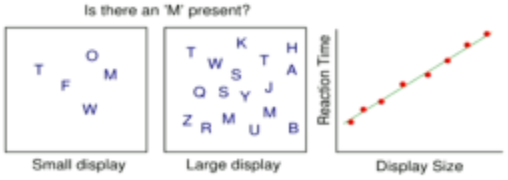
LECTURE 11: ATTENTION IN SPACE AND TIME

The Psychological Function of Spatial Attention

- To assign limited-capacity processing resources to relevant stimuli in environment
- Must *locate* stimuli among distractors and *process* (identify) them

Visual Search

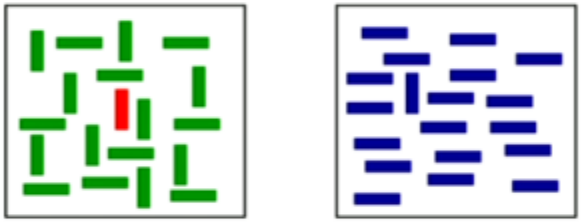


Measure mean RT as a function of display size.

Pop-Out Effects

Some search targets seem to 'pop-out' from the background, others require attention.

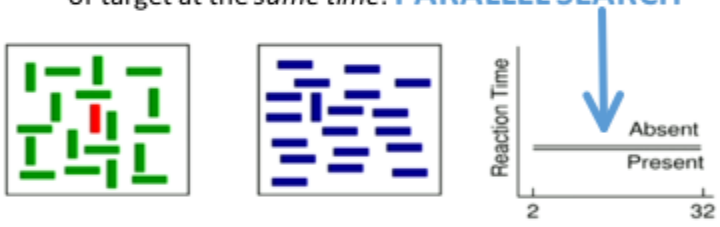
Pop-Out Effects with **Simple Features**



Unique colors and unique orientations both pop out.

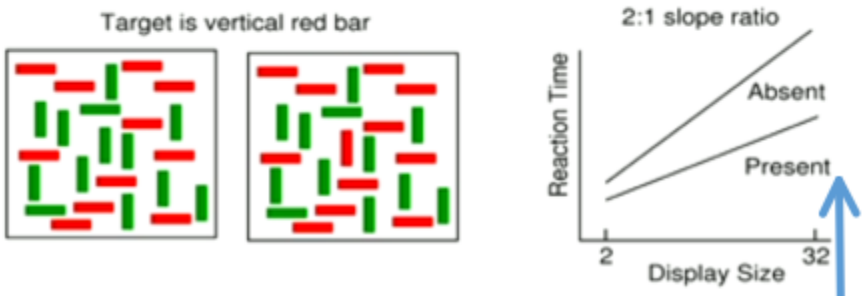
Parallel Search for Feature Targets

- Mean RT doesn't increase with display size
- Compare contents of each display location with mental representation of target at the *same time*: PARALLEL SEARCH



Conjunction Targets DO NOT POP OUT

- Target defined by combination of color AND orientation
- RT increases **linearly** with display size
- Slope twice as steep for target absent as target present trials



- Subjectively, this is a more effortful task.
- Requires controlled allocation of attention to the display in order to solve the task.
- The search target is no longer defined by a single-unique feature, but by a combination or *conjunction* of features

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- **DISTRACTORS:** same orientation and different color; OR
  DISTRACTORS: same color and different orientation

Big difference between target present and target absent trials.
Target Absent: Takes longer to make a decision, slope of the function (slope of the straight line that relates the average reaction time to the display size is appreciably steeper).

- In fact, it is just about twice as steep (2:1 slope ratio between target absent and target present trials).
  - This is taken as evidence for a serial search.

Evidence for Serial Search

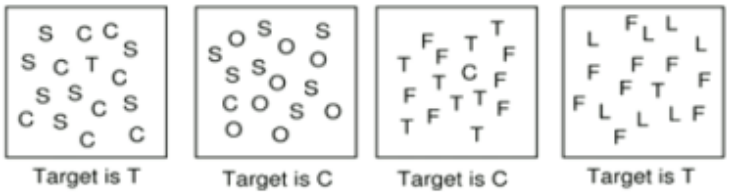
- Seem to need to focus attention on target to detect it - focus attention on each item in turn
- Constant scanning rate predicts linear RT/display size function
  - Each additional item (distractor) in the display adds a constant amount of time to the comparison time (time required to perform the search)

Self-Terminating Serial Search

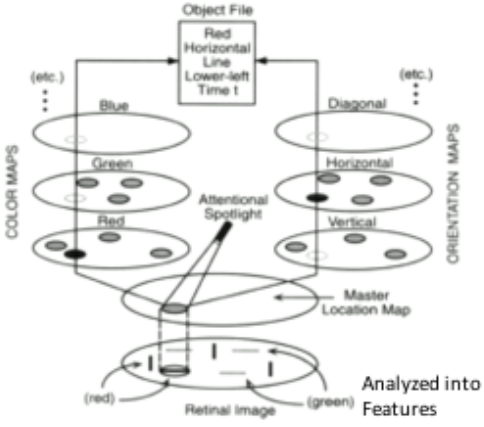
- Stop when target is found
- On average, search half the display on target present-trials, all of the display on target-absent trials
- Constant scanning rate predicts 2:1 slope ratio

Pop-out Effects With Letter Stimuli

- Pop out when targets can be identified by a single features (straight lines among curves or vice versa)
- No pop-out when target can't be identified by a single feature (straight line among straight lines or curve among curves)



TRIESMAN & GELADE (1980): FEATURE INTEGRATION THEORY



- The role of spatial attention is to bind features into perceptual compounds
- Each feature (lines, colors, etc.) registered in its own **feature map**
- Without attention features are free-floating, may lead to *illusory conjunctions*

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Preattentive Stage	Objects are analyzed into separate features. For example, the rolling red ball would be analyzed into features such as color (red), shape (round), and movement (rolling to the right). Because each these features are processed in separate areas o the brain, they exist independently of one another at this stage of processing.
Preattentive Stage Study	Display consisted of four objects flanked by two black numbers. They flashed this display onto a screen for 1/5 of a second, followed by a random-dot masking field designed to eliminate any residual perception that might remain after the stimuli were turned off. Subjects were told to report the black numbers first and then to report what they saw at each of the four locations were the shapes had been.
Preattentive Stage Results	In 18% of trails, subjects reported seeing objects that were made up of a combination of features from two different stimuli. For example, after being presented with the display in which the small triangle is red and the small green circle, they might report seeing a small red circle and a small green triangle. These combinations of features from different stimuli are called **ILLUSORY CONJUNCTIONS**: this can occur even if the stimuli differ greatly in shape and size.
Focused Attention Stage	According to Treisman's model, these "free-floating" features are combined in the second stage, called the **FOCUSED ATTENTION STAGE.** During the focused attention stage, the observer's attention plays an important role in combining the features to create the perception of whole objects. To illustrate the importance of attention for combining the features, Treisman repeated the illusory conjunction experiment using the stimuli, but this time she instructed her subjects to ignore the black numbers and to focus all of their attention on the four target items. This focusing of attention eliminated illusory conjunctions so that all the shapes were paired with their correct colors.
BALINT'S SYNDROME	A crucial characteristic is the inability to focus attention on individual objects. Case of R.M., a patient who had parietal lobe damage that resulted in balint's syndrome. According to feature integration theory, lack of focused attention would make it difficult for R.M. to combine features correctly, and this is exactly what happened. When R.M. was presented with two different letters of different colors, such as a red T or a blue O, he reported illusory conjunctions such as "Blue T" on 23% of trials, even when he was able to view the letters for as long as 10 seconds.

Feature Integration Theory

- Conjunction targets require feature binding, so need focused attention - leads to serial search
- Feature targets don't require feature binding, don't need focused attention - leads to parallel search.
    - This is shown in lots of experiments.

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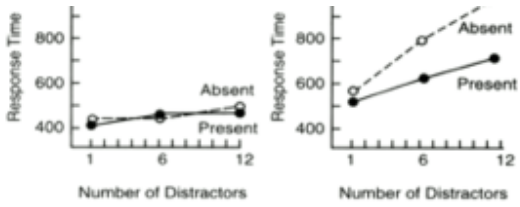
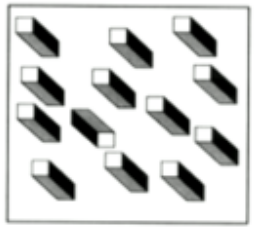


Problems with FIT: ENNS & RENSINK (1990)



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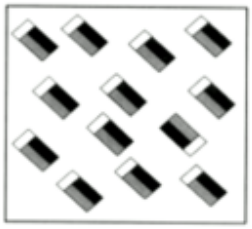

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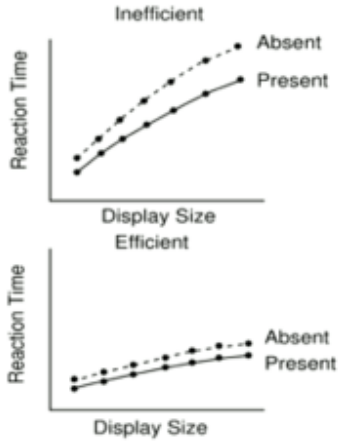
Hypothesis:
Enns & Rensink (1990) argued that pop-out, according to the theory, should only occur when targets are defined by unique features (because then you can interrogate a feature map directly and see whether there is activity there)
Targets defined by conjunction theory should require spatial attention

- However, pop-out sometimes depends on complex object properties, not just simple features.
- High-level, not low-level properties predict pop out.
- Inconsistent with idea that pop out only occurs at level of simple features.

Efficient vs. Inefficient Search



- Many tasks show intermediate patter, don't provide clear evidence of either serial or parallel search
- **WOLFE:** better described as inefficient or efficient search
  - He suggested there is no evidence of dichotomous population of search slopes; parallel and serial functions look like ends of continuum (of very efficient search to very inefficient search)

Parallel Search: most efficient search possible, no increase in reaction time through an increase in display size.

Serial Search: Most inefficient form of search, whereby adding each new item increases reaction time by a constant amount.

Inefficient	Reaction time does slow appreciably with an increase in display size, and there is a big difference between target absent and target present trials. However, the points of the function fall on a curve which flattens out (a negatively accelerating curve: rather than a straight line). **This is not consistent with a simple serial search** (a simple serial search says that each new item you add to the display should, on average, add to the search time by

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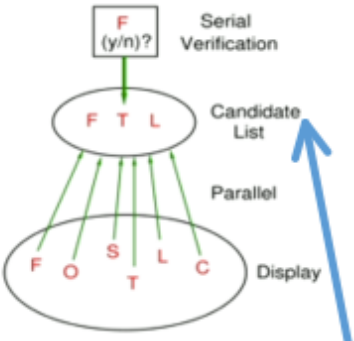
	add to the display should, on average, add to the search time by a constant amount). However, this shows that things are slowed down by adding more items, but not as much as a simple serial search would predict.
Efficient	There is an small, but measurable increase in reaction time with display size.

WOLFE (1989): GUIDED SEARCH THEORY



- Two-stage theory
  - Says there's preattentive processes and processes of focal attention cooperating to produce search performance
- Initial parallel (fast, efficient) stage provides a *candidate list* of possible targets
- Second serial (slow) stage checks candidate list for targets
  - Does not go through entire display

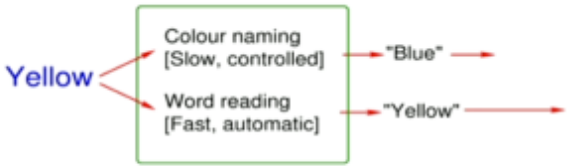
- Search efficiency depends on similarity of target and distractors
- Similar targets and distractors lead to large candidate list and inefficient search
- Dissimilar targets and distractor lead to small candidate list and efficient search
- C.f. auditory theories - parallel processing followed by limited capacity channel.

Failures of Focused Attention

- Visual search looks at costs of divided (distrusted) attention: performance decline with increasing display size is evidenced of capacity limitations
- Some situations where there is a *benefit* not to divide attention: avoid processing distractor stimuli
- Limitations of focused attention and involuntary processing of irrelevant stimuli

STROOP (1939): THE STROOP EFFECT

- Name the color of the *ink* in which the word is written; measure RT
- Fast with compatible (top), intermediate with neutral (middle), slow with incompatible (bottom)



- Parallel processing of color naming and word reading
- Word reading is fast and involuntary, word name available before color names, create output interference
- ASYMMETRICAL: no interference of ink color on word naming

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John Ridley Stroop (1897-1973)

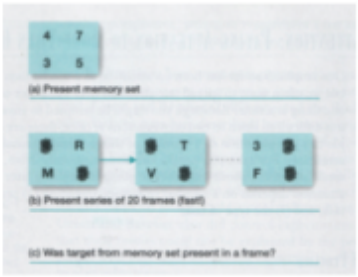
- From Stroop's bio: "*from his college days on, he preached every Sunday, often taking a train out into the country and being paid with a chicken or a bag of potato's, if at all*"
- Published seven books of religious studies
- Stroop's children were all color blind!

Automaticity

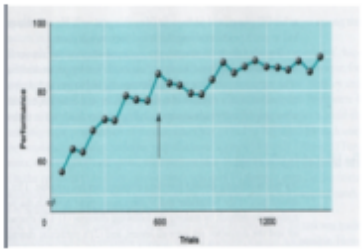
The Stroop Effect:

- Word reading: fast and automatic
- Color naming: slow and controlled
- What makes a process automatic?
  - Learned stimulus responses associations
- Criteria for automaticity: fast, parallel, effortless, doesn't require capacity
- Automaticity basis for skill acquisition (reading, driving, playing a musical instrument etc.)

SHIFFRIN & SCHNEIDER (1977): CONTROLLED AND AUTOMATIC PROCESSING



- Search for digit targets in arrays of distractor letters in rapid sequences (or vice versa)
- Vary size of target (memory) set: 1-4 items
- Vary size of stimulus displays: 1-4 items
- **Consistent mapping (CM):** target and distractor sets were distinct
- **Varied mapping (VM):** targets on some trials were distractors on others



- Performance under CM became automatic with practice (>90%)
  - Regardless of how many items were in the memory set or in each frame
- Became independent of memory set and display size
- Subjectively effortless, spontaneous pop-up of targets from text
- Never became automatic under VM
- Requires consistency of target set membership
- Consistent with capacity-free, effortless encoding account

The Eriksen Flanker Task

Is the central character an E or an F? - Measure RT

- RT (compatible) < RT (neutral) < RT (incompatible)
  - Compatible: E flanked with a number of other letters (all of which are the same, all would

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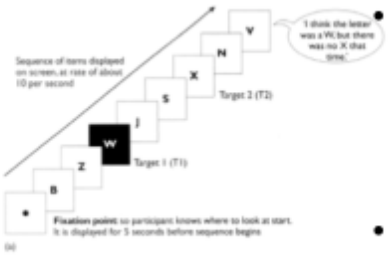
lead to make same response)
- Neutral: target E is flanked with neural letters (e.g. Xs)
- Incompatible: flanked with letters that are associated with the other response

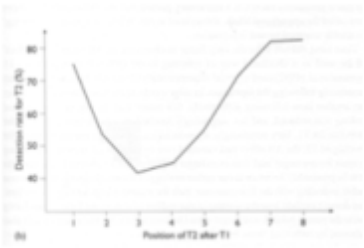
- Despite flankers being irrelevant, involuntary processing of flankers even when attempting to ignore them

Findings:

- Implies some parallel processing of conjunction stimuli
- Failure of focused attention
- Decreases with spatial separation, disappears at 1-1.5 degrees
- Provides estimate of size of focus of attention ("spotlight")
  - Size of spotlight is reasonably well matched with foveal vision
- Stimuli failing within spotlight processed automatically

Attention in Time: The Attentional Blink





- Rapid serial visual presentation (RSVP) task
  - Present set of stimuli (letters or digits e.g.) very rapidly on computer screen in quick succession at the same location
- 100m/s exposure per item; each item *masked* by following item
- Two targets: report the *white* letter, detect whether there was an X present

- Plot second target (T2) performance as a function of the time (lag) since the first target (T1)
- T2 performance declines and then recovers: ATTENTIONAL BLINK

- Only find it if T1 is processed; if T1 is ignored, no AB
- Depending on T1 processing
- Worst performance not immediately after T1 but some time later (Lag 1 sparing)
- Effect takes time to build up, but relatively long lasting (up to 600 ms)

A Tentative Resolution

- Translating perception into action: must distinguish relevant from relevant stimuli: form *representations* of relevant stimuli, make *decisions* about them
- Good at monitoring for relevant (target) stimuli, rejecting irrelevant stimuli preattentively
- Forming representations of relevant stimuli and making decisions about them makes us insensitive to new stimuli for 500-1000ms (double-target deficit, AB)
- Need to study visual short-term memory and decision making

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