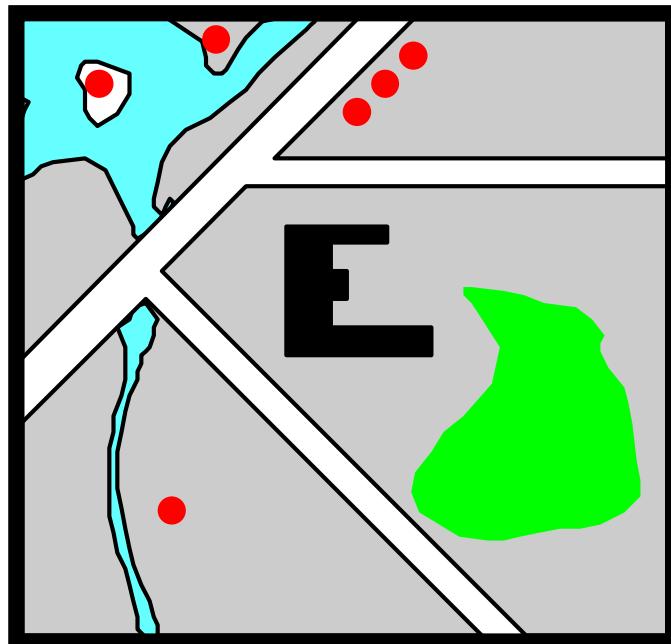
What about gray and white?

Sensitivity



In a limit positioning tool, colour coding indicates that selection will be unaffected while the lower limit stays within the white region (no movement in the information space). When a limit moves into the yellow region selection will be affected (movement in the information space)

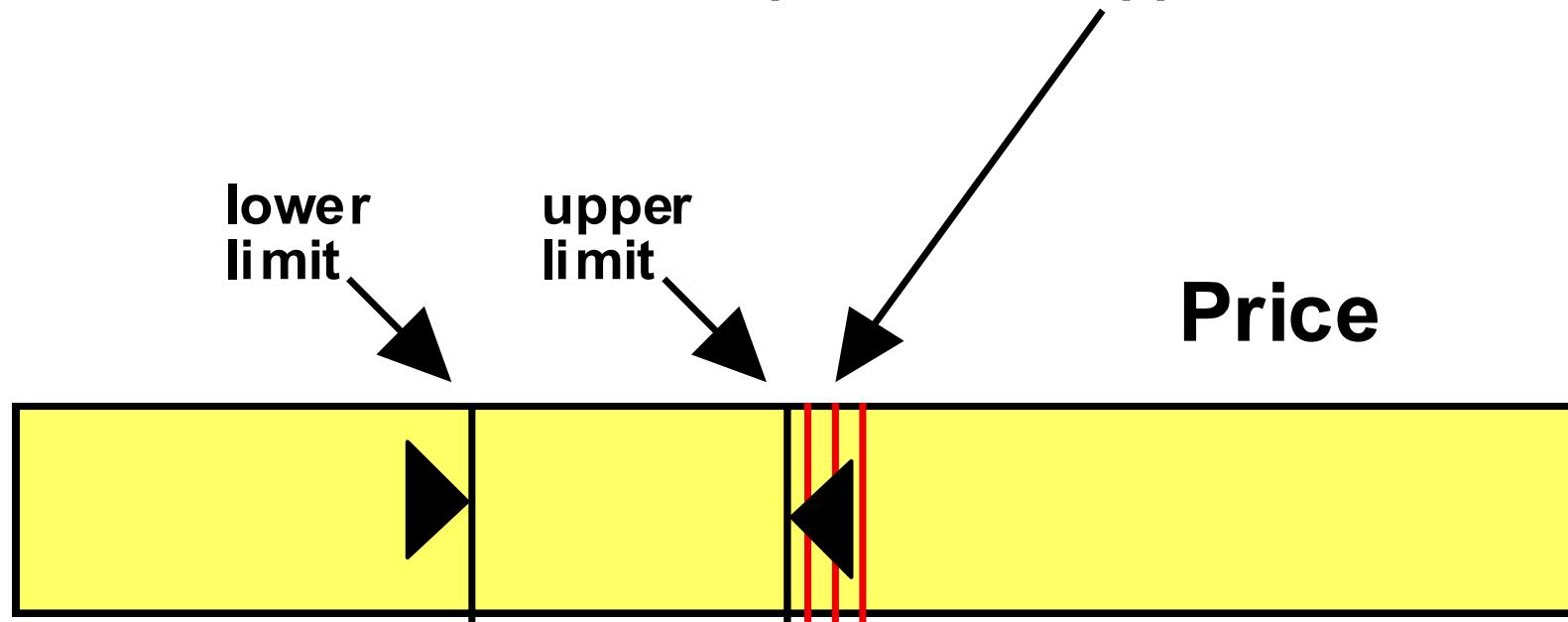
Dynamic Query Interface (No sensitivity encoding)



The Dynamic Queries interface. Limits placed on house attributes by a user leads to the display of houses satisfying those limits on the map

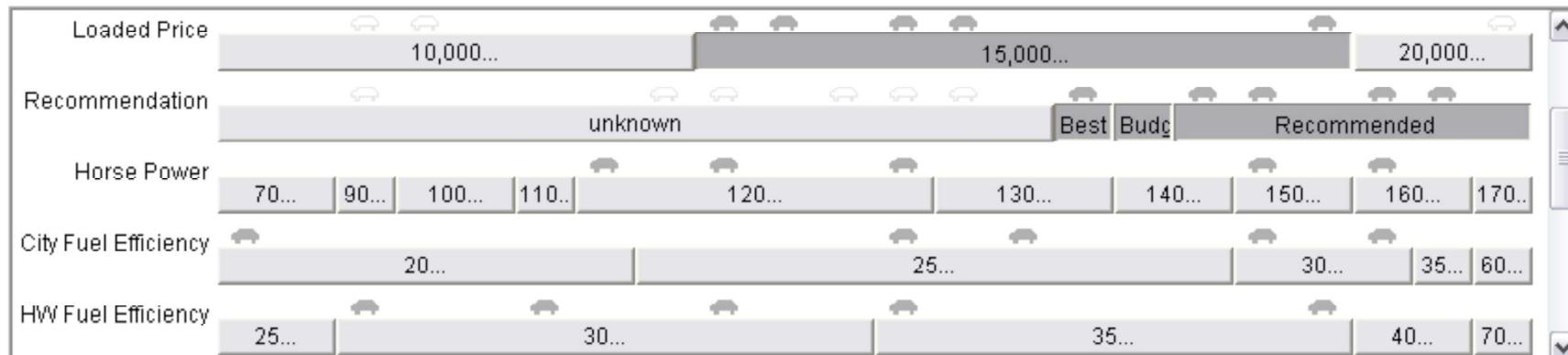
Dynamic Query Interface

Three houses which satisfy all limits with the sole exception of the upper limit on Price



A possible modification to the Dynamic Queries interface. Houses violating only one limit are identified, so that sensitivity is explicit rather than having to be discovered by manual movement of the limits

EZChooser



5 vehicles that match your feature selections.



[Chevrolet Cavalier](#)



[Chevrolet Prizm](#)



[Honda Civic](#)



[Mazda Protege](#)



[Toyota Corolla](#)

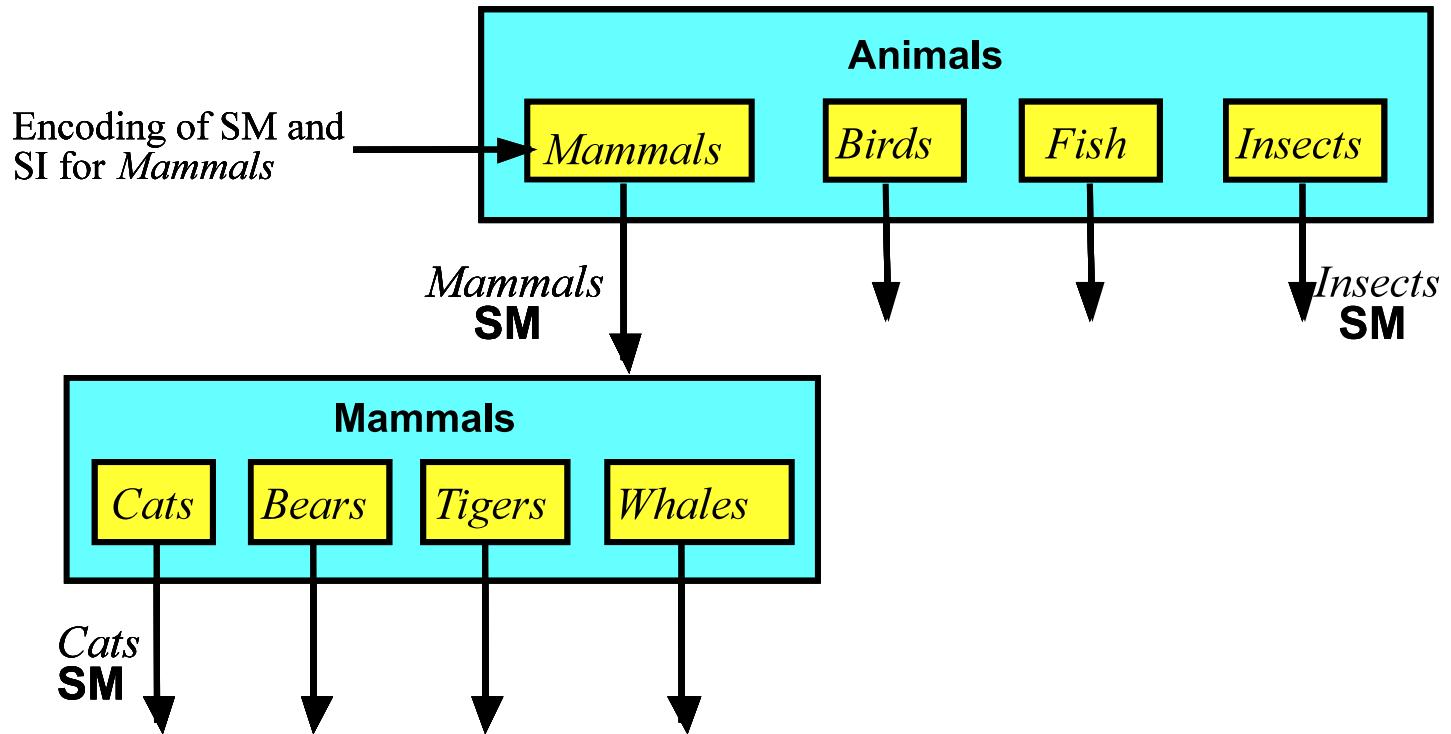
In the EZChooser outline cars are those that satisfy all requirements except one. Selection of the range immediately underneath an outline car ensures that the car then satisfies all requirements

That help in deciding the next step!

Residue

- What lies beyond?
- Sensitivity answer the question for the next step
- Adding to a single movement SM the information of what lies beyond can greatly improve the navigation
- Residue: an indication of distant content in the SM encoding
- Distant means requiring more than one movement

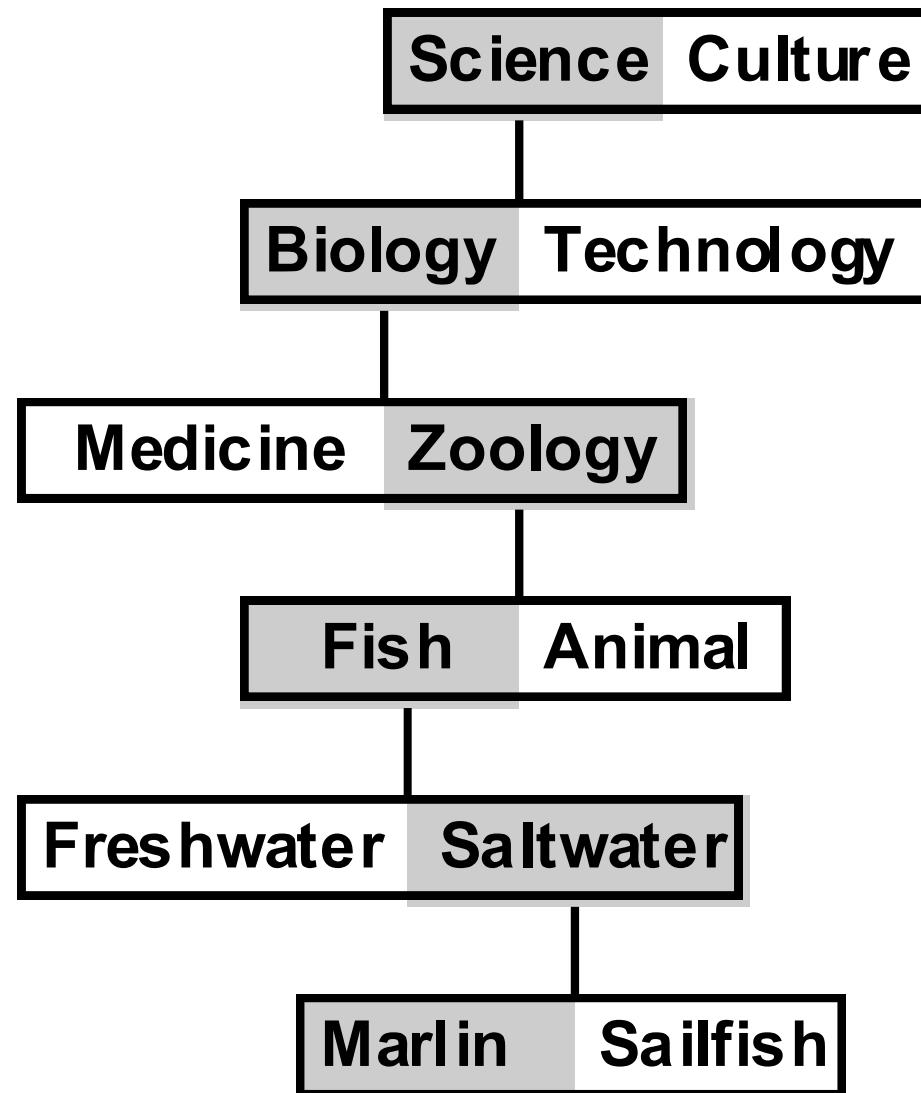
Residue



Representation of the top two levels of an hierarchically structured menu-based system providing information about animals
Mammals encode sensitivity AND residue
Obviously it requires specific knowledge (e.g., do not search whales under fish...)

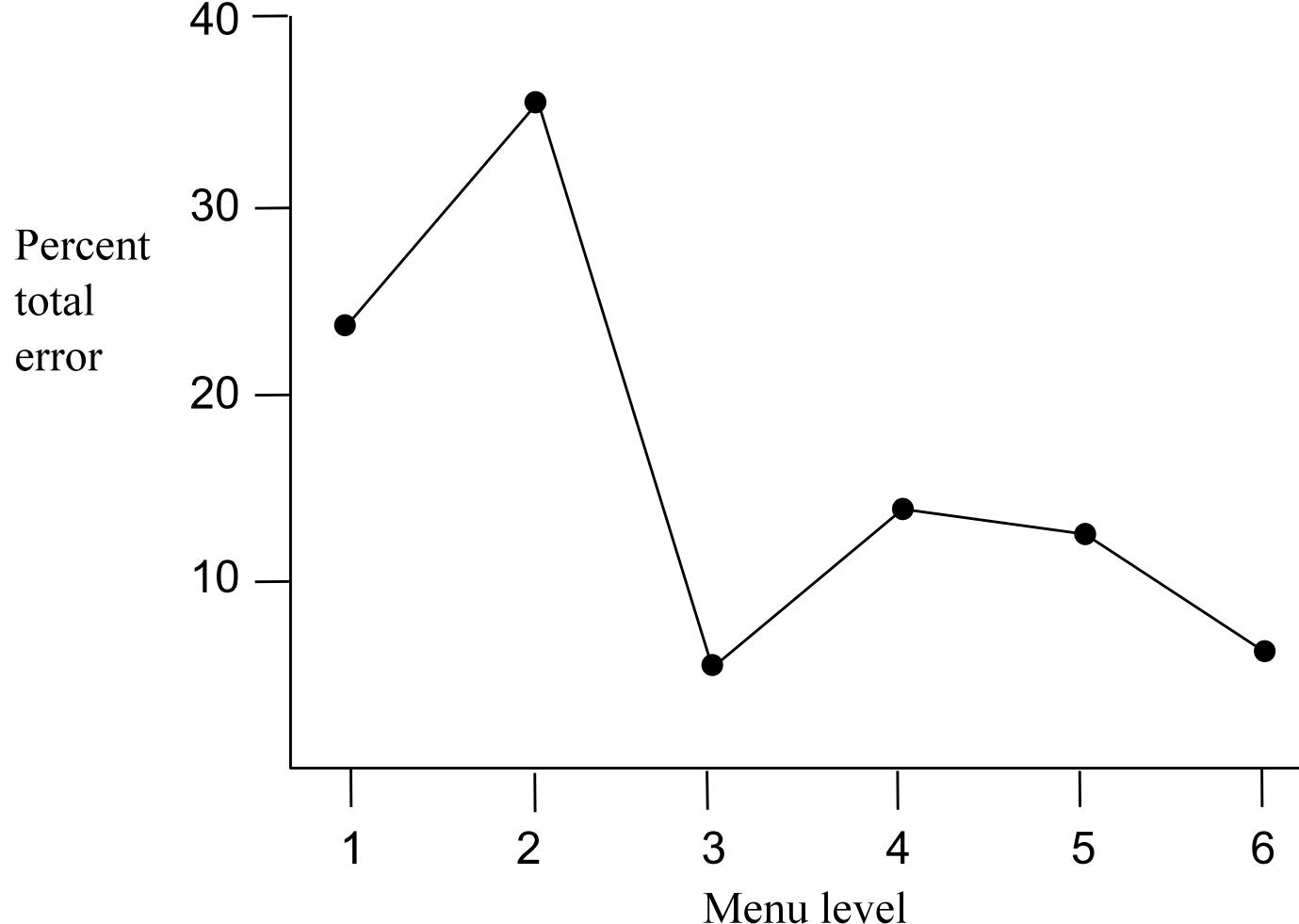
An experiment

- 64 words arranged on a binary tree
- several people were asked to search for a particular word
- Errors were counted



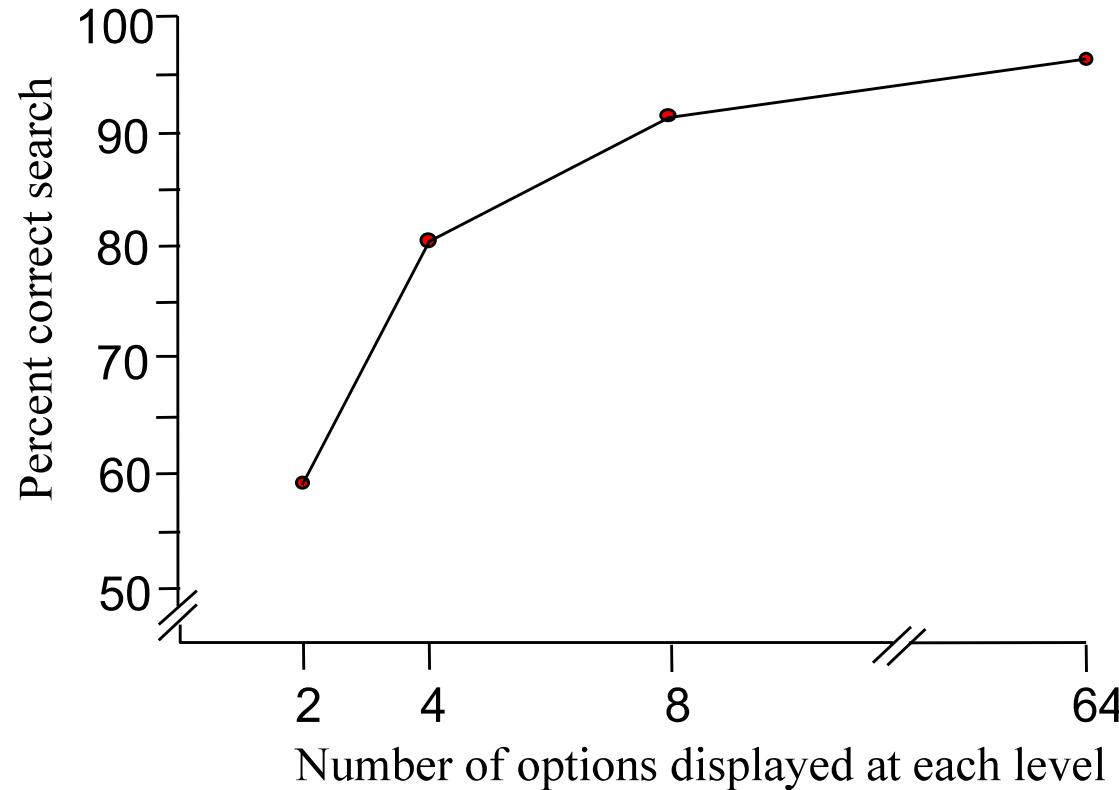
That part of a 2^6 menu to be traversed in a successful search for the target word 'Marlin'

Residue is harder to represent at the top levels



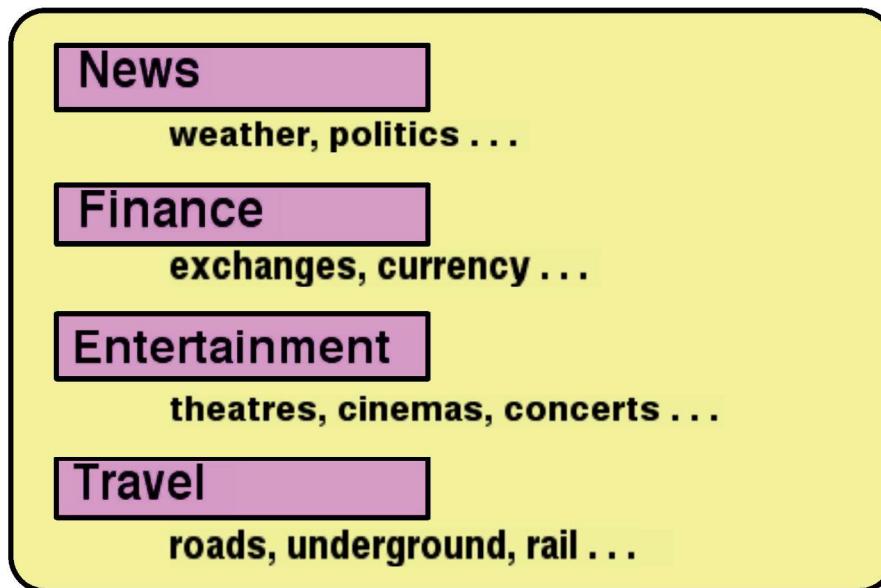
Errors made at different levels of a narrow and deep six-level menu in the search for a target at the lowest level

Another experiment



Percentage correct search as a function of menu structure
Broad and shallow menu structure perform better
This is way using cell phones is so hard....

Improving menu efficacy



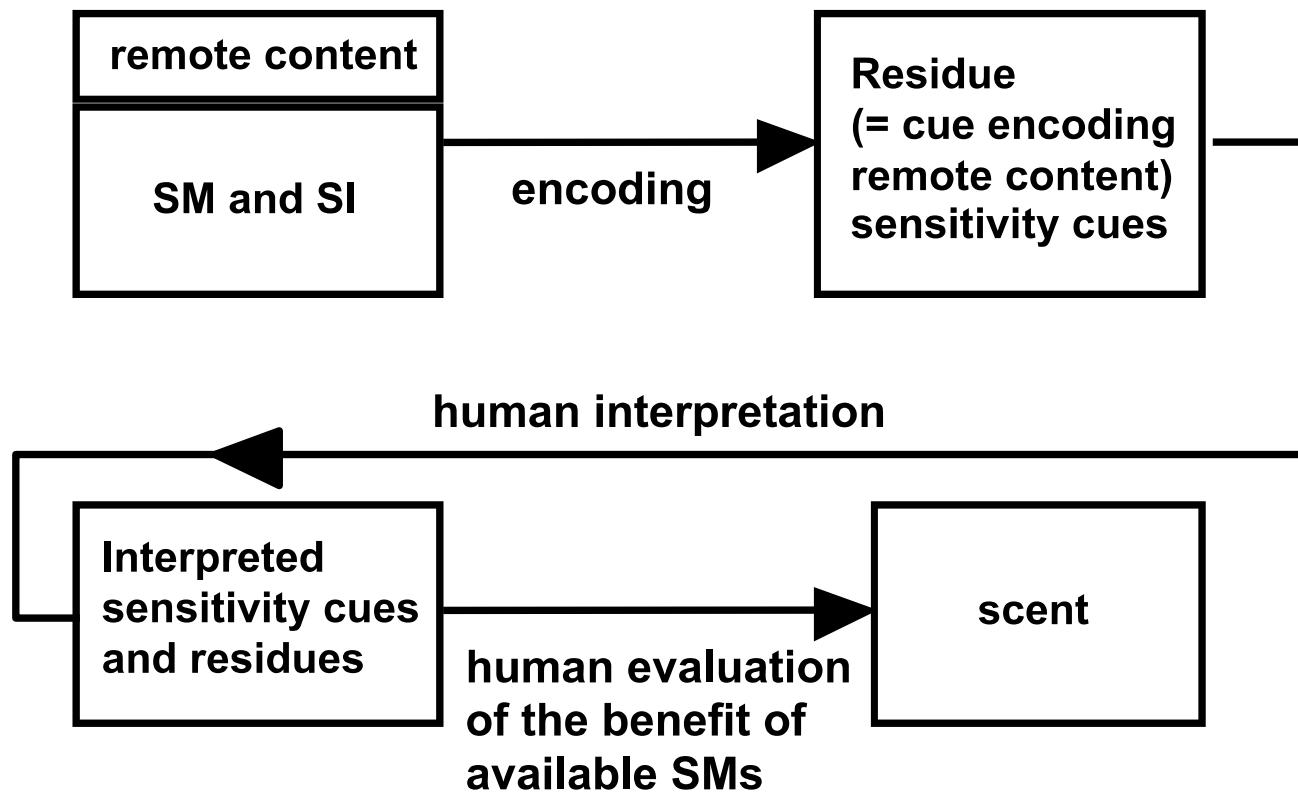
Example of the provision of an ‘Upcoming’ help field, where samples from the next lower level help to enhance confidence in the interpretation of the menu options

8-10% errors vs 22-28% error percentage

Scent

- When can I go from here?
- Where can I **most beneficially** go from here?
- Scent: perceived benefit associated with a SM, evaluated through one or more cue
 - high-order cognitive process
 - it depends on user's current internal model of the information space
 - it depends on the strategy adopted to carry out a task

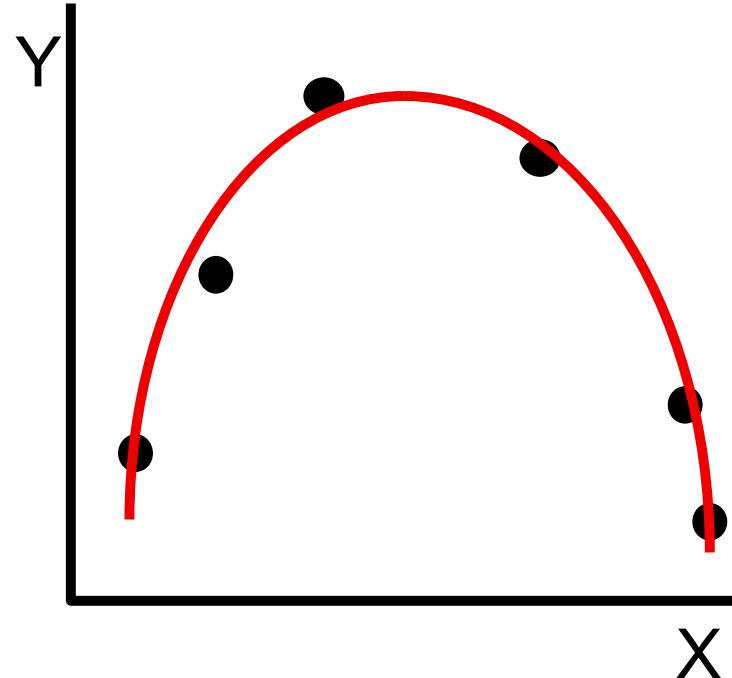
Scent



The relation between sensitivity, residue, and scent

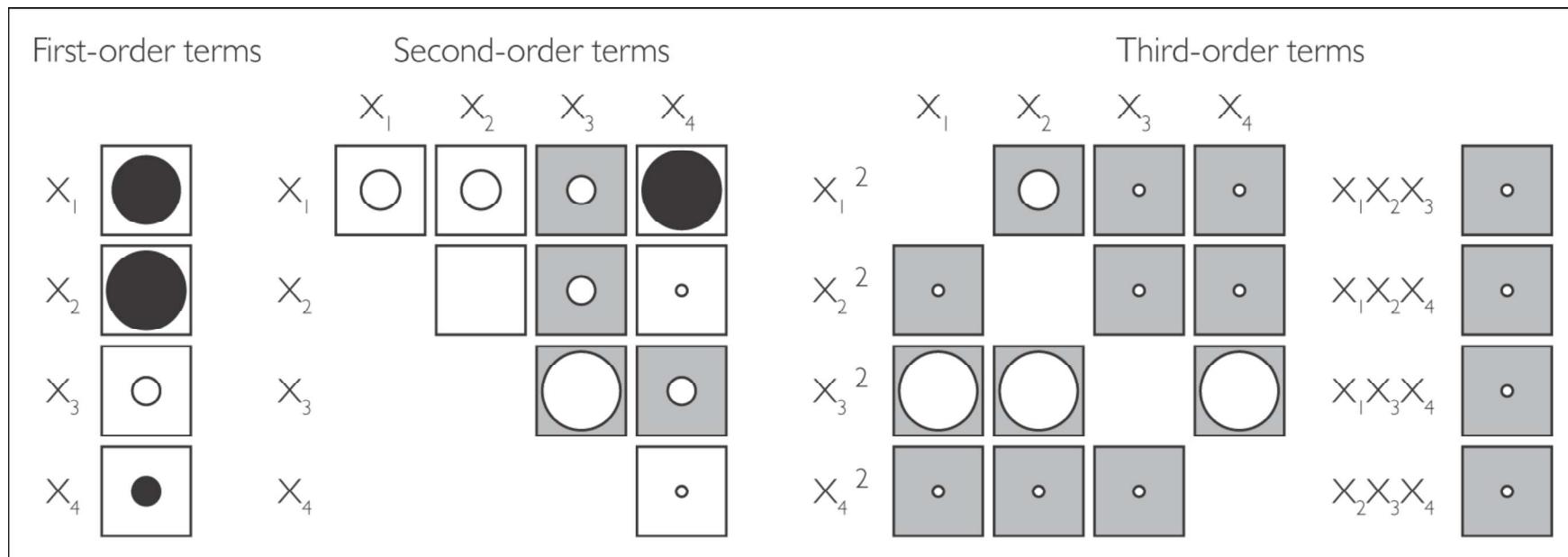
Scent example

- The value of Y has been measured or calculated for six different values of X. The task is to find a simple mathematical function that relates Y to X with acceptable accuracy
- A statistical package will calculate the coefficient of the following equation
- It is crucial decide what terms are significant
 - X_1X_2 ?
 - X_1X_3 ?
 - ...



$$Y = a + bX_1 + cX_2 + dX_3 + eX_1X_2 + fX_2X_3 + gX_3X_1 + hX_1^2 + jX_2^2 + kX_3^2$$

The model maker interface



- SM and SI are encoded by the box
- White : included in the model , black not
- Size: the extent to which that term is beneficial to the fitting process
- They provide a clear scent of the next steps

A weighted menu



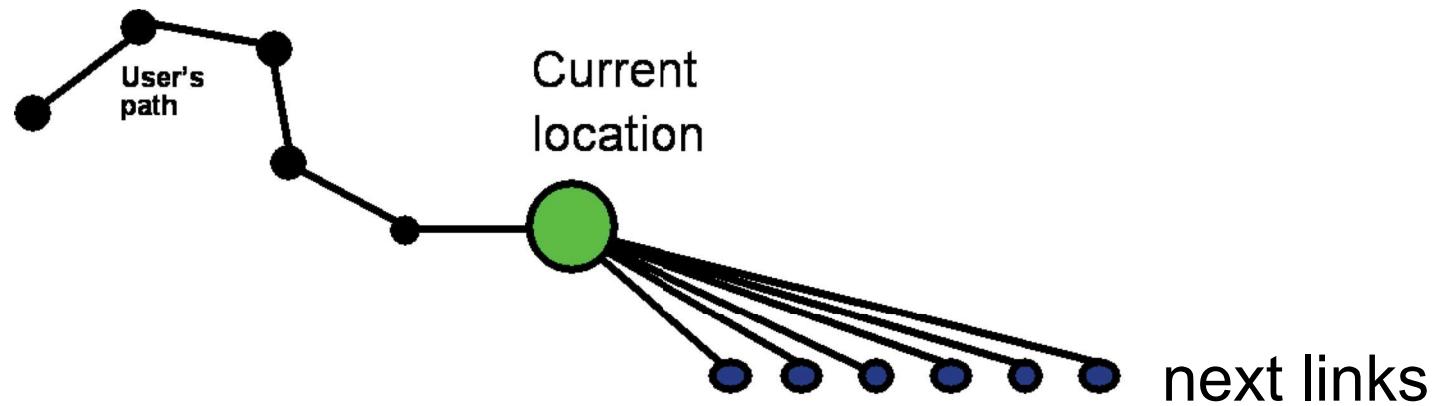
The size denotes the extent of the data connected to the menu item

Where am I ?

- Where can I go from here?
- How do I get there?
- What lies beyond
- Where can I usefully go from here?
- Where I have been? I want to go back!
- Two kind of breadcrumb trails
 - path breadcrumbs
 - location breadcrumbs

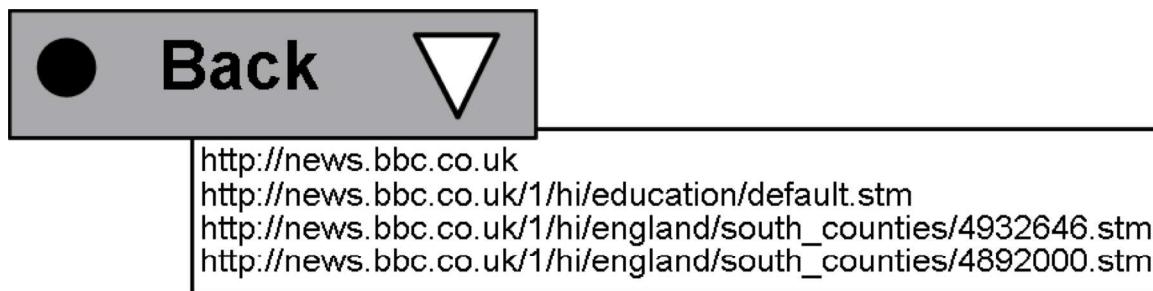
Path breadcrumbs

- They represent the user path in the information space
- They represent recent location AND SIs
- They favorite selective retreat, a very common web browsing activity (60% of WWW activities...)

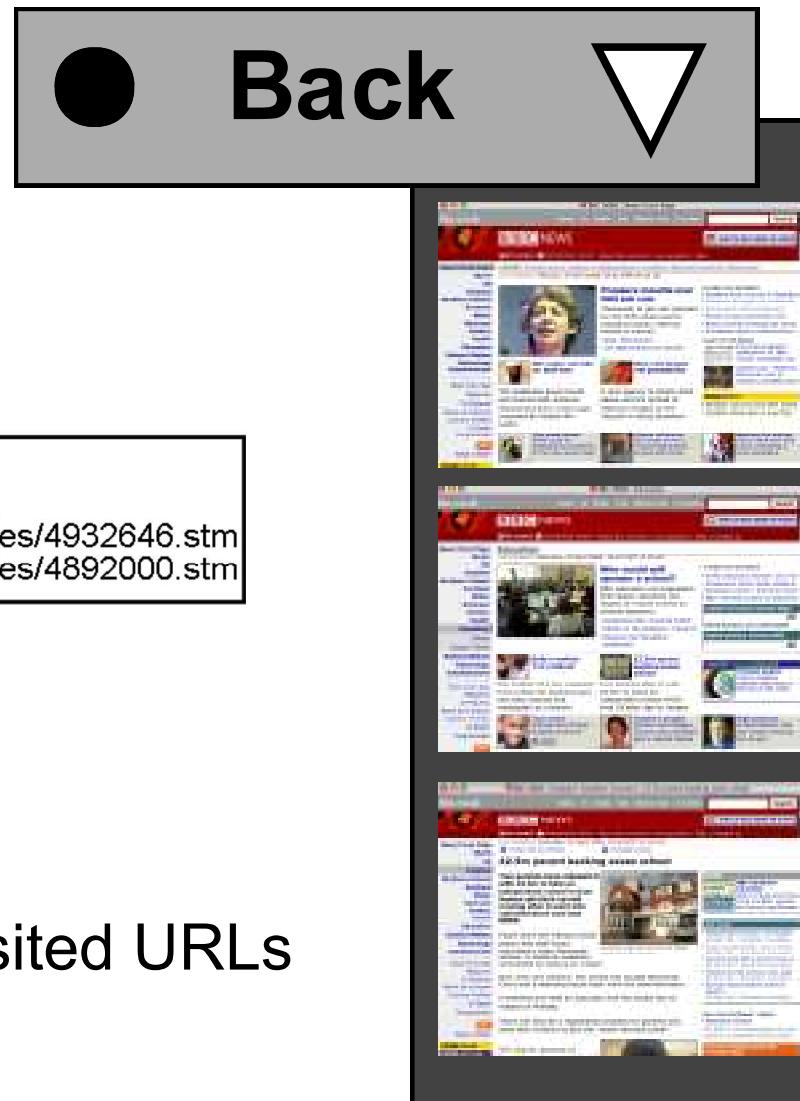


A representation of history leading to the current location

Browser history

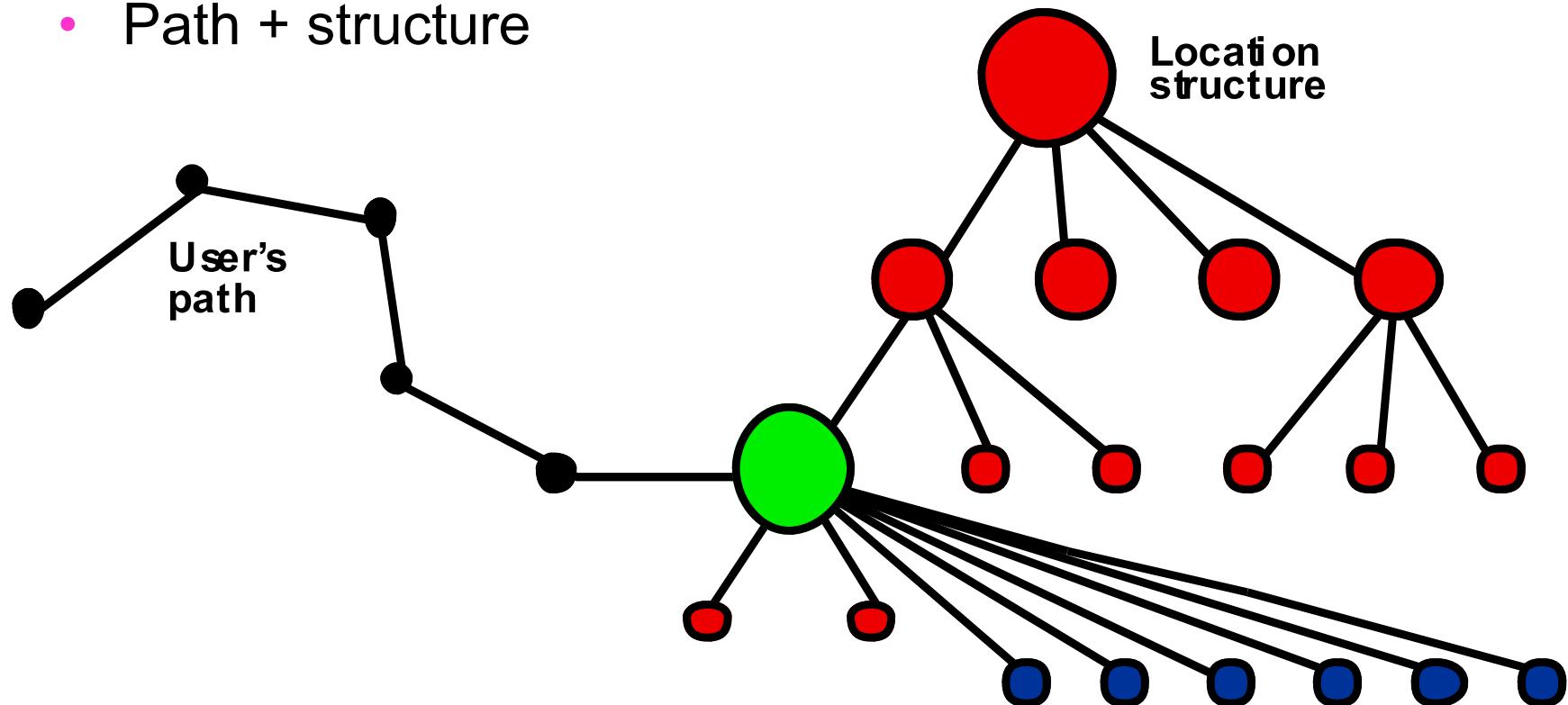


An ordered list of recently visited URLs



Location breadcrumbs

- Path + structure



Location breadcrumbs (red) provide an awareness of the structure of a site within which the current location resides

Path breadcrumbs within the site

The screenshot shows a website for Sandbanks Hotel. At the top, there is a purple header bar with the hotel's name, "Sandbanks Hotel". Below the header, a breadcrumb navigation trail is displayed in a light blue bar, enclosed in a red rectangular box. The trail consists of the following items: "Fine Hotels - Home > England > Poole > Sandbanks Hotel". A black arrow points from the text "Path breadcrumbs within the site" to this redboxed area. The main content area below the breadcrumb bar features the hotel's name again, its address ("15 Banks Rd, Sandbanks, Poole, Dorset, BH13 7PS"), and a photograph of the building and surrounding area. To the right of the photo, there is promotional text about a "special offer" for a "Family Special" available from Sunday 03 April 2005 to Thursday 07 April 2005. Below this, another text block reads, "One of the first impressions you will...". To the far right, there are two vertical boxes: one for "Prices" (Rooms from £6) and one for "Location" (Bournemouth, Nearest Major...).

Sandbanks Hotel
15 Banks Rd, Sandbanks, Poole, Dorset, BH13 7PS

special offer Family Special available from Sunday 03 April 2005 to Thursday 07 April 2005

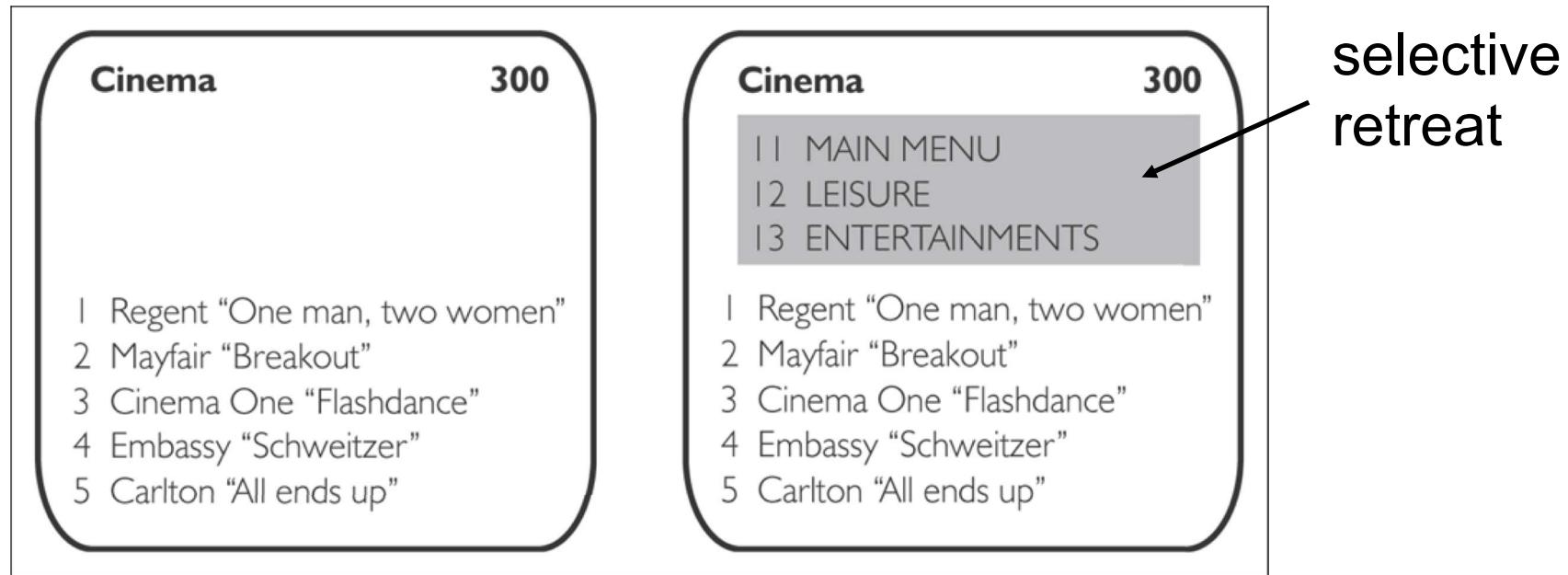
One of the first impressions you will...

Prices
Rooms from £6

Location
Bournemouth, Nearest Major...

An example of path breadcrumbs within a website

A menu with path breadcrumbs



Two menu systems investigated by Field and Apperley (1990)
The selective menu performs better (50% accessed pages vs 40%, 50% efficiency vs 63 %) and gives a better understanding of the database structure

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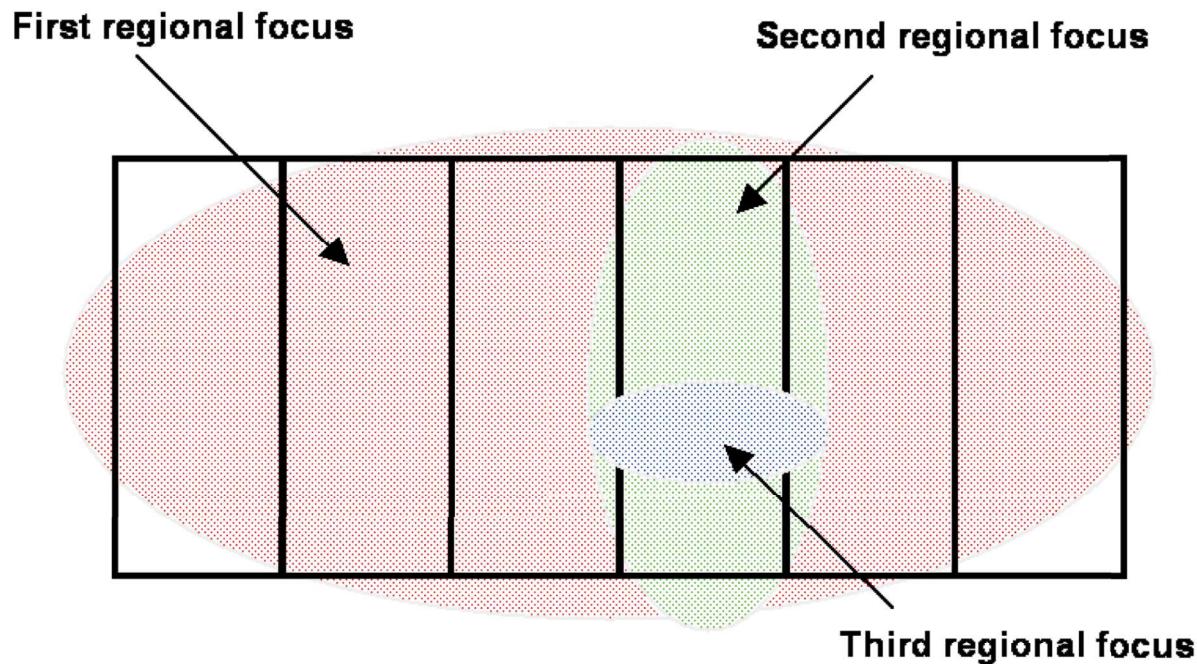
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Passive interaction

- During a typical use of a visualization tool most of the user's time is spent in this activity
 - observing the screen and being involved in high cognitive processes
- It does not implies a static display
- Static display
 - designed to answer a specific question (Minard's map)
 - authored by the user

Eyes's browsing

- Exploratory browsing
 - get a model of the scene
- Opportunistic browsing
 - just see what's there
- Involuntary browsing
 - not associated with conscious intent



Visual browsing undertaken by a person with an interest in books on cognitive psychology, on approaching a book display. The first regional focus (red) **explores** the entire collection to establish a new focus (green) associated with psychology. As a result of the **exploration** of the green region a new region of focus (blue) is established concerned with cognitive psychology

Moving displays

- Still passive interaction
- Data driven : the user is not controlling the motion



time

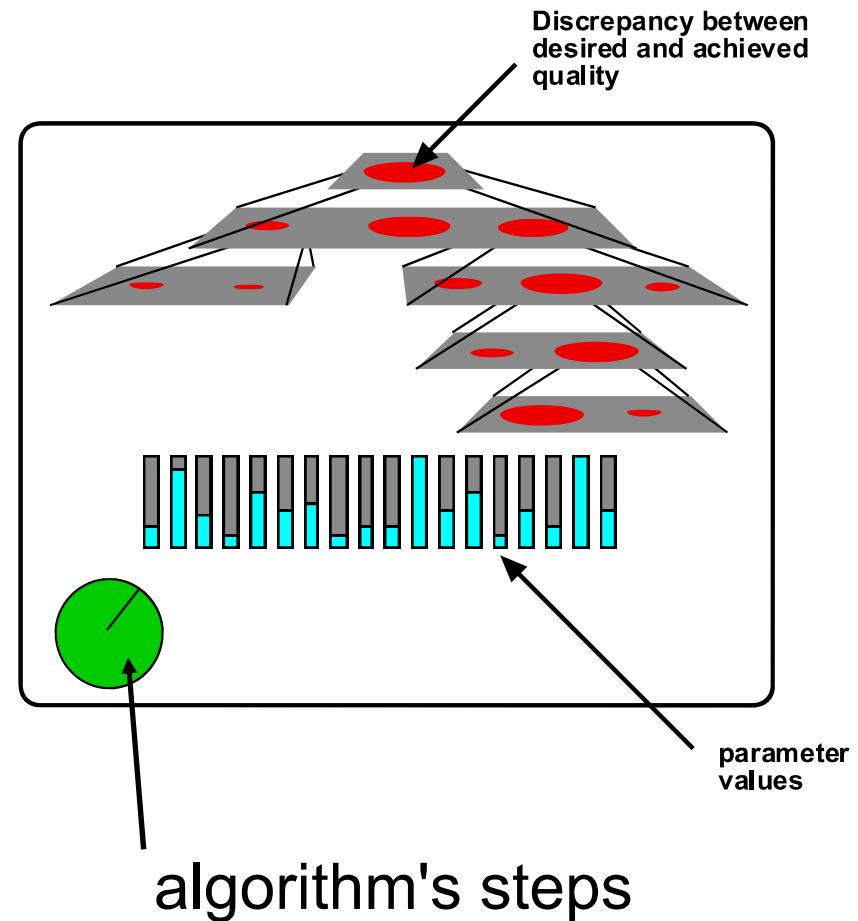


etc.

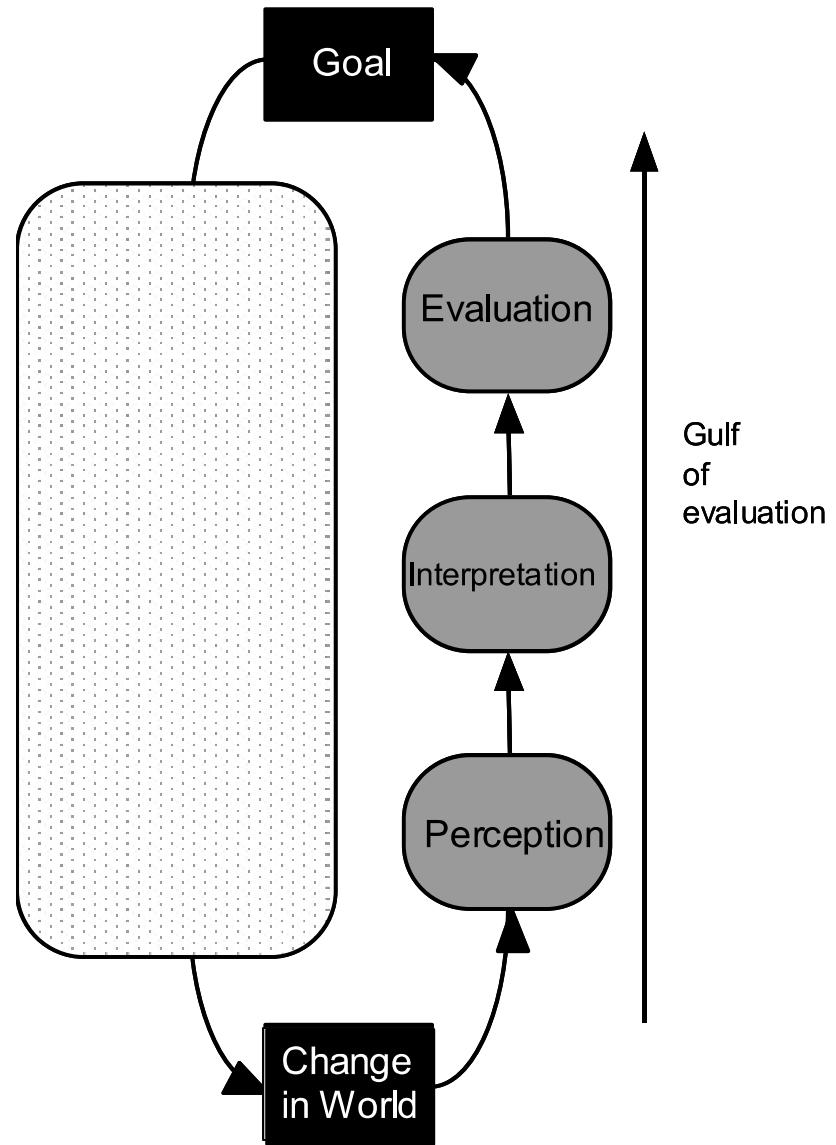
A continuous sequence of representations of the US dollar – euro exchange rate

Moving displays

Sketch of the ‘cockpit’ of a computer-aided circuit design system supporting the human guidance of automated design. The clock hand rotates in discrete steps to represent the iterative behaviour of the optimisation algorithm. Simultaneously, the parameter values chosen by the algorithm and the various performances of the designed circuit are represented, respectively, by the size of the blue bars and red circles. At any time the designer can halt the algorithm and adjust either the details of the algorithm or certain allowed limits to circuit performance



Involuntary browsing at a coffee table



Norman's Action Cycle for involuntary browsing

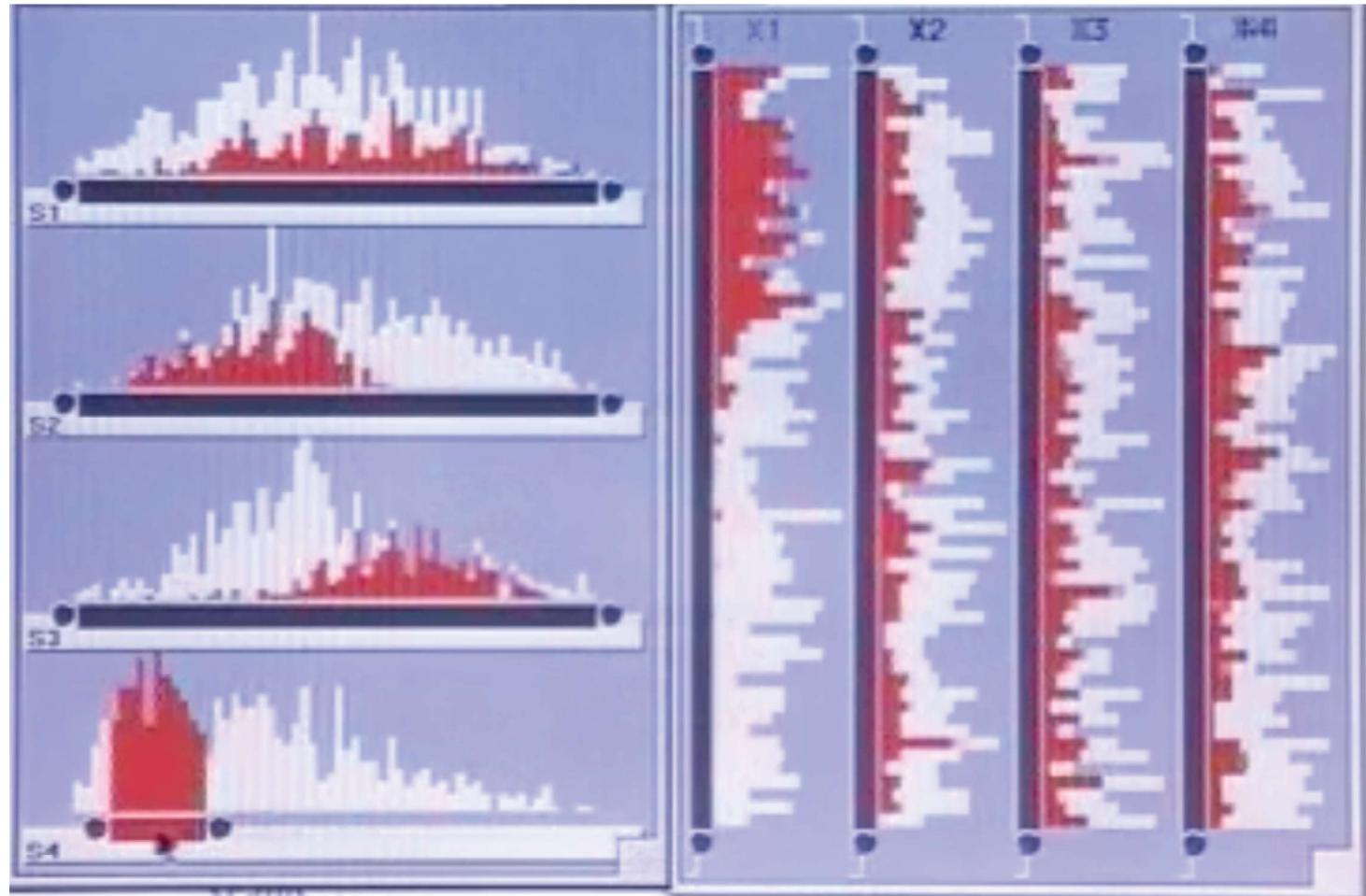
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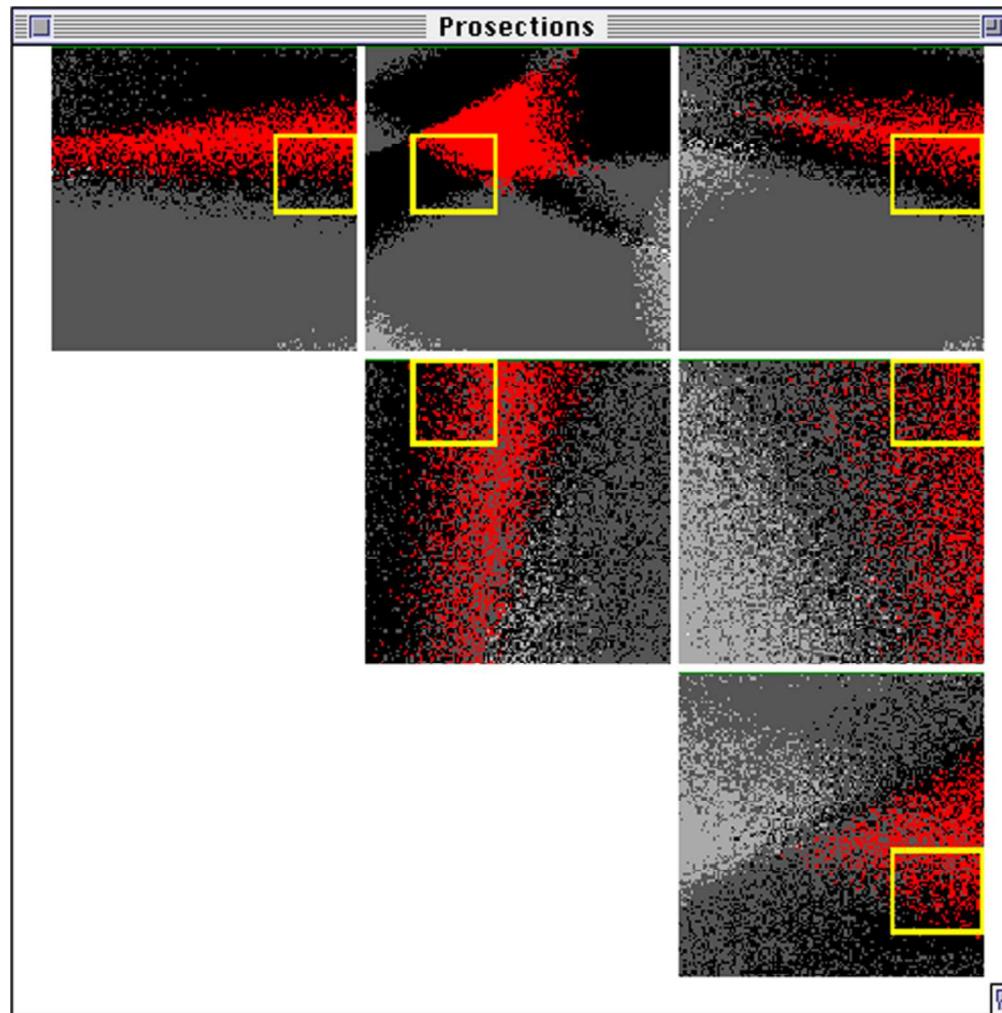
Composite interaction

- Real cases require a mixture of the interaction modalities discussed so far
- E.g. Large data set
 - stepped interaction to locate the subset of data
 - continuous and passive interaction to explore the subset
- E.g. Controlling an algorithm behavior
 - observing algorithm's step with passive interaction
 - stepped interaction to change parameters

Back to the lamp design example



Continuous interaction: limits placed on the four stresses S1 to S4 have been brushed into the parameter histograms, with red designs indicating those which satisfy all limits on S1, S2, S3 and S4



A scatterplot matrix associated with a design involving four parameters. Red indicates the location of designs that satisfy all performance limits. Yellow defines the regions within which the designs of a mass-produced design will lie as a result of manufacturing tolerances on the parameters

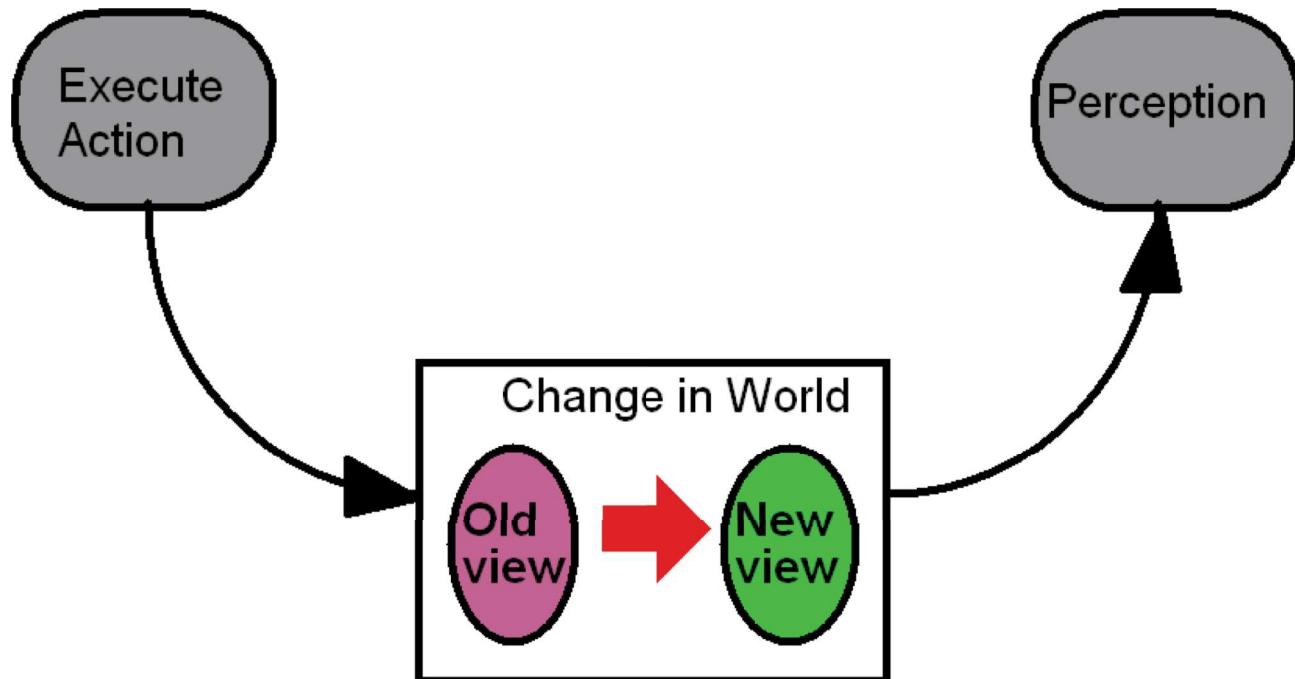
Several years later....

- Claire

Outline

- Interaction and scenarios
- Information space and user interaction
- User intention and interaction framework
- Continuous interaction
- Stepped interaction
- Passive interaction
- Composite interaction
- **Interaction dynamics**
- The last palette

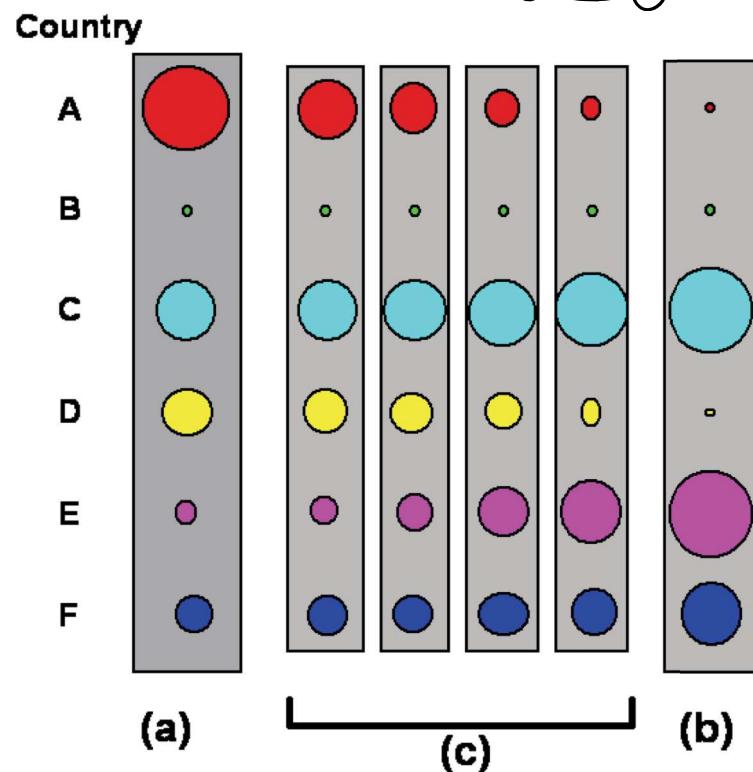
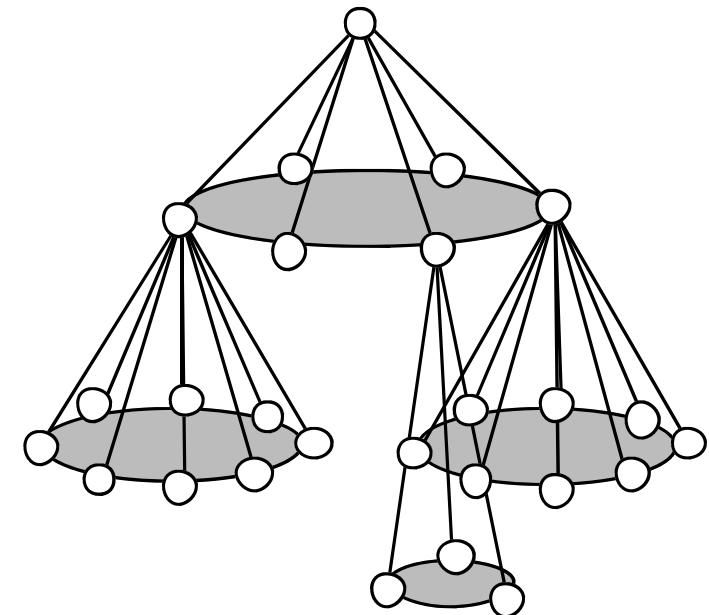
Interaction dynamics



With information visualization, Norman's 'change in world' consists of an old view of data being replaced by a new view

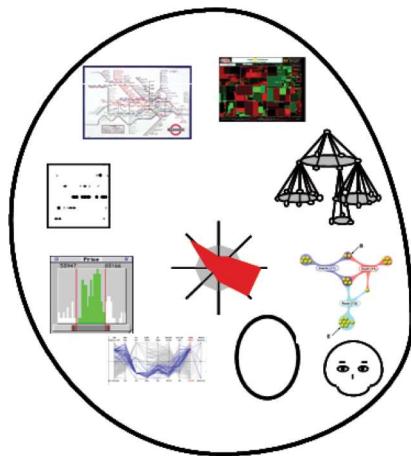
Blindness

- Change blindness
- Inattentional blindness
- Animation
- Visual momentum
 - presentation structure as constant as possible

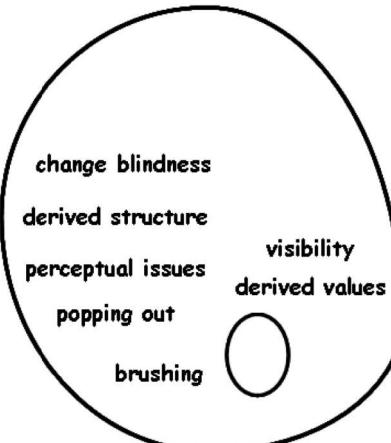


Outline

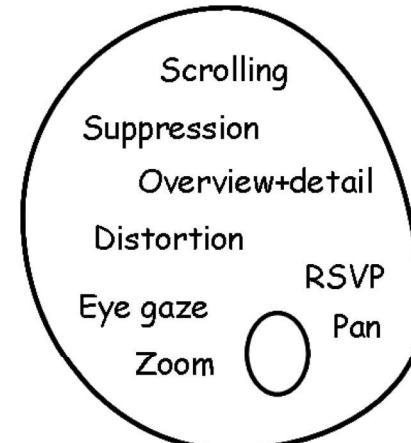
- Interaction and scenarios
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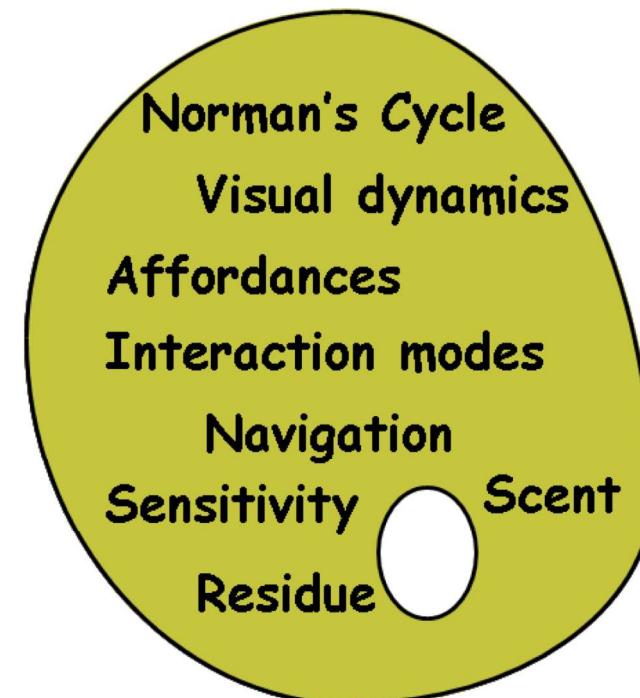
Techniques



Concepts



Presentation



The last palette