CPSC 532E — Seminar (week 2)

Preattentive Vision I

- Visual search; attentional “pop out”
- Visual “primitives”
- Applications to display design

Visual Tasks

For many real-time tasks, **speed** is essential
  - driving, supervisory control, teleoperation
For many other tasks, finding **relations** is essential
  - numerical estimation, data mining
**Ease of use** (minimal fatigue) is also important

-> Very useful to have “at-a-glance” displays
   How to do this?

Much of this depends on **visual attention**
Attention important in two main ways:

1) What draws attention (alerts)
2) What are attentional units

Both of these processes depend on what happens prior to attention

- preattentive vision
  (rapid vision)

“An understanding of what is processed preattentively is probably the most important contribution that vision science can make to data visualization”

(Ware, p.163)
1. Rapid (Preattentive) Vision

Look first at initial stages of visual processing

1. Transduction stage (light to pixels)
   - minimal interactions

2. Primary processing (pixels to edges)
   - local inhibition/ excitation

What properties are determined at the earliest level?

1. (Retinal)
What properties are determined at the earliest level?

2. (Retinal)

Characteristics of initial (early) stage of processing:

- rapid — less than 200 ms
- spatially parallel
- local operations (poor spatial coherence)
- volatile (poor temporal coherence)
- automatic — no conscious effort

Properties at this level are visual primitives ("graphemes" (Ware))
How does this show up in visual perception?

Where's the blue dot?

Visual Search: Measure time to determine presence (or absence) of a given target

Unique color is easy to spot when few other items around
Also easy to spot when many other items around.

For color, a unique value is always easy to notice.

Reaction time does not depend on number of items

-> “pop-out”
Similarly with orientation…

Unique orientation is easy to spot when few items around

Also easy to spot when many other items around
For orientation, a unique value is always easy to notice

In general, “pop-out” is an indicator of a visual primitive - a unique value automatically draws attention

“Visual primitives”

An item will automatically pop out if it has a unique
- color
- intensity
- orientation (2D)
- size (length)
- curvature
- motion
- stereoscopic depth

created rapidly and in parallel

These properties will always draw attention
Visual primitives are coded coarsely:

Colors: At least six basic colors
   (black, white, red, green, blue, yellow)

Orientation: At least 3-4 orientations
   (30-45° separation between primitives)

Note: smaller separations between colors and orientations is possible for some tasks
   - Healey et al (1996) - numerical estimation
     - color: 1.5 hue steps (Munsell)
     - orientation: 15° separation

Note: Unique items are not always easy to notice

Unique L-shaped item is not always easy to spot
And this gets more difficult as more items are in display

For L-shapes, reaction time depends on number of items

Reaction time depends **linearly** on number of items
Two response patterns:

**Rapid search**
- target has a unique property that is **primitive**
  (dimension)

**Slow search**
- target has unique property that is **not primitive**.
  (arrangement not primitive)

Interpretation (Treisman & Gormican, 1988):

**Rapid search:**
- Visual primitives calculated in absence of attention
  (→ “pre-attentive features”)
- Unique preattentive feature draws attention

**Slow search:**
- Combination (conjunction) of pre-attentive features
  requires a **spotlight of attention**
- this “welds” together these visual primitives
  at a rate of c. 30 ms/item

  (→ spatial relationships cannot be seen rapidly)
An important aspect of display design is the assignment of features to data types

a) Individual features
   - quantities (e.g. speed) should be assigned to visual quantities (e.g. length)
   - cyclic properties (e.g. direction, season) should be assigned to cyclic visual quantities (e.g. orientation)

b) Combination of features
   - separable features (e.g., color, texture)
   - integral features (e.g., height, width)

Separable features
   - operate independently
   - can pay attention to (respond to) each separately
   - useful for general trends in multivariate data?
     - e.g. Healey et al (1996) - no interference in numerical estimation task

Integral features
   - operate as a unified complex
   - cannot pay attention to each separately
   - useful for graphical objects?
     - design of glyphs?