

Preattentive Processing

Dr. Gaurav Bansal

Preattentive Processing

- Preattentive processing occurs “at a glance” (reacting to stimuli without thinking).
- It requires no conscious effort from the user (or viewer) to do this processing – it’s automated and takes less than 500 milliseconds to complete.
- This can be very useful in design and in particular in information visualization design because it allows the designer to grab the attention of the user without their input or effort.
- This in turn allows for increased complexity of data that must be processed in short-term memory.
- If the low-level visual system can be harnessed during visualization, it can be used to draw attention to areas of potential interest in a display.

Preattentive processing helps threes stand out “at a glance”

How many threes?

45929078059772098775972655665110049836645
27107462144654207079014738109743897010971
43907097349266847858715819048630901889074
25747072354745666142018774072849875310665

How many threes?

45929078059772098775972655665110049836645
27107462144654207079014738109743897010971
43907097349266847858715819048630901889074
25747072354745666142018774072849875310665

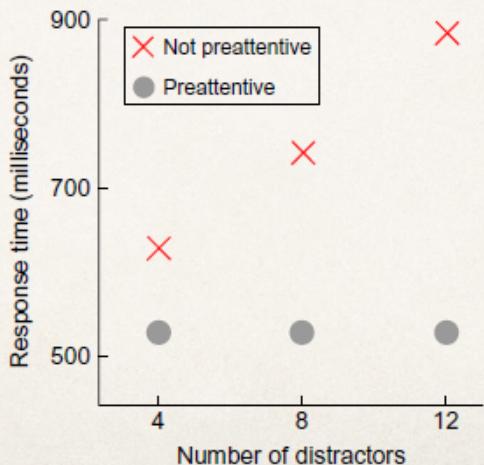
Preattentive Duration

Preattentive vs Attentive

pre-attentive attentive

parallel

serial



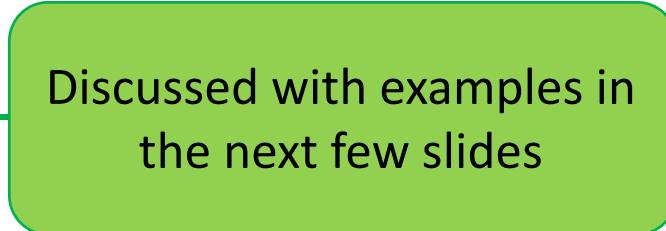
No matter how many distractors there are, in preattentive processing, the time taken is equally fast i.e. around 500 ms. (Ware, 2004)

Preattentive processing – time taken is same around 500ms irrespective of number of distractors whether 4 or 12

Preattentive Features

The following features can be assessed easily by the viewers without indulging in sequential processing:

- Form
- Color (Hue)
- Motion
- Concave / Convex



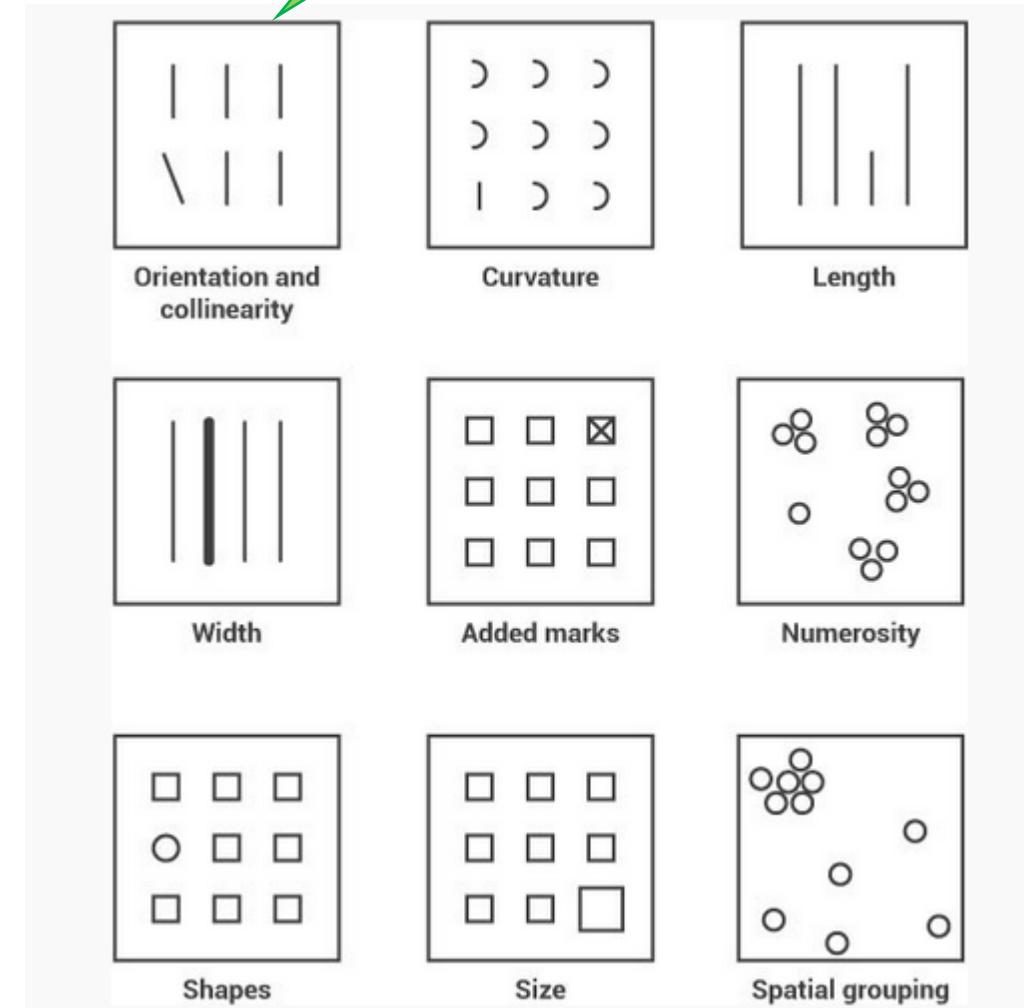
Discussed with examples in
the next few slides

Preattentive Form Features

For instance, we can see that line orientation can be assessed without indulging in sequential processing

Form:

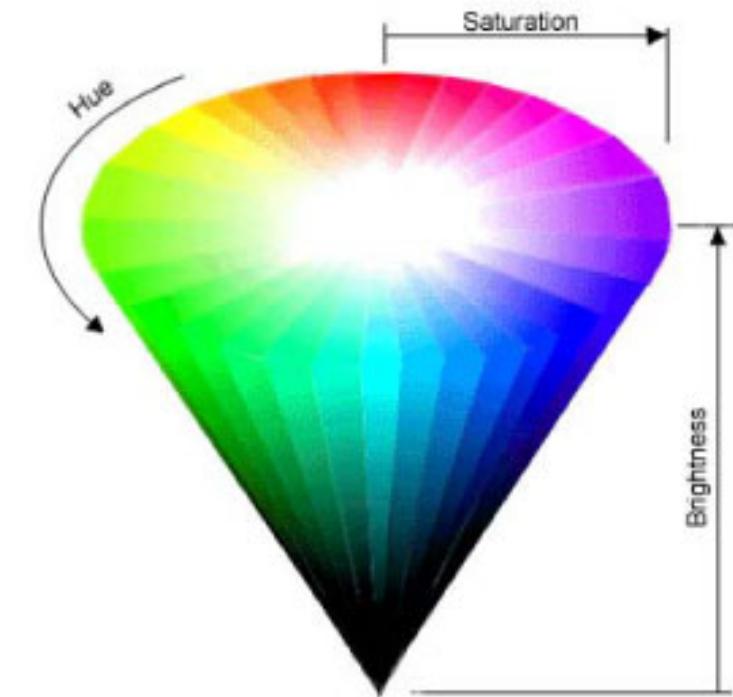
- Line orientation
- Curvature
- Line Length
- Line width
- Added marks
- Numerosity (one, two, or three objects)
- Shapes
- Size
- Spatial grouping



Preattentive Color Features

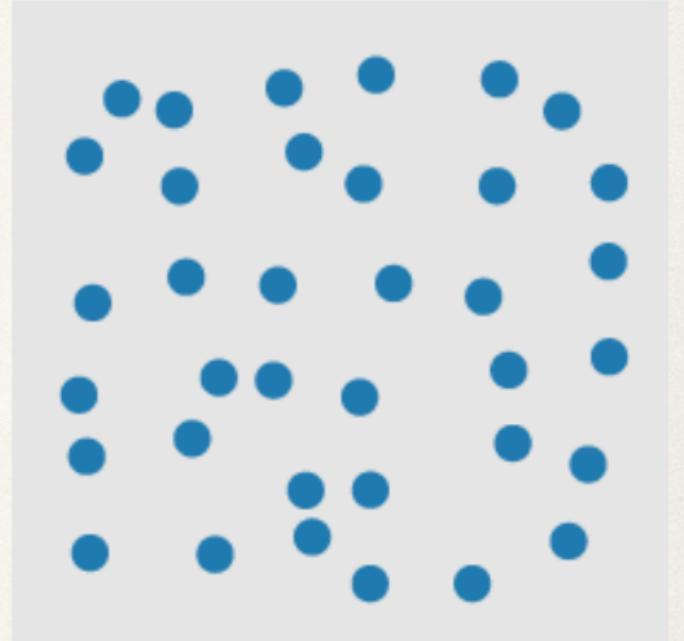
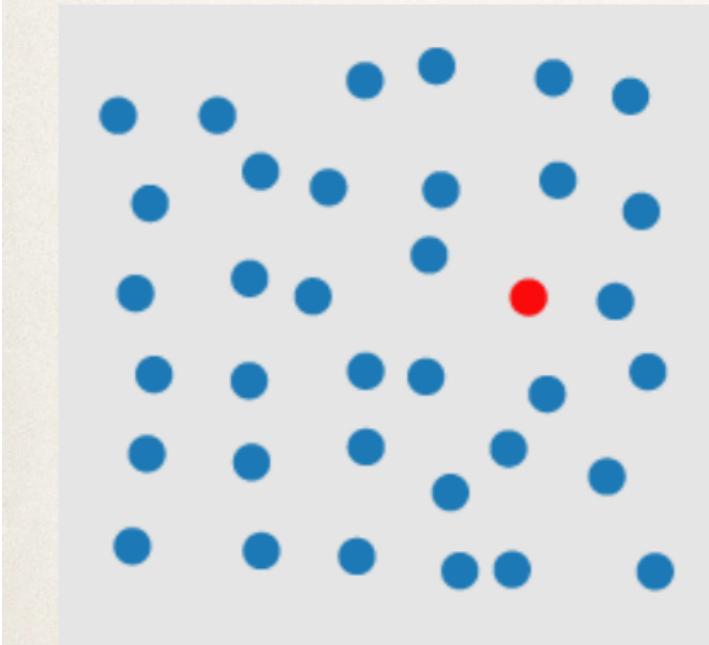
Change in Hue, Saturation, and Brightness works as a preattentive feature.

- **Hue:** the actual color
- **Saturation:** the purity of the color, measured from the center of the cone (0) to the surface (100) meaningless.
- **Brightness:** measured in percent from black to white, both hue and saturation are neutral



Preattentive Features: Color

Is there a red circle?



Preattentive Motion Features

Motion

- Flicker
- Direction of Motion

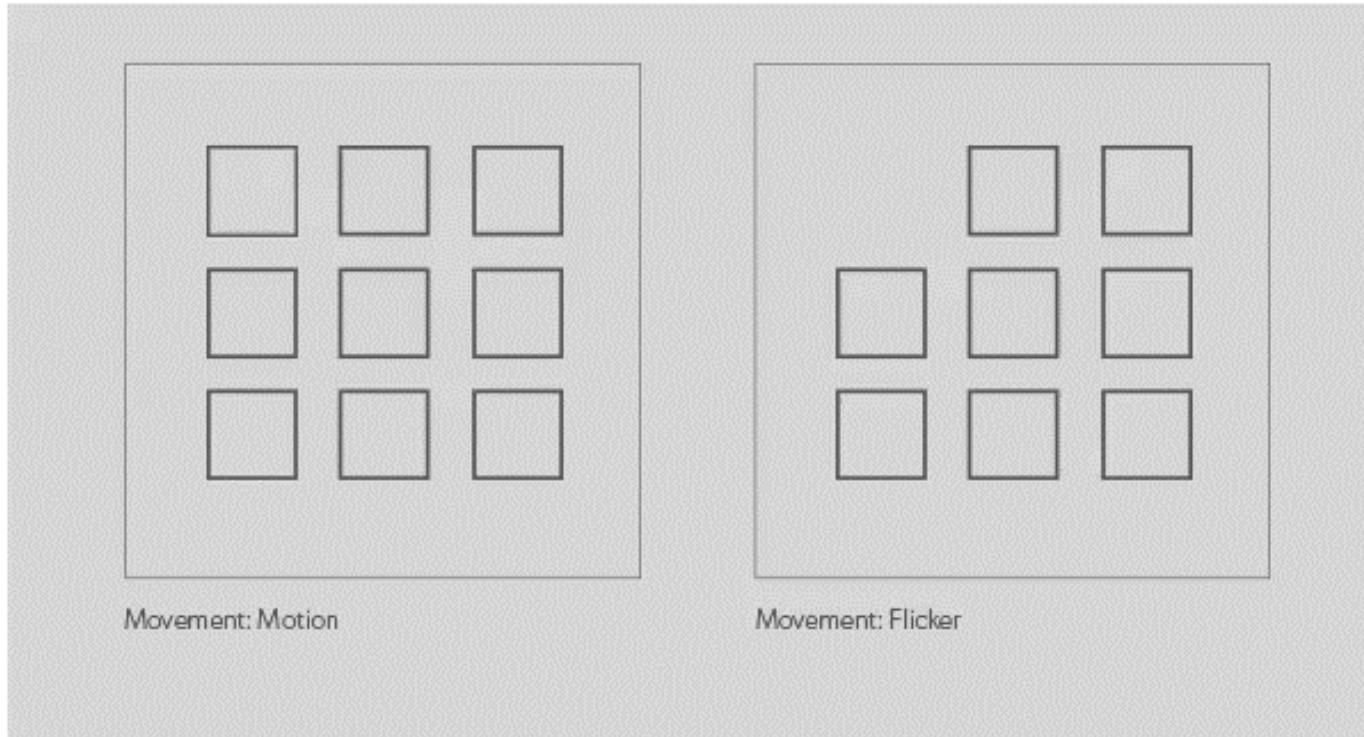
Motion is much more effective than change in color or shape, especially when the signal is farther from the focus of attention.

Moreover, motion can persistently attract attention, unlike a change in an icon, such as the raising of a mailbox flag , which fades rapidly from attention.

Motion is “annoying”, and hence needs to be used carefully in advertising.

Reference: Ware, C. (2012). *Information visualization: perception for design* (Third Edition). Morgan Kaufmann.

Flicker vs. Motion

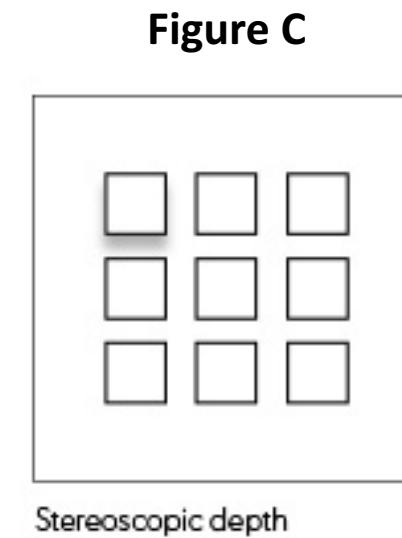
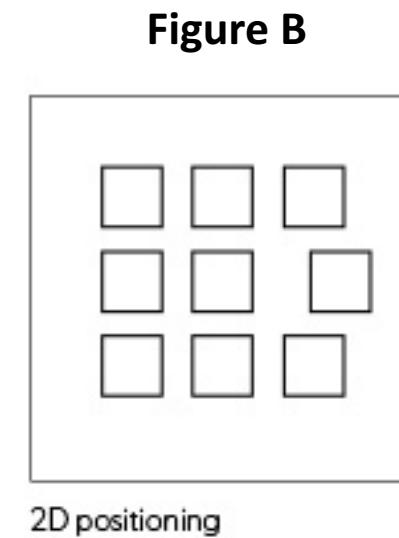
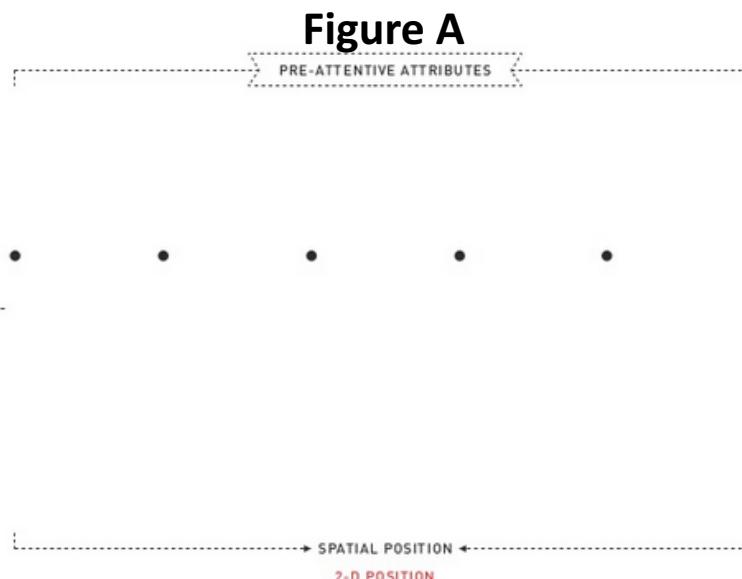


Click the picture
to play the video
clip.

Preattentive Spatial Position Features

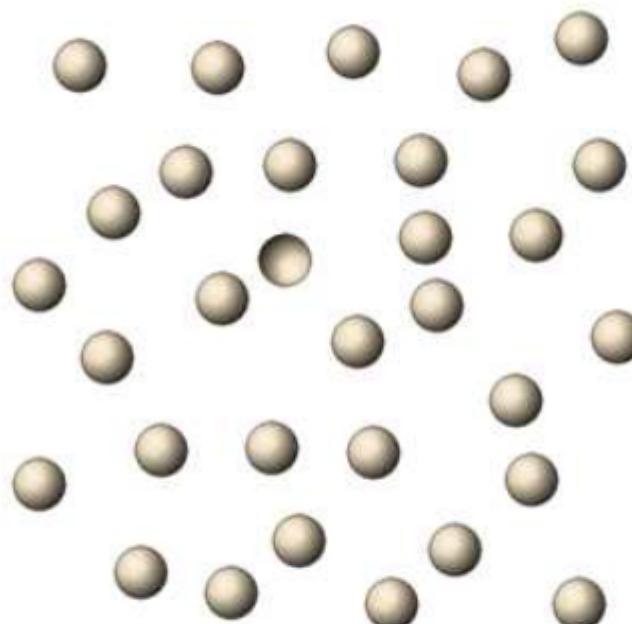
Spatial Position serves as Preattentive Feature as well.

- Two-dimensional position (Figures A and B)
- Stereoscopic depth (Figure C)



Convex / Concave shape from shading

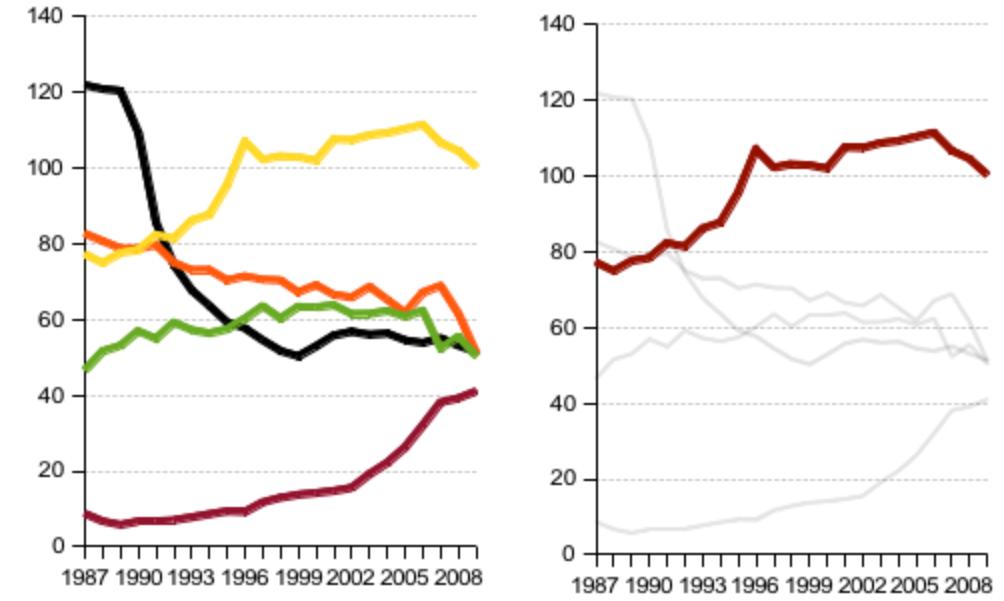
The same circle, if we shade at bottom, looks concave. If we shade at top, it looks convex. We subconsciously know that light comes from the top, so concave surfaces have shadow at the bottom.



Change in shape i.e. convex object surrounded by concave ones (or vice-versa) is processed “preattentively”

Rules of Thumb

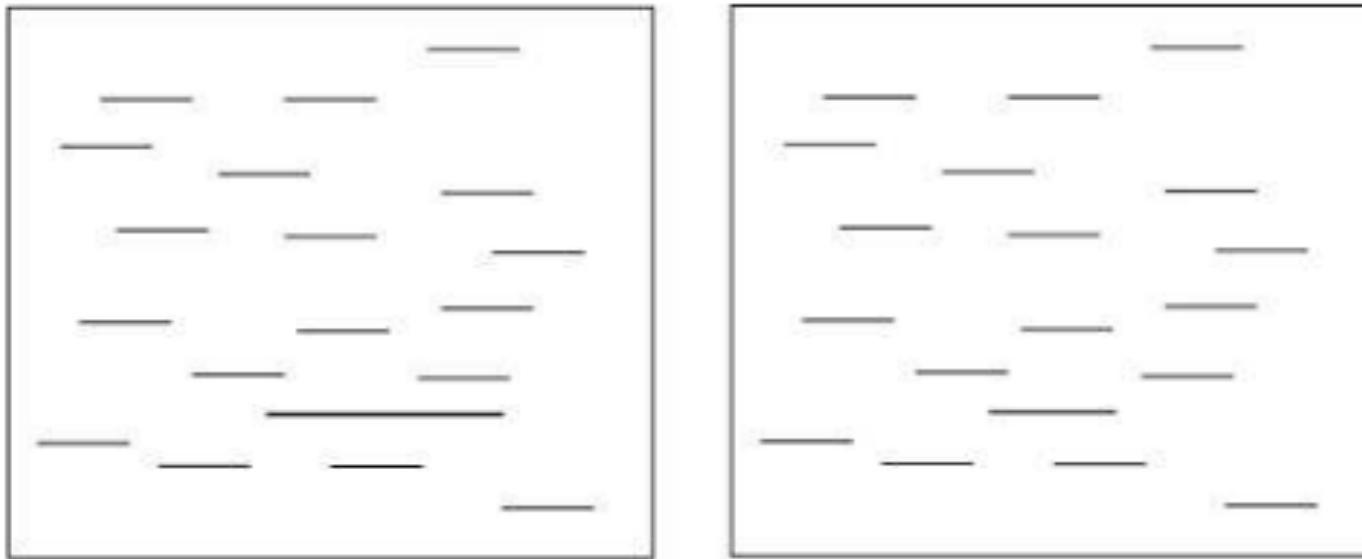
- Use strong preattentive cues before weak ones where ease of search is critical.
- For maximum pop out, a symbol should be the only object in a display that is distinctive on a particular feature channel; for example, it might be the only item that is colored in a display where everything is black and white.
- If symbols are to be preattentively distinct, avoid coding that uses conjunctions of basic graphical properties.



Example: Graph on the right uses the “preattentive cues” to highlight the story pertaining to the red line!

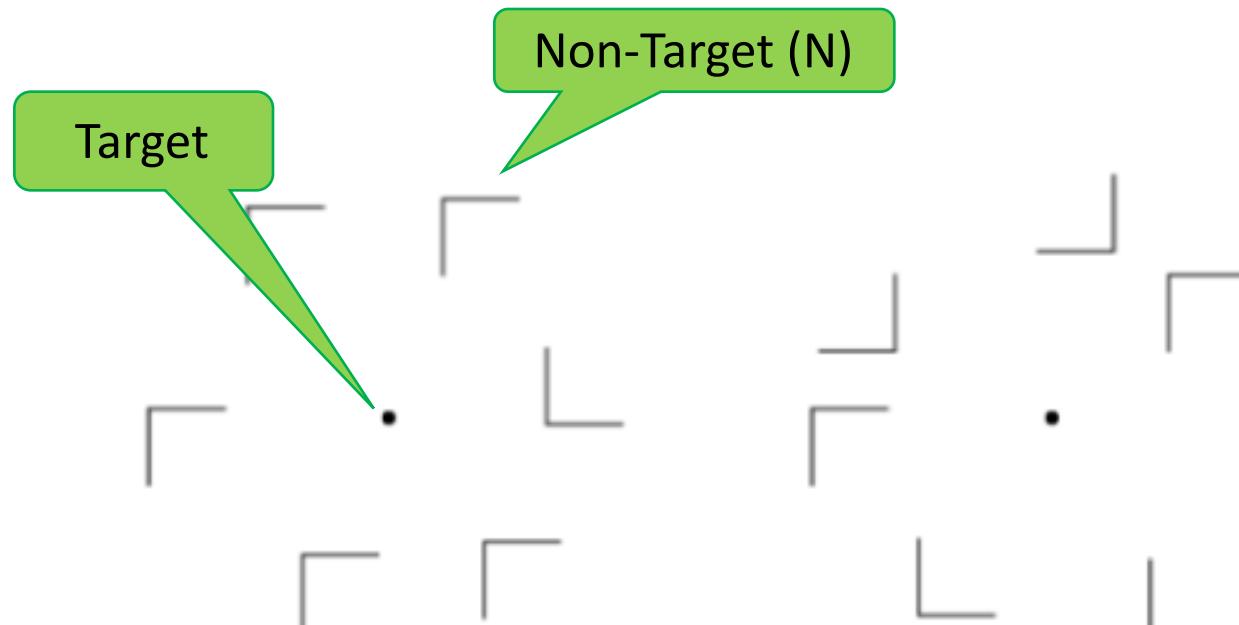
Some Notable Points

Feature Integration Theory



According to Feature Integration Theory for Preattentive Processing, the left figure is more preattentive than the right one because the target has a higher degree of difference to its distractors (Treisman and Gormican, 1988)

Similarity Theory



High N-N
Similarity

Low N-N
Similarity

According to Similarity Theory of Preattentive Processing, the left figure is more preattentive than the right one because it has higher similarity among the non-targets (termed as High N-N Similarity). The right figure has low N-N similarity that causes longer search time.

Reference:

Attention and Visual Memory in Visualization and Computer Graphics

Christopher G. Healey, Senior Member, IEEE, and James T. Enns

Number of Target Items

The popout effect also depends on the number of target items.

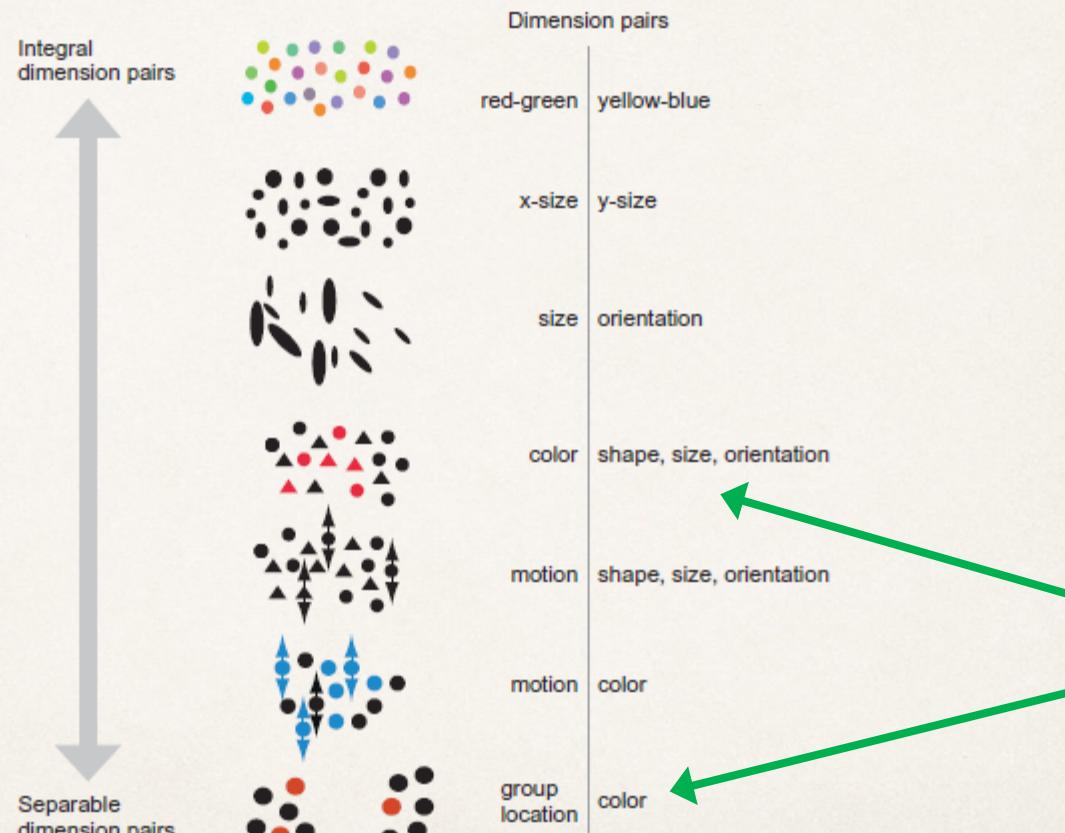
It is easy to recognize one to four objects in a group at a glance.

It gets usually a lot harder if the number of objects increases beyond four, because explicit counting (sequential processing) gets necessary then (Ware, 2004).

Conjunctive Preattentive Processing

Conjunctive search where more than one element is present (example: color, position, shape, size, orientation etc.)

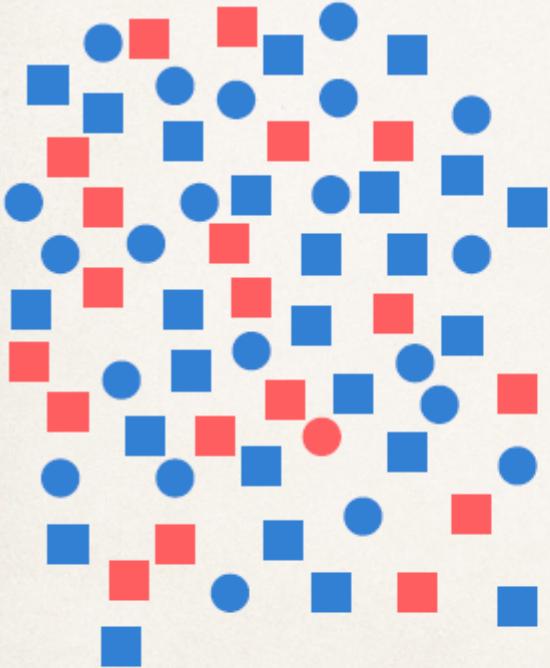
Integral - Separable attributes



Although early research suggested that conjunction searches were never pre-attentive, it has emerged that there are a number of pre-attentive dimension pairs that do allow for conjunctive search.

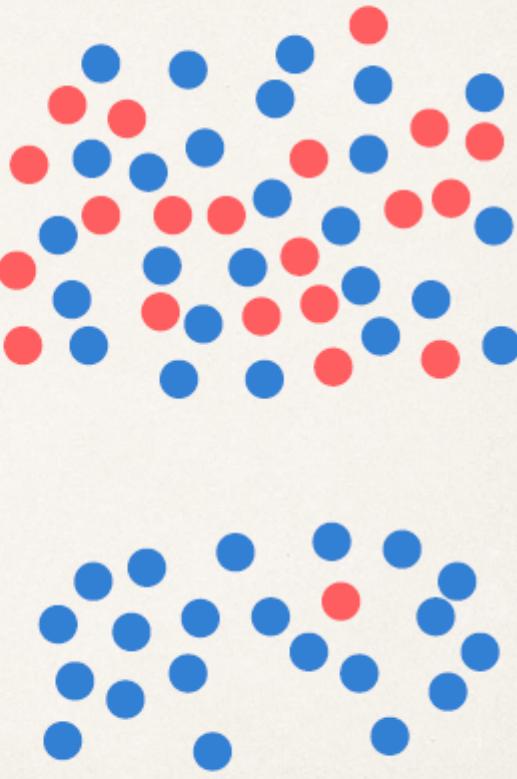
Example: **color and position** are easier to separate than **color and shape**.

Preattentive conjunctions



Color and shape

Figure A



Color and position

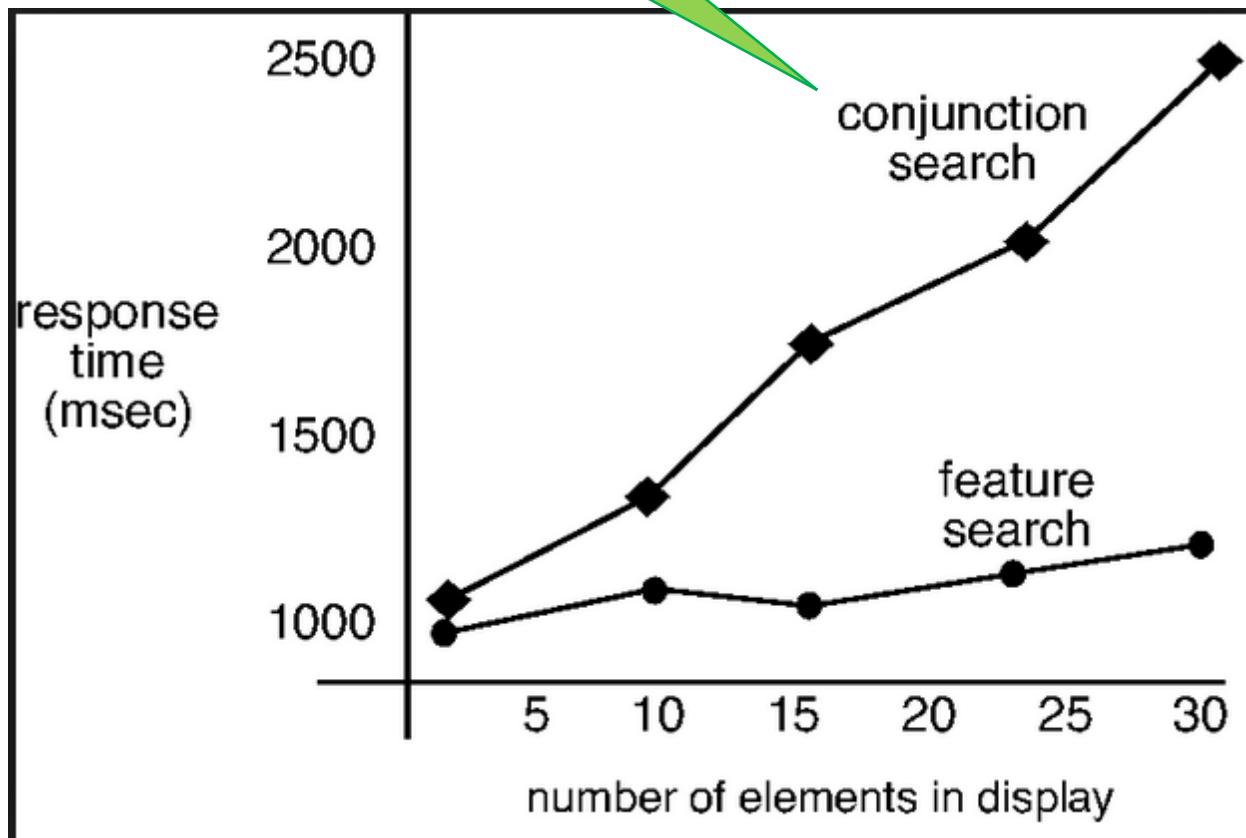
Figure B

Conjunctions in Figure A:
Color and Shape

Conjunctions in Figure B:
Color and Group Position

It is easier to detect the target from conjunctions of color and group position, than from conjunctions of color and shape.

Conjunction search: Where you have more than one attributes (e.g., shape and color) both changing



As number of elements goes up in conjunction search one needs more response time to detect the target

Figure 1 has two changing attributes, whereas Figure 2 has three changing attributes. Thus it is easy to detect the target in Figure 1 as opposed to Figure 2.

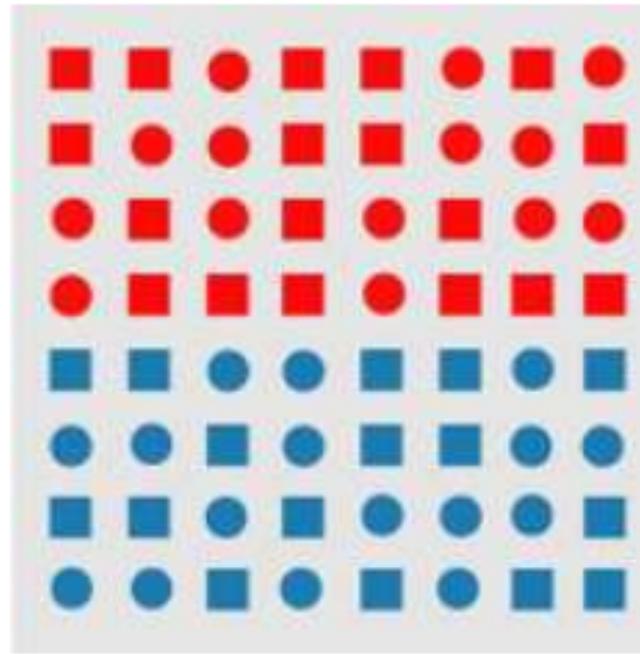


Figure 1

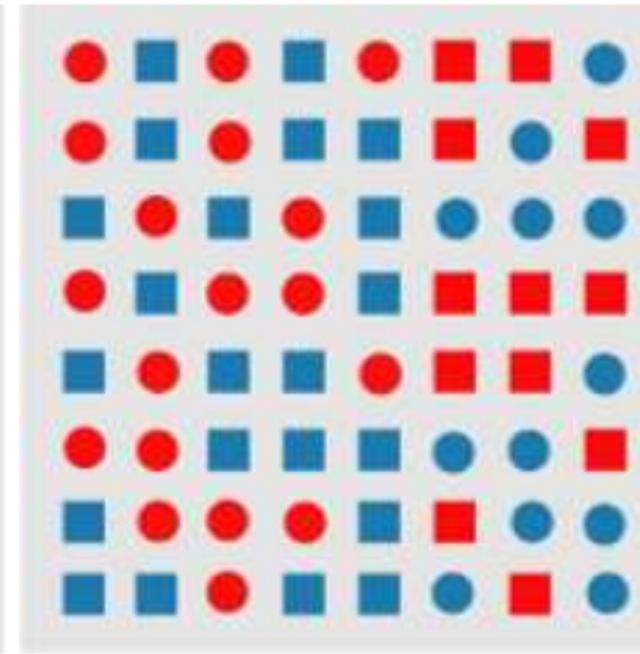


Figure 2

Attributes of Preattentive Processing (Stephen Few)

Type	Attribute	Quantitatively Perceived
Form	Length	Yes
	Width	Yes, but limited
	Orientation	No
	Size	Yes, but limited
	Shape	No
	Enclosure	No
Color	Hue	No
	Intensity	Yes, but limited
Position	2-D Position	Yes

Not all attributes are quantitatively perceived. We can infer quantitative differences in length preattentively. However, we cannot perceive the quantitative differences with same ease and speed when examining two lines at different angles.

Explanatory V. Exploratory Analysis

Preattentive processing is particularly useful in telling explanatory stories (as opposed to exploratory analysis).

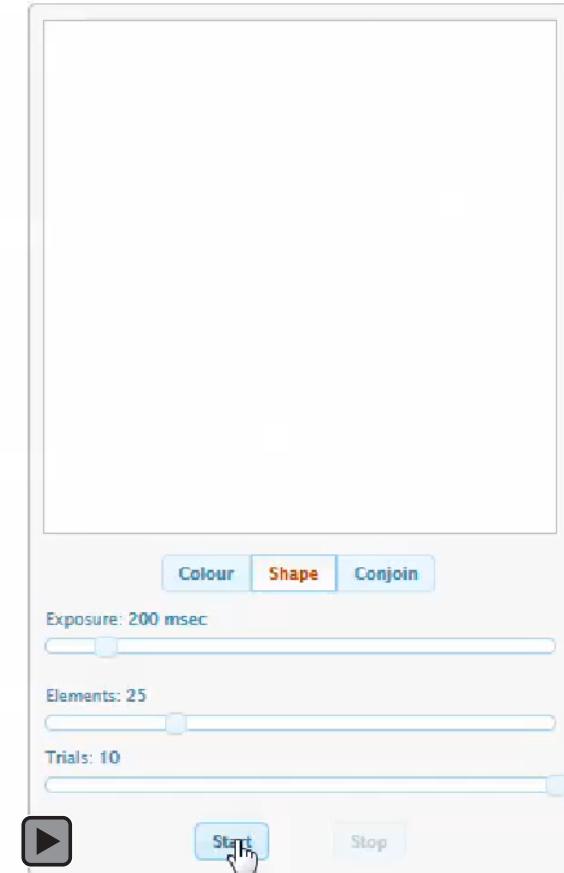
Reference: Knaflic in “Story telling with Data.”

Activity for Fun!

Color



Shape



Click the pictures to play the clips.

Note: You will need to download this .pdf document for the images to play correctly. Use the

 Download

button at the bottom of the page.

Activity

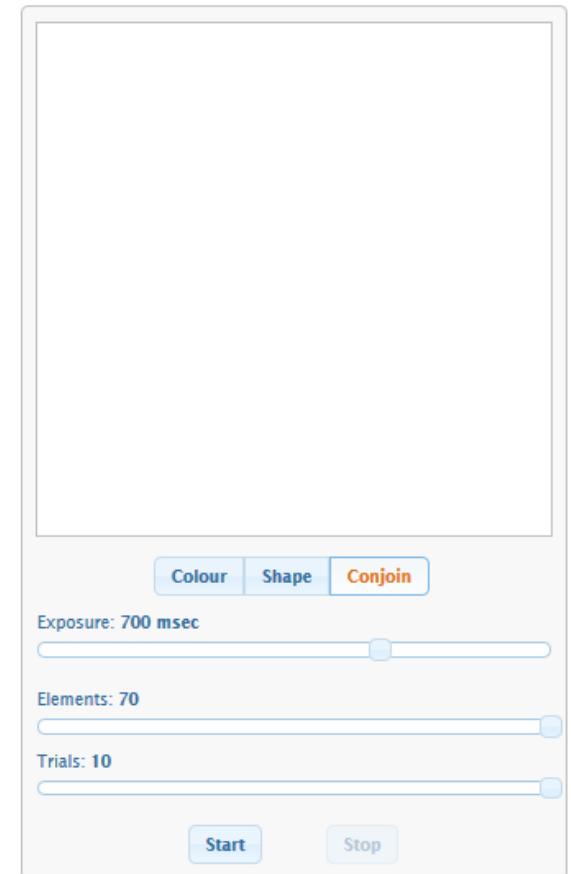
Play with the JavaScript applet found at:

https://www.csc2.ncsu.edu/faculty/healey/PP/index.html#jscript_search

What happens when you:

- decrease/increase the exposure time and increase/decrease the number of elements?
- you are examining conjoins with varying exposure time and number of elements?

Document your observations and reflect on how preattentive processing could be a useful tool in creating effective visualizations





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