Image from “Where’s Waldo?” removed for copyright reasons.
You can read these words. *

And these are fine, too.

Fixate on the ***
Some visual features seem to escape the bottleneck
Others

Don’t
We think that there are about 12-18 “basic feature” dimensions.
Is there a tilted line? Say "yes" or "no" as fast as possible
Is there a tilted line? Say "yes" or "no" as fast as possible
Is there a tilted line? Say “yes” or “no” as fast as possible
Is there a tilted line? Say “yes” or “no” as fast as possible.
Feature Search: A limited set of features support highly efficient "parallel" search.

<table>
<thead>
<tr>
<th>Set Size</th>
<th>Reaction Time (msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>slopes = ~0 msec/item</td>
</tr>
</tbody>
</table>

Set Size
Is there a “T”? Say “yes” or “no” as fast as possible
Is there a “T”? Say “yes” or “no” as fast as possible
Is there a “T”? Say “yes” or “no” as fast as possible
Is there a “T”? Say “yes” or “no” as fast as possible
Many other searches are inefficient and seem to require serial deployment of attention from item to item.

![Diagram showing reaction time vs set size for target absent and target present cases.](Image)

- **Target absent**: 40-60 msec/item
- **Target present**: 20-30 msec/item
Is there a “Red Horizontal”?
Say “yes” or “no” as fast as possible
The core idea of Guided Search

**Give me all the red items**

Find the red vertical
Guided Search

Give me all the verticals

Find the red vertical
The intersection of those sets is a good place to deploy attention.

Find the red vertical
Guided Search

Preattentive processes *guide* the deployment of attention.
Bottom-up guidance: Is there a “T”?
Top-down guidance: The “T” is red.
Why do we need attention?

What are those features doing before attention arrives?
The idea: Before selection, features are loosely bundled into objects

I am a red, green, vertical, horizontal, pointy object
Attention enables the binding of features into recognizable objects.

I am a “plus” with green vertical and red horizontal regions.
Preattentive features are *bundled* into preattentive object files.

Attention is required to *bind* features into recognizable objects.

Find the "*red verticals*"
Easy to find red verticals
Hard to find red verticals

Find the 2 red vertical lines
Why is this “plus” search so inefficient?

Absent - 141 msec/item

Present - 57 msec/item
Why guidance fails

One Object
red & green
& vert. & hor

One Object
red & green
& vert. & hor

Two Objects
1-red & vert
& 2-green & hor
Do things stay together once you bind them?

Meet the dancing chickens
How bad are you?
The “IsWas” Paradigm
You can see all these red and green dots.

Does the cued dot change color?
No
Yes
No
Basic color and form information are immediately available.

Why can’t you do the task?
More Dots….Tell me the color that the highlighted dot IS

If the dot turns black, tell me the color that it WAS.
More Dots….Tell me the color that the highlighted dot IS

If the dot turns black, tell me the color that it WAS.
More Dots….Tell me the color that the highlighted dot IS

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More Dots….Tell me the color that the highlighted dot IS

If the dot turns black, tell me the color that it WAS.
Results from a two-color version of the ISWAS exp.
Results from a four-color version of the ISWAS exp.
Visual Short Term Memory

How big is it?
Remember these
Did anything change?
Remember these
Did anything change?
Remember these
Did anything change
How about now
Any change?
What if we combine color, shape and orientation?
What if we combine color, shape and orientation?

Note: That is 4 objects but 12 features.
How much do we really see?
Change Blindness:

What are you really seeing right now?

Image of painting removed for copyright reasons.
What changed?

Image of painting (slightly different than previous slide) removed for copyright reasons.
Go back
Change Blindness:
Low level visual transients attract attention.

Image of painting removed for copyright reasons.
See?

Image of painting (slightly different than previous slide) removed for copyright reasons.
Why are we so bad at this?
And why are surprised that we are so bad?
The answer lies in the architecture of visual processing.

*Early Vision*

Recognition of objects (and their color) starts when early visual processes feed a selective processing pathway.
A selective pathway

Early Vision

with an attentional bottleneck

feeding object recognition

and subsequent awareness

Binding Recognition

The selective path

Visual experience
Access to the bottleneck is controlled by guiding representation.
The selective pathway gives you the status of the current object of attention.

That is the single pathway story.

Early Vision

Visual experience

The Guiding Representation

Color
Orientation
Size
Motion
Depth
etc.

Binding Recognition

The selective path
What is the status of the current object of attention?

But where does the rest of the experience come from?
A non-selective pathway can fill in the rest of the experience.
Different pathways, Different functions

Early Vision

The non-selective path

Texture statistics
Minimal semantic analysis
Ambient visual experience

Feature binding
Object recognition
Focal visual experience

The selective path
Relationship to other things you know

Brain structure diagram removed for copyright reasons.

Remember the What vs Where idea?
“Selective” would be the “What” pathway.

Visual experience

Early Vision

The Guiding Representation

The selective path

- Color
- Orientation
- Size
- Motion
- Depth
- etc.

Binding Recognition
Lesion yields agnosia.
Non-selective pathway would map onto the “Where” pathway.
Would a lesion yield simultagnosia?
And a lesion of guidance?

Problems with visually directed action?