Where Objects Come From: Attention, Segmentation, and Textons

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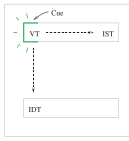
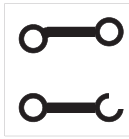
1: Motivation: Joining Two Literatures

Object-Based Attention



[Egly et.al., 1994]



[Watson & Kramer, 1999]

Object-Based Attention (OBA)

Background : The units of attention are discrete objects
Problem : Objects are often defined only intuitively

Texton-Based Segmentation (TBS) in Early Vision

Background : Rigorous models of boundary formation
Problem : Little contact with other aspects of visual cognition

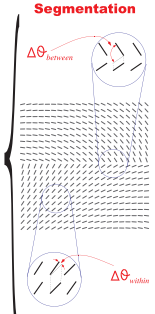
Our Goal

Bridge these literatures with one of the most conspicuous features (textons) of early vision: **Orientation.**

Questions

- Does texture segmentation (based on either orientation or curvature) result in multiple 'objects' of attention?
- *How* does early visual structure defined by textons influence the flow of attention through scenes?
- Can attentional effects provide new types of empirical support for models of texture segmentation?

Orientation-Based Segmentation

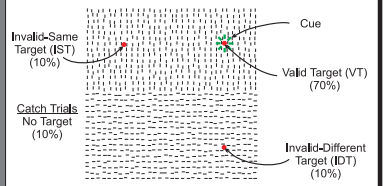


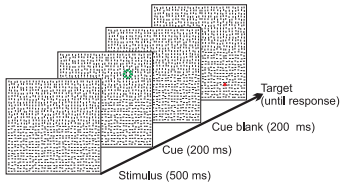
[Nothdurft, 1991]
[Musap & Levi, 1999]
[Ben-Shahar & Zucker, 2002]

2: Methods: Converging Evidence from Two Attentional Paradigms

Cueing (RT)

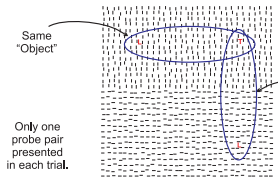
Speeded target detection

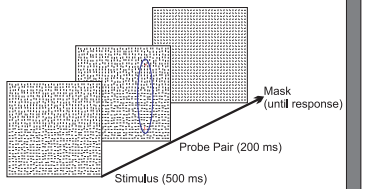




Divided Attention (Accuracy)

Are the 2 probes identical?





3: Results

Regular Uniform Flows + Cueing Task	**Same** With the grain **Different** Against the grain	**Results (RT)** Same-Object Advantage: **No Effect** p > .05 (N = 24)	**Conclusion** The 'grain' of a texture flow does not directly influence the spread of attention.
Regular Discontinuous Flows + Cueing Task	**Same** No boundary crossing **Different** Cue/target span boundary	**Results (RT)** Same-Object Advantage: **43 ms** p = .03 (N = 24)	**Conclusion** Orientation-based texture segmentation yields 'objects' of attention!
Regular Uniform Flows + Divided-Attention Task	**Same** With the grain **Different** Against the grain	**Results (Accuracy)** Same-Object Advantage: **No Effect** p =.87 (N = 16)	**Conclusion** Replication with a new task and dependent measure The 'grain' of a texture flow does not directly influence the spread of attention.
Regular Discontinuous Flows + Divided-Attention Task	**Same** No boundary crossing **Different** Probes span boundary	**Results (Accuracy)** Same-Object Advantage: **4.5%** p < .001 (N = 16)	**Conclusion** Replication with a new task and dependent measure Orientation-based texture segmentation yields 'objects' of attention!
Jittered Uniform Flows + Cueing Task	**Same** With the grain **Different** Against the grain	**Results (RT)** Same-Object Advantage: **No Effect** p > .05 (N = 23)	**Conclusion** Still no direct effect of texture flow 'grain' on the spread of attention.
Jittered Discontinuous Flows + Cueing Task	**Same** No boundary crossing **Different** Cue/target span boundary	**Results (RT)** Same-Object Advantage: **No Effect** p > .05 (N = 23)	**Conclusion** No boundary effect with jittered textures: Not enough sensitivity?
Jittered Uniform Flows + Divided-Attention Task	**Same** With the grain **Different** Against the grain	**Results (Accuracy)** Same-Object Advantage: **No Effect** p = .34 (N = 17)	**Conclusion** 4th Replication! The 'grain' of a texture flow does not directly influence the spread of attention.
Jittered Discontinuous Flows + Divided-Attention Task	**Same** No boundary crossing **Different** Probes span boundary	**Results (Accuracy)** Same-Object Advantage: **4.5 %** p = .002 (N = 17)	**Conclusion** Orientation-based texture segmentation yields 'objects' of attention defined by global structure!
Jittered Kt- Discontinuous Flows + Divided-Attention Task	**Same** No boundary crossing **Different** Probes span curvature boundary	**Results (Accuracy)** Same-Object Advantage: **7%** p = .03 (N = 8)	**Conclusion** Even curvature-based texture segmentation yields 'objects' of attention defined by global structure! This holds for 'objects' defined by both tangential curvature and normal curvature.
Jittered Kn-Discontinuous Flows + Divided-Attention Task	**Same** No boundary crossing **Different** Probes span curvature boundary	**Results (Accuracy)** Same-Object Advantage: **4.9 %** p = .04 (N = 8)	

4: Implications

Main Conclusions

Texture boundaries, defined by either orientation or curvature discontinuities, yield `objects' of attention.

However: The texture's grain (or main direction) does not directly influence attention (contra Avrahami, 1999). In other words, it is changes in the distribution of textons, rather than their absolute values, that influence attention.

The formation of attentional objects in static texture flows is a result of global structure as opposed to local grouping.

Contributions of TBS to OBA

A wealth of stimuli whose partition into objects goes beyond intuitive appeal.

Opportunity to study the connection between attention and fundamental visual features that later give rise to objects: 'texton-based attention'?

Contributions of OBA to TBS

Use of proven methodologies to provide new types of empirical support for models of segmentation.

Linking early visual processes to other aspects of visual cognition.

Methodological Contributions

The first study to use converging evidence from two different OBA paradigms and dependent measures.

A lesson for OBA research: The divided attention paradigm is stronger and more sensitive than cueing.

And a Final Take-Home Message

Merging two otherwise disparate fields benefits both in new and surprising ways, raises novel questions, and opens new research directions.