Seminar on Attention and Perceptual Organization
John Palmer and Cathleen Moore
Fall 2008

This is a summary of a seminar that considered the relations between attention and perceptual organizations. This document contains the syllabus, weekly question sets, and a summary of the discussion for each week. At the end there is also a a set of brief questions and answers that summarize the seminar in a page.

Psychology 031.227 – Fall 2008 – Attention

Department of Psychology, E11 Seashore Hall, Phone: 335-2406

Mon 3:30-6:00 in 169 Van Allen

Instructors: Prof. **Cathleen Moore**, E119 Seashore Hall, 335-2427, cathleen-moore@uiow.edu
Office Hours: by appointment

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Readings: All readings are available as pdfs on the ICON site for this course.

Description: This is a graduate-level seminar in which we consider many of the fundamental questions of attention by following the specific theme of the role of objects, or more generally perceptual structure, in attention. The focus is on behavioral measures, rather than neuroscience measures, but we will sometimes consider the relations between the two types of measure when appropriate. The readings are mainly empirical papers drawn from both visual psychophysics and cognitive psychology, but we will also read a few review and theoretical papers throughout the semester.

Course Structure and Responsibilities: Drs. Moore and Palmer will lead discussions together with one discussant who has been selected for the week. To help guide the discussion, study and discussion questions will be disturbed each week for the subsequent week's meeting. The study questions have answers that can be found in the reading. The discussion questions are open ended.

Prior to each meeting. All seminar participants are expected to read main readings in detail before the class meeting. Most weeks this includes one base reading and one contrast reading. The supplemental readings are provided as references for anyone who is especially interested in the topic. All participants are expected to work out answers to the study questions and to think about the discussion questions, having something to say about each one. These questions are based on the main readings. The discussant for a given meeting is expected to meet with Drs. Moore and Palmer a few days before class to discuss the material and to prime the discussion.

During each meeting. Seminar participants are expected to participate actively in the discussion. Having understood the study questions and having prepared your thoughts on the discussion questions will facilitate this. Discussants are expected to take "minutes" of the discussion. These will then be used to write up a description of the discussion.

After each meeting. Seminar participants are expected to read over the description of the previous meeting and send any comments, additions, or questions regarding it to Drs Moore and Palmer. The discussant from the immediately preceding meeting is to meet with John and Cathleen and prepare a written description of that week's discussion in time for it to be edited for distribution at the next meeting.

Course Grade: The course grade will be based on preparation for class, participation in discussions, and quality of summaries that are prepared when discussant.

Collegiate Policies

Administrative Home. The College of Liberal Arts and Sciences is the administrative home of this course and governs matters such as the add/drop deadlines, the second-grade-only option, and other related issues. Different colleges may have different policies. Questions may be addressed to 120 Schaeffer Hall or see the Academic Handbook. **www.clas.uiowa.edu/students/academic_handbook/index.shtml**

Academic Fraud. Plagiarism and any other activities when students present work that is not their own are academic fraud. Academic fraud is reported to the departmental DEO and to the Associate Dean for Academic Programs and Services who enforces the appropriate consequences.
www.clas.uiowa.edu/students/academic_handbook/ix.shtm

Making a Suggestion or a Complaint. Students with a suggestion or complaint should first visit the instructor, then the course supervisor and the departmental DEO. Complaints must be made within six months of the

incident. **www.clas.uiowa.edu/students/academic_handbook/ix.shtml#5**

Accommodations for Disabilities. A student seeking academic accommodations should register with Student Disability Services and meet privately with the course instructor to make particular arrangements. For more information, visit this site: **www.uiowa.edu/~sds/**

Understanding Sexual Harassment. Sexual harassment subverts the mission of the University and threatens the well-being of students, faculty, and staff. Visit **www.sexualharassment.uiowa.edu** for definitions, assistance, and the full University policy.

Reacting Safely to Severe Weather. In severe weather, the class members should seek shelter in the innermost part of the building, if possible at the lowest level, staying clear of windows and free-standing expanses. The class will continue if possible when the event is over. (**Operations Manual** 16.14. i.)

Brief Course Outline

Week	Topic	Discussant
08/25	Organizational	
09/01	Labor Day	
09/08	01 Attention: A brief introduction	Teresa Stephens
09/15	02 Is there evidence of "object-based" divided attention?	Brendan Hodis
09/22	03 Is there evidence of "object-based" selective attention?	Caglar Tas
09/29	04 What are the mechanisms of object-based attention?	Marc Halusic
10/06	05 What is the role of attention in the perceptual organization of space?	Ian Rasmussen
10/13		
10/20	06 What is the role of attention in the perceptual organization of time?	Ben Dow
10/27	07 How does judging relations between objects differ from judging attributes of single objects?	Libo Zhao
11/03	08 Are objects identified one at a time by a serial process or in parallel?	Keith Apfelbaum
11/10	09 What role do objects play in the control of attention?	Lynn Perry
11/17		
11/24		
12/01	10 An alternative approach: The Boolean map theory of attention	Elisabeth Hein
12/08	11 Finale	

Topic Questions and Main Readings

1. Attention: A brief introduction

Readings:

Pashler (1998). *The psychology of attention*. MIT Press.

Chapter 1
From Chapter 3: pp 101-132 (report tasks)
From Chapter 4: pp 176-191 (cueing)
From Chapter 6: pp 265-287 (dual tasks)

2. Is there evidence of "object-based" divided attention?

Base Reading:

Duncan, J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology: General*, *113*, 501-517.

Contrast Reading:

Awh, E., Dhaliwal, H., Christensen, S., & Matsukura, M. (2001). Evidence for two components of object-based selection. *Psychological Science*, *12*, 329-334.

3. Is there evidence of "object-based" selective attention?

Base Readings:

Vecera, S. P. (1994). Grouped locations and object-based attention: Comment on Egly, Driver, and Rafal (1994). *Journal of Experimental Psychology: General*, *123*, 316-320.

Contrast Reading:

Kravitz, D. J., & Behrmann, M. (2008). The space of an object: Object attention alters the spatial gradient in the surround. *Journal of Experimental Psychology:Human Perception and Performance*, *34*, 298-309.

4. What are the mechanisms of object-based attention?

Base Reading:

Shomstein, S. & Yantis, S. (2002). Object-based attention: Sensory modulation or priority setting? *Perception & Psychophysics*, *64*, 41-51.

Contrast Reading:

Han, S., Dosher, B. A., Lu, Z-L (2003). Object attention revisited: Identifying mechanisms and boundary conditions. *Psychological Science*, *14*, 598-604.

5. What is the role of attention in the perceptual organization of space?

Base Reading:

Moore, C. M. & Egeth, H. (1997). Perception without attention: Evidence of grouping under conditions of inattention. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 339-352.

Contrast Reading:

Freeman, E., Driver, J. & Sagi, D. (2004). Configuration-specific attentional modulation of flanker-target lateral interactions? *Perception*, *33*, 181-194.

6. What is the role of attention in the perceptual organization of time?

Base Reading:

Moore, C. M., & Lleras, A. (2005). On the role of objects in substitution masking. Journal of Experimental Psychology: Human Perception and Performance, 31, 1171-1180.

Contrast Reading:

Woodman, G. F., & Yi, D-J (2007). Masked-target recovery requires focused attention on the target object. *Visual Cognition*, *15*, 385-401.

7. How does judging relations between objects differ from judging attributes of single objects?

Base Reading:

Poder, E. (1999). Search for feature and for relative position: Measurement of capacity limitations. *Vision Research, 39*, 1321-1327.

Contrast Reading:

Humphreys, G. W. (1998). Neural representation of objects in space. Phil. Trans. Royal Society of London B, 353, 1341-1351.

8. Are objects identified one at a time by a serial process or in parallel?

Base Reading:

Walker, S., Stafford, P. & Davis, G. (2008). Ultra-rapid categorization requires visual attention: Scenes with multiple foreground objects. *Journal of Vision*, *8*, 21,1-12.

Contrast Reading:

Li, F. F., VanRullen, R., Koch, C. & Perona, P. (2002). Rapid natural scene categorization in the near absence of attention. *Proceedings of the National Academy of Sciences*, *99*, 9596-9601.

9. What role do objects play in the control of attention?

Base Reading:

Yantis, S. & Hillstrom, A. P. (1994). Stimulus-driven attentional capture: Evidence from equiluminant visual objects. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 95-107.

Contrast Reading:

Franconeri, S. L., Hollingworth, A., & Simons, D. J. (2005). Do new objects capture attention? *Psychological Science*, *16*, 275-281.

10. An alternative approach: The Boolean map theory of attention

Base Reading:

Huang, L., & Pashler, H. (2007). A boolean map theory of visual attention. *Psychological Review*, *114*, 599-631.

11. Finale: TBA

Attention and Perceptual Organization
Questions for Week 1: A brief introduction to attention
Cathleen Moore & John Palmer
September 8, 2008

Base Readings

Pashler (1998). *The psychology of attention*. MIT Press.
Chapter 1 (pp 1-34)
From Chapter 3: pp 101-134 (report tasks)
From Chapter 4: pp 176-191 (cueing tasks)
From Chapter 6: pp 265-287 (dual tasks)

Supplemental Readings

Example Studies:

Bonnel, A. M., & Hafter, E. R. (1998). Divided attention between simultaneous auditory and visual signals. *Perception & Psychophysics*, *60*, 179-190. **Dual Task**

Pashler, H. (1994). Divided attention: Storing and classifying briefly presented objects. *Psychonomic Bulletin & Review*, *1*, 115-118. **Report Task**

Shiu, L-P, & Pashler, H. (1994). Negligible effect of spatial precuing on identification of single digits. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 1037-1054. **Cueing Task**

Reviews:

Kinchla, R. A. (1992). Attention. *Annual Review of Psychology*, *43*, 711-42. [*Especially good for dual-task approach and issues*.]

Luck, S. J., & Vecera, S. P. (2002). Attention. In H. Pashler (Series Ed.) & S. Yantis (Volume Ed.), *Stevens' Handbook of Experimental Psychology: Vol. I. Sensation and Perception*. (3rd ed. Pp. 235-286) New York: Wiley.
[*Good overview of tasks, and more recent*.]

Reynolds, J. H., & Chelazzi, L. (2004). Attentional modulation of visual processing. *Annual Review of Neuroscience*. *27*, 611-647.
[*Good for getting a sense of the Biased Competition approach to attention*.]

Swets, J. A. (1970). Attention. *Annual Review of Psychology*, 21, 153-366.
[*It's old, but it's a nice presentation of the issues when they were relatively new. Also, being old, the issues are relatively unmuddled by time and later-generation theorists*.]

Study Questions

1. How does Pashler characterize the folk psychology of attention? What pitfalls in the use of the term "attention" does he point out?

2. What are selection and capacity? (In the reading, these terms are defined by example.)

3. What are the differences between early and late selection theory?

4. How are early and/or late selection theories modified by the suggested alternatives of the controlled parallel theory, attenuation, and capacity sharing?

5. What are the alternative interpretations of the set-size effects for searching a brief display. How does such an interpretation depend on assumptions about noise?

6. What are the key properties of the partially-valid cueing paradigm? How is the effect of selective attention measured? Why is this a useful paradigm for controlling sensory effects?

7. What are the key properties of a dual-task paradigm? How is the effect of divided attention measured?

Discussion Questions

1. Pashler presents selection and capacity as the primary components of attention. Are there any other components of equal importance that we should consider? If not, does this constrain how one should think about attention?

2. Might the controlled parallel theory be a better starting point for the analysis of attention than either early or late selection theory because it reflects the optimal processing strategy? Are there precedents to this theory? Is there a better name?

3. What are possible alternative interpretations of a cueing effect (e.g. noise reduction, capacity allocation)? How can one distinguish the alternatives?

4. What are possible alternative interpretations of a dual-task deficit (e.g. capacity allocation, memory load)? In addition, these limits might be in perception, memory or decision. How can one distinguish the alternatives?

5. While not done in this introduction, would it be useful to define the phenomena relevant to the study of attention? In particular, how can one exclude clearly nonattentional phenomena such as light adaptation or perceptual learning?

6. What are some potential roles for objects/organized representations in attention? For example, in the reading on divided attention, Pashler writes “[t]his interference seems to be avoided when the attributes are part of a single object?” (p. 132) Why might that be?

Attention and Perceptual Organization
Summary for Week 1: A brief introduction to attention
Teresa Stephens, Cathleen Moore and John Palmer
September 9, 2008

Readings

Selections from Pashler (1998). *The psychology of attention*. MIT Press.

Chapter 1, pp 1-34, theoretical concepts;
Chapter 3, pp 101-134, report and search paradigms;
Chapter 4, pp 176-191, cueing paradigms;
Chapter 6, pp 265-287, dual-task paradigms.

Discussion Summary

Overview. Cathleen Moore explained the purpose of the readings for the first week. The readings from Pashler (1998) provide an overview of the issues in attention and several of the paradigms used to study attention. The first chapter provides Pashler's view of the most important theoretical issues of attention. The following chapters provide details about specific paradigms that are encountered in later reading assignments throughout the semester. Specifically, search, dual-task and cueing paradigms are addressed in today's reading. The flanker paradigm is addressed later in the semester.

The folk psychology of attention. Cathleen Moore asked what is the general public's view of attention. Marc Halusic offered that attention is thought of as a unitary construct and that attention is used as an umbrella term for different processes. Christopher Kovach offered that attention is thought of as a finite resource that can be allocated to one thing or another. John Palmer asked if the description that attention is divided resonated with everyone's intuitions about attention. Marc replied that it would depend on how similar are the tasks. Ian Rasmussen commented that divided attention could be process or modality specific. Christopher added to the description of intuitions about attention by saying that attention is associated with effort. In particular, the allocating of attentional resources requires effort. Another intuition about attention is that it has to be something to which we are consciously aware. The cocktail party effect was offered as a potential counter example to this conscious awareness requirement because perhaps we are not consciously aware that our name is being processed until it is identified.

Selectivity and capacity are important aspects of attention in folk psychology as well as research psychology. The research usage differs in that the terms are operationalized using specific empirical procedures in addition to the introspections of folk psychology.

Selection. In perception, selection is processing some sources of information to the exclusion of other sources of information. Cathleen posed the following comparison. In one case, she directed her gaze at one person and then the other. In the second case, she held her gaze constant and covertly attended to one person or the other. Are these both examples of

selection? Yes. Libo Zhao commented that in the case of directing the gaze, selection is unintentional because one can only process what is in the field of view. In contrast, when the gaze is held constant, then selection must be intentional because the stimulus is held constant. Lynn Perry raised the question of whether or not it might be possible to attend to a person even if you turn your back to them through audition or memory. These examples are meant to highlight that selection is possible from a constant physical stimulus, a changing physical stimulus or even a memorial representation.

To study attention, it is helpful to keep the stimulus constant and manipulate attention using some kind of prior instruction. When both the attentional instruction and the stimulus changes it is harder to distinguish whether the effects are due to the change in stimulus or the change in attention. The aim is that understanding such idealized conditions will help one to eventually understand more general conditions where both stimuli and attention varies. John made the analogy that studying visual attention without eye movements is like studying physics on a frictionless table. The idealization keeps things simple at the start.

Capacity. In divided attention, the question is whether processing multiple sources of information is the same as processing a single source of information. The term capacity arises from the idea of how much information can be processed at one time. The idea of capacity can be characterized in terms of independence (or lack of independence) in the processing of multiple sources of information simultaneously. Unlimited capacity is that processing is independent of the number of relevant sources of information. In contrast, limited capacity is that processing is dependent on the number of simultaneous sources of information.

Consider the example of detecting warning lights on the dashboard while driving as a simple example. Is it possible to process each of the lights independently regardless of the number of lights? Or is the processing of the lights dependent on the number of other lights? In particular, Marc stated that one can assess capacity in this example by comparing performance when processing one light to performance when processing many lights simultaneously. If there is no difference in performance, this is evidence that the lights are processed independently and there are no capacity limitations. If there is a difference in performance, then this is evidence that the lights are not processed independently and there is some sort of capacity limitation. A question then becomes what sort of capacity limit?

Early and late selection theory. What is the distinction between early and late selection? One important distinction between early and late selection is the location of the filter. In this approach, processing is described as a sequence of stages such as simple feature processing, perceptual categorization and identification, and encoding into a durable memory. Given such a sequence, where does selection occur? In early selection theory, the selection occurs early in the sequence, typically before stimulus identification. Unattended stimuli are not identified. In contrast, in late selection theory, the selection occurs late in the sequence. Unattended stimuli are identified. In summary, early selection blocks semantic processing of unattended stimuli, whereas late selection allows such processing. This has consequences for filtering tasks such as the Stroop and Flanker paradigms to be discussed later.

Serial and parallel processing in early and late selection. Another distinction between early and late selection theory involves the ability to process multiple stimuli simultaneously. For both, processing before the filter is parallel and after the filter is serial. Thus, the key difference is that stimulus identification is a serial process in early selection theory and a parallel process in late selection theory. This has consequences for measures of divided attention such as visual search as described later.

Parallel and serial processing have consequences for capacity. Parallel processing can be either independent (unlimited capacity) or dependent (limited capacity). Keith Apfelbaum asked about serial processing? The exact usage of the term capacity matters for the answer to this question. Broadbent used the term with regard to the entire system. This usage might be termed "system capacity". Others, such as Townsend, use the term with regard to individual processes. Yet others use it with respect to an individual processing stage such as "perceptual capacity". Here, we focus on system capacity. In those terms, a typical serial process has limited capacity. If one assumes that the duration of the serial process for one stimulus is independent of the number of stimuli, then processing for n stimuli will take n times as long. Since capacity is defined as processing per unit time, this is sharply limited capacity.

Processing stage assumptions. Both early and late selection theories of attention imply stage-like processing. Typically, theories of perceptual tasks identify at least a few stages such as the sensory processing of simple features, perceptual categorization, stimulus identification, encoding into a durable memory, decision making, etc. Determining if each of these processes have selectivity and capacity limits is an essential question for this approach to attentional theory. Consider a crude version of early selection theory with stages for sensation, perception and decision. Sensation is parallel while perception and decision are serial. Sensation has no selectivity while perception and decision are selective. In contrast, late selection differs in that the perception stage is parallel and not selective. Many arguments will turn on whether a particular selectivity or capacity phenomena is due to one stage or another.

Controlled parallel theory. Cathleen suggested that early and late selection can be summarized using a table from Pashler's introductory chapter (Figure 1.6, pp. 22). This two-by-two table specifies the possible answers for two questions: Are unattended stimuli identified? And, can multiple attended stimuli be processed simultaneously? Whether unattended stimuli are identified is determined by the selectivity of the stimulus identification process. This can be determined by experiments such as the Stroop or Flanker paradigms that attempt to measure indirect effects from unattended stimuli. Whether stimuli are processed simultaneously is determined by whether the stimuli are processed in parallel or in serial. This can be addressed from some search and dual-task paradigms. More on these points as we discuss tasks below. In summary, the properties of early selection put it in the lower right corner of the table and the properties of late selection put it in the upper left corner of the table.

Controlled parallel theory is an alternative to early and late selection theories. It occupies the upper right corner of Table 1. The idea is that selectivity can be early but is optional. One can select narrowly if it is useful in ignoring irrelevant information or on can select broadly to process many stimuli simultaneously. Thus, the stage of stimulus identification can be either

parallel or reduced to a single process depending on the nature of selection. Thus, controlled parallel theory can be thought of as the best of both early and late selection.

Table 1.
Are unattended stimuli identified?

Processing of multiple attended stimuli	Yes	No
parallel	Late selection	Controlled parallel
serial		Early selection

Libo asked if executive control plays a role in the implementation of controlled parallel theory. If you want to attend, you will and if you do not want to attend you will not. It seems so. One can also think of the controlled parallel theory as having filters in both early and late locations in the stages of processing and letting through the information that you want to let through at each filter.

Ian pointed out that one cannot prove that participants have not processed the information, only that it did not have consequences for behavior. This is true. But what kind of argument can you make. Consider the Stroop task and results consistent with a failure of selective attention. In short, the Stroop task demonstrates a failure to ignore a color word (e.g. red) when trying to respond to ink color. Thus, this is evidence that the word was processed to some extent despite the instruction to ignore it. If one can demonstrate cases with such effects and other cases without such effects, then one can have evidence that certain information is processed in the first case and not in the second.

Attenuation. Another modification to the early and late selection theory is an attenuation theory. Treisman (1960) has proposed a filter-attenuation model of attention that involves processing of the attended stimulus and only partial filtering of unattended stimuli. Information from both the attended and unattended stimuli reach the identification stage of processing, however, the information from the unattended stimuli are of a lesser quality or intensity as a result of attenuation. John explained that parallel processing is required on both sides of the attenuator. Attenuation has been used to account for the cocktail party effect. It may be possible that certain units are primed and require less activation in order to be detected and identified. For example, among several conversations in at a party, your name might be noticed in an otherwise ignored conversation.

Discussion of Attentional Paradigms

The report paradigm. In report tasks, subjects must report the stimuli in a display. For example, briefly present n letters and have subjects write down as many letters as possible. This measure is called "full report" or the "span of apprehension". Typically subjects can report about 4 letters. The question of interest for such tasks concern capacity limitations. Is processing independent regardless of the number of stimuli? It is possible to measure capacity limitations in report by comparing performance for displays with one letter and displays with many simultaneously presented letters. If processing is independent then there should be no differences between performances with different display set sizes. If processing is not independent then there should be differences between performances in the two display set sizes. For an example with clearly visible displays, performance might be perfect for one to three letters and then fall sharply with more letters. This suggests that the system has a capacity for processing at least 3 or 4 letters but limitations above that number.

Marc asked whether effects found in report tasks are due to capacity limitations on perception or on memory? Libo described the Sperling partial report studies that have shown that participants can report a cued letter even when the cue is presented after the letters have disappeared. Results from partial report studies provide evidence that it is possible to process information from many items and report the letter that occupied a specific location even when the location is not known prior to the letter presentation. This result suggests that memory limitations play a large role in report tasks.

The search paradigm. In search tasks, subjects view a display and search for a particular target stimulus ignoring other distractor stimuli. For example, they might search for the letter T among a variety of other letters. Or they might search for a pink disk among grey disks. In this task one can again determine the capacity limitations by varying the set size in the display. Because this task requires one to report about only a single target stimulus, the memory demands are much reduced relative to a full report task. In particular, one can argue that the memory demands are unchanged as the set size increases. Despite this nice control of memory, performance often declines with larger set sizes. Again, the lack of independence implies that the system as a whole has limited capacity. Is this specifically a capacity limit in perception?

Limitations in perception versus decision. An alternative explanation for attention effects found in larger set sizes is an effect on decision making. Consider a simple yes-no search task in which half the trials have a target and half do not and the subject responds either "yes" the target is present or "no" the target is not present. As set size increases, the proportion of errors increase. Fabian Soto explained that there is a certain probability of mistaking any given distractor for the target and that when there are more distractors there are more chances of an error. In particular, if two decisions are independent then the probability of an error on both is simply the joint probability of the two errors. Essentially, increasing the set size increases the number of decisions that have to be made concerning the presence of the target. Thus the decision is subject to noise from more stimuli, and it becomes increasingly likely that the subject makes an error.

The key assumption in this analysis of noisy decision making is that noise does limit performance. One exception to this is known as the high threshold model. In it, distractors never have an effect in themselves to produce a yes response. In this model, such false alarms are the result of guessing rather than noise from the distractors. In this case, the noise does not accumulate for larger set sizes. Recent research has consistently rejected the high threshold theory. Thus, to interpret set-size effects in search, one must consider the possible effects of noise on decision.

Ian asked if the effects of noise on decision can be seen in response time as well as accuracy. John argued that response time is probably influenced by noisy decisions as well. When noise increases so does the difficulty level of the task and deciding if a target was present in the display. It is likely that this increased difficulty results in increased response time. However, predicting the magnitude of the effect requires quite a detailed theory of response time. Ian also asked about ceiling and floor performance for discriminability tasks. Clearly it is necceary to avoiding ceiling and floor effects. No effect of set size does not imply unlimited capacity if it is due to either a floor or a ceiling effect.

The cueing paradigm. In spatial cueing paradigms, advance information is given to specify what location is relevant to the task. In particular, we concentrate on the partially valid cueing paradigm. In partially valid cueing, a cue is presented prior to target presentation that indicates the location of the target on many but not all trials. When the target occurs in the cued location it is called a valid trial and when the target occurs in an uncued location it is called an invalid trial. The primary way to measure attention effects is to compare performance for valid and invalid trials. This compares attended and unattended locations while holding constant the stimulus and task. Differences between the valid and invalid conditions must have something to do with attention.

Fabian asked about how to distinguish between attention effects on perception and memory in this task. First, lets consider the simple response time version of this task due to Posner (1980). In this version, the task is to detect a flash of light and respond as quickly as possible when it occurs and not to respond otherwise. Typically, cueing a location speeds the response at valid locations relative to invalid locations. One interpretation is that perceptual processing is speeded by the cue. On the other hand, it may be that the presentation of a cue lowers the criterion for responding to information at the cued location relative to the uncued location. Thus, it will take less evidence at the valid location to trigger a response compared to an invalid location. This distinction is similar to the issue of distinguishing perceptual and decision mediation of set-size effects in visual search.

Cathleen described another more recent line of partially valid cueing experiments due to Shiu and Pashler (1994). They used a task in which a character discrimination must be made such as which of four digits appeared in the display. Each display was followed by as mask. In prior experiments, masks were presented at all possible stimulus locations and large cueing effects where found. Shiu and Pashler suggested that this might be due to an effect on decision called noise reduction. When the cued location is considered alone, one can ignore the noisy contributions of the other locations. Thus performance is better based on the cued location than based on all locations as must be consulted when the cue is invalid. They introduced single mask

displays as a way to reduce the role of decision. When a mask is only presented at the target location they found no effect of cueing. They argued that the one mask condition reduces the uncertainty about the target location thus the decision can be based on information about one location in both the valid and invalid conditions. Because this eliminated the effect of the cue, these results are consistent with a noise reduction account of this effect. Thus for this study, while cueing shows selectivity and a capacity limit somewhere in processing, it appears to be more consistent with decision than perception.

The dual-task paradigm. There are two types of dual-task procedures those that have speeded responses and those that are not speeded. In the Pashler readings, he cites important advantages for the interpretation of the speeded tasks. But, we focused on the unspeeded version of the dual-task paradigm because that is the one used in the studies considered in the seminar.

A dual task involves performing two tasks at once. Again the question is about capacity: are the two tasks independent or not? Does the presence of a simultaneous task influence performance or is the performance of each task independent of the other? Typically, the effect of attention is summarized by comparing performance for both tasks to performance for the single tasks performed alone. Dual-task paradigms have several advantages. One is that they can be applied to a wide range of different tasks. Another is that the decision component remains constant which is not true of search-like tasks. However, there is also the disadvantage that entire sequence of processing stages is present for both tasks. Thus, any dual-task interference may be due to perception, memory, decision, etc.

An effort to sort out the stage that contributes to dual-task interference can be found in the research of Bonnel and Hafter (1998). They measured several dual tasks involving auditory and visual stimuli. In a dual detection task, subjects were required to detect a light and to detect a tone. Under these conditions, there is no dual-task interference. They then required participants to discriminate whether a light was brighter or dimmer than a standard, and to discriminate whether a tone was louder or softer than another standard. Under these conditions, there is evidence of dual-task interference. Thus for detection the two tasks are independent and in discrimination the two tasks are dependent. In further work, they made the case that it was the memory of the two standards that was key to the limited capacity shown in the discrimination task. Thus, they concluded that two pure perceptual judgments can be independent.

Other aspects of attention? Pashler characterizes attention by selection and capacity. Is this characterization exhaustive? Marc suggested considering conscious versus unconscious processes. John suggested considering the control of attention as distinct from effects of attention. Ian suggested that selective ignoring might be useful to consider. Another possibility is to consider arousal. While selection and capacity are important components of attention these other examples suggest that they may not be exhaustive.

Wrap up. Today's goal was to provide an overview of the issues and methods involved in attention research. In particular, we focused on selection and capacity as the two key theoretical ideas in attention. We also considered three of the four paradigms that will be addressed in this seminar: search, dual-task, cueing and flanker paradigms. Next week, we will begin to consider the role objects play in attention.

Attention and Perceptual Organization
Questions for Topic 2: Is there evidence of "object based" divided attention?
Cathleen Moore & John Palmer
September 15, 2008

Main Readings

Base Reading:

Duncan, J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology: General*, *113*, 501-517.

Contrast Reading:

Awh, E., Dhaliwal, H., Christensen, S., & Matsukura, M. (2001). Evidence for two components of object-based selection. *Psychological Science*, *12*, 329-334.

Supplemental Readings

Behrmann, M., Zemel, R. S., & Mozer, M. C. (1998). Object-based attention and occlusion: Evidence from normal participants and a computational model. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 1011-1036. [*This is one of several papers assessing whether object-based attention effects occur even when the objects require completion behind occluding surfaces (see also Moore et al., 1998 and Fulton & Moore, 2005 during Topic 3: Object-based Selective Attention). It also presents a connectionist model—MAGIC—that reproduces many of the object-based attention patterns that were found in the human data. Consistent with the grouped-array idea of Vecera and colleagues, "objects" are defined as specific groups of spatial locations.]*

Davis, G., & Holmes, A. (2005). Reversal of object-based benefits in visual attention. *Visual Cognition*, *12*, 817-846. [*This is one of several papers from this group identifying limiting conditions under which within-object advantages like those reported by Duncan (1984) occur in divided attention tasks. The argument is that these effects are essentially spatial. Some of the work is cited in the Awh et al. paper from the main readings*.]

Kramer, A. F., Weber, T. A., & Watson, S. E. (1997). Object-based attentional selection: Grouped arrays or spatially invariant representations? Comment on Vecera and Farah (1994). *Journal of Experimental Psychology: General*, *126*, 3-13. [*This paper was the starting point for the Awh et al. (2001) paper in the Main Readings*.]

Sohn, W., Papathomas, T. V., Blaser, E., & Vidnyansky, Z. (2004). Object-based cross-feature attentional modulation from color to motion. *Vision Research*, *44*, 1437-1443. [*This is an example of a study that used methods from psychophysics to address the question of whether all features of an object are processed when one feature is selected*.]

Vecera, S. P., & Farah, M. (1994). Does visual attention select objects or locations. *Journal of Experimental Psychology: General*, *123*, 146-160. [*This was the paper in which the grouped-array idea was raised explicitly and was first addressed empirically*.]

Study Questions

1. As defined by Duncan, what are the discrimination-based, space-based, and object-based theories of visual attention?

2. What are the key features of Duncan's stimuli that allowed him to distinguish object-based attention from discrimination- and space-based attention?

3. How did Duncan use dual-task logic to test a key feature of object-based attention?

4. Awh and colleagues used a dual-task method but without the single-task controls. How is their logic different from Duncan's use of the dual task?

5. Awh and colleagues use a postcue procedure in which they tell observers the attribute to report after the stimulus is gone, rather than before. How does this make the task different? How did Awh and colleagues use this task to conclude that there are two distinct object-based mechanisms of selection?

6. What is the conceptual difference between the object-based and the grouped-array account of divided attention? How have people distinguished these accounts experimentally?

Discussion Questions

1. In recent years, discussion has focused on distinctions between space-based and object-based selection mechanisms. Discrimination-based accounts have fallen out of the picture? Should they be revived? How do they fit into the distinction between space-based and object-based selection?

2. How essential is spatial-invariance to object-based attention?

3. Awh and colleagues suggest that the object-based effects in their Experiment 2 are due to memory and not perception. How might such an attention-in-memory hypothesis work?

4. If one accepts Awh and colleagues interpretation that these dual-task effects are due to attention in memory, what is the status of object-based attention in perception? Might there be none?

5. Is the effect of object-based attention to facilitate performance within an object, or is it to avoid interference from other objects or attributes? Consider using the single-task controls as one possible "neutral" condition.

6. How might one find larger effects of object-based attention? For example, might one use more objects in a search task? Or choose discriminations that require serial processing?

7. What are the alternative hypotheses for the role of objects in attention?

Attention and Perceptual Organization
Summary for Week 2: Is there evidence of "object based" divided attention?
Fabian Soto, Cathleen Moore and John Palmer
September 19, 2008

Readings

Duncan, J. (1984). Selective attention and the organization of visual information. *Journal of Experimental Psychology: General, 113,* 501-517.

Awh, E., Dhaliwal, H., Christensen, S., & Matsukura, M. (2001). Evidence for two components of object-based selection. *Psychological Science, 12,* 329-334.

Discussion Summary

Overview. Cathleen Moore introduced the guiding question of this session: Is there evidence for divided attention being based on objects? The assigned readings consist of an influential early paper by Duncan (1984) and a more recent paper by Awh et al. (2001).

The dual-task paradigm. Given that Duncan uses the dual-task paradigm to test predictions of an object-based theory, Cathleen reviewed the logic behind this paradigm. A dual task is used to indicate the presence of capacity limitations somewhere in the system. It uses a very intuitive approach to this problem by asking if there is any difference in performance when two tasks must be performed together compared to being performed separately. We discussed this paradigm last week within the context of experiments in which subjects are instructed to pay more attention to one or the other. Such a trade-off is usually depicted as an attention operating characteristic (AOC) relating performance in the two tasks. One example is to present participants with colored letters and ask them to identify the color of a particular letter and to identify the identity of a particular letter. Are these two tasks are performed independently or do they interfere with each other in any way? For more details on this example, see Pashler (1994) from last week's supplemental readings.

Cathleen asked what strengths and limitations are inherent to the dual-task paradigm. Lynn Perry indicated that an advantage of the dual-task paradigm is that it avoids the confounding of decision and perceptual effects found in search. In particular, increasing the set size in search affects decision by increasing the chances of an error with additional stimuli. In contrast, the decision for any one task is held constant in the dual-task paradigm. Regarding its disadvantages, Theresa Stephens said that performing two tasks creates the possibility of interference for each component process of the tasks. It also may introduce the issue of coordinating between the two tasks. This is pronounced if one has to perform two speeded tasks. Unspeeded task reduce the coordination problem. More generally, the problem of identifying where a capacity limitation lies within the system will reoccur throughout future discussions.

What is attended. Cathleen stated that one of the reasons why Duncan's paper has been influential is that it was the first to explicitly distinguish three broad classes of attentional theories: object-based, discrimination-based and space-based. Our discussion considered each of these in turn. Marc Halusic described the space-based theories as having selection restricted to a limited area of the visual field. For example, by the spotlight metaphor, attentional selection is

restricted to the spatial region covered by the spotlight. Theresa described discrimination-based theories in terms of limiting the number of discriminations that a can be made at any given time. Marc asked if this was equivalent to Allport's analyzer theory. Cathleen answered that Allport's theory can be considered an example of a discrimination-based theory. In his version, there are processing limitations if two or more discriminations simultaneously require the use of information from the same analyzer. There are no limitations if the discriminations require information from separate analyzers. Another kind of discrimination-based theory limits performance based on the number of discrimination regardless of whether they share a location, object or analyzer. Finally, object-based theories put the limitation in the number of objects that can be attended to at the same time.

What is an object? Lynn asked what is the definition of an object? This is important to know if objects are the unit to measure attentional limits. Marc answered that objects are defined by the Gestalt properties that allow one to segment it from the background and other objects. John Palmer suggested that one can define objects using an observer's judgments. For example, show photographs to people and ask them to segment the image into objects. At least for the simple case of isolated objects, one expects considerable agreement across observers. Shaun Vecera said that objects are formed through organizing areas within the visual field into units. For example, he offered, two regions that have the same color and are near by each other, but separate, may well be represented as a single object. Cathleen added that this would be especially likely if they appeared simultaneously, whereas if one region appeared abruptly before the other, they would be less likely to be represented as a single object, at least at first. This question is an important one to keep in mind, and will be revisited many times.

Experimental discrimination of these theories. Cathleen explained that in many cases the number of relevant objects is confounded with the number of relevant spatial region. How does Duncan overcome this confounding in his experiments? Libo Zhao answered that the visual displays used by Duncan consisted of two objects superimposed in space: a box with a diagonal line drawn through it). Thus, there are two objects and only one spatial region. Duncan required one or two of several possible judgments: the size of the box, the position of a gap in the side of the box, the texture of the line, or the tilt of the line. The stimuli were designed so that the relevant information to be reported would be separated by a similar distance in the display when the attributes to be reported where in one object or in two different objects. Also, the number of discriminations to be performed is equivalent across experimental conditions, and the selection of judged properties gives no reason to suspect different processing for cases with one object or two.

Cathleen asked how Duncan combined these displays with the dual task method in his experiments. Lynn answered that Duncan had subjects report two properties of the same object or one property of each of two objects. Different groups of subjects were assigned different properties. For each of these conditions, he also asked for reports of each property by itself. The measure of most interest is a comparison between the dual-task condition and these single-task controls. If there is a limit in attentional capacity, then there must be a deficit in performance for the dual-task condition relative to the single-task condition. Furthermore, if the attentional limitation is specific to objects, then there is no dual-task deficit for properties of the same object. By this hypothesis, the deficit occurs only when the properties are from different objects.

Summary of predictions. The predictions for Duncan's experiments are in Table 1.

Table 1

Predictions for Duncan's Dual-Task Experiments

Object-based	Single task	= Dual-task/Same object	> Dual-task/Different objects
Location-based	Single task	= Dual-task/Same object	= Dual-task/Different objects
Disc.-based	Single task	> Dual-task/Same object	= Dual-task/Different objects

Duncan's results. Moving on to results, Ian Rasmussen began a discussion of the results in Table 1 of Duncan (1984). The observed results are consistent with an object-based theory. Ben Dow pointed out that the decrement in accuracy indicating an object-based limitation is only found for the second reported property, not for the first. In other words, there is no dual-task deficit for any condition for the first reported property. This is not consistent with a general capacity limit on perception.

A concern with Duncan's design is that different groups were tested in the single-object and multiple-objects tasks. Unexpectedly, these different groups had different performance even for the single-task controls that were identical for the different groups. Perhaps these are just subject differences and can be eliminated by a within subject design. John speculated that Duncan was concerned that a within-subject design would have made the same versus different object manipulations obvious to the participants, which may have resulted in a effort to please the experimenter and perform less well in the "more complex" different object conditions. This appears not to have been the case because these results have been reported in both within and between subject experiments.

Ian asked what was the stimulus duration in the experiment. Keith Apfelbaum answered that it varied from observer to observer because of the use of adaptive methods. But it was always between 50 and 100 ms. Shaun added that although Duncan reports the overall display duration, he does not report if there were any differences in the distribution of times used for the different groups of subjects.

Grouped-array theory. Ben explained that we can think of the grouped-array theory of visual attention as proposing an attentional spotlight that is narrowly restricted to the region in space occupied by an object. But then how does this approach differ from object-based theories? The "strong" object-based approach proposes selection to be spatially invariant. Objects are processed the same irrespective of spatial location in the visual field, because what is being selected is the representation of an object distinct from its spatial location. In contrast, the grouped-array theory allows that space can have an effect, because what is being selected is a representation that is defined in terms of spatial locations. This difference between the strong object-based and grouped-array hypotheses is tested in the Awh et al. (2001) experiment. This experiment uses the strategy developed by Vecera and Farah (1994) and adopted by Kramer, Weber and Watson (1997). Cathleen noted that in all of these studies the focus is on the comparison between reporting two properties of the same object versus reporting one property of each of two objects. Single-task performance was not measured. So the logic is a bit different

than that used in the original study by Duncan. Keith added that they also manipulate a new experimental factor: the spatial separation between the objects. This was the key innovation of the original Vecera and Farah (1994) study. Awh et al. (2001) found both object effects and spatial effects of the separation between the objects. On the face of it, the spatial dependence is consistent with the grouped-array hypothesis and inconsistent with the strong object hypothesis. Calgar Tas was concerned that the effect of the spatial manipulation in Awh et al.'s Experiment 1 is significant, but very small. Indeed it is small. Marc noted that the effect of spatial distance was the same for the first and second reported attributes of the between condition. This is in contrast to a larger object within-object advantage for properties reported second than properties reported first. This contrast between the effect of spatial distance and the within-object advantage led Awh et al. to hypothesize that perhaps there are two components of object based attention, with the within-object advantage reflecting a memory effect.

Two components of object-based attention. Calgar explained the logic behind Awh et al's second experiment. The idea was to minimize the effects on perception by not providing any advance information to the participants about which target they will be reporting during a trial. Instead, instructions about the relevant target objects and properties were given at the end of each trial using postcues that appeared 200 ms after the offset of the stimulus display. This postcue procedure was assumed to avoid selection during the presentation of the display. The results of Experiment 2 was to eliminate the spatial effects and to also eliminate the object effects for the 1st response. An object effect remained for the second response. Awh and colleagues argued that this second experiment was pure measure of divided attention effects on memory rather than perception. They interpreted the first experiment as a combination of perceptual and memory effects.

Fabian Soto asked about the possibility that people keep spatial representations in working memory and selection from this memory is the basis of both the object effect and the spatial effect. Cathleen answered that it is a possible alternative. John added that the role of spatial representation evolves through processing. Early visual processing is organized spatially in a retinotopic fashion, whereas later in visual processing the representations become less spatial. But exactly where and how this change occurs is debated.

Differences between and grouped-array and other theories. Cathleen reminded us all that the strong object-based hypothesis proposes that processing limitations are space-invariant. How important is this feature for the theory? Libo noted that apparently both space-invariant and space-dependent factors can play a role in determining attentional limitations in the grouped-array hypothesis. Shaun Vecera indicated that it is important to take into account what features are relevant for a particular task, and what features group together in a display according to probabilistic cues indicating that they form a good group. The grouped-array hypothesis is an example of object-based attention because attention that is allocated within a particular spatial area extends to other parts of the visual space with the aid of perceptual grouping factors. Attentional effects are task-dependent because it is the task faced by participants that defines to some extent what is the relevant array in a particular display.

John pointed out another role that objects play in the grouped-array hypothesis. Consider the case of attending to each of two overlapping objects. Is the grouped array formed first for one object then the next? Are two grouped arrays formed? Or are the two objects combined into one

composite grouped array? Shaun indicated that his original thinking was to make each grouped array specific to an individual object.

Cathleen asked about what distinguishes the grouped-array hypothesis from the space-based hypothesis. If in space-based theories the limit is in the number of places that one can attend to at the same time, and in object-based theories the limit is in the number of objects, then where is the limit according to a grouped-array hypothesis? Is it simply the number of different grouped arrays? Ian answered that in the grouped-array hypothesis attentional limitations are not merely spatial. Whereas space-based theories propose attentional allocation that is more or less arbitrary beyond focusing the center of attention on a relevant spatial area, the grouped-array hypothesis proposes that attentional allocation respects the organization of the scene, being like a spotlight which boundaries change according to principles of perceptual grouping. John said that one way to operationalize a space-based hypothesis is that attention operates over a retinotopic representation. Shaun indicated that the grouped-array hypothesis is not necessarily retinotopic, but it is space-based in the sense that it acts upon a representation in which spatial distances between different parts of the image are conserved.

The attention-in-memory hypothesis. Awh and colleagues argue that their results can be explained as the combination of two different attentional processes. There is a selection process that is space-dependent operating over early perceptual representations, and a different process that is spatially invariant and operates over representations in working memory. Ian indicates that Duncan's results can be explained through a working memory hypothesis that assumes a limited number of memory slots (e.g. Luck & Vogel, 1997). Each slot can store all of the information about one object. Thus, if memory is required, two objects might be more difficult to remember than one. The multiple-object disadvantage in Duncan's results only occurs for the second property reported during his experiments. This is consistent with the observed limitation being due to memory rather than due to perceptual processes. Libo developed further an explanation of Duncan's results in terms of a working memory model. According to this idea, different components of the same objects are associated with each other during perceptual processing, and then this association is stored in memory. If the different features that are associated typically belong to the same object, a limitation in the number of available slots in working memory translated in a limitation in the number of objects that can be stored at the same time without any loss in information.

John indicated that while this memory hypothesis focuses on storage limitations there are other possible memory hypotheses. Lynn proposed that the capacity limit might be due to limitations in retrieval from memory. Ben added that priming effects during retrieval might depend on object representations. Marc asked for more background on retrieval limitations in working memory. John gave an example of retrieval from working memory that was performed in a serial fashion and thus affected being a bottleneck. Fabian pointed out that this suggests a limitation in processing speed not accuracy as in Duncan's experiment. True, but given limited time, effects on processing time may become effects on accuracy.

Calgar argued that limitations in encoding can also be responsible for these effects, and asked how it is possible to design an experiment to clarify what type of limitation is involved. John answered that one way to begin solving this problem is by manipulating variables that are known to affect one aspect of the process and not others. For storage, the key manipulation is the

retention interval. For retrieval, one can vary the number of retrieval cues that are available as pointers to a particular piece of information that has been stored in memory (e.g. recognition versus free recall in verbal memory).

Attentional effects in perceptual processing. Cathleen asked if there was any evidence in these papers of an attentional effect occurring in perceptual processing. John explained that Awh et al.'s second experiment attempted to eliminate these perceptual effects, leaving only an effect based on object representations in memory. But these researchers did not devise a condition in which memory effects are controlled to isolate an attentional effect on perception. They simply argued that the difference between the results in their first and second experiments is due to attentional limits on perception. In order to give experimental evidence for this claim, it is necessary to have an experiment which controls memory effects. Lynn commented that one possibility for ruling out memory effect is to hold them constant in all conditions, so that any further difference would be the result of the experimental manipulation. One possibility to perform such experiment is to use a search task. The idea is to reduce the memory demands to simply remembering the target and then manipulate the number of distractors (see Moore & Osman, 1993).

Cathleen described another approach to control for memory effects (see Behrmann, Zemel, & Mozer, 1998). Consider an experiment that uses a same-different discrimination task in which subjects have to indicate if the bumps at the end of a rectangle are the same or not. In some cases, the target object is presented covered by an occluder, whereas in other cases it is presented as two rectangles with a gap between them. In both cases the relevant information about the bumps is separated by the same spatial distance. The results are that subjects are faster in the occluder condition rather than the no occluder condition. There is nothing about manipulating the occluder that affects the likelihood of a memory limitation. The reference to representations stored in memory is the same in both displays, and therefore there is no reason to believe that the effect is due to memory limitations. Libo suggested that such an effect might depend on learning. Lynn noted that objects representations may be essentially statistically reliable groupings of features. Cathleen noted that consistent with these suggestions, these object-specific effects can be modulated by experience (Zemel & Behrmann, 1999).

Summary of alternative hypotheses. To summarize, we constructed a list of the hypotheses considered in the day's discussion. One distinction was between the purely spatial hypothesis, the grouped-array hypothesis and the spatial-invariant, object-based hypothesis. A second distinction was between what stages of processing contributed to the dependence between different tasks. The primary distinction was between perceptual and memory limitations. In addition, we considered whether any memory effect is due to memory encoding, memory storage, or memory retrieval. Thus, there are a number of possibilities to consider further. These distinctions define a set of hypotheses regarding object based attention. We will be considering these further with the goal of creating as exhaustive a set as possible. We can then consider which are the most viable, and under what circumstances, as well as design experiments to discriminate among them where they do not exist in the literature.

Attention and Perceptual Organization
Questions for Topic 3: Is there evidence of "object based" selective attention?
Cathleen Moore & John Palmer
September 22, 2008

Base Readings:

Vecera, S. P. (1994). Grouped locations and object-based attention: Comment on Egly, Driver, and Rafal (1994). *Journal of Experimental Psychology: General*, *123*, 316-320.

Contrast Reading:

Kravitz, D. J., & Behrmann, M. (2008). The space of an object: Object attention alters the spatial gradient in the surround. *Journal of Experimental Psychology: Human Perception and Performance*, *34*, 298-309.

Supplemental Reading:

Driver, J. & Baylis, G. C. (1989). Movement and visual attention: The spotlight metaphor breaks down. *Journal of Experimental Psychology: Human Perception and Performance*, *15*, 448-456.

[This is one of the earliest object-based selective attention papers. Although, there is a paper by Bundesen (Bundesen, 198?) that is empirically very similar. It was not, however, as explicitly focused on the contrast between space-based and object-based selection. Both these papers show that flankers in the flanker task that are spatially distant but somehow grouped with the target (e.g., by common fate or common color) can interfere with target processing more than flankers that are closer to the target spatially but are not grouped with it.]

Egly, R. Driver, J., Rafal, R. D. (1994). Shifting visual attention between objects and locations: Evidence from normal and parietal lesion subjects. *Journal of Experimental Psychology: General*, *123*, 161-177.

[This is a highly cited paper in the object-based attention literature. It was the basis of the Vecera (1994) base reading. The paper reports data from both normal and parietal patients, but the paper is cited almost exclusively for the method and the data from the non-patient subjects.]

Moore, C. M., Yantis, S., & Vaughan, B. (1998). Object-based visual selection: Evidence from perceptual completion. *Psychological Science*, *9,* 104-110.

[This paper is similar to the Behrmann, Zemel, & Mozer (1998) paper in the supplemental readings for divided attention. It asks whether the object-specific effects in the two rectangles paradigm occur even when the rectangles have to be completed behind occluding surfaces or are defined by illusory contours. They do.]

Moore, C. M., & Fulton, C. (2005). The spread of attention to hidden portions of occluded surfaces. *Psychonomic Bulletin & Review*, *12*, 301-306.

[This paper asks whether parts of objects that are not explicit in the image because, for example, they are represented as continuations of an object behind an occluding surface, show effects similar to parts of objects that are explicitly present. They do.]

Study Questions

1. What is the logic of the two-rectangles paradigm? How does it distinguish object-specific and location-specific attention effects?

2. What theoretical challenge does Vecera present to the interpretation of the two-rectangle experiments? How does he address that challenge experimentally?

3. What general hypothesis does the Kravitz and Behrmann (2008) set out to test? What specific hypothesis is addressed in each of the experiments?

4. What is the logic of each of their experiments? Walk through and understand the conditions in Figures 1, 3, & 5?

5. Kravitz and Behrmann's method is similar to the two-rectangles method in some ways and different in other ways. Identify as many of these similarities and differences as you can.

Discussion Questions

1. Is the basic Egly et al. effect compelling evidence that selection can be object-based? Is there anything that would make it more compelling?

2. Are the effects reported in these studies effects on perception? If they are not, what other processes might have caused them, how can they be interpreted?

3. How essential is spatial invariance to object-based selective attention? If spatial invariance is not essential, what defines object-based attention as object-based?

4. Can one think of variations on the Egly method that might lead to larger effects? For example, might making it a discrimination task and/or adding distractors help? How would these affect the interpretation?

5. Kravitz and Behrmann introduce their studies in the context of biased competition? What is biased competition and how does it relate to potential attention mechanisms that we've talked about already, such as signal enhancement and noise reduction?

6. Kravitz and Behrmann hypothesize that objects alter the spatial gradient surrounding themthe objects How does this idea relate to potential attention mechanisms? Can this hypothesis apply to any processing other than perceptual processing?

7. Kravitz and Behrmann suggest the possibility that monitoring a space for probabilistic targets (i.e., a partially valid-cueing situation like the one they used) might result in a different spatial profile than a situation in which the location of the relevant stimulus is known and the challenge is to avoid being distracted by other stimuli (p. 306). How might that work?

8. What are the alternative hypotheses for the role of objects in selective attention?

Attention and Perceptual Organization
Summary for Week 3: Is there evidence of "object-based" selective attention?
Caglar Tas, Cathleen Moore and John Palmer
September 29, 2008

Readings

Vecera, S. P. (1994). Grouped locations and object-based attention: Comment on Egly, Driver, and Rafal (1994). *Journal of Experimental Psychology: General, 123*, 316-320.

Kravitz, D. J. & Behrmann, M. (2008). The space of an object: Object attention alters the spatial gradient in the surround. *Journal of Experimental Psychology: Human Perception and Performance, 34*, 298-309.

Discussion Summary

Overview. Cathleen Moore introduced the two readings and explained why we did not read the original study of the two-rectangle paradigm by Egly, Driver, and Rafal (1994). Instead we read the more recent version of the paradigm as presented by Vecera (1994) because the original study contains some unrelated experiments while Vecera is to our point of interest.

The difference between divided and selective attention. Last week, we reviewed Duncan's dual-task paradigm. The two-rectangle task used in Vecera's (1994) experiment is different from the Duncan's paradigm. The dual-task paradigm is about object-based divided attention in which the main task is to spread attention to several stimuli. So, what is the difference between Duncan's divided-attention paradigm and Egly et al.'s selective-attention paradigm? Libo Zhao answered that divided attention means that both objects are selected and thus one has to divide attention to both objects. By comparison, Fabian Soto said that in the two-rectangle cuing paradigm that the cue manipulation introduces a degree of selection among locations and objects. John Palmer elaborated that by cueing only one location and comparing valid and invalid locations, the paradigm emphasizes the effect of selective attention. Cathleen described the popsicle sticks experiment (Behrmann, Zemel & Mozer, 1998) discussed last week as another example of divided attention.

Ian Rasmussen asked when we make this distinction, are we making task distinction or a distinction among attentional mechanisms. Cathleen responded that selective attention is the other side of divided attention. For example, in early selection theory, the ability to use a single filter mechanism determines whether one can select and whether a process has capacity limits. In contrast, the controlled-parallel theory disengages these two aspects of attention. By this theory, being able to select does not determine the degree of capacity limitations. Selective and divided attention work independently. Fabian asked how we can differentiate selective and divided attention experimentally. For example, is there anyone who used the same task, stimuli or parametric manipulations for both selective and divided attention before? Cathleen answered that direct comparison between selective and divided attention is hard because they are using different tasks. However, there are some tasks that integrate these two tasks. In the individual search tasks, you may first select the relevant stimuli based on the color and then limit your attention with these stimuli, and then divide your attention among the selected stimuli.

John described one of his visual search experiments that involved both selective and divided attention (Palmer, 1994). He manipulated both the number of displayed stimuli and the number of relevant stimuli using cueing. The effect of increasing the number of stimuli is an effect of divided attention. The effect of reducing the number of relevant stimuli is an effect of selective attention. These effects can be of similar magnitude but need not be.

Two-rectangle paradigm. Cathleen asked about the logic of the two-rectangle paradigm used in Vecera (1994) and Egly, Driver, and Rafal (1994). Ian responded that the basic idea is to combine the manipulation of cuing with perceptual structure. One location is cued and the performance is measured for valid and invalid cues. The difference between performance for valid and invalid cues provides a measure of selective attention. Furthermore, the innovative idea is a comparison between different invalid cue conditions. The invalid cues can either be on the opposite end of the cued object or in a different object (see Figure 1 below). Because these locations are matched in distance from the cued locations, any difference must be due to perceptual structure. Next, Cathleen asked about the results found using these cuing tasks? Observers are faster and more accurate when they respond to a valid cue compared to invalid cues. Furthermore, they are faster in the same-object invalid condition compared to the different-object invalid conditions.

What are the interpretations of this cuing result? First, why do people think it is an attentional task? It's because perceptually everything is constant so the source of any difference must be attentional. Second, what is critical in the comparison between the same-vs.-different object conditions of the two-rectangle paradigm? Marc Halusic answered that the because the invalid cues are equidistant from the cue, the results can not be explained by space-based attention. Therefore, the results must be due to object-based attention.

Figure 1. The Two-rectangle Task

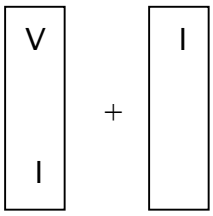
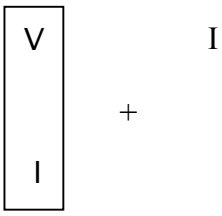


Figure 2. Alternative Design



John sketched an stimulus display modified from the two-rectangle design (Figure 2) and asked how one can interpret the difference between the two invalid conditions in this alternative design. Keith Apfelbaum answered that being in the same object should have an advantageous effect on performance. Libo added that the typical hypothesis is that attention spreads to the object's boundaries. John pointed out that in this alternate design the visual display near the invalid locations are not identical as it was in the two-rectangle design. This, in this case any effect might not be attentional but rather due to perceptual differences (e.g. masking by the boarder).

Fabian asked whether horizontal or vertical positions of the rectangles make a difference. The answer is essentially no because the manipulations of interest are counterbalanced across this factor. Ian asked whether all locations are tested by invalid cues. Cathleen answered that in the original Egly et al. study, not all locations were tested. In particular, the location in the different object and the far end was never tested. But recently there are studies in which all four locations were tested without changing the qualitative results.

John suggested that in the two-rectangle paradigm one can primarily attend the cued location but other locations are also relevant to a lesser degree. That is, one may also attend to the invalid locations because the target might be present at these locations. Thus, selective attention might not be as selective for this paradigm as possible. Are there any other tasks which might show larger effects of selective attention? The flankers task is most studied and relevant alternatives. Ian described the flankers task. In it, subjects must attend to a target stimulus while ignoring some neighboring flanker stimuli. Cathleen added that another feature of the original flankers task is the flankers where chosen so that if one based a response upon them rather than the target, it would be correct in the congruent condition and incorrect in the incongruent condition. Thus this task potentially provides a more sensitive and demanding measure of selective attention.

Cathleen asked what was the theoretical challenge made in Vecera's paper. Keith replied that Vecera manipulated the distance between the two objects and found performance to vary by this spatial manipulation. Thus, the results cannot be explained by object-based attention alone. In addition, the space between the objects also matters. What is Vecera's proposal to explain the results? Lynn Perry described the grouped-array hypothesis. Rather than modifying processing of an entire object in a uniform way, one can modify the processing at a set of spatial locations that is a function of the shape of an object.

Experiment 1 of Kravitz and Behrmann. Cathleen asked about the basic idea of Kravitz and Behrmann's experiments (2008). Teresa Stephens described them as addressing whether there is an object-based attentional advantage for the surround of the object as well as the object itself. The particular proposal is that attention spreads from the center of mass of the cued object into the surround rather than spreading from just the cued location.

Ian suggested that the center of mass effects were consistent with the biased competition model. Cathleen explained the biased competition model. This model can be consistent with the idea of the grouped array.

Next we considered the details of the experiment as shown in Figure 1 (p.300). It is helpful to first focus on the barbell condition. Ian described the experiment. The target can be either in the object or in the surround of the object. The locations in the surround were equidistant from the cued location. The primary result of Experiment 1 was that faster responses occur for targets in the surround when they are closer to the center of the mass of the object. Ian asked if these results can be explained by perceptual effects. John answered that some comparisons can be interpreted this way. In particular, comparing the within-object locations to surround locations is problematic. But, comparing near to far locations in the surround seems good because the nearby stimuli are matched (empty fields).

Ian was not sure how the authors calculated the difference scores displayed in Panel B of the Figure 2. Cathleen answered that these difference scores are relative to the valid target condition. Why are people faster with valid trials for barbell condition compared to the circles? Cathleen answered that the local perceptual differences between barbell condition and other conditions may well be the source of this problem consistent with the general concerns already discussed.

Experiment 2 of Kravitz and Behrmann. What is the basic logic of Experiment 2? Keith answered that the targets are equidistant from the cue but their distance from the center of mass of the object were varied systematically. The result is participants were faster responding when the target is closer to the center of mass of the cued object. This is consistent with attention spreading out of the center of the mass of the object.

Possible problems: Selection of Participants. Cathleen expressed concern about subject selection. Kravitz and Behrmann eliminated a number of subjects due to their false alarm rates. They also eliminated specific blocks with multiple false alarms. This raises the possibility they were selecting for a subset of subjects that naturally perform this task very conservatively. John added that because they selected the data on false alarms, one cannot interpret the remaining conditions as actually having low false alarms. At the extreme, the blocks might have only differed by chance and they selected the fraction the of the blocks with low false alarm rates. A better procedure is to select subjects on the basis of one data set and then observe an independent data set and measure false alarms again.

John told a story about the original Shepard-Metzler mental rotation studies as an example of extreme subject selection. The question was how long it would take for the participants to mentally rotate an object. In the details of the procedure a number of the subjects were thrown out of the experiment. Consequently, the results were based on a selection of particular subjects that were very good at mental rotation. In larger studies since, it has become clear that many subjects cannot perform this task without many errors. Cathleen also gave an example of mental imaging study. In one of the early experiments, subjects were explicitly instructed to create a mental image and scan the locations in an instructed way. In summary, the use of such selection and instruction manipulations change the point of these studies. They show that some effect can be obtained under their special circumstances rather than that the effect is obtained in general.

Possible issues: Center of mass. Shaun Vecera commented that the center of mass effects are occurring outside of the object. He wondered if such effects also occur within the object. Cathleen described prior work on a similar center-of-mass hypothesis in the domain of eye movement research. For example, in one study (Melcher & Kowler, 1999) participants were presented with fields of random dots which defined various shapes. The interesting result is that the eyes tended to land in the center of the mass of the shapes. Shaun gave another example of multiple-object tracking study by Brian Scholl in which he used moving lines. He explained the results as an effect of center of mass.

Possible problems: Stimuli & Design. Ian suggested that another problem might be a bias of due to orientation rather than location. The within-object location is always vertically or horizontally related to the cued location. John commented that in the first experiment the near object location in the vertical condition becomes the far object location in the horizontal condition. Therefore, the surround effect cannot be explained by the specific locations of the near and far objects.

Another point is that in the second experiment the barbell was either upward or downward oriented. It would be better if the bar was presented in every possible angle. Ian also added that the cue is always in the same location. They only changed the location of the targets but not the cued location.

Christopher suggested that another possible explanation that presence of clusters of contours and lines that draw attention rather than the object's center of the mass. Is it possible that these effects are only as a result of attending being biased to the presence of any "stuff" in the display? One way to resolve this concern is to use the full two-rectangle paradigm, as in Vecera (1994), to control the presence of local stimuli around the various locations of interest.

The mechanism of two-rectangle paradigm. Cathleen asked what is the mechanism of the improvement in performance in the cueing paradigm used in the two-rectangle experiments. Is it signal enhancement, noise reduction, or changes in the decision criteria, or some combination of these possibilities? More generally which of these mechanisms are responsible for the object-based attention effects?

Signal detection theory

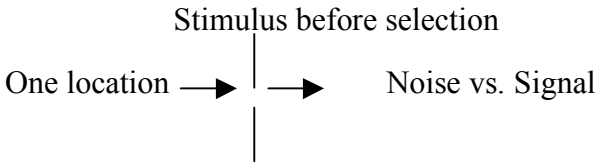
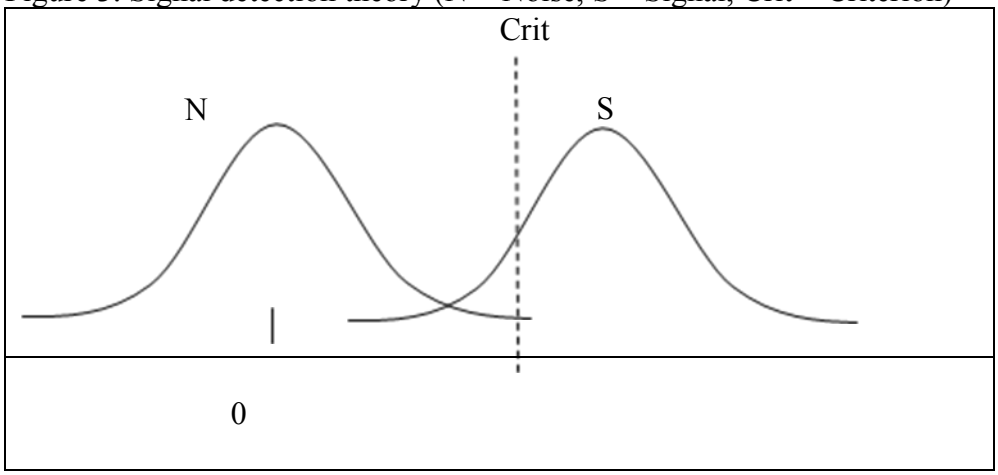


Figure 3. Signal detection theory (N = Noise, S = Signal, Crit = Criterion)



Our previous discussion of Shiu and Pashler (1994) introduced several alternative accounts of cueing effects. John began the discussion by reviewing the ideas of signal detection theory as shown in Figure 3. Begin by restricting consideration to detecting a light at a single location with a yes-no task. Either a target flash (signal) or an empty display (noise) is presented. The single location is assumed to be selected and nothing special is assumed about this filtering process. The essential idea is that the cases of signal and noise can be represented by two random variables that correspond to the evidence for the target. The decision is made by setting a criterion amount of evidence and responding "yes" if that criterion is exceeded.

This discussion describes only effects on accuracy. Response time theories are more complex to describe in any detail. But generally speaking, if the difference between noise and signal distributions is increased, the result is faster reaction times in addition to improvements in accuracy. The following discussion focuses on accuracy with the suggestion that a similar argument can be developed for response time.

1. Criterion Shift

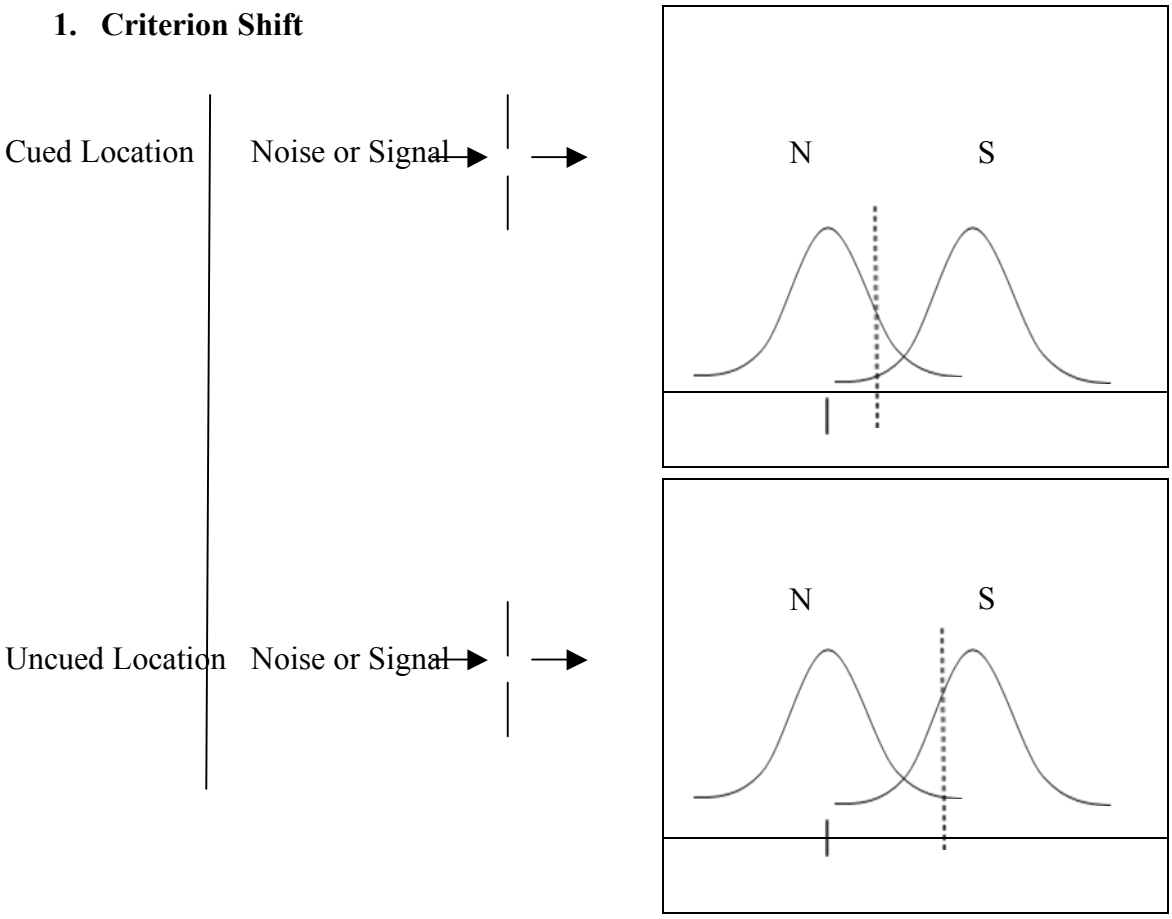


Figure 4.

Now turn to the case of interest with two locations and a cue that specifies one of these locations as more likely. Furthermore, assume that we apply the signal detection theory to each location independently. According to the *criterion shift hypothesis*, there is no difference in the processing of the two stimuli. Instead, the difference between cued and uncued locations is to adjust the decision process by shifting the criterion used for the two locations.

Amplification with Late Noise

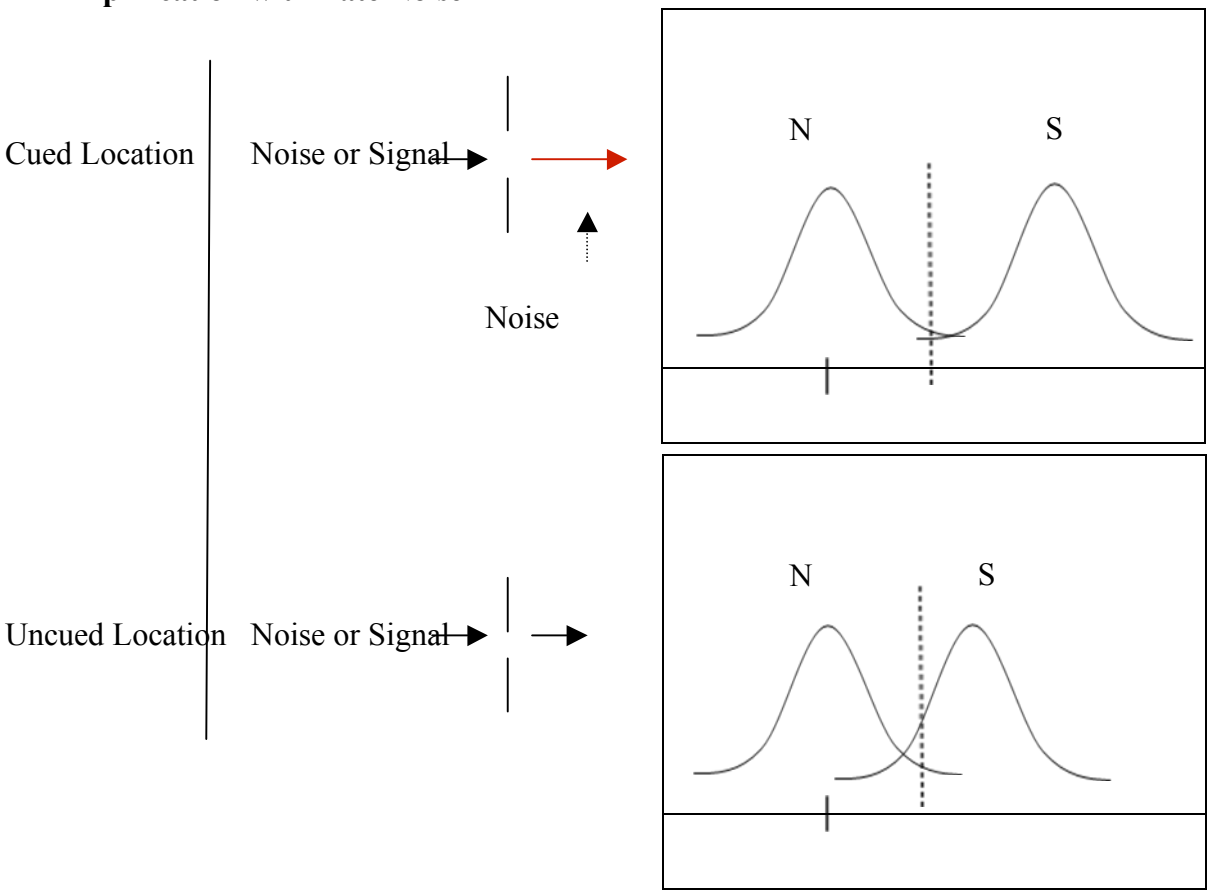


Figure 5

An alternative hypothesis is presented in Figure 5 that is called *amplification with late noise*. By this hypothesis, the signal at the cued location is amplified. The noise that limits performance is assumed to be after this point in processing so that amplification has no effect on the noise. Consequently, the signal is improved at the cued location relative to the uncued location. In addition, the noise distributions for both cued and uncued locations remain the same. Thus, the shift of the signal distribution results in a change in the signal-to-noise ratio at the cued location. Therefore, the responses are more accurate and/or faster for the cued location.

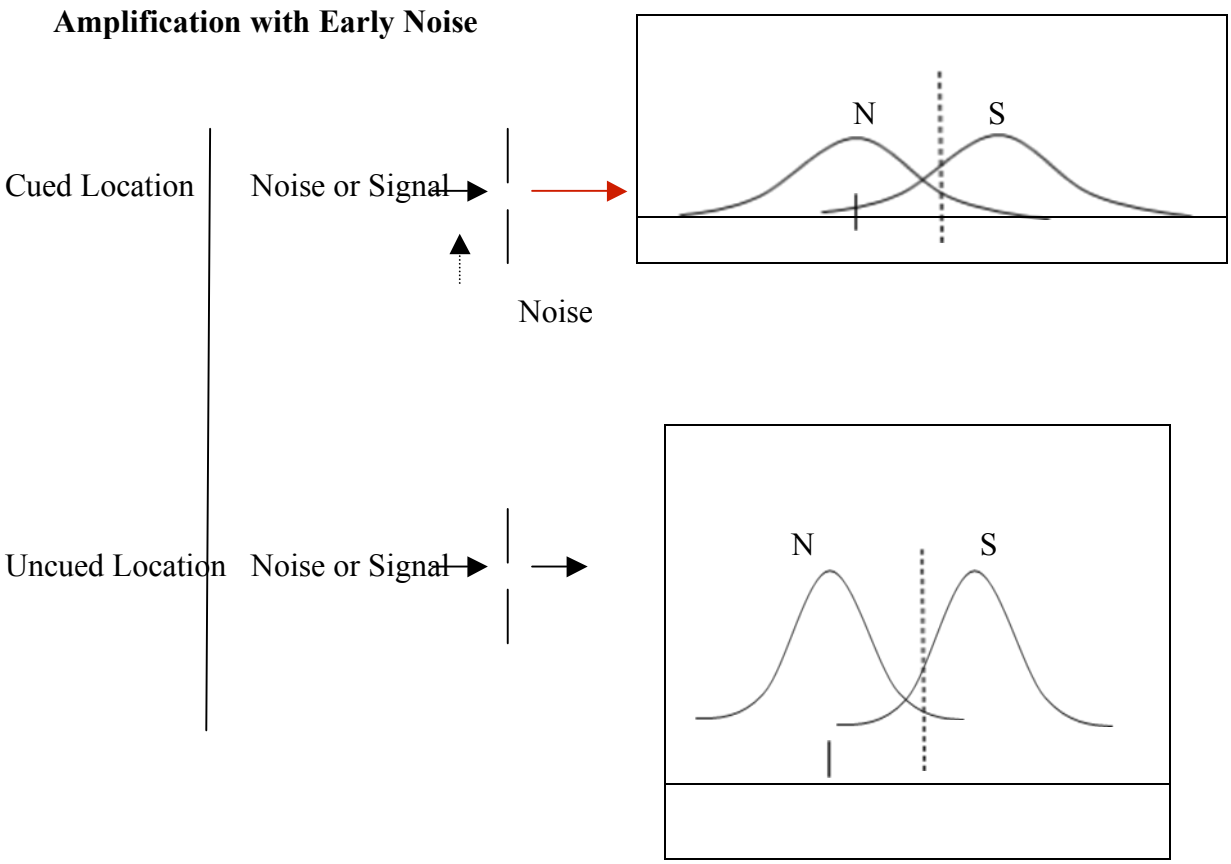


Figure 6.

In Figure 6, consider a hypothesis with *amplification and early noise*. By "early", it is meant that the limiting noise before the selection process. Because the noise is before the amplification, then noise is also amplified. Therefore, both noise and signal distributions are spread out in the cued condition. If one puts the criteria at the same location as the uncued location, this results in more hits and more false alarm at the cued location compared to the uncued location. Because the target is more likely at the cued location, this can result in an overall improvement in performance. Note however that if the criteria is adjusted proportionally, it is possible to obtain the identical performance for cued and uncued locations. This is because the signal-to-noise ratio does not change at the cued location.

Attenuation with Early Noise

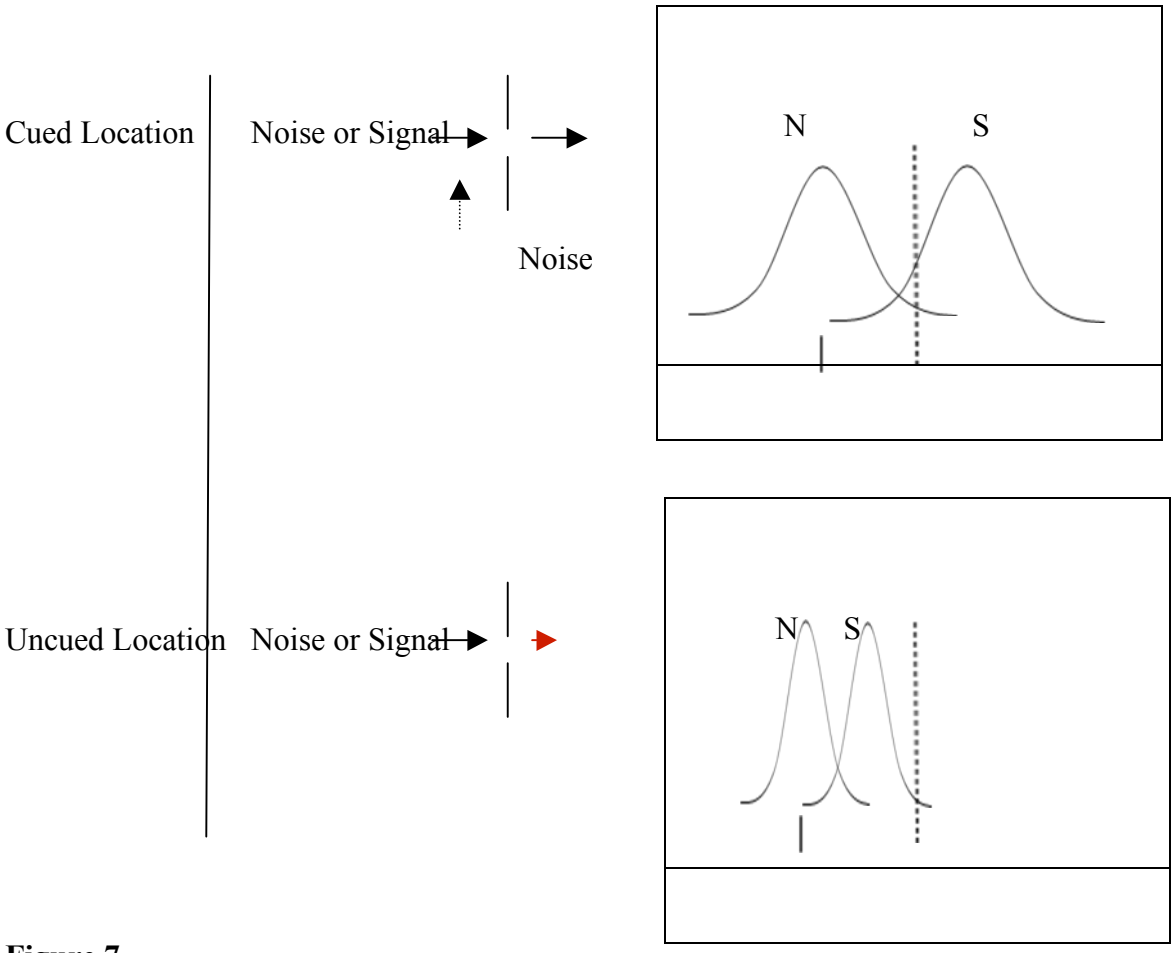


Figure 7.

In Figure 7, consider a hypothesis with *attenuation and early noise*. Here the idea is to attenuate information at the invalid location rather than amplify information at the valid location. One attenuates the uncued location because information from this location is less useful that from the cued location. The distributions for the cued location do not change but the distributions in the uncued location become narrower. This model is similar to amplification with early noise. In the former, you attenuate the unnecessary location whereas in the latter you amplify the cued location. The net results for behavior are much the same.

Table 1.

Properties of the Models

Model	Change of Criterion Shift	Change in sensory representation in cued location	Change in S/N ratio in cued location
Criterion Shift	YES	NO	NO
Amplification + Late Noise	NO	YES	YES
Amplification + Early Noise	NO	YES	NO
Attenuation + Early Noise	NO	NO	NO

Which hypothesis represents sensory enhancement as described in the readings? Several properties of the various hypotheses are summarized in Table 1. Which property is related to sensory enhancement? A narrow definition of sensory enhancement is in terms of the signal-to-noise ratio for the cued location. That clearly is an improvement in perception at that location. Alternatively, one can consider a broader definition by which any positive change in the sensory representation is sensory enhancement. In that case, any amplification hypothesis qualifies. They may not improve local signal-to-noise ratio, but they may affect other aspects of the process such as direct measures of the physiology of early visual processes. Thus, we suggest that different authors are using different definitions of sensory enhancement.

Cathleen asked what these different hypotheses predict about the performance on same-object and different-object conditions. Christopher suggested that with these models it is hard to distinguish the reaction time differences. John commented that indeed one does need an more elaborate model to describe reaction time results. But, speaking generally, there are corresponding response time models to each accuracy model.

Cathleen asked Shaun which models was he thinking of when writing about the grouped array hypothesis. Shaun replied that of the models described, his thinking was the closest to amplification with late noise.

Ian asked if one proposes that the noise is after you process the stimulus then why would this noise limit performance. John replied that in the easiest to define examples late noise represents problems in processing that don't specifically relate to the stimulus. Examples include forgetting, decision making, lapses of attention. One can also include more perceptual errors but they have to be after selection. For example, if the model was early selection then any error in stimulus identification contributes to late noise.

Ian asked how these models describe the change in attention across space. Several of the models are similar in suggesting that gain varies across space: amplification with early noise, amplification with late noise, and attenuation with early noise. All of these models have a gain mechanism that affects the cued relative to uncued locations. In the criterion shift hypothesis, the criterion changes rather than the gain. Thus, one can model a criterion that varies depending on where the stimulus is presented.

The role of memory. Last week, we argued that there might be a memory explanation for the object-based effects on divided attention. Is there a memory or a spatial invariant component for the selective attention effects in the cueing paradigm of the two-rectangle experiments? There does not appear to be an easy memory explanation for two-rectangle paradigm. It is built on search and detection paradigms that were designed to minimize the role of memory. This is quite different than the dual-task paradigm used by Duncan.

The role of spatial invariance. Last week the suggestion of a memory hypothesis left room for a spatially invariant contribution to the object-based attention effects. What about for this task. Here, spatial effects seem more the rule. However, John suggested that one must achieve some degree of an object constancy across different location. For example, one could not be recognize people on the street without a way to compare objects across different viewpoints. Cathleen asked how we can differentiate between memory and location tasks? Christopher replied that accuracy dependent tasks mostly depend on memory. For example, discrimination tasks are mostly based on memory. John argued that the most important distinction is the manipulation of the experiment. If you use two speeded task (the PRP paradigm), the dual-task effect is very large and probably due to something about response selection. Shaun added that both the location and the features of the object affect the decision process. To sum up, the audience tended to argue that spatial invariance is not critical for object-based attention.

A preview of next week's reading. John mentioned that the Han, Dosher, and Lu (2003) paper attacks the issue of early versus late noise. Essentially, they can compare attenuation with late noise to amplification with early noise. The basic idea is that if one adds enough noise to the stimulus, it eliminates any attention effect predicted by amplification with late noise while preserving the effects predicted by models with early noise. Shaun also recommended thinking about Duncan's (1984) paper while reading Han et al.'s paper.

Attention and Perceptual Organization
Questions for Topic 4: What are the mechanisms of object-based attention?
Cathleen Moore & John Palmer
September 29, 2008

Base Reading:

Shomstein, S. & Yantis, S. (2002). Object-based attention: Sensory modulation or priority setting? *Perception & Psychophysics*, *64*, 41-51.

Contrast Reading:

Han, S., Dosher, B. A., Lu, Z-L (2003). Object attention revisited: Identifying mechanisms and boundary conditions. *Psychological Science*, *14*, 598-604.

Supplemental Reading:

Chen, Z., & Cave, K. R. (2006). Reinstating object-based attention under positional uncertainty: The importance of subjective parsing. *Perception & Psychophysics*, *68*, 992-1003.
[This paper addresses the Shomstein & Yantis (2002) paper. The main finding is that when additional contextual support is provide that supports the representation of the different rectangles as distinct objects, object-specific effects occur even with location certainty.

Lamy, D., & Egeth, H. (2002). Object-based selection: The role of attentional shifts. *Perception & Psychophysics*, *64*, 52-66.
[This paper presents evidence that object-specific effects occur when attentional shifts within the display are required, but not when they are not necessary. This can be due to either attention being distributed very broadly or very tightly. This is generally consistent with the Shomstein & Yantis (2002) conclusion.]

Moore, C. M., Yantis, S., Vaughan, B., & Handwerker, D. A. (unpublished manuscript). Functional differences between space-based and object-based visual selection.
[This is a paper that is reviewed quite a bit in the Shomstein & Yantis (2002) paper. It was a theoretical departure point for that paper. It takes a different approach, and has different strengths and limitations.]

Richard, A. M., Lee, H, Vecera, S. P. (in press). Attentional spreading in object-based attention. *Journal of Experimental Psychology: Human Perception and Performance.*
[This paper addresses the Shomstein & Yantis (2002) paper as well. The main finding is that when the to-be-judged attribute is more integral to the objects, object-based flanker effects occur even in the face of location certainty.]

Study Questions

1. How do Shomstein and Yantis (2002) characterize the distinction between sensory enhancement and prioritization as possible mechanisms of object-based attention? How do they distinguish between these in Experiment 1?

2. Shomstein and Yantis (2002) use the Egly task as a departure point for their study. Identify as many similarities and differences between their basic experiment and the Egly paradigm as you can.

3. What is being tested in Experiment 5 of Shomstein and Yantis (2002) and how is it tested?

4. What is a psychometric function? How do Han et al. (2003) use psychometric functions in their study?

5. Han et al. (2003) use the Duncan task as a departure point for their study. Identify as many similarities and difference between their experiment and Duncan's as you can.

6. What is the purpose of the noise manipulation in the Han et al. (2003) study?

Discussion Questions

1. Shomstein and Yantis (2002) distinguish between sensory enhancement and prioritzation. How does this relate to serial vs. parallel processing, signal enhancement vs. noise reduction, perception vs memory, and attenuation vs. blocking.

2. How do the hypotheses considered by Han et al. (2003) fit into those contrasts?

3. What other contrasts can be considered in regard to possible mechanisms of object-based attention?

4. Compare Experiment 1 and Experiment 5 in Shomstein and Yantis (2002). What are the key differences that might give rise to finding an object-specific effect in Experiment 5, but not in Experiment 1? What hypotheses about the mechanism behind these effects do they suggest?

5. What other experiments in the literature that contrast with Experiment 1 of Shomstein and Yantis? (Some in the supplemental readings include: Richard et al. (2008), Chen & Cave (2006), Driver & Baylis (1989) from topic 2. Are there others?) *Note: We are not expecting you to do a literature search here or to read the supplemental readings necessarily. This is a brain storming exercise.*

6. The two objects in the Han et al. (2003) study were presented at different locations. How does this limit its scope with regard to object-based attention?

7. Review the set of hypotheses that were generated during the discussions of Topics 2 (object-based divided attention) and 3 (object-based selective attention)? Can that set be expanded, limited or revised based on the discussion of this topic?

Attention and Perceptual Organization
Summary for Week 4: What are the mechanisms of object-based attention?
Marc Halusic, Cathleen Moore and John Palmer
October 6, 2008

Readings

Shomstein, S. & Yantis, S. (2002). Object-based attention: Sensory modulation or priority setting? *Perception & Psychophysics*, 64, 41-51.

Han, S., Dosher, B.A., Lu, Z-L (2003). Object attention revisited: Identifying mechanisms and boundary conditions. Psychological Science, 14, 598-604.

Discussion Summary

Overview. We have spent the last few classes exploring evidence for whether there is object-based attention. Today we investigate some potential mechanisms of object-based attention.

The difference between sensory enhancement and prioritization. Shomstein & Yantis describe two possible models of the effects of object-based attention exemplified in Egly's two-rectangle paradigm. We first discussed the possibility that the difference was that sensory enhancement is a parallel processes model and prioritization is necessarily serial. Ian Rasmussen described prioritization as meaning that one region in an object tends to be selected, and if that region does not contain the expected information, people by default shift attention to other regions in that object before checking other possible locations. Fabian Sato asked whether this meant that the distinction was parallel vs. serial. John Palmer said that although the language used suggests that prioritization is a serial model, footnote one of the article explicitly states that serial processing is not a necessary component of prioritization. He asked how a parallel model can fit prioritization as described by Shomstein & Yantis. Cathleen Moore said that one alternative is a parallel, weighted model. Ian said that last week's parallel decision criterion model is a good candidate. In this model, the attention effects are caused by changing the criteria for responding to different portions of the visual field. Cathleen asked why such a model is not sensory enhancement. Wouldn't such a model blur the distinctions between sensory enhancement and prioritization? (An answer consistent with the following discussion is that this hypothesis is not sensory enhancement because it does not change the percepts.)

Early versus late processing. We then discussed a second possibility: that the difference is early vs. late processing. Perhaps what is unique about sensory enhancement is that it places attentional processes in early parts of visual analysis. The neural representation in an early visual area such as V1 might be altered as a result of these processes by either enhancing the signal for relevant stimuli or decreasing noise due to irrelevant stimuli. By contrast, prioritization is a late process that affects processing after the stimuli have been perceived. It is important to pin down what is meant by early and late processing. Chris suggested that they refer to processes before stimulus identification (early) or after identification (late). Cathleen put up a diagram to clarify the processing sequence (Figure 1).

Stimulus → Perception → Decision → Response Preparation → Response

Figure 1. Example processing sequence.

Cathleen suggested that "early" refers to processes that occur during or before perception and "late" refers to processes after perception such as decision. Thus, by this definition, sensory enhancement affects perception whereas prioritization does not. Chris Kovach pointed out that in our second class, we discussed early versus late selection, and that used stimulus identification to define early versus late processes. Stimulus identification can be considered a specific landmark process within perception.

Chris also asked whether a decision bias is considered an example of selective attention. Because it is an effect of attention, it does count as an instance of selective attention although not a typical one in the context of studies of perceptual attention.

Ian argued that sensory enhancement was not convincingly rejected by the study. Because flanker effects are small (e.g. 20 ms), the fact that flankers in the object didn't cause a greater effect might have been due to a lack of power. Even though they did a power analysis in Experiment 4, Ian was unconvinced that the study was sensitive enough to rule out a small effect.

Ian then raised a related problem. Perhaps there was a ceiling for these flanker effects. If so, the objects might affect selection, but it would have no consequences on behavior. This concern has been voiced before when such indirect measures have been compared to direct measures of detection. For example, it appears that priming effects are very sensitive but "saturate" quickly as the stimulus strength increases. To pursue this possibility, one can vary the stimulus strength (e.g. contrast) as done in the Han et al. study discussed below.

Experiment 1 of Shomstein and Yantis. Subjects were shown a vertical or horizontal rectangle with a target in the center of the display and flankers to the right and left. The target and flankers were chosen from four possible letters. The letters H and V required that subjects press the left response key, and U and X required that they press the right response key. In the case of a horizontal rectangle, flankers were inside the rectangle, to either side of the target, and two, smaller vertical rectangles were placed directly above and below its center. In the case of a vertical rectangle, the two small rectangles were horizontal at either side of its center and contained flankers. This manipulation maintained a constant distance between the target and the flankers. It also put flankers in either the same object or in different objects. Flankers were either letters compatible with the target or letters incompatible with the target. Response time and error were measured as a function of compatibility and whether the flankers and targets were in the same or different objects. There was a compatibility effect for both object conditions (about 20 ms and 2% errors). The main finding was that the flanker effect did not differ as a function of whether the targets and flankers were in the same object or in a different objects.

Contrasting the paradigms of Egly et al. and Shomstein & Yantis. Chris wanted to know why Shomstein & Yantis didn't use Egly's parallel rectangle design. John responded by drawing Egly's parallel rectangles. Fabian pointed out that the flankers in this design would

probably have no effect because they are so far from the targets and thus easier to ignore. Typically, flanker experiments keep the separations within a degree or so.

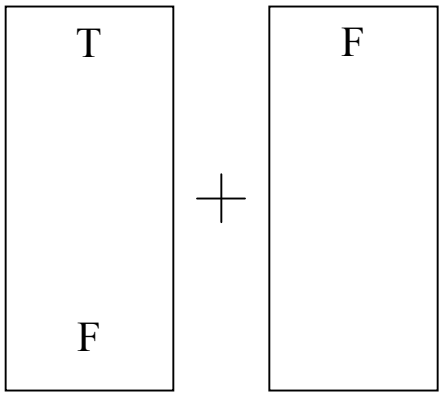


Figure 2. Egly's two-rectangle task if it had been used as a flanker task.

We went on to enumerate as many differences between the paradigms as possible.

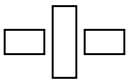
Egly	S & Y
1. Cuing paradigm	Flanker paradigm
2. Parallel rectangles 	"Overlapping" rectangles 
3. Target uncertainty	Target certainty
4. Possible floor effect	Possible ceiling effect
5. Light detection	Letter discrimination
6. Monitoring	Filtering
7. Large separation (distinct targets)	Small separation (targets may be seen as a unit)

Figure 3. List of differences between experiments of Egly et al. and Shomstein & Yantis

Object "goodness". Chris pointed out that a cross is a common shape so that S & Y's claim that some flankers were within the same object and other flankers were in different objects might not be accurate. Experiment 4 addressed this problem by increasing the space between the small rectangles, but still found no effect. However, the possibility remains that the rectangles were seen as a single object. Cathleen agreed that object quality is likely to mediate the flanker effect. This is a recurrent problem raised in the seminar. Lynn Perry asked whether experiments that find null results for comparisons between one and two objects ever check to make certain that their objects are perceptually separate. Cathleen said that they usually do not, and instead try to demonstrate an effect of the manipulation under at least some conditions. This problem is more important for null results rather than positive results. Chris expanded on this point by

explaining that manipulations of context can affect the goodness of an object such that the same object may be good or bad as a function of the context.

Experiment 5 of Shomstein and Yantis. Experiment 5 introduced several changes in the displays and procedure in an effort to find an object-based effect on the flanker paradigm. It introduced target location uncertainty by using a display where there were four possible target locations each surrounded by its own flanker locations. An uninformative cue was presented in the center of the larger rectangle. The target was presented in either the cued rectangle or the uncued rectangle. In this experiment, the flankers always appeared in a different object than the target. In sum, the experiment was a 2 by 2 by 2 factorial design that manipulated flanker compatibility, cueing either the target or flanker rectangles, and eccentricity of the flankers. The results were that the flanker effect was larger when the flankers were in the cued rectangle than when the target was in the cued rectangle. They argued that this was consistent with a priority account in which the flankers receive extra processing when they are in the cued rectangle relative to when they are in the uncued rectangle.

Cathleen asked what was the key differences between Experiment 5 and Experiments 1-4. Keith said that in the article, they argue that the key change in Experiment 5 was that subjects did not know in advance where the target would appear. According to the authors, when spatial certainty exists, subjects are relatively unaffected by flankers. In contrast, when there is spatial uncertainty, subjects need to have attention less focused, and so are influenced by flankers. This explanation does not make clear why this would specifically produce an object-based effect. Other elements of the experiment were changed as well. Lynn pointed out that there was also an uninformative cue to draw attention to the center of the cross. Ian reminded the class that the target and flankers were always in different objects. The new design makes it so that we are no longer dealing with a typical flanker task where there is one relevant discrimination. Instead it is a search task with an added set of flankers. Lynn reminded us that people performed more slowly on Experiment 5 in general, so effects might be due to taking people away from a ceiling. Finally, yet closer reading suggests the authors think the key effect is the ordering of processing of flanker and target that resulted from a combination of spatial uncertainty, cueing one object and keeping the flankers and targets in separate objects.

Alternative versions of sensory enhancement and prioritization. Cathleen asked how one can relate sensory enhancement and prioritization to other possible mechanisms. Keith Apfelbaum suggested that we can distinguish them by classifying sensory enhancement as early selection while prioritization is late selection. Ian similarly mentioned that while the language used in Shomstein and Yantis suggested parallel versus serial, either mechanisms can be implemented using a parallel or a serial model.

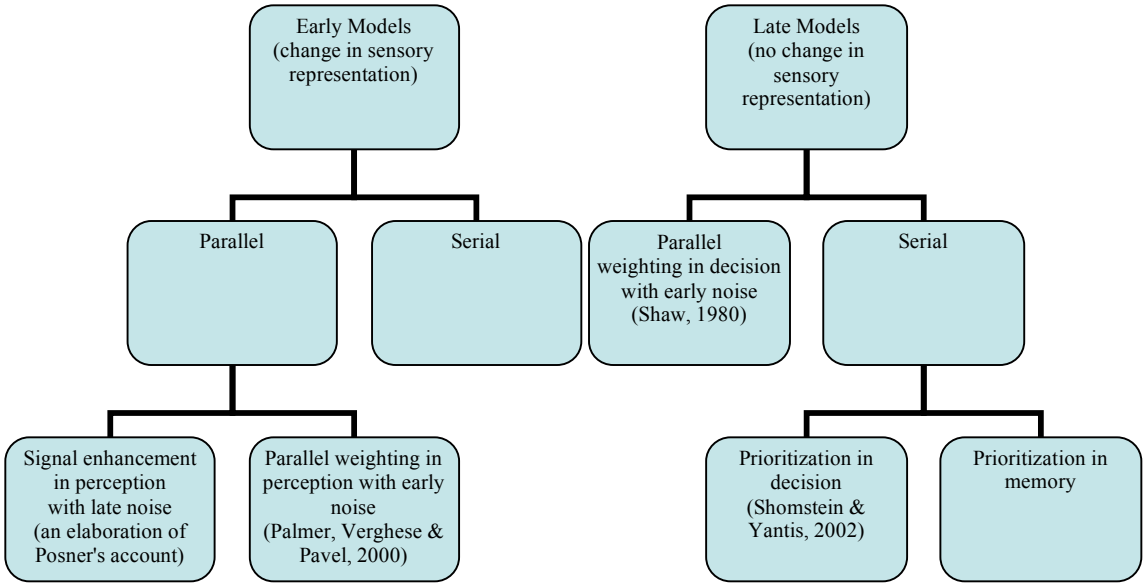


Figure 4. Alternative models of selection.

To clarify the possibilities, Cathleen laid out a diagram of alternative hypotheses. In this diagram the most general theories are at the top and their special cases are below. At the top is the primary distinction of early versus late defined in terms of whether there are changes in the sensory representation. Then each hypothesis can be specialized by assuming either parallel or serial processes. We then considered four more specific models. First is the signal enhancement idea championed by Posner. As discussed last week, one way this can be implemented is by amplification of the signal followed by a late noise source. This is perhaps the most clear case of what is referred to as sensory enhancement. Second, we described one version of the prioritization idea from Shomstein and Yantis (2002). Here a serial process is assumed and the selection process orders the sequence of decision making. Third, we discussed a parallel version of the prioritization idea. This model followed Shaw's work (1980) by weighting evidence from perception in making a decision about the stimuli. Thus, selection did not change the perception itself, but how it is integrated into a decision. Fourth, we briefly described a model that is largely equivalent to Shaw's but moved the idea of noisy integration into perception rather than putting it into decision (Palmer, Verghese & Pavel, 2000). As before, information is weighted but now that processes is applied within perception. One way to think of this is in terms of the biased competition model. If two stimuli are competing for a representation in the same neural receptive field, top-down weights and a "winner-take-all" rule may determine which dominates the neural response. This provides a alternative account of sensory enhancement. It differs from the signal enhancement version in that the local stimulus is not itself enhanced. Instead, the integrated percept is enhanced that combines information from multiple sources. There are several other possibilities that fill out this tree but we did not get to them in discussion. How about a early serial process where the ordering of processing enhances perception. This might be appropriate for word recognition. Another account is prioritization in memory encoding as suggested in our prior discussions of Duncan's dual-task experiments.

Variations on Shomstein & Yantis. Experiments since Shomstein & Yantis have identified some boundary conditions on when object-based effects are found and not found. A

study by Chen and Cave (2006) first replicated the Shomstein and Yantis study in not finding object-based effects for a simple flanker task (as in Experiment 1). Then Chen and Cave conducted a second experiment that included filler trials with the various objects in separate displays. On these filler trials, sometimes the large rectangle was displayed and sometimes the two-part second rectangle was displayed. They reasoned that this variation would increase the salience of the separate objects. Under these conditions, they found object-based effects. This suggests that the quality of the objects may be critical.

Richard, Lee and Vecera (2008) also pursued this issue. They created a stimulus in which the test attributes were changes in the contour of the object context. Specifically, the rectangles had round or square "bites" taken out of their edges. For these stimuli, they found object-based effects. These experimenters also replicated S & Y's finding with simpler stimuli that did not show object-based effects. Again the quality of the objects and the integration of the tested attribute within the object appear to be critical.

Next Article: Han, Dosher and Lu (2003). Whereas Shomstein and Yantis was modeled after the selective attention task of Egly et al., Han et al. employed a divided attention task similar to Duncan (1984). It differed from Duncan in a several ways. First, they added to Duncan's comparison of a single task and a dual task. Subjects made decisions about one or two objects and about one or two discriminations. Specifically, they judged one dimension of a single object, two dimensions of a single object, the same dimension of two objects or different dimensions of two objects. Han et al. also used near-threshold Gabor patches as the stimuli rather than relatively visible, overlapping outline forms. For the purposes of this article, the most noteworthy attributes of the Gabor patches is that they can vary along three dimensions. They vary in orientation, vary in phase (the center may be dark or light), and vary in contrast. The experiment is run in blocks in which participants know the task for that block (e.g. report the same dimension of two objects). Right before presentation of the stimulus, the an arrow is presented that tells the subject whether to report first the object on the right or left. They also included conditions with pixel noise as well as clear displays.

To vary the difficulty of their judgments, Han et al. measured the psychometric function for contrast. For each condition, the contrast was varied from a level that yielded near chance performance to a level with near perfect performance. Thus, they have a range of performance from floor to ceiling and don't have to worry about floor or ceiling effects. The advantage of such a technique is that some effects may only be apparent at certain levels of difficulty. Further, the shapes of the psychometric functions can be diagnostic. In the no noise condition, people responded similarly in all conditions until performance in each condition reached an asymptote. Only near the asymptote does the two-object, different-discrimination condition have worse accuracy than the other conditions. In the high noise condition, the conditions each eventually reach a roughly similar level of accuracy, but do so at different rates. Because these effects are sensitive to difficulty level, it calls into question the generality of Duncan's results that depended on a single difficulty level. It might have been the difficulty level and not fundamental processes that led to his finding no difference under some conditions.

Cathleen asked what were the results for this study. Libo responded that the two-object, different-discrimination condition showed a clear accuracy decrement compared to the other

conditions. This suggests that there is something special about making different discriminations about different objects that decreases performance even when compared to making two similar discriminations about two objects. Ian suggested that the difference might be the cost of task switching. However, John points out that in that case, we should also see problems with the one-object, two-discrimination condition, which we don't.

Marc Halusic argued that the two-object, same-discrimination task might be transformed by participants into a one-object pattern judgment. For example, if the target on the left is angled with its top pointing to the left, and the target on the right is angled similarly, the effect is to see one pattern as illustrated in Figure 5. If so, two-object, same-discrimination conditions might be perceptually equivalent to one-object, one-discrimination conditions. Han et al. mentioned this explanation in their discussion section, but only to say that the logic is circular that two objects might be seen as one. No one was satisfied with this comment.

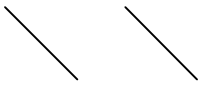


Figure 5. Example of ambiguity between how to parse patterns into objects.

A further point of uncertainty is whether the results are due to object-based or space-based attention. Chris suggested that because the targets are spatially separated in this study, one cannot distinguish the effects are due to objects or space. Thus, their results provide interesting constraints on attention, but it is uncertain whether they apply to object-based attention in particular.

Cathleen asked what one expect from Han et al.'s paradigm if object-based attention was due to faster orienting of response selection. By this hypothesis, the effects are on processing time rather than on the accuracy obtained with sufficient viewing time (cf. Santee & Egeth, 1982). Consequently, one does not expect an object-based effect using an accuracy measure of performance. Ian described this as using "early" methodology to test a "late" mechanism. Cathleen described it in terms of "data-limited" versus "resource-limited" processes.

John described the rational provided in other Dosher and Lu papers on the use of external noise to distinguish alternative hypotheses. In brief, the idea is that the external noise acts like "early" noise. If the mechanism already assumes early noise as do typical noise reduction accounts, there is an increasing attention effect with increasing external noise. Alternatively, if the theory depends on late noise as do typical signal enhancement accounts, then the effect of the late noise is swamped by the addition of large amounts of external noise. In this case, the attention effects decrease with increasing external noise. Han et al found larger attention effects with external noise than with no noise. This is consistent with noise reduction accounts such as the weighting models described earlier (e.g. Shaw, 1980; Palmer et al. 2000).

In closing, the two papers provide insight into the possible hypotheses to account for attention effects in general and with object-based effects in particular. Our effort to summarize the possibilities for attention effects in general is in Figure 4. It combines three distinctions: the early vs. late distinction made by Shomstein & Yantis, the distinction between early and late noise sources made by Han, et al. and the distinction between parallel and serial processes.

Attention and Perceptual Organization
Questions for Topic 5: What is the role of attention in the organization of space?
Cathleen Moore & John Palmer
September 29, 2008

Base Reading:

Moore, C. M. & Egeth, H. (1997). Perception without attention: Evidence of grouping under conditions of inattention. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 339-352.

Contrast Reading:

Freeman, E., Sagi, D. & Driver, J. (2004). Configuration-specific attentional modulation of flanker-target lateral interactions? *Perception*, *33*, 181-194.

Supplemental Reading:

Driver, J., Davis, G., Russel, C., Turatto, M. & Freeman, E. (2001). Segmentation, attention and phenomenal visual objects. *Cognition*, *80*, 61-95.
[This chapter reviews a large body of work, most of which is from Driver's group, from which it is concluded that not only does perceptual organization play a role in determining what and how information is attended (object-based attention), but also attention plays a role in perceptual organization.]

Freeman, E., Sagi, D., Driver, J. (2001) Lateral interactions between targets and flankers in low-level vision depend on attention to the flankers. *Nature Neuroscience*, *4*, 1032-1036.
[This is the original paper on which the Freeman et al (2004) contrast reading was based.]

Mack, Tang, B., Tuma, R., Kahn, S., & Rock, I. (2002). Perceptual organization and attention. *Cognitive Psychology*, *24*, 475-501.
[This is the original paper on which the Moore & Egeth (1997) base reading was based.]

Polat, U., & Sagi, D. (1993). Lateral interactions between spatial channels: Suppression and facilitation revealed by lateral masking experiments. *Vision Research*, *33*, 993-999.
[This is the paper in which the base flanker-enhanced detection task was introduced.]

Wolfe, J. M. (1999). Inattentional amnesia. In V. Coltheart (Ed.) Fleeting memories. (p. 71-94) Cambridge, MA: MIT press.
[This an oft-cited paper in which Mack and Rock's body of work, which is characterized as reflecting "inattentional blindness", a perceptual limitation, is challenged as instead reflecting "inattentional amnesia", a memory limitation.

Study Questions

1. Moore and Egeth (1997) set up their paper by noting that perceptual organization is often assumed to occur preattentively. Think of ways and say how that assumption has been a part of different papers that we have read and discussed in this class so far.

2. How do Mack et al. (1992) and Rock et al. (1992)—hereafter "Mack and Rock"—distinguish "inattention" from other conditions of less-than-full attention, sometimes called "preattentive", "unattended", "divided attention", etc.?

3. Describe Mack and Rock's method for testing processing under conditions of inattention. Why is it important to include the "full attention" condition?

4. Describe the memory interpretation of Mack and Rock's results that is raised by Moore & Egeth (1997). Why is this important with regard to object-based attention?

5. How do Moore & Egeth (1997) test the memory alternative? What do they find and conclude?

6. Describe the flanker-enhanced detection effect that serves as the basis of the Freeman et al (2004) study? Then describe how (in their previous work, replicated here), that effect is modulated by attention.

7. In this study, Freeman et al. (2004) seek to discriminate among alternative reasons for the attentional modulation of the flanker-enhanced detection effect: global orientation match, local orientation match, and top-down modulation of early visual processes. Describe each of these alternatives.

8. How do Freeman et al. (2004) test among these alternatives? What do they find and conclude?

Discussion Questions

1. How does the paradigm of Freeman et al. (2004) relate to Duncan's divided attention paradigm? Are the two paradigms simply tapping into different processes? What changes to each of the experiments could be made to make them more comparable?

2. Freeman et al.'s (2004) results ruling out local orientation match as the critical factor for attentional modulation of flanker-enhanced detection seem to imply that the effect is not caused by feature-based attention. How strongly has the feature-based account been ruled out? Are there other ways of testing it?

3. Ignoring feature-based attention for the moment, is the attention effect that is probed by Freeman et al. (2004) object-based or space-based?

4. On the face of it, the implications of these two papers seem to conflict: perceptual organization occurs without attention (Moore & Egeth, 1997) versus attention plays a key role in perceptual organization (Freeman et al., 2004). Think of as many ways as you can that the studies can be contrasted.

5. What theoretical positions are compatible with the results from both papers?

6. The memory hypothesis favored by Moore & Egeth's (1997) is that the output of perceptual organizational processes requires attention to be encoded into memory, and may or may not be perceived if not encoded. This can be distinguished from a hypothesis put forward by Wolfe (1999), which is that things are perceived without attention, but are later forgotten. Can these different accounts be distinguished?

Attention and Perceptual Organization
Summary for Topic 5: What is the role of attention in the organization of space?
Ian Rasmussen, Cathleen Moore and John Palmer
October 17, 2008

Readings

Moore, C. M. & Egeth, H. (1997). Perception without attention: Evidence of grouping under conditions of inattention. *Journal of Experimental Psychology: Human Perception and Performance,* 23, 339-352.

Freeman, E., Sagi, D. & Driver, J. (2004). Configuration-specific attentional modulation of flanker-target lateral interactions? *Perception*, 22, 181-194

Discussion Summary

The preattentive hypothesis for perceptual organization. The discussion began by asking what processes necessarily occur prior to selection. One possibility is that the processes underlying perceptual organization are "preattentive" and provide the raw materials for object selection. This lead to a discussion of the how to describe the processing stages involved in vision. Marr's ideas were described that specify a sequence of three representations. First is a two-dimensional retinotopic image, then what he called the 2 and ½-D sketch which describes surfaces at depth and finally a more abstract object representation within a three-dimensional space. Prima facia it is suggested that in order to select an object or spatial location, these objects or locations must first be perceptually defined, and thus perceptual organization must occur preattentively

It was then asked that regardless of whether or not the phenomena studied in Moore & Egeth are preattentive, it is still possible that other types of perceptual organization might occur post selection. That is, there doesn't seem to be a reason to say that all perceptual organization must be either pre or post selection. It might be that perceptual organization can be further subdivided, and that simple perceptual organization such as combining cues for depth or contours can take place preattentivly, while perceptual grouping across objects can occur only after selection.

The Mack and Rock paradigm. The discussion then moved to Mack and Rock upon which the Moore and Egeth study was based. Mack and Rock argued that there was no perceptual organization before selection. They showed evidence for this using a paradigm they developed. In the paradigm, participants were given a hard perceptual task that was superimposed on a background of black and white dots. These black and white dots made a random pattern for most of the experiment. But on critical trials they formed specific patterns. When asked via direct questioning whether they had noticed any structure in the background, participants stated they were unaware that anything other than random dots had been presented in background. In addition, they unable to respond above chance to two-alternative, forced-choice questions about properties of the background. Mack and Rock used this to argue that the background stimuli had not been processed to the level of perceptual organization.

Comment added after the seminar: Mack and Rock called their paradigm "inattentional blindness". This is a bad name for a task because it assumes the explanation. But, it is a fine name for a hypothesis to account for the phenomena. Accordingly, we will call it the "Mack and Rock" paradigm and their account of it the "inattentional blindness" hypothesis.

A discussion followed on the use of awareness as a benchmark of perceptual processing. It was asked why consciousness is being used here as a measure of perceptual processing. Why do some researching tend to "glorify awareness"? In response, John Palmer pointed out that at different points in the history of psychology, different attitudes have been held in regards to awareness. Long ago, the introspectionists viewed awareness as being central to the scientific study of perception. Next in history were the behaviorists who denied any role for awareness. More recently, cognitive scientists have been willing to study awareness as one aspect of behavior and its underlying mechanisms.

Cathleen Moore argued that awareness is wholly irrelevant to the topic of perceptual organization. Instead, the question is whether there are consequences of perceptual organization on behavior. Moore & Egeth were agnostic to the issue of the awareness of perceptual organization. In contrast, Mack and Rock in their recent book have changed their focus from "no perceptual processing without attention" to "no direct perceptual awareness without attention".

The Moore and Egeth paper. Moore and Egeth argued that one possible reason Mack and Rock were not able to find effects of perceptual organization in their study was that their questions depended on accurate memory as well as an effect on perception. Motivated by this memory hypothesis, Moore & Egeth developed an implicit, "on-line" measure of the effects of perceptual organization.

Moore and Egeth began with the Mack and Rock paradigm in that they had participants perform a difficult perceptual task that was displayed on a background of white and black dots. In particular, the participants had to judge the relative length of two briefly displayed line segments. In the first block of trials, the background dots were always presented in random patterns. In a later block, some trials had the dots presented in a pattern designed to give rise to an illusional effect on the lines being judged. They used the Ponzo and the Muller-Lyer illusion. In these critical trials, the two line segments were always equal. The logic being that, if the participants grouped the unattended objects, they must show the illusion in their judgments of relative line length. Finally, Moore and Egeth also had the participants perform a final block of trials to replicate the "inattention" part of the Mack and Rock paradigm.

Moore and Egeth found that the background patterns did have a indirect effect on the line length judgments. Even though the line segments were always the same, participants responded consistent with the expected illusions. Additionally, they argued that these items were not attended, because the participants were not able to report that they had noticed a pattern in the background, nor report via a two-alternative, forced choice question which pattern had appeared in the background. Together, these results were consistent with the background stimuli being grouped preattentively and then not selected for encoding into memory.

The Freeman, Sagi and Driver paper. The Freeman et al. paper expanded previous studies that have shown the facilitation of detecting oriented Gabor patches detection when collinear flankers are presented near the critical stimulus location. For example, suppose participants detect a central Gabor patch using a two-interval, forced choice task. In other words, a Gabor patch is presented in one interval and not in a second interval and the participant must state which interval contained the patch. The further manipulation is to add flankers that were either collinear or not collinear. The flankers improve performance when they are collinear.

Freeman and colleagues have used this methodology to investigate the relationship between attention and perceptual organization. They asked whether spatial attention modified these flanker effects. In this paper, they oriented attention using a vernier task about the relative positions of two of the flankers. Now four flankers are presented around the central location. Two were collinear and two are not. The vernier task used two line segments to cue a relative position between two of four flanker locations. At those locations, flankers appeared at those relative positions in one interval and at complementary positions in the other interval. The participants had to report the interval that had the cued relative positions. In sum, this task required two different judgments. A two-interval, forced choice of the presence of the central patch and a two-interval, forced choice of the relative position of one pair of flankers.

For the different attentional conditions, the displays were identical. They differed only in a different pair of Gabor patches being cued as relevant to the vernier task. In one condition, the collinear flankers were cued and in the other condition the noncollinear flankers were cued. They found that the flankers facilitated target detection when the collinear flankers were cued and not when the noncolinear flankers were cued. This is despite the fact that collinear flankers were still present when the non-collinear flankers were cued. This is consistent with grouping occurring for the cued pair and not for the uncued pair.

Two new conditions were also presented in this paper. The first addressed the hypothesis that the global orientation of the Gabor patches might have facilitated performance rather than the collinearity. The second addressed the hypothesis that the common local features facilitated performance rather than colinearity. Each of these possibilities were tested using a new combination of stimuli.

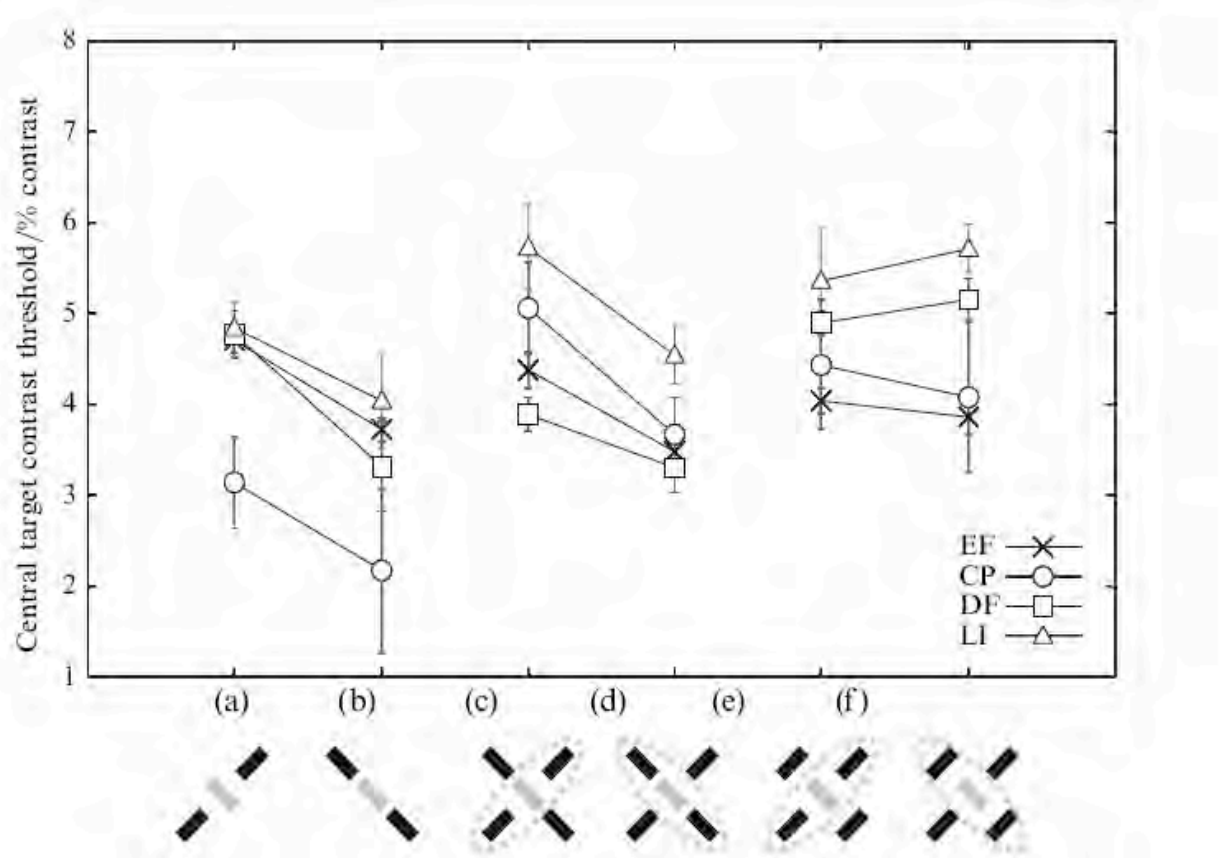


Figure 3. Central target contrast thresholds for experiment 1. (a) and (b) Single-axis, orthogona

The results of Experiment 1 of Freeman et al. can be seen in Figure 3 from that paper (as shown above). In columns (a) and (b), the authors replicated the "nonattentional" collinear flanker effect. In conditions (c) and (d), they replicated the attentional modulation of the colinearity effect. For these conditions, the collinear flankers facilitate detection only when cued and not when the noncollinear flankers are cued. Also, perhaps surprisingly, the magnitude of this attentional effect is as large as the purely stimulus-based effect of conditions (a) and (b). This suggests that selecting these flankers is functionally equivalent to removing the nonselected flankers. The lack of a difference between (e) and (f) show that the global orientation of the objects does not facilitate detection of the target when local features are not collinear.

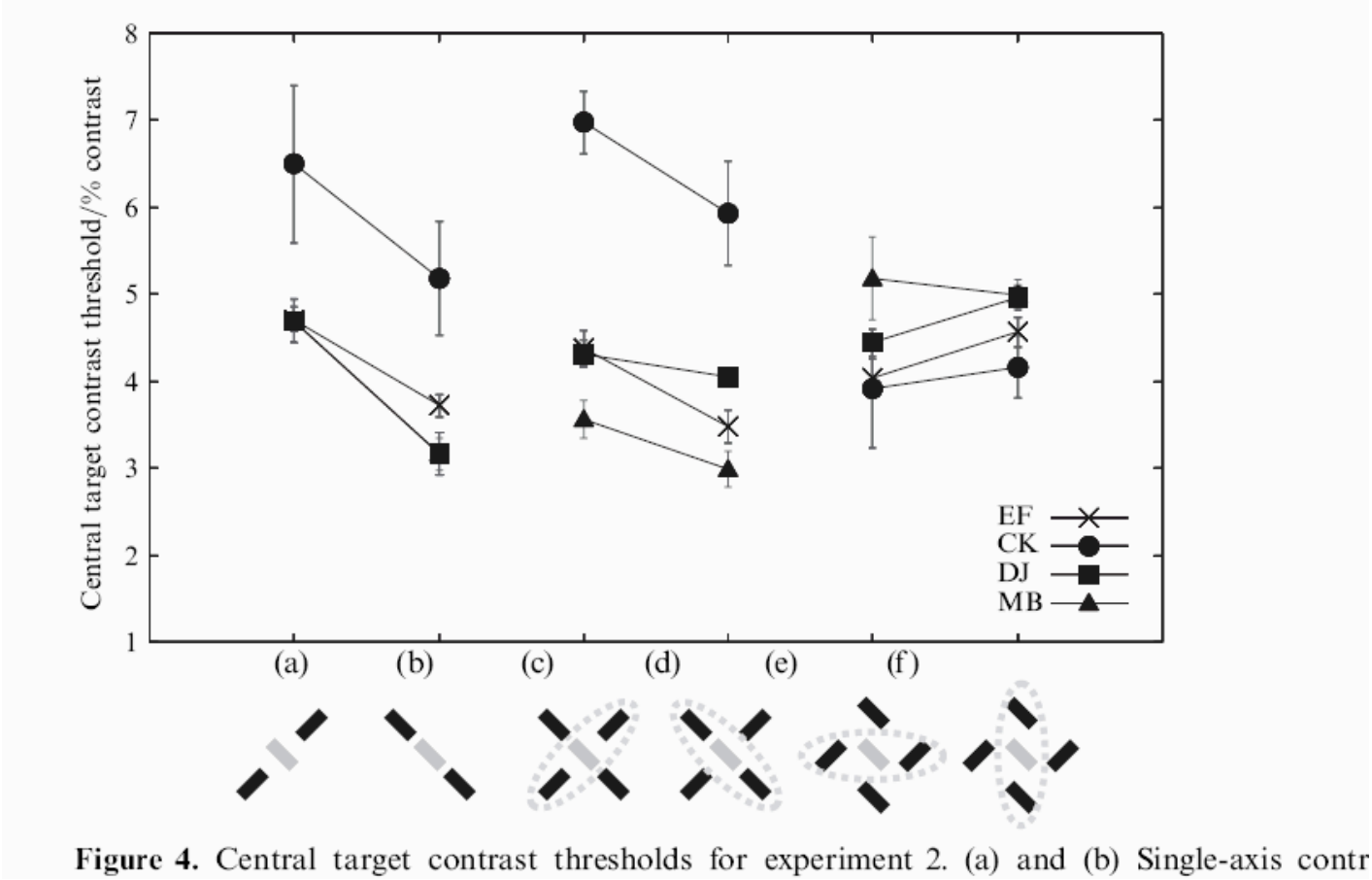


Figure 4. Central target contrast thresholds for experiment 2. (a) and (b) Single-axis contr

The results of Experiment 2 from Freeman et al. are shown in their Figure 4 (shown above). Columns (a) to (d) replicate the corresponding results of Experiment 1. In addition, the lack of a difference between (e) and (f) is consistent with the local orientations not facilitating detection when they are not collinear. In conclusion, they argue that only attended collinear flankers improves detection performance.

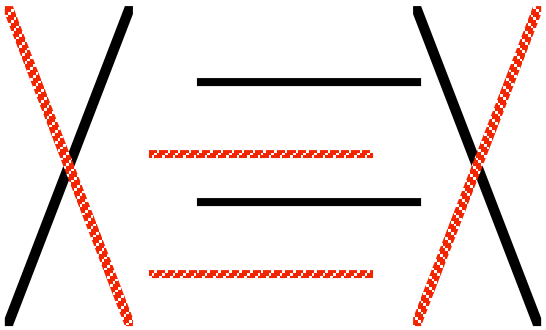
General discussion of both papers. Cathleen and John suggested that on the face of it, the two papers are in conflict. Moore & Egeth argue that perceptual organization occurs preattentively, while Freeman and colleagues argue that attention is required for perceptual organization.

It was suggested that while these hypotheses are in conflict the results are not in direct conflict because of the multiple differences between the experiments. One possible resolution is that that, in the Freeman et al. experiment, selection of one pair of flankers may disrupt perceptual processing of the unselected flankers. Or, alternatively, the selection process might override a default perception organization with another organization. Freeman et al. never ran a condition similar to the Moore and Egeth experiment. Namely a condition in which none of the flanker locations are cued. Instead, instructions would emphasize the central detection task and not the flankers. Would the collinear flankers have an effect under these conditions?

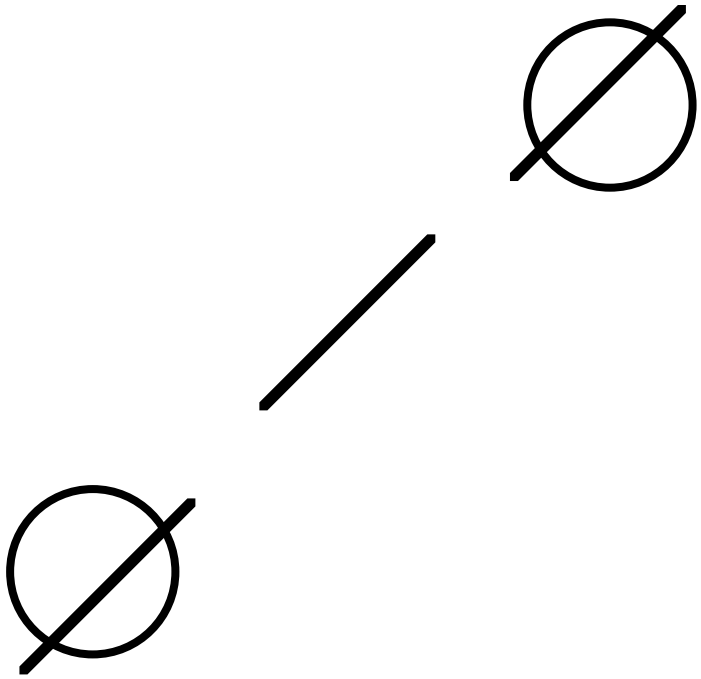
This lead to a wider discussion on the task differences between the two papers. Both papers tried to manipulate the perceptual organization of the background. However, they differed in how they manipulated attention. Freeman et al. cued peripheral locations prior to the task in order to manipulate the locus of attention; Moore & Egeth instructed participants to attend only to the central line discrimination task and ignore the stimuli in the background.

From this point, it was suggested that perhaps the attentional effect found in the Freeman et al. is not an indication that perceptual organization does not occur preattentively as the authors argued, but perhaps the act of selection lends to alternative organizations. One of the differences between the two studies is that one promotes attentional orientation and finds modulations on perceptual grouping, while the other promotes restricting attention to only task relevant locations and finds grouping of ignored stimuli. It is possible that orienting attention causes an implicit grouping of the ambiguous stimuli within the locus of attention. This changes the Freeman et al. interpretation to something more along the lines that the flanker facilitation effect occurs only within perceptually organized objects and not between them.

These discussions led to a complementary effort to modify the Moore and Egeth experiment to make it more like the Freeman et al. experiment. To do that, two conflicting context were suggested as illustrated by the dashed red and solid black lines. With this ambiguous context, might one shift the perceptual orientation of the background by directing attention to targets of different color? Would the background still satisfy the inattention constraints of Mack and Rock?



Location versus object mediation. The question was raised whether the attentional collinearity effects with Gabor patches were mediated by locations or objects. Clearly, both interpretations are possible with the Freeman et al. experiment. One idea to address this issue is to exploit the superimposed stimuli used by Duncan. Consider the display shown below. Following Freeman and colleagues, there are two tasks, a central line orientation task and a flanker vernier task. Assume there are colinearity effects of flanker lines for the central line orientation task. Then, in one condition, the vernier task is applied to the flanker circles and in the other to the flanker lines. Does attending to the circles eliminate the effect of the flanker lines?



Conclusion. Both papers offered their own accounts on whether or not attention is necessary for perceptual organization. Moore and Egeth claim that perceptual organization can occur without attention; Freeman and colleagues claim that no perceptual organization occurs without attention. However, the fact that attention can modulate perceptual grouping does not mean that some pre-attentive perceptual organization does not occur. Conversely, the fact that some preattentive organization can occur does not mean that attention is not a necessary component for other aspects of perceptual organization.

Attention and Perceptual Organization

Questions for Topic 6: What is the role of attention in the organization of time?

Cathleen Moore & John Palmer

October 20, 2008

Base Reading:

Moore, C. M., & Lleras, A. (2005). On the role of objects in substitution masking. Journal of Experimental Psychology: Human Perception and Performance, 31, 1171-1180.

Contrast Reading:

Woodman, G. F., & Yi, D-J (2007). Masked-target recovery requires focused attention on the target object. *Visual Cognition*, *15*, 385-401.

Supplemental Readings:

DiLollo, V., Enns, J., & Rensink, R. A. (2000). Competition for consciousness among visual events: The psychophysics of re-entrant visual processes. *Journal of Experimental Psychology: General*, *129*, 481-507.

[This is the main introductory paper on "object substitution masking". The basic phenomenon and ideas surrounding it were introduced in a short Psych Science paper in 1997, but this paper explores it in much more depth and develop the theoretical ideas that the Di Lollo and Enns group espouse regarding it.]

Kahneman, D., Treisman, A., & Gibbs, B. J. (1992) The reviewing of object files: Object-specific integration of information. *Cognitive Psychology*, *24*, 175-219.

[This is the paper in which the object-reviewing paradigm was introduced and the construct of an "object file" was initially developed. There are references to it in several earlier papers, but this is the first one in which object files are the main focus.]

Lleras, A., & Moore, C. M. (2003). When a target becomes a mask: Using apparent motion to isolate the object component of object-substitution masking. *Journal of Experimental Psychology: Human Perception and Performance*, *29*, 106-120.

[This is a paper referred to in the Moore & Lleras (2005) reading in which we isolated an object component of OSM using apparent motion.]

Study Questions

1. What makes "object substitution masking" (OSM) different from other forms of backward masking?

2. What evidence do Moore & Lleras (2005) cite to support a role of attention in OSM?

3. On what basis do Moore & Lleras claim that there is a component of OSM that is "object-based"? What is the alternative space-based account for OSMl?

4. What idea do Moore & Lleras (2005) test? They test it three different ways. What are these three ways?

5. What are object files and how do Moore & Lleras (2005) relate their findings to the object-file framework?

6. What is Masked-target recovery?

7. What hypothesis regarding masked-target recovery do Woodman & Yi (2007) test? They test it two different ways. What aret these ways?

8. Describe the three possible roles of attention in masked-target recovory that Woodman & Yi (2007) raise in the General Discussion.

Discussion Questions

1. What parallels are there between perceptual organization in space and percetual organization in time?

2. What common roles could attention play in space and time? What different roles could attention in space and time?

3. Are there possibilities for the role of attention in masked-target recovery other than the three suggested by Woodman and Luck?

4. What experiments could test among the alternative possibilities for the role of attention masked-target recovery?

5. Is the role of attention in OSM related to the role of attention masked-target recovery? What parallels are there between the two phenomena? What changes to the paradigms could be made to make the more easily comparable?

6. Moore & Lleras (2005) argue that their object-mediated effects on OSM concern perception, whereas much of the research concerned with the object file construct has concerned memory. Does this distinction work? Can Moore & Lleras' ideas be subsumed within the object-file framework? Would this be a good thing to do?

Attention and Perceptual Organization
Summary for Topic 6: What is the role of attention in the perceptual organization of time?
Ben Dow, Cathleen Moore and John Palmer
October 30, 2008

Readings

Moore, C. M., & Lleras, A. (2005). On the role of objects in substitution masking. Journal of Experimental Psychology: Human Perception and Performance, 31, 1171-1180.

Woodman, G. F., & Yi, D-J (2007). Masked-target recovery requires focused attention on the target object. *Visual Cognition*, *15*, 385-401.

Discussion Summary

Overview. Last class we examined perceptual organization with regard to space, and specifically, the role of attention in such perceptual organization. Today, we examined perceptual organization in time. Cathleen Moore began the discussion by suggesting that we keep the Freeman, Sagi and Driver paper from last time in mind when examining the current papers, and to consider the potential similarities and differences between perceptual organization in space and time.

Masking. The discussion began with a brief review of masking. Caglar Tas gave a general description of masking: a stimulus is presented followed by another stimulus which sometimes interferes with the processing of the first stimulus. The second stimulus is the mask and this case is referred to as "backward masking". There are several kinds of masking. Relevant to the discussion today is backward masking which occurs when presenting a mask after target stimulus presentation. Forward and simultaneous masking is also possible.

Cathleen continued the discussion by asking, intuitively, what is the mask doing? Marc Halusic replied that it seems to be working within perceptual representation in memory, replacing one stimulus representation with another before it can successfully be encoded into memory. Caglar added that the target stimulus is processed, but once the mask is perceived the target stimulus is prevented from being encoded further. John Palmer commented that the mask effectively shortens the duration of the target stimulus. This hypothesis is known as interruption masking. Alternatively, the mask can combine with the original stimulus often obscuring its features. That hypothesis is known as integration masking.

The discussion then moved to a distinction between sensory and information masking. Ian Rasmussen thought that object substitution masking is a case of informational masking whereas metacontrast masking is a case of sensory masking. Cathleen stated that in the object substitution masking from the Moore and Lleras paper, only four dots were used, often referred to as “dot masking”. Unlike metacontrast masking, the dots don’t provide much contour between the target and the mask to interfere with processing.

Object substitution masking. Cathleen then asked what makes object substitution masking different from other forms of backward masking? Marc replied that the mask in object substitution masking does not need to be structurally similar to the target, it can be extremely sparse and does not need to occlude any part of the target. The offset in the delayed condition in the Moore and Lleras wipes out the target representation. Caglar added that it depends on attention and the number of items in the display. Cueing also is able to negate the effect of object substitution masking.

Object substitution masking was then compared to metacontrast masking. Cathleen explained an example of metacontrast masking, one that also involves a Landolt-C, masked by a completed circle. This example can be seen below in Figure 1.

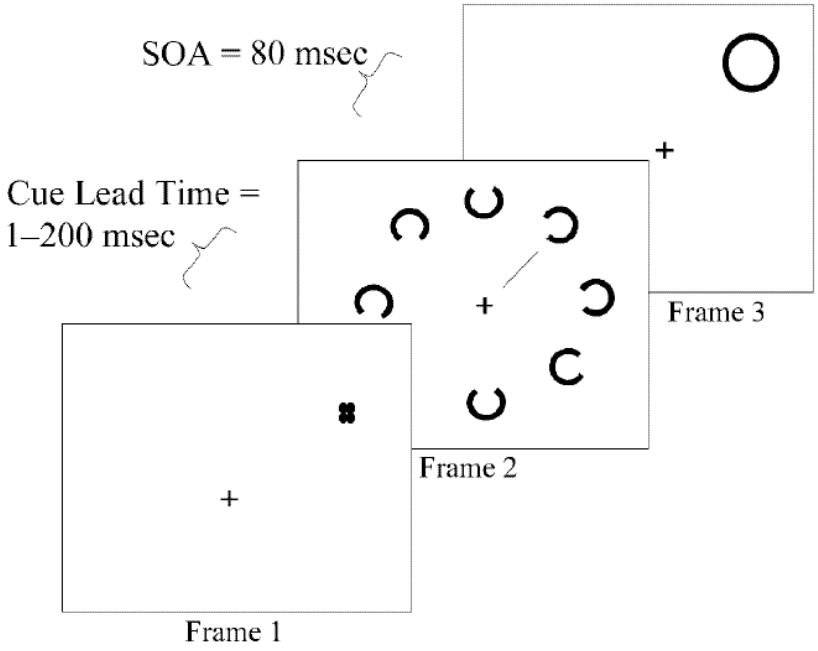


Figure 1: Metacontrast masking example.

In metacontrast masking, the mask shares much of the contour of the target. In the case of the Landolt-C and circle mask, the circle mask does not overlap, but is very close to the same size as the Landolt-C, just slightly larger. The timing between the stimuli is critical to the masking effect. As the diameter of the masking circle increases compared to the target stimulus, the effect becomes smaller.

Like the metacontrast masking, four dot masking does not require the stimuli to overlap. However, the dots do not have to be as close as the circle in the metacontrast masking example to have an effect. Ian asked if the effect of metacontrast masking is because of perceptual smearing, because it doesn't occur when the stimuli are present simultaneously. This led to a brief discussion of visual persistence as compared to informational persistence.

Is object substitution masking based on object representations? Cathleen then asked if there was evidence that object substitution masking is object based. Elisabeth Hein responded by saying that the target and mask are near each other spatially, but can be seen as the same or

separate objects, suggesting there is an object effect. Cathleen then asked what was the hypothesis in the Moore and Lleras paper. Teresa Stephens responded that when the mask and target are grouped as the same object, an object substitution masking effect occurs. When the target and mask are not grouped as the same object, no effect occurs. The idea is that when separate representations for the target and the mask are established early on, these representations are protected from being over-written by new representations. John asked whether these representations were retinatopic.

Moore and Lleras Experiment 2. The discussion then moved to Experiment 2 in the Moore and Lleras paper. Ian stated that in this experiment, the target and mask jiggled; they moved either separately to establish different object representations, or together to represent the same object representation. When the target and the mask are jiggled independently, the results were different than when they were jiggled together. When they jiggled together, they were seen as the same object and an object substitution masking effect resulted. The timings and the start and end presentations were the same in this experiment. The difference was the "movie" that occurred, convincing the participant that the target and stimulus were either one object or not. This "movie" established a history of the object, or separate objects.

John then asked if the relevant history was very local, such as the last 100ms, or if it was more long term, over the last five trials. Cathleen mused that the establishment of the object is a dumb process, which led her to believe that only the local, short term history was relevant. Chris Kovach then asked if the grouping is an all-or-none. In other words, a pair of stimuli are either grouped or not. Cathleen answered that this is often assumed to be the case.

Object files. Ian then asked about object files, and how they relate to Moore and Lleras' study. An object file is a representation with a pointer in time. The information in the object file can be analogous to a police report file, or a file on a computer. When recalling this file, all information known about it is pulled, and when a new object is compared and corresponded to the old object, the object file is updated with the new information and the new object takes all the information from the old object, via the object file. This theory and process is in some ways indistinguishable from the explanation and hypothesis from the Moore and Lleras paper. However, the Moore and Lleras paper does not require all the theoretical constructs involved with object files to explain the observed phenomena. John stated that a difference is that object files are post selection and probably involve memory. The effects in the Moore and Lleras paper are probably not due to memory, or at least are due to very early memory processes. Some object effects occur in memory, some occur before. The Moore and Lleras result seems more likely to be a perceptual process.

At this point Cathleen used a visual representation to help explain object files, which can be seen in Figure 2.

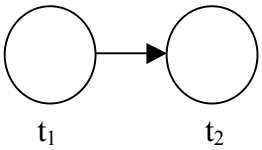


Figure 2: Object file display.

Cathleen explained that at time t_2, the system decides if the object at time t_2 is the same as the object at time t_1. If so, a correspondence is established, and consequently impletion occurs. Even if the objects were different, such as a circle and a square, correspondence can occur, and the first object can be perceived as "morphing" into the second object. In the review process, you can query an object file and automatically pull the information about the object and the previous object.

Ian then asked about multiple object tracking and Pylyshyn's FINST (Fingers of instantiation) theory. He asked if attention is necessary in this paradigm. An example of a multiple object tracking display can be seen in Figure 3.

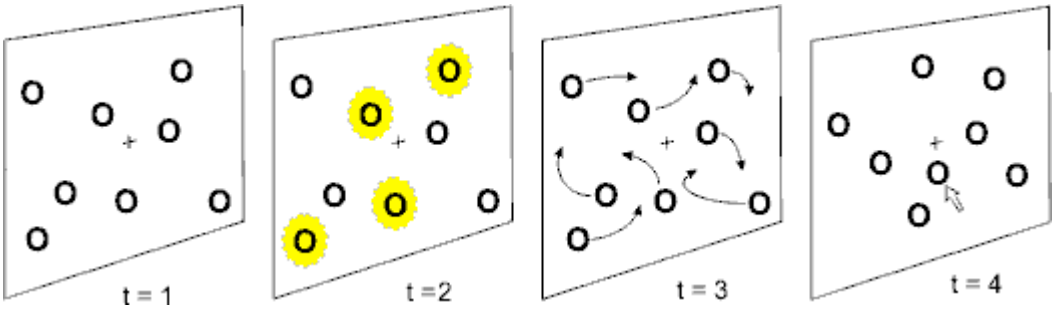


Figure 3: Pylyshyn's multiple object tracking experiment.

Cathleen explained that in this experiment, participants were asked to track four moving objects over time and to identify after they have moved. Ian suggested that FINST can be viewed as a bootstrap into object files.

Masked-target recovery. The discussion then moved to the Woodman and Yi paper and masked-target recovery. Libo Zhao began the discussion by describing this paradigm. A stimulus is presented followed by a sequence of two masks. After the second mask, the report of the target is better than with only the target and first mask. Cathleen added that one can think of this as masking the mask. In the paper, a pattern mask is followed by a light mask.

Cathleen then asked what question was addressed in the Woodman and Yi paper. Libo responded that masked-target recovery depends on attention. If one only one object is present,

the target stimulus, then one obtains masked-target recovery. However, if there are multiple distractors competing for attention, one does not obtain masked-target recovery. Marc added that in the third experiment the participants were presented with five circles initially, and then were presented with either a sudden onset condition where the target appeared in the empty spot as seen in Figure 3 of the Woodman and Yi paper, or in the distractor condition where the target morphed from one of the existing circles. In this way, the masked-target recovery only occurs when the target abruptly appeared, and not when it morphed from an existing stimulus. Cathleen commented that morphing doesn't seem to draw attention as much as a stimulus appearing abruptly.

Roles of attention in masked-target recovery. Woodman and Yi describe three potential hypotheses for the role of attention in masked-target recovery. The first hypothesis is that if you pay attention to the target, the masking is less robust and some representation remains to be recovered. If attention is not paid to the target, there is nothing to bring back. The second hypothesis is that attention changes the temporal grouping of the masks and the target. In the absence of attention, all stimuli are integrated. With attention, the target and the mask is more segregated when there is a second mask present. The third hypothesis is that attention is mediated by the second mask being a post-stimulus cue for the location of the target. In other words, the second mask somehow improves the ability to retrieve the representations from memory. John summarized the proposed hypotheses as having the recovery mediated by perception, perceptual organization or memory.

Comparing perceptual organization in time and space. One of the goals of this discussion is to compare perceptual organization in time to that in space. Ian began by stating that there was no reason why attention shouldn't have a temporal effect, and asked, why can't there be the effects be considered in a wider spacio-temporal framework. Cathleen responded that was a good goal, but to consider time and space separately might be an intermediate step. To build a parallel, what is analogous in Freeman's study to Moore and Lleras's second experiment. In time, jiggling stimuli together grouped the target and distractors. In space, the orientation the patches with the same angle grouped the target and the mask.

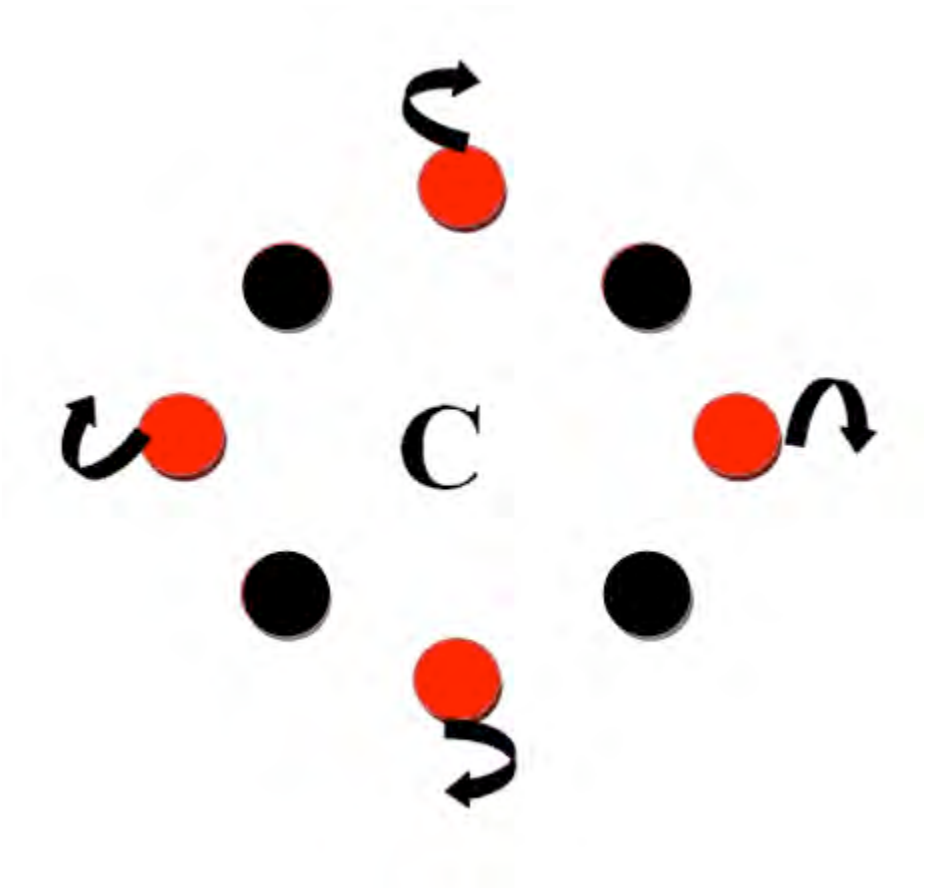


Figure 4: Experiment idea.

To help clarify, Cathleen asked us to propose an analogous experiment to Freeman by employing perceptual organization in time as Freeman did with perceptual organization in space. The additional feature of Freeman's work is that there were two different organizations present and one of these organizations can be cued rather than the other. One way to do this can be seen in Figure 4. Here the idea is to use two sets of dot masks, one black and one red. If one of these is jiggled with the central stimulus and the other not jiggled, then one should be able to selectively mask with the commonly jiggled dots and not the others. Now suppose one attends to only one set of dots or the other. Will attending to one or the other set of dots mediate the masking effect? [JP: This experiment isn't quite right yet. Need to be able to present the same final mask stimulus rather than two different colored masks.]

Fabian suggested an experiment similar to Pylyshyn's multiple object tracking with multiple targets. The idea is to ask participants to attend to some targets and not others. A diagram of this experiment can be seen in Figure 5.

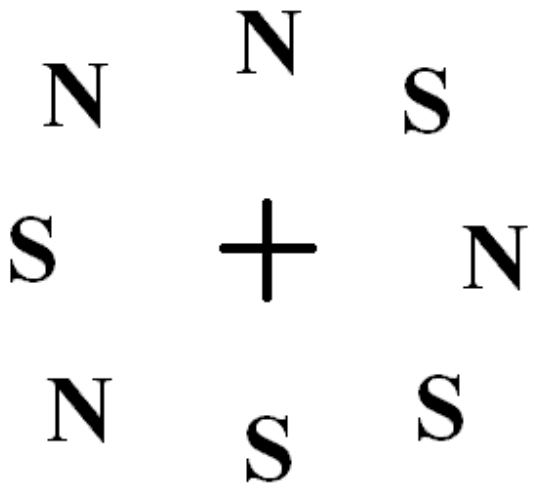
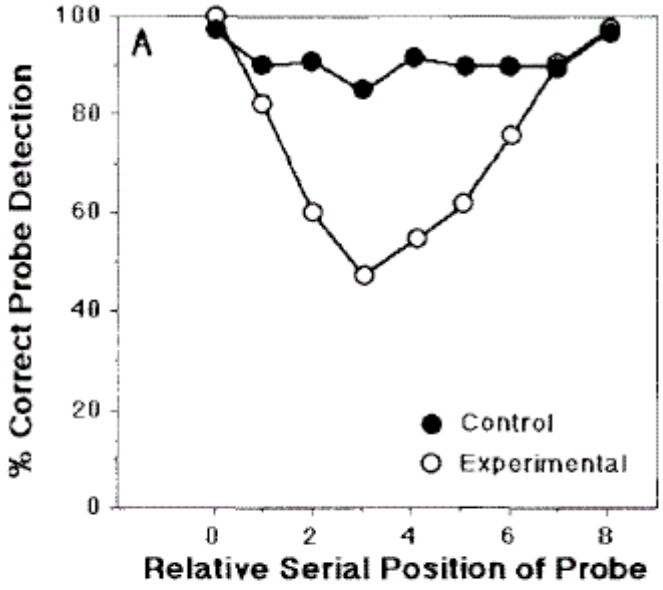


Figure 5: Multiple target tracking experiment idea.

In the above example, the targets and masks jiggle like that in Experiment 2 of Moore and Lleras. The N's represent targets and masks that jiggle together, the S's represent targets and masks that jiggle separately. Will masking occur for both kinds of stimuli?

Several other ideas for stimuli that might form a basis for an experiment were suggested in quick succession. Ian suggested a stimulus with two blinking disks moving toward one another. Chris suggested using a series of flickering disks to organize a scene. Fabian suggested using biological motion displays.

Attentional Blinks. Cathleen posed the question, how do we attend in time? She gave an example of attentional blinks. An attentional blink is a phenomenon observed in rapid serial visual presentation (RSVP). Here, a string of visual stimuli are presented at the same spatial location. The participant often fails to detect a second target immediately after the first target is detected. This is the attentional blink. She drew a figure similar to Figure 6, which is taken from Raymond, Shapiro, and Arnell (1992).



Conclusion. Today's goal was to develop an understanding of perceptual organization in time. Two papers were presented that examined the role of attention on perceptual organization in time. Like perceptual organization in space, attention may play a key role in perceptual organization in time. Next week, we will consider a quite different topic in the role of objects in divided attention: How does judging relations between objects compare to judging attributes of single objects.

Attention and Perceptual Organization
Questions for Topic 7:
How does judging relations between objects differ from judging attributes of single objects?
Cathleen Moore and John Palmer
October 20, 2008

Base Reading:

Poder, E. (1999). Search for feature and for relative position: Measurement of capacity limitations. *Vision Research, 39*, 1321-1327.

Contrast Reading:

Humphreys, G. W. (1998). Neural representation of objects in space. Phil. Trans. Royal Society of London B, 353, 1341-1351.

Supplemental Reading:

Davis, E. T., Shikano, T., Peterson, S. A., & Michel, R. K. (2003). Divided attention and visual search for simple versus complex features. *Vision Research*, 2213-2232.

Delvenne, J. & Bruyer, R. (2006). A configural effect in visual short-term memory for features from different parts of an object. *Quarterly Journal of Experimental Psychology*, *59*, 1567-1580.

Palmer, J. (1994). Set-size effects in visual search: The effect of attention is independent of the stimulus for simple tasks. *Vision Research*, *34*, 1703-1721.

Robertson, L. C., & Treisman, A. (2006). Attending to space within and between objects: Implications from a patient with Balint's syndrome. *Cognitive Neuropsychology*, 23, 448-462.

Xu, Y. (2002). Feature integration across parts in visual search. *Perception*, *31*, 1335-1347.

Study Questions

1. Poder (1999) adopted a method from Palmer et al. (1993; Palmer, 1994) to control target-distractor discriminability in visual search. How does that method work? Why is target-distractor discriminability an important thing to control when asking about capacity limits?

2. What question did Poder (1999) address in his study? Describe the qualities of the stimuli in Figure 1 that allowed him to address that question.

3. What conclusions does Poder (1999) draw regarding the processing of basic features versus the processing of relative position? On what basis does he draw those conclusions?

4. Humphreys (1998) recounts a theoretical argument regarding why one needs in principle different representations for object recognition and to direct action to objects. What is that argument?

5. What is Humphreys' (1998) hypothesis regarding the within-object versus between-object representations? How does he relate this distinction to what-versus-where distinction?

6. Describe and compare the following neuropsychological phenomena: neglect, extinction, and Balint's syndrome.

7. In Humphreys (1998), Figure 1 summarizes some data from an experiment with patient GK. Describe the experiment and what conclusions Humphreys (1998) draws from these data.

8. Describe patient JR's particular set of deficits. In what way does this pattern support Humphreys' (1998) general hypothesis?

9. Humphreys (1998) argues that the coding of visual space is poor beyond his proposed within-object and between-object codes. On what basis does he make that claim?

Discussion Questions

1. Poder (1999) suggests that feature and relative position stimuli are "…near the endpoints of an imaginary continuum that measures the necessity of the involvement of limited resources…" How can one know that a given stimulus represents one or the other extremes?

2. Why might the coding of relative position be capacity limited?

3. Was symmetry an important factor in the Poder (1999) study (see Figure 1)? If it is, does that change the conclusions? Can an experiment be designed to distinguish the relevance of symmetry and relative position?

4. Can experiments be designed in neurologically intact subjects that test Humphreys (1998) hypothesis?

5. If Humphreys' (1999) hypothesis is correct, how might object-based attention work? Think about the various mechanisms that we have been considering. How can they be considered in the context of the two different object representations?

6. How can between-object and within-object relations be tested in an experiment like Poder's (1999) using Palmer's (1994) method of testing for capacity limitations?

Attention and Perceptual Organization
Summary for Topic 7:
How does judging relations between objects differ from judging attributes of single objects?
Libo Zhao, Cathleen Moore and John Palmer
November 3, 2008

Readings

Põder, E. (1999). Search for feature and for relative position: Measurement of capacity limitations. *Vision Research, 39*, 1321-1327.

Humphreys, G. W. (1998). Neural representation of objects in space. *Phil. Trans. Royal Society of London B, 353*, 1341-1351.

Discussion Summary

Overview. Cathleen indicated that this week and next week the focus of reading and discussion shifts from attention effects on perceptual organization to object effects on divided attention. John further explained that after Duncan's and Egly's core papers on object based attention, we moved to focus on perceptual organization for two weeks, and now to divided attention for two weeks. For these next two weeks, the core issues are whether perception has limited capacity and requires serial rather than parallel processing. In particular, what stimuli and tasks require limited capacity and what other stimuli and task allow unlimited capacity processing. The papers we read today consider differences in capacity between judgments of single object versus a combination of objects.

Divided attention and search task. Cathleen asked what are the central issues of divided attention. Fabian said that it is about whether there is limited capacity. If there is a capacity limitation, then adding stimuli produces a cost in performance. Otherwise adding stimuli won't. Cathleen further asked about what is a visual search task and what are the advantages of using visual search task to studying divided attention. Lynn answered that it involves searching for the target among a number of distractors. Marc added that the set-size effect is used to measure the cost of adding additional stimuli. Teresa said that the advantage of visual search task is that subjects need to make only one response. Marc then added that any effect of memory is minimized due to the fact that only one response is required.

A psychophysical analysis of visual search. Cathleen asked what is the method that Põder's adopted from Palmer et al. (1993; Palmer, 1994)? Why is target-distractor discriminability a critical thing to control? Marc answered that similarity between target and distractors was parametrically manipulated. Fabian added that the threshold target-distractor discriminability of detecting target at 75% of accuracy was measured as a function of set size. In particular, the entire psychometric function was measured. That is, by systematically manipulating the similarity and locating the 75% threshold, one can compare conditions that are equated in terms of similarity. Cathleen added one more reason to control for the target-distractor difference: when this factor is controlled, the magnitude of the set-size effect is specific to capacity limitations, and not subject to further effects of discriminability. John elaborated that in

general one must measure both set size and discriminability and consider the two-way interaction of these variables. The threshold method is a trick to reduce this two-dimensional measurement to a one-dimensional measurement.

Ian asked whether the task used by Põder involved memory due to the brief duration displays. John explained that memory is indeed involved, but it is arguably not differentially involved for different set sizes. This is because for every set size only one decision is made and can be made immediately.

Cathleen repeated Ian's question on memory again and asked again about memory. John referred people to Fig. 2. He explained that in the feature condition, for the level of set size 8, when the target-distractor difference was big, the performance was almost perfect. But if you change the search task into an explicit memory task, performance is reduced because of the limited number of objects that can be remembered.

Cathleen emphasized that in search task, one decision was to be made independent of set size. Ian insisted that it depends on how one views the comparison process. John said that distractors in this task were homogenous, but if they are not homogenous, for example, different distractors appeared in different locations, the task can be very challenging and the simple models used here are not adequate.

Cathleen asked what question was addressed by Põder. Teresa described the two conditions: a feature condition in which the target had an asymmetric bisector among distractors with symmetric bisector; and, a relative position condition in which the target was an asymmetric bisector to one side (say left) among distractors that had an asymmetric bisector to the other side (say right). For the feature condition, the target is assumed to be defined by one feature; for the relative position condition, the target is assumed to be defined by the relative position of a pair of features. Are these cases different in terms of capacity limits?

Calgar described Poder's results and interpretations. Feature search showed a smaller set-size effect than relative position search. In particular, feature search was consistent with the predictions of the decision integration model, while relative position search was consistent with a fixed capacity model.

John asked if everyone understood how to get from Figure 2 to Figure 3. Figure 2 is a psychometric function that plotted proportion correct as a function of the change in position. Figure 3 is a graph of the difference threshold for change in position as a function of set size. Libo explained that one first determines the threshold target-distractor difference for each set size. These thresholds are then plotted using log values for the threshold-versus-set-size graph.

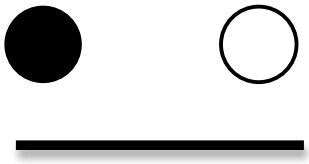
Fabian asked why wouldn't the unlimited capacity model predict a flat function of set size? Marc answered that assuming noise from each distractor, adding one distractor increases the false alarm rate even if perceptual capacity is unlimited. John added that the exact prediction of the model was specific to the definition of a threshold. If 90% criterion for the threshold was used instead of 75% criterion, the predicted effect of set size is different. The effect of set size depends on the difficulty of discrimination.

Fabian asked whether there are models in which distractors facilitate processing? John said there is indeed such models. Jim Townsend refers to them as having super capacity. Processing improves when there are more processes simultaneously active.

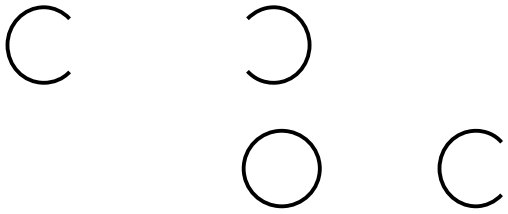
Ian asked: what is the difference between feature and relative position conditions in terms of heterogeneity? In particular, for changes in the position of the bisector, only the target changed for the feature condition, while both targets and distractors changed in the relative position condition. To reduce any increase in variability from trial to trial, these conditions were blocked.

Ian asked: might the conditions differ because of a difference in difficulty? John argued there was enough range of difficulty in both conditions that the level of difficulty overlapped. In addition, the use of the same threshold criterion focused the analysis on data with the same level of difficulty. But, one could have been even more careful to equate the range of difficulty in the two conditions.

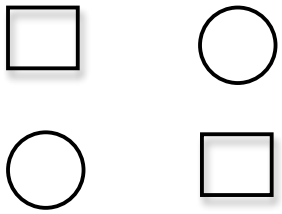
Ian questions the interpretation of Põder's comparison in terms of relative position rather than something else. John agreed that generality of these effects is a real concern. There are a number of similar studies that have contrasted other pairs of conditions. In his own work, he had subject judge the relative position of two objects. They had reverse polarity on a grey background to minimize grouping between the objects. This relative position task was compared to a "feature" task in which one judged the length or orientation of a line segment.



Another example is from studies by Elisabeth Davis that compared Landolt-Cs. When they were mirror images on one another, they obtained results similar to the relative position results. When one searched for a C among circles, then they obtained results similar to the feature result.



Cathleen Moore also studied a similar comparison using the relative position of a square and a circle. For example, the target might be a square and a circle with the square to the left while the distractors were a square and a circle with the circle to the left.



More generally, a range of such spatial configuration tasks have been studied in the literature. A summary can be found in the recent study of Thornton and Gilden (2007). They find that spatial configuration tasks do have generally larger set-size effects than simple feature tasks but they also vary considerably among themselves in the magnitude of their set-size effects.

The link between the two papers. To provide some context, Cathleen explained that while there are wide differences between Humphrey's and Põder's paper, the commonality is that Humphreys contrasts within-object and between-object spatial relations which is similar to Põder's contrast of features and relative position.

What versus where pathways. Cathleen asked why we need to have separate representations to recognize objects and to control action. Elisabeth said that recognizing an object needs a representation that allows one to discount viewpoint. In contrast, when one needs to interact with the object, the particular location matters.

Keith described the within-object and between-object representations from the Humphrey's paper. Each representation acts independently and shows double dissociations in neurological patients. Fabian added that the distinction between within-object representation and between-object representation is similar to the distinction between the what-and-where pathway.

Cathleen provided some more background for the what-where distinction:
The processing of "what" information is associated with the ventral pathway, extending from the occipital lobe to the temporal lobe. This pathway is associated with the recognition of objects. In contrast, the processing of "where" information is associated with the dorsal pathway, extending from occipital to parietal lobe. This pathway is associated with the processing spatial information and action. Cathleen added that Goodale has provide an alternative characterization of this distinction in terms of perception versus action.

Neuropsychological phenomena. Calgar provided the definition of the three neuropsychological phenomena of interest. In neglect, patients fail to react to stimuli presented on the side of space contralateral to their lesion. In extinction, patients are able to detect the presence of a single stimulus in the contralesional field, but fail to detect the same item when it is presented simultaneously an item in the ipsilesional field. In the more extreme Balint's syndrome, patients fail to perceive more than one object at a time and misreach under visual guidance.

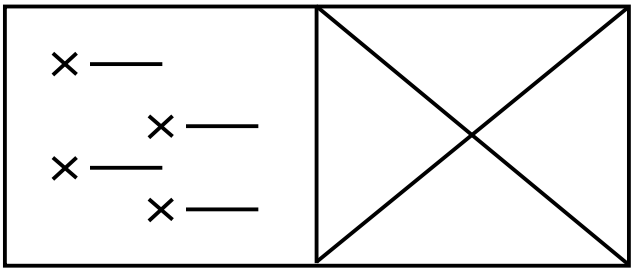
Cathleen said that for neglect and extinction, the lesion is usually confined to one side of the brain, usually in the parietal lobe. For Balint's syndrome, the lesions tend to be bilateral. In

addition, neglect is more severe compared with extinction, and neglect often gives away to extinction as a patient recovers from their injury. Cathleen commented that what is amazing about these patients is that they show normal vision, but fail in attentional tasks. The selective deficits in attentional tasks of these patients provide unique insights to our understanding of attention.

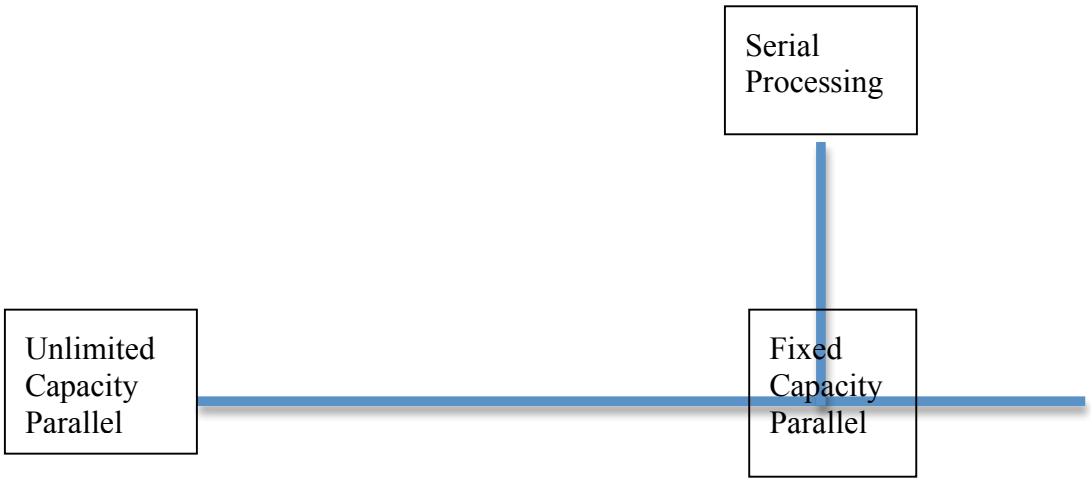
Within-object representation vs. between-object representation. Keith described the findings from the patient GK with neglect symptoms. He was presented with two separate objects one in each field. When they were unrelated the contralesional object was largely ignored. But when cues were added that allowed the two object to group, the contralateral part was ignored less. And when the two objects in the two fields become a single object, neglect goes away.

Calgar described the symptoms of patient JR reported in the Humphreys paper. This was an unusual patient with bilateral lesions. For a task that required processing a word as a whole object (e.g. reading the word), JR showed left side neglect. In contrast, for a task that required processing each letter within a word as a separate object (e.g. reading letter by letter), JR showed right side neglect. Thus, the type of neglect manifested is task dependent.

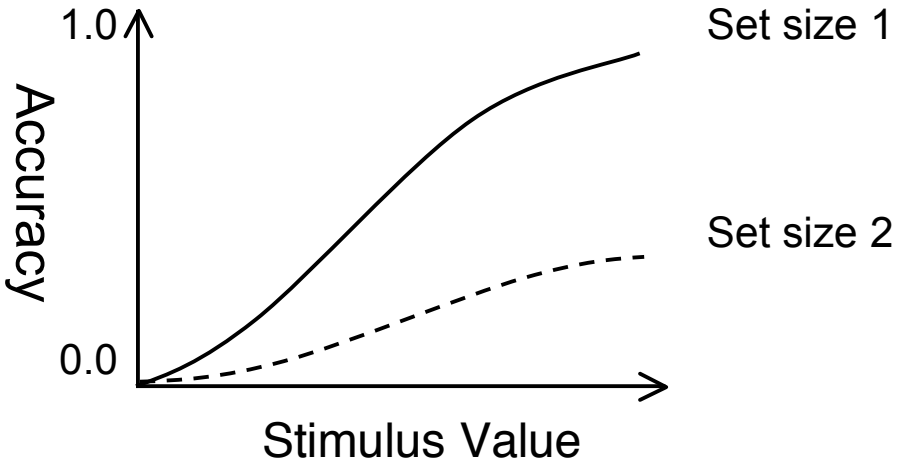
Cathleen drew the graph to illustrate that whether such a neglect patient neglects the whole field that is contralateral to one lesioned side (the right field), or the left side of objects of the left field, depends on the task demands. (In the figure, the Xs mark sites with neglect.) The correlation between different locations of lesions and the different symptoms allows one to test ideas about the localization of function.



Discussion questions. Cathleen asked about how one can know that a given stimulus represents one or the other extremes of a continuum from unlimited capacity to highly limited capacity. Cathleen said it is easier to identify that unlimited capacity represents one end. John said that it is an asymmetrical continuum because the unlimited capacity occupies only a single point, and all the rest represents limited-capacity models that vary in degree. Keith suggested that the other end of extreme is serial processing, meaning to process items one at a time. John disagreed and said that while a serial model has fixed capacity, there are also parallel models with fixed capacity. Instead, the other landmark is a fixed capacity model that can be either parallel or serial. Such a model processes a fixed amount of information per unit time. This is not necessarily the endpoint of the capacity scale, but it does mark a specific point on the scale. Serial versus parallel processing is a second dimension.



Calgar asked whether the psychometric function is linear if only one item can be processed at a time? John drew the Figure below to answer that question. Suppose that only a single stimulus can be processed at a time and performance is given as a function of the stimulus as shown for set size 1 in the figure. For serial processing, performance for two stimuli is a mixture of cases where the relevant stimulus is attended and other cases where it is ignored. Assuming no guessing, performance at any point is half what one obtains with a single stimulus.



Fabian asked whether there is implicit assumption about time, that is, under brief display, attention can not shift to another stimulus? John agreed and said that it is argued that relative to these brief displays, attention shifts are slow. Thus, one cannot shift from one to another stimulus under these conditions.

Cathleen asked about the connection between the two papers. Both distinguish within-object relations and between-object relations. Therefore, she thought Põder's method adopted from Palmer's (1994) might be applicable to test Humphrey's hypothesis. She suggested the following table can be used to outline the required experiment combining the two distinctions.

Table of Proposed Conditions

	Feature Task	Spatial Relation Task
Within	_____	_____
Between	_____	_____

John drew the diagram for his between-object task, and asked how to change it into a within-object task? Keith suggested that the two objects can be connected to make a bar bell shape.

Cathleen described one of her studies that used depth cue to achieve different organizations with same stimuli. Recall her study of the relative position of a square and a circle. The space between them was filled a large rectangle. The rectangle was cued to be either in front of or behind the other two objects. In the former case, the two objects are grouped into a single unit because the possibility of occlusion. In the latter case, they don't. Fabian said that for Cathleen's previous experiment listed above, how the two shapes are different could be manipulated to get the psychometric function.

Ian raised another idea that Gabor patches can be used with the Palmer threshold method. The collinearity of Gabor patches can be manipulated as a way to vary the degree to which the single object is formed, and the contrast within the Gabor can be manipulated to get the psychometric function.

Closing. That concluded our discussion. Next week we take up object recognition.

Attention and Perceptual Organization
Questions for Topic 8: Are objects identified one at a time by a serial process or in parallel?
Cathleen Moore and John Palmer
November 3, 2008

Base Reading:

Walker, S., Stafford, P. & Davis, G. (2008). Ultra-rapid categorization requires visual attention: Scenes with multiple foreground objects. *Journal of Vision*, *8*, 21,1-12.

Contrast Reading:

Li, F. F., VanRullen, R., Koch, C. & Perona, P. (2002). Rapid natural scene categorization in the near absence of attention. *Proceedings of the National Academy of Sciences*, *99*, 9596-9601.

Supplemental Reading:

Underwood, G., Templeman, E., Lamming, L. & Foulsham, T. (2008). Is attention necessary for object identification? Evidence from eye movements during the inspection of real-world scenes. *Consciousness and Cognition*, *17*, 159-170.

Biederman, I, Blickle, T. W., Teitelbaum, R. C., Klatsky, G. J. (1988). Object search in nonscene displays. *Journal of Experimental Psychology: Learning Memory and Cognition*, *14*, 456-467.

Evans, K. K., & Treisman, A. (2005). Perception of objects in natural scenes: Is it really attention free? *Journal of Experimental Psychology: Human Perception and Performance*, *31*, 1476-1492.

Study Questions

1. In the current papers, what is meant by "attention demanding"? (Hint: In the questions below, we emphasize an interpretation in terms of limited-capacity processing. Namely, a process has *unlimited capacity* if it performs independently of the presence of other processes. Alternatively, a process has *limited capacity* if its performance degrades in the presence of other processes.)

2. The Li et al. (2002) study uses a dual-task paradigm to ask whether semantic categorization has limited capacity. Describe the details of their tasks and results for their main experiments (i.e., those involving semantic categorization) and their control experiments (i.e., the T-vs.-L and color-pattern discriminations).

3. What significance did Li and colleagues attribute to the contrasting results between their main experiments and their control experiments?

4. What criticism do Walker et al. (2008) raise in regard to previous attempts to ask whether semantic categorization has limited capacity (e.g., Li et al., 2002)?

5. What did Walker et al. (2008) do to address their concerns? What did they find?

6. Identify as many similarities and differences as you can between the experiments of Li et al. (2002) and of Walker et al. (2008).

Discussion Questions

1. The Walker et al. (1998) and Li et al. (2002) studies used the dual-task paradigm to determine whether semantic categorization is a limited-capacity process. Are there other ways to address this question?

2. How can the Walker et al. (1998) and Li et al. (2002) studies be reconciled? What experiments address that reconciliation?

3. How does the issue of capacity limits relate to the contrast between parallel and serial processing? Suppose semantic categorization has limited capacity, how can one distinguish if it is a serial or parallel process?

4. What is the relationship between capacity limits in perception and capacity limits in visual short-term memory (VSTM)? Walker et al. (2008) argue that if an increased load in a VSTM task is does not disturb a second task, then that additional task has unlimited capacity. What assumptions are made in this argument? What experiments might distinguish between capacity limits in VSTM and capacity limits in perception?

5. Both the Walker et al. (2008) paper and the Li et al. (2002) paper are concerned with object categorization in the context of natural scenes. Is object categorization the same thing as scene comprehension, such as what occurs when the gist of the scene is understood? How might the dual-task experiments conducted in these studies be changed to address the question of whether gist understanding is an limited-capacity process?

6. Studies on the apprehension of gist (e.g., work by Potter and by Biederman) have been done using RSVP streams of scenes. What dual-task experiment might be conducted using RSVP streams to address the question of whether gist understanding is an limited-capacity process?

7. Is the "scene" relevant in these studies? What experiment can address the question of whether the scene itself matters?

Attention and Perceptual Organization
Summary for Topic 8: Are objects identified one at a time by a serial process or in parallel?
Keith Apfelbaum, Cathleen Moore and John Palmer
November 10, 2008

Readings

Walker, S., Stafford, P. & Davis, G. (2008). Ultra-rapid categorization requires visual attention: Scenes with multiple foreground objects. *Journal of Vision*, *8*, 21,1-12.

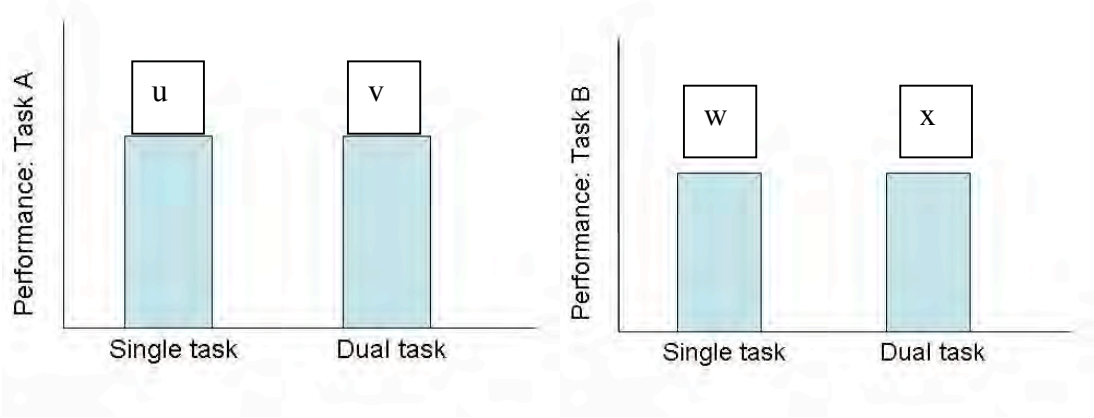
Li, F. F., VanRullen, R., Koch, C. & Perona, P. (2002). Rapid natural scene categorization in the near absence of attention. *Proceedings of the National Academy of Sciences*, *99*, 9596-9601.

Discussion summary

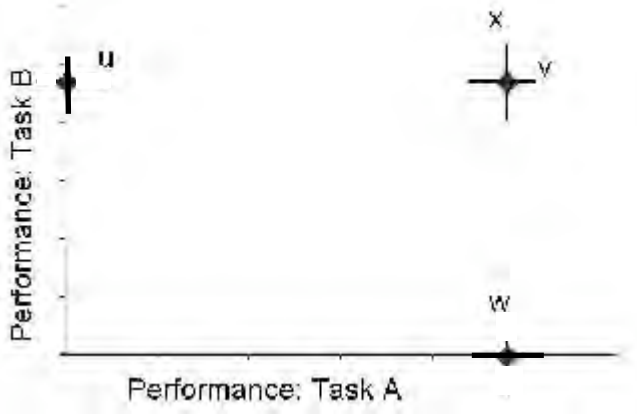
Overview. We considered whether multiple objects can be identified simultaneously and independently, or if there are dependencies such as identifying them in sequence. Our discussion focused on a paper by Walker et al. (2008) arguing for limited capacity of some kind and a paper by Li et al. (2002) arguing for unlimited-capacity, parallel identification.

Review of dual-task methods and logic. Caglar said that in the dual-task paradigm, a subject makes two responses to two inputs. Marc discussed the logic and goals behind using a dual-task approach. Specifically, it addresses the degree of independence between the tasks. If performance declines in the dual-task condition relative to the single-task condition, the tasks are not independent. In other terms, they have some capacity limitations in their component processing. If performance remains at the same level in both the single- and dual-task conditions, the tasks are independent or equivalently have unlimited capacity. Cathleen then asked how is the dual-task paradigm different from the search paradigm. Libo pointed out that in a dual-task paradigm, multiple responses are required unlike the single response in a search task. There are also often additional memory requirements in dual-task paradigm. In short, in a dual task, a subject must complete two full tasks from perception to response, whereas a search task requires performing only a single task.

Graphic methods used in these studies. Li et al. used graphs of the attention operating characteristics (AOC) to illustrate their results. Whereas a typical graph plots a dependent variable against an independent variable, an AOC plots a dependent variable against a second dependent variable. To better understand their graphs, John showed us how the same data can be plotted in the traditional way, and how this can be translated into an operating characteristic. For example, traditional plots of dual- vs. single-task performance might look like the following figure. In this figure, the letters label the performance level in each condition.



Alternatively, these can be plotted as an attention operating characteristic. In this graph, the performance on task B is plotted against performance on task A. The single-task conditions appear on the axes and the dual-task conditions appear in the interior. The corresponding data values appear as marked by the letter labels.



In this example, dual-task performance is just as good as the single task performance for both tasks. The dual-task data appear at what is known as the independence point. If the two tasks are not independent, the dual-task performance falls below the single task value for at least one and perhaps for both of the tasks.

What is meant by "attention demanding" in these papers? Both of these papers are concerned with whether what they call "ultra-rapid categorization" is "attention demanding". We discussed rephrasing this into the terminology used in this seminar. Caglar said that their definition of "attention demanding" mirrors that of capacity limitations. Within these papers, something is deemed attention demanding if performance on it decreases when another attention demanding task must be performed simultaneously. John pointed out that their use of the term "attention" addresses only capacity and does not speak to selection.

Does semantic categorization have limited capacity? In discussing how Li et al. attempted to address this question, Libo described how they used a dual-task paradigm. In their experiment, they had a central task that was assumed to be attention demanding combined with a peripheral task. The central task was always a same/different judgment task signaling whether all the letters in a display were Ts or if there was an L present. The peripheral task was a categorization in which the subject must decide whether an animal was present in a scene. Subjects responded to the peripheral task as fast as possible and took their time on the central task. If their performance in the categorization task was unchanged under the dual-task condition compared to the single-task condition, this is consistent with unlimited capacity for this kind of categorization. Li et al. further interpreted their results as showing that semantic categorization has unlimited capacity.

Two control tasks were designed to show that tasks that *do* have capacity limitations show deficits using this dual-task paradigm. The control tasks involved either letter identification (Ts and Ls) or a spatial configuration judgment (relative position of two color patches).

Chris commented that the Li et al. design used speeded responses, whereas the Walker et al. study instead used successive responses to the two tasks, and had the categorization response second. This may add a memory component to their task which is not present in the Li et al. design. We come back to this point later in discussion.

Results. Lynn noted that in the dual-task condition, the performance on the categorization task did not decline compared to the single-task condition. Figures 2 and 3 in the paper illustrate this using attention operating characteristics in which accuracy clusters around the independence point. (But buried in the text there is a dual-task deficit for response time.) By comparison, the control tasks resulted in large declines in accuracy in the dual-task condition. Thus, a capacity limit can indeed be detected with this paradigm.

Fabian brought up the possibility that the categorization may not have been semantic. He cited work showing that the global statistics of images can sometimes be used to distinguish semantic categories (see Brady & Oliva, 2008). He suggested that in order to perform the categorization task, a subject might not need to process anything to the level of semantics, but can instead perform the task on the basis of these "low-level" visual statistics. The 10 hours of training, with feedback, used in the Li et al. study further supports this possibility. Subjects have a very good opportunity to learn to respond to any available cues, rather than actually perceiving whether animals are present in the scenes. John here pointed out that their conclusions make a leap; they take the independence in this task, and make broad attributions to how semantic processing occurs. He argued that it would be better to talk about categorization rather than semantics more generally. (A similar argument can be found in Evans and Treisman, 2005).

Cathleen and Ian pointed out that some argue that global statistical processing might in fact be the same as semantic processing. If we divide semantic categories based on homogeneities in their global statistical properties, then using these statistics to perform this task is still a type of semantic categorization. Libo said that this all hinges on how one defines semantics. Lynn noted that whichever definition you apply, this study does not answer whether semantic categories are being accessed.

Cathleen asked what studies might better address this question. Elisabeth suggested using categories that overlap in visual statistics – for example, having subjects identify whether a fish or mammal was present, and presenting a dolphin. Global statistical information would enforce the fish label, whereas semantic activation instead leads to responses of mammal. Chris suggested some modification of the Stroop task might help, perhaps using picture/word interference.

Cathleen mentioned some new findings the same lab showing these categorization tasks when judging the gender of a rapidly presented face. When given a normally-oriented face, subjects' performance does not change between dual- and single-task conditions. However, when presented an inverted face their there was a dual-task deficit. Many of us felt this was a more impressive display of their findings, because the control task (the inverted face) has a relative consistency in global statistical properties.

Walker et al. When discussing Walker et al's criticisms of Li et al's design. Ben and then Marc pointed out that Li et al. had only a single object in the foreground of the displays. With only a single object, categorization process is not taxed. Cathleen suggested that perhaps Li et al. showed independence because their task is too "easy".

We began discussing Experiment 3, as the first two experiments used a serial presentation of the tasks, introducing a short-term memory component that was not present in the simultaneous displays used by Li et al. In Experiment 3, the central task is to determine whether a vowel is present in a display of four letters. Marc pointed out that this task might involve more semantic access than the same/different central task used by Li et al. Cathleen asked if this would be a legitimate challenge if raised by Li et al. Chris argued that the central task does not matter, as long as it uses attention and can cause interference in other attention demanding tasks.

The peripheral task was again to categorize whether an animal was present in a displayed scene. In the Walker et al. design, the peripheral displays consist of either a single object with no context, a single object in a scene context, or 4 objects in a scene context. The second of these conditions is most similar to the Li et al. experiment. This design allows us to investigate whether, with an increased load, there is a dual-task deficit during categorization. If so, this would be consistent with semantic categorization having capacity limitations.

Results. We discussed an aspect of the analysis that differed between the two studies. Walker et al. used a conditional analysis of the results. They only analyzed the categorization data for trials in which subjects correctly responded to the central task. They did this to minimize cases when subjects were ignoring the central task, and instead attending to the peripheral task. However, as Chris explained, this does not eliminate cases when they were not attending to the central task, but answered correctly due to lucky guesses. Cathleen pointed out that one can never be sure what a subject is attending to using this design. To address this, John suggested another technique that allows for better control of where subjects are attending. Specifically, he discussed using a correlational analysis from Sperling and Melcher (1978). This analysis can detect if observers switch attention from trial to trial.

Walker et al. found, that in the multiple-object condition, subjects were noticeably impaired in the dual-task compared to the single-task condition. In fact, they even found slight deficits in the dual-task condition for the single-object conditions. In attempting to determine the source of the differences, we tried to identify all of the differences between the two studies. These differences are listed below. Obviously, there are several possibilities.

Li et al.	**Walker et al.**
Spatial separation	Overlap
Speeded response on semantic task	Unspeeded response on semantic task (and respond second to semantic task)
Practice	No practice
Many images	Fewer images
Natural and unique images	Rendered and factorial (repetition)
Non-conditional analysis	Conditional analysis
Presentation very rapid and masked	Slower presentation and unmasked
T's and L's same/different central task	Vowel search central task
One object	Multiple objects vs. one object

Discussion. Cathleen asked if semantic categorization has a limited capacity based on the results presented in these papers. While no one was convinced that these papers had answered this question, John said he'd bet object categorization does have limited capacity.

We then began discussing how this technique can be applied to investigating scene gist. Elisabeth mentioned studies showing that people are faster to recognize animals in a scene if the animals fit in the scene than if they are out of place. John said that object categorization and gist might be very different processes. Object categorization involves identifying one object from an array of many, whereas a scene has only a single gist.

The role of gist might also explain the differences between the results of Li et al. and of Walker et al. It is possible that when only one object is in the scene, attention is not necessary. Whereas when multiple objects are present, one needs to attend to disambiguate the separate objects. Ian suggested that Li et al's single object displays are similar to a gist task because the scenes are very focused on the animals, while Walker et al's multiple object trials are more similar to object recognition tasks. However, this distinction is not perfect. As Elisabeth pointed out that this still doesn't explain why Walker et al. found decrements in categorization in dual-task conditions when only a single object was present.

Close. Next we turn to the role of perceptual organization in the control of attention.

Attention and Perceptual Organization
Questions for Topic 9: What role do objects play in the control of attention?
Cathleen Moore and John Palmer
November 17, 2008

Base Reading:

Yantis, S. & Hillstrom, A. P. (1994). Stimulus-driven attentional capture: Evidence from equiluminant visual objects. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 95-107.

Contrast Reading:

Franconeri, S. L., Hollingworth, A., & Simons, D. J. (2005). Do new objects capture attention? *Psychological Science*, *16*, 275-281.

Supplemental Readings:

Brockmole, J. R., & Henderson, J. M. (2008). Prioritizing new objects for eye fixation in real-world scenes: Effects of object-scene consistency. *Visual Cognition*, *16*, 375-390.

Hillstrom, A. P., & Yantis, S. (1994). Visual motion and attentional capture. Perception & Psychophysics, 55, 399-411.

Christ, S. E., & Abrams, R. A. (2008). The attentional influence of new objects and new motion. *Journal of Vision*, *8*, 1-8.

Von Muhlenen, A., Rempel, M. I., Enns, J. T. (2005). Unique temporal change is the key to attentional capture. *Psychological Science*, *16*, 979-986.

Prelude

There is a distinction made between the effects of attention and the control of attention. For spatial attention, this is the difference between how one selects the relevant locations and the consequences of processing relevant versus irrelevant locations. This distinction is assumed in these papers. The control of attention is discussed in Pashler on pages 235-251.

Study Questions

1. What strategy has Yantis and colleagues used over the years to test whether abrupt onsets/new objects capture attention? Franconeri et al. (2005) refer to this strategy as the "irrelevant-feature search task".

2. What are the luminance-increment and new-object hypotheses that Yantis & Hillstrom (1994) lay out? How do they test between these two hypotheses and what do they find?

3. Spatial cueing experiments have shown that even when a luminance increment is anti-predictive (i.e., it indicates that the target is *less* likely to appear in that location), responses are faster when stimuli do appear there than elsewhere. How does this seem to conflict with Yantis and Hillstrom's (1994) conclusion? How do they reconcile their conclusion with these results?

4. What is Yantis and Hillstrom's (1994) model of stimulus-driven attentional capture?

5. What fundamental challenge do Franconeri et al (2005) offer in regard to the evidence that Yantis and colleagues cite in favor of the new-object hypothesis?

6. How do they test this challenge and what do they find?

7. At the end of their paper, Franconeri et al (2005) note "Thus, at a functional level, one might still speculate that new objects capture attention." What is this functional account?

Discussion Questions

1. Franconeri and colleagues argue that their results allow the rejection of the new-object hypothesis. Consider all of the ways that their experiments differ from the experiments of Yantis and Hillstrom. Are there other possible accounts of the differences in the results for the two studies?

2. Have motion, transience, and "new object" been fully distinguished in these studies? Are they separable? Are they mutually exclusive?

3. Are you satisfied with the operationalization of "attention capture" that is used in these studies? Are there reasons other than capture that these patterns of effects might emerge? How else might "attention capture" be operationalized?

4. When describing their model of stimulus-driven attentional capture on p. 105, Yantis and Hillstrom note that "prioritization" might apply to a serial or a parallel model. How does that work according to them? Are you comfortable with that idea? We were not comfortable with that possibility when we were discussing the contrast between Shomstein & Yantis and others during our "mechanisms" week (topic 4). Is "prioritization" being used in the same way in these two contexts?

5. Yantis and Hillstrom (1994) refer to a phenomenon referred to as "novel popout" (see first column on p. 105). How does that phenomenon relate to our discussion of topic 8 when we were asking about semantic access for unattended information?

6. Consider the topic of the control of attention more generally. What are the consequences of having a theory of attentional control depend on an image representation rather than an object representation? What other phenomena might be relevant to this distinction?

Attention and Perceptual Organization
Summary for Topic 9: What role do objects play in the control of attention?
Lynn Perry, Cathleen Moore, John Palmer
November 20, 2008

Readings

Yantis, S. & Hillstrom, A.P. (1994). Stimulus-driven attentional capture: Evidence from equiluminant visual objects. JEP: HPP, 20, 95-107.

Franconeri, S.L., Hollingworth, A., & Simons, D.J. (2005). Do new objects capture attention? Psychological Science, 16, 275-281.

Discussion Summary

Overview. We discussed two papers on attentional control. The first by Yantis & Hillstrom posits that new objects determine the stimulus control of attention. The second by Franconeri and colleagues counter that it is the transient properties of stimulus onset, rather than the new objects themselves, that determine the stimulus control of attention. We discussed these papers and their implications for the control of attention.

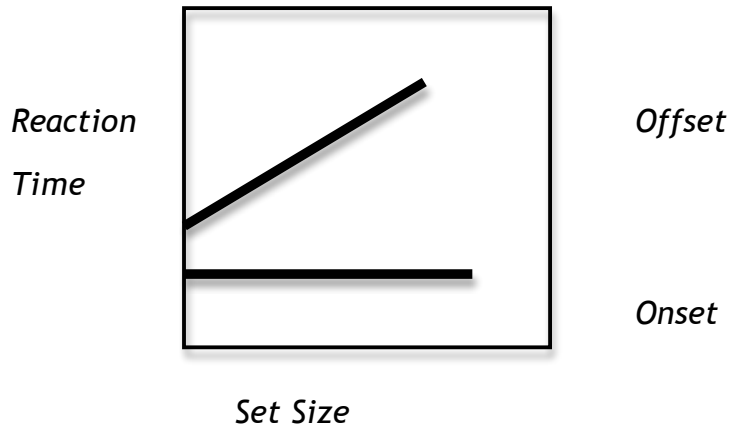
Prelude. Cathleen said that today's topic was a departure from our previous topics in that there is a possible distinction to be made between the control of attention and effects of attention. Keith defined control of attention as the way in which attention is allocated. Ian agreed that there is a distinction in that the previous topics were about how the effects of attention interacted with object perception. He added that the study of attentional control gets at the question: what determines whether one object is selected instead of another.

John provided the following example to ground these distinctions: Suppose one shines a spotlight on Cathleen as a metaphor for selective attention. What is control and what is effect? The operation of the spotlight is about control. The improved perception of Cathleen under the spotlight is about effect.

Cathleen said that if we think about the past topics—for example, whether the effects of attention reflect reduction in decision noise or change in quality of perception—we've implicitly assumed a mechanism of control. Are we are asserting the existence of a homunculus? Ian said that often when considering cognitive processes, a good place to start is with a homunculus as a sort of placeholder until you can pin down a mechanistic account of that component of processing. Cathleen pointed out that we can understand our previous topics as using such a placeholder for the control of attention, and today's discussion as trying to find a mechanism for that placeholder.

We then discussed the idea of control more generally. Cathleen mentioned that there are two traditional ways in which to consider control processes working: top-down and bottom-up. Libo described top-down processes as goal directed, while bottom-up processes are stimuli driven. John noted that almost everything we've discussed in class thus far has been instances of goal-directed attention. Ian brought up a contrasting example of the computational models that have simulated salience in natural scenes using nothing but bottom-up processes. Cathleen

suggested that the contrast between the topics in our seminar and this example highlight the need to merge bottom-up and top-down contributions to attentional control.



Yantis & Hillstrom. Yantis and Hillstrom studied control using a visual search task. Subjects needed to find the target among distracters. The display starts with placeholders at the locations corresponding to most of the stimuli. Most objects appear by removing part of the placeholder (offset condition). But there is also a new object that appears suddenly at a location without a previous placeholder (onset condition). The new object was either a target letter or a distracter letter with the same probability as at the offset locations. If attention is guided to the onset location, performance should be better regardless of set size when the new object is also the target. When the new object is a distracter, and another object is the target, performance should decrease with increases in set size. See the hypothetical results above.

Traditional accounts posit that the abrupt onset determines the control of attention. Marc pointed out, however, that in previous experiments, new objects are confounded with luminance changes. It is the hypothesis of the current authors that it is a new object alone that controls attention.

The authors reconcile their results against luminance onsets with previous results consistent with the onset account. Marc said that the authors say that the mechanism of capture is specific to the task. A particular task induces subjects to adopt attentional control to luminance, for example. Luminance is not necessarily fundamental to attentional control, but the subjects are using it because it relevant to their main task. Cathleen suggested that this process is never purely stimuli driven, but that there is a control setting on the part of the observer. Thus, while luminance might not capture in some tasks, it can in other tasks.

Ian asked whether this argument makes the distinction between exogenous vs. endogenous meaningless. Cathleen explained that this distinction was an example of stimulus-driven versus goal-directed control. In similar experiments, color singletons show an effect only when they are related to the target in a particular task. Marc asked whether we should think about this as a sensitization to color when it is relevant, or as not habituating to color when it is relevant. Cathleen described it as learning to ignore the irrelevant stimuli.

Ian brought up a recent talk he had attended at the Psychonomic Society conference in Chicago (von Muhlenen, 2008). He said that in this study, the authors described a similar capture experiment. They examined practice effects and found that during initial blocks, there was capture by color singletons that went away in later blocks. It appears that subjects start out being captured by color singletons. Then they learn over the course of the task, that this information is irrelevant for identifying the target item and are able to ignore it. Next, the author pointed out a difference between this color singleton task and the usual luminance onset task. Unlike the color case, there is no "marker" that distinguishes the onset stimuli from the offset stimuli once the stimulus display is presented. They provided such a marker by coloring the onset stimulus but not changing the onset in any other way. Under these conditions, subjects learned to ignore the onset just like they did for the color singleton. Thus, they argue the key feature is the ability to learn to ignore the irrelevant but salient stimuli. This challenges both of the accounts considered in the papers in this week's readings.

Franconeri et al. This article provides another challenge to Yantis and Hillstrom. Yantis and Hillstrom argue that it was the introduction of a new object, rather than luminance, that controls attention. In contrast, Franconeri et al. argue that it is the transient properties of object onset, rather than the object onset itself, that controls attention. Marc described the procedure in the Franconeri et al. experiments: the new object appears at just the moment all of the objects are occluded. Thus, the luminance increment is obscured. According to Yantis and Hillstrom, subjects should attend to the new object irregardless. Instead, Franconeri et al. find capture occurs only when the transient is present. A new object alone isn't enough to capture attention.

Cathleen asked what it meant when the authors conclude that on a functional level, attentional capture is still about new objects. Keith said that every time we see a new object enter our visual field in the real world, it is generally accompanied by a transient. So, because these two things are highly correlated, it is as if new objects capture our attention even though it can be distinguished from the transient.

Ian brought up a connection to the change blindness literature. We know that in this paradigm, subjects have great difficulty noticing new objects in the scenes they are comparing. This occurs only if the transient is obscured much like the Franconeri et al. procedure. Thus, this paradigm provides broad support for the idea in the Franconeri et al. article.

The authors conclude that their results suggest attentional capture is determined by luminance onsets. Cathleen wondered if they can make this strong claim. Marc said that it becomes a question of does luminance meet some sort of “necessary and sufficient” guideline. Even if luminance transients are sufficient for attentional capture, but that doesn’t mean that they are the only things that can be necessary. There might be other kinds of transients that work equally well.

John said that one can think about the findings of these two papers in terms of a pair of properties that can be presented in a 2-by-2 table as shown below. The properties are the presence of a luminance transient and the presence of a new object. The common case in the old literature (Standard) is to have both a luminance transient and a new object. Experiment 1 of Yantis and Hillstrom (YH) is a case of a new object and no luminance transient. Their Experiment 3 is a case of a luminance transient and no new object. The Franconeri et al. experiment (F) repeated the standard case and the same case as Yantis and Hillstrom Experiment

1: new object with no luminance transient. It is here that they find conflicting results. They do not address the case of Yantis and Hillstrom's Experiment 3 which is needed to make a complete argument for luminance transients.

	New Object	Old Object
Luminance Trans.	Standard & F	YH E3
Not	YH E1 & F	

Discussion questions. We began by considering what weaknesses do you find with the current operalization of attention capture. Keith liked the talk presented at Psychonomics. It might seem a good strategy to start by choosing to attend to the featural singleton. Then learning can adjust your response depending on whether the stimulus is relevant to the current task. John added that if capture is under such top-down control, it would be subject to instructional control. For example, if the experimenter was to tell the subjects not to look to a particular object, it should affect the results.

Elisabeth suggested to consider more difficult discriminations instead of using how RT slopes change with set size. This can be done by masking stimuli after presentation and asking what was in a particular location. If subjects were still better with new stimuli, it would support authors' hypotheses.

Ian suggested that attentional capture can be thought of in two different ways: as attentional guidance to certain stimuli versus the inability to disengage from attending to certain stimuli or locations.

Cathleen pointed out that there is a confound with attentional capture in the current paradigm. The initial placeholders are a type of forward mask. One needs a baseline to ensure the effects are caused by attentional capture as opposed to forward masking.

John was disappointed that they didn't really work out a more detailed model of these processes. Sometimes the processing appears serial, other times it appears parallel. It is ambiguous what is going on at the level of serial versus parallel processes.

Ian brought up the fact that the authors don't address other sorts of objects. The objects used in these current studies are those defined spatio-temporally. Ian asked if they had used dogs and cats that change into each other, would new objects still capture attention? Cathleen hypothesized if the transition was smooth enough, it wouldn't make a difference if these were cats or figure 8s. Likewise, real world examples that isolated transients from new objects should also work. Mark pointed out that circles that grow at exponential rates are perceived as more real than those that grow at steady rates. Ian added that subjects react more quickly to objects that look like they will hit them, rather than ones that appear to nearly miss them.

We stopped early in honor of Psychonomics.

Attention and Perceptual Organization
Questions for Topic 10: An alternative approach: The Boolean map theory of visual attention
Cathleen Moore and John Palmer
December 1, 2008

Base Reading
Huang, L., & Pashler, H. (2007). A Boolean map theory of visual attention. *Psychological Review*, *114*, 599-631.

Study Questions

1. According to Huang and Pashler, what is selection and access? Give examples of each.

2. What is the domain of the theory? What are spatial transformation tasks?

3. How do Experiments 1 and 2 test how many colors can be accessed at one time? What is the ABBA versus ABCD paradigm?

4. How does Experiment 3 test how many colors can be accessed at one time? What are the alternative hypotheses distinguished by the simultaneous-sequential paradigm? Does this experiment address perception or memory?

5. How does Experiment 4 test how many locations can be accessed at one time?

6. What is a Boolean map?

7. The theory is summarized in two principles and five tenets on page 603. What are they and what do they mean?

8. How are Boolean maps created by union and intersection of a new map and the previous map? What kinds of tasks does this method help solve?

Discussion Questions

1. What is the difference between access and capacity?

2. Experiments 1-4 address the possibility of serial processing in the access of various kinds of information. What other paradigms might be used to address this question?

3. What is the role of memory in access?

4. How does the Boolean map theory compare to one using top-down salience maps?

5. What does the Boolean map theory add to a image based theory of attention? What does it share with various object-based theories of attention? How can if be differentiated?

6. How does the Boolean map theory compare to hierarchical object representations for describing spatial patterns? Can we identify all of the differences?

Attention and Perceptual Organization
Summary for Topic 10: An alternative approach: The Boolean map theory of visual attention
Christopher Kovach, Cathleen Moore, John Palmer
December 10, 2008

Readings

Huang, L., & Pashler, H. (2007). A Boolean map theory of visual attention. *Psychological Review*, *114*, 599-631.

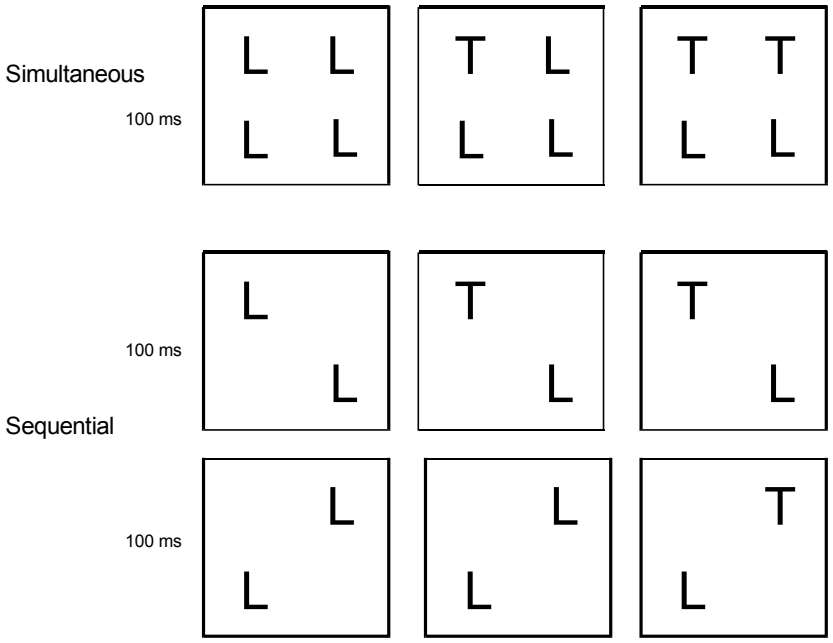
Discussion Summary

Overview. Cathleen introduced this week's reading: "A Boolean map theory of visual attention" by Huang and Pashler. This is a theoretical paper that addresses many disparate issues. The paper's organization is somewhat unusual. The experiments are only briefly described with details given in an appendix. In addition, many of the author's arguments rely on appeals to phenomenology rather than experimental data. A show of hands on whether people "liked" the paper came up with mixed reviews.

Discussion of Question 1: Selection versus Access. Cathleen opened discussion of Question 1 on the difference between selection and access. Ben and Libo described access as the availability of information to conscious awareness. Cathleen asked whether selection necessarily implies access. John pointed out that a key property of selection has to do with task relevant stimulus properties which guide selection. Christopher described access and selection, as defined by the authors in the context of Boolean map theory: selection is the process of generating a Boolean map, while the content of what is accessed is the information represented by the map. This suggests that, under Boolean map theory, access is a necessary sequel to selection.

John asked for a more general definition of access and selection, outside of Boolean map theory. Consider Figure 1 in Huang and Pashler. Figure 1 has four quadrants showing each combination of easy and hard examples of selection and access for access to color and selection by shape. Elements are selected based on shape (square target) and information about color is accessed. In the upper left quadrant selection is presumed to be easy because there is one shape and access is also easy because there is only one color in the selected area. In the upper right quadrant, selection is hard because it must exclude circle distractors, but access to color is easy because only one color is contained in the selected area. The lower left quadrant gives an example of easy selection: only the target shape is present, while access to color is claimed to be difficult because there are two colors in the selected area. The lower right quadrant gives an example of hard selection (circles are present) and hard access (multiple colors in the selected area). From this it seems that by access the authors mean the availability of feature labels which describe the content of selected information. A central claim of Boolean map theory is that any Boolean map cannot have more than a single label within any dimension, and consequently maps which encompass multiple feature values within a single dimension can't be associated with a label in that dimension. Access is related to the ability to attach a feature description to the selected elements.

Cathleen and John described Duncan's 1980 paper which showed that access to selected information is capacity limited while the rejection of distractors shows little sign of capacity limit. Duncan applied the simultaneous vs. sequential paradigm. The task involved reporting the presence of one or two targets under two conditions, one in which targets and distractors are all presented simultaneously and one in which subsets of the targets and distractors are presented sequentially. Performance is not affected by the different number of simultaneously presented distractors in the sequential and simultaneous conditions, implying that there is little cost from simultaneous distractors. Performance is severely affected by the different number of targets when two targets are present, with identification of two simultaneous targets much poorer than sequentially presented targets. Consider the following figure:



The target is a "T" and the distractors are "L". Each of the columns represent a different condition. In addition, two top row represents the simultaneous condition and the bottom two rows represent the sequence shown in the sequential condition. Performance is not different in the left two columns between simultaneous and sequential presentation. In the rightmost column, performance is much better for sequential than simultaneous.

Ian asked about the role of capacity limits in this context. John replied that the experiment implies a capacity limit for the target of one, while no limit is apparent in the ability to reject distractors. There are many different ideas why this is the case. The limited ability of memory to encode information about the target is the most widely accepted explanation.

Cathleen said that detection of the target depends on the process described by "access." She pointed out that the authors claim in Figure 1 is not intuitive. At least with simple figures, one doesn't experience obvious switching in accessing the multiple colors. Rather one has the sense that we are aware of the blue and the yellow square simultaneously. This might be

explained by "quick switching," and evidence in support of this possibility is given by the sequential-simultaneous paradigm. Christopher and John discussed the idea that simultaneity and continuity of visual experience might be illusory, with absence of change detection and awareness of the impoverished nature of peripheral vision as examples.

Experiments 1 and 2: ABCD vs. ABBA. Cathleen turned to Experiments 1 and 2. Keith and Caglar described the ABCD and ABBA experiments. The stimuli are matrices of colored squares with four different colors. The task requires a judgment of similarity. In the ABBA task, the colors of 4 squares of two colors are changed. In the ABCD task colors of 4 squares in each of the 4 colors are changed. Detection of the difference is faster in the ABCD task than the ABBA task.

An illustration of the Boolean map theory explanation for this effect is shown in Figure 8. Each of the 4 colors are analyzed serially. Detection of differences involves constructing a Boolean map for each color in turn then analyzing the shape of the map. In the ABCD task a difference is present in each map, so detection should always be possible with the first map, while in the ABBA case two of the maps contain no differences.

Keith asked whether the effect depends on the importance and salience of the color dimension under this specific task.

John said that the main point of the experiment is that it rejects a location by location analysis, since the time to find differing locations should be the same, on average, for ABBA and ABCD. The only apparent way of explaining the difference is that the analysis is color by color.

Keith asked whether the mechanism holds for less salient differences. He also points out that there is another potentially confounding difference between the ABCD and ABBA conditions. In ABCD the colors appear not to be balanced in the second matrix while in ABBA they are. It might be possible to detect the ABCD difference based on mismatch in the number of squares of a given color without having to analyze their spatial distribution.

Cathleen pointed out that focusing on a single color seems phenomenologically to be a "good way" to do the task, but asks whether it is a necessary strategy. Keith wondered whether the same principle might be demonstrated with a feature dimension other than color, such as shape. Perhaps the effect is unique to color?

Experiments 3-4. Cathleen turned to Figure 10 and asked for a description of Experiments 3 and 4. She pointed out that this experiment contradicts the apparent phenomenological simultaneity of access to color information in Figure 1. Caglar described the structure of the experiment. In Experiment 3 there are two conditions: one in which two colors are presented simultaneously and another in which they are sequential. In Experiment 4, there are also simultaneous and sequential conditions. In each case, the probe is presented after the test stimuli so that both colors need to be selected for matching to be successful more than half the time. There is an advantage for sequential presentation with color but not with location, implying that only one color is selected at a time while location is analyzed as a single spatial pattern.

John mentioned that this looks like an explicit memory test. It is memory because the probe is presented after the test stimuli as in a probe recognition memory paradigm. In the usual variant of sequential-simultaneous paradigm the target is known in advance. Performance on this task appears to be quite low, but the effect is large.

Fabian asked about the role of the mask in these kinds of the experiments. Is there a standard way of constructing masks? John answered that masks are generally ad hoc. In this case it seems that the stimuli were masked by a 2 x 2 colored checkerboard, but the method is not well described in the Psychological Review paper.

Keith pointed out that the response to the color was only color identity, not location. Ian criticized the comparison between the color and location tasks. The effect of masking might be very different in each case, since in the location task the presence or absence of onset responses related to the mask might help perform the task.

Cathleen reiterated the implication of Experiment 3 is that multiple colors aren't accessed simultaneously. This greatly simplifies Duncan's version of the paradigm because it relies on basic feature values rather than more complex shapes (letters), making it an even more striking demonstration of a capacity limit in access for an otherwise elementary stimulus.

Ian repeated his concern about the difference in mask types between Experiments 3 and 4. John argued that the information on experimental design is too sparse to know how serious an issue this might be.

Theory. Cathleen opened with the question: what is a Boolean map? Theresa replied that it has to do with where attention is directed. Moreover, it is spatial in nature. It is a spatial representation of selected and non-selected areas.

John criticized the choice of name. George Boole was a mathematician in the 1800s. A Boolean variable is a binary variable. This name seems to be too general for a theory of visual attention. In contrast, a salience map is represented by a real value, and it would seem odd to call a salience map a "real value" map. Fabian and Christopher suggested that the source of the name is the Boolean operations which can be applied to the map rather than the binary nature of the variable.

Cathleen emphasized that Huang and Pashler are trying to address the nature of the capacity limitations through the notion of a data structure. The salience map, in contrast, is an large array of real variables upon which some other process acts; capacity limits are described in terms of the mechanisms which produce the salience map and which act on it. The Boolean map, on the other hand, is a structure associated with specific kinds of information. The limits in Boolean map theory are a consequence of the nature of the information available in the structure, not of how that information is generated or used.

Christopher questioned the incompatibility of salience maps and Boolean maps. The generation of a Boolean map requires a down-sampling of visual information, akin to an analog to digital conversion. The computational process involved in generating the map is potentially

elaborate and might resemble a salience map, with the difference that rather than a single point, multiple discontinuous locations can be selected at once. Cathleen pointed out that the authors allow for bottom up salience, but object to the idea of top down salience.

Christopher suggested that the use of Boolean operations might lead to a theory which is mathematically similar, if not equivalent, to some types of salience maps. The Boolean operation of intersection is equivalent to addition of the log odds for inclusion in separate maps under the assumption that there is some stochasticity in forming the maps and that the maps are independent of each other. If the log odds of selection within a map is monotonically related to the underlying "analog" signal from which the map is generated, then the operation is mathematically equivalent to a (possibly nonlinear) summation of the analog signals, similar to that assumed in Wolfe's guided search theory. Additivity of log odds of selection seems to be a necessary consequence of the assumptions of Boolean map theory for independent maps and may lead to some strong and potentially testable quantitative predictions.

Ian pointed out that the theory doesn't specify how boundaries within the feature space are drawn, or even what distinguishes different feature dimensions. John answered that this is a problem which is wide open and confronts any feature dependent theory. Cathleen said that, at the very least, each feature value is defined as a contiguous set in feature space. What is definitely not allowed is the selection of discontinuous sets.

John summarized the theory using the five tenets and two principles from the paper.

Five tenets:

1. Obligatory encoding of location
2. Single feature access
3. Multiple location access
4. Feature-by-Feature selection
5. Availability of Boolean operations

Two principles

1. Principle of access: A Boolean map is a spatial representation which divides visual space into two subsets, selected and not selected. Only one feature label may be associated with a map per dimension, and it describes the feature value for all of the selected elements. Conscious awareness at any instant is represented by only one Boolean map.

2. Principle of Selection: Top down control acts only by directing how Boolean maps are created. Boolean maps are created in one of two ways: (a) selecting all locations with a given feature value in one dimensions, or (b) through the Boolean combination of an existing map and a new map through the operations intersection and union.

Ian suggested that the five tenets are reminiscent of Treisman's feature integration theory. John replied that Treisman's theory is not strongly location based in how features are represented. Jules's texton theory is much more dependent on location. In contrast to Boolean

map theory, neither of these theories stipulate that only one feature may be accessed at a time. This is a unique aspect of Boolean map theory. In addition, Boolean map theory allows selection of spatially discontinuous areas, making the locus of selection less spatially constrained than in feature integration theory and guided search.

Cathleen wondered whether Treisman really belongs in the opposite column in Table 1, opposing the access of one feature at a time. John pointed out that Pashler has a very different take on binding problem than Treisman. Features are always identified with locations. Binding to location is inherent, and there is a strong dependence on location in the representation of features. John wondered how maps are represented physiologically. Contrary to many claims, single cell responses often do not reflect just one feature, but instead it is common that they reflect sensitivity to multiple features.

We turned to Figure 16, noting that identification of symmetry by segmenting warm colors from cool colors is difficult. This seems to pose a problem both for salience maps and for Boolean map theory. Keith noted that he has the same experience with Figure 15, which the authors claim is easily identified as symmetric. Keith says that he can see the symmetry only with effort.

Discussion Questions 1 and 3. John opened a discussion of Question 1: what is the difference between access and capacity. He suggests that access is essentially memory, but notes there are several ideas about what constitutes access. Cathleen replied that while the evidence from Experiments 3 and 4 suggests a relationship between access and memory, the symmetry judgments are on-line. All the items are present, and there doesn't seem to be any need for a durable store. It doesn't seem that the authors intend the theory to be about memory.

John described Mary Hayhoe's findings that many types of difficult matching tasks induce back and forth eye movements, which implies that they are heavily dependent on memory. Christopher noted that such a strategy seems to be necessary in detecting symmetry in Figure 16, again making memory an essential factor. As Cathleen points out, though, Figure 16 seems to be an example in which Boolean map theory fails.

Christopher said that the Boolean operations in Boolean map theory must happen in some kind of buffer, so that a dependence on memory seems to be inherent in the theory.

Caglar raised the paradigm of multiple object tracking. How is it possible to track four different objects with four different color under Boolean map theory? Cathleen replied that the idea is that the objects are encompassed in a single Boolean map, but color identity is lost, so that, for example, one should be blind to switching of the colors.

Caglar asked, then what is the capacity of the Boolean map? John answered that the capacity of the map is high. What is limited is access to features within the map.

The end.

Attention and Perceptual Organization
Questions for Topic 11: Finale
Cathleen Moore and John Palmer
December 4, 2008

The following questions are from CM and JP along with edited versions of questions from the other participants in the seminar.

Foundations of Attention

1. Purely attentional tasks and processes? Are there purely attentional tasks which exclude memory and perception? Or must we be satisfied with tasks that hold the contribution from perception and memory constant across conditions? If so, are the mediating processes attentional, or some combination of attention, perception and/or memory? Caglar Tas

2. Is attention integral with other processes? We have generally considered attention as a separate entity from visual perception. Namely, we assume that visual perception occurs in certain ways, and that attention can influence perception. Attention is assumed to be mediated by a different set of processes than perception. Is this distinction necessary? Should we view attention as separate from visual processing, or are they a single, integrated system? Keith Apfelbaum

3. Attention or attentions? Does it make sense to talk about attention as a singular mechanism that can be adapted flexibly or should we rather consider the existence of distinct attentional mechanisms, and thus talk about attentions? Elisabeth Hein

4. Capacity and the processing sequence? Capacity limitations might lie in perceptual processes, memory processes, or decision processes. What do we understand about capacity that is shared by these different stages of processing? Alternatively, can one describe capacity limitations without appealing to assumptions about the processing sequence? Libo Zhao

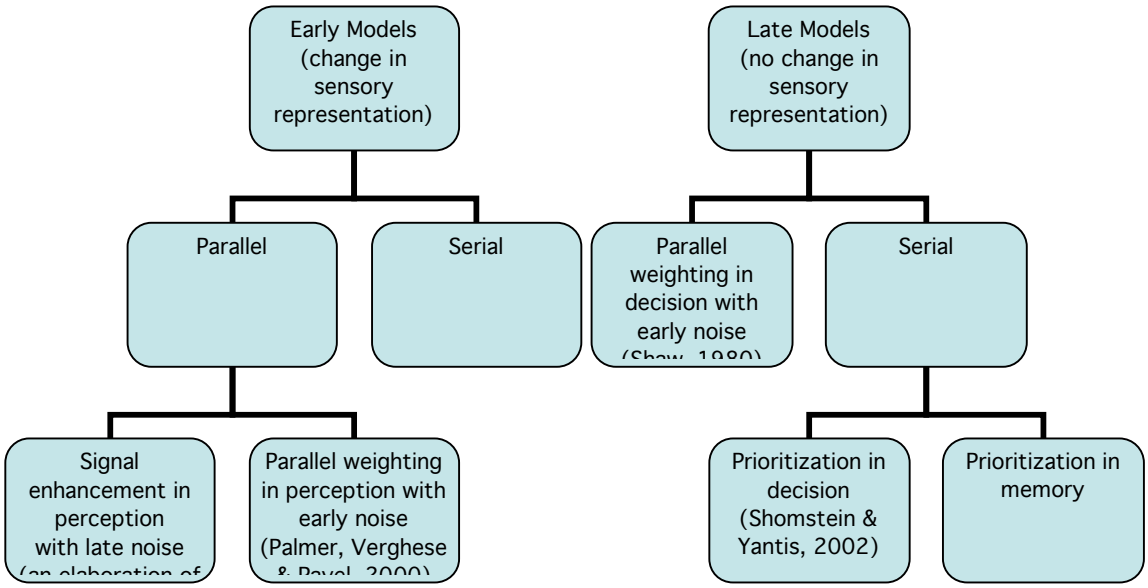
5. Selection and capacity? This course has emphasized the concepts of selection and capacity. How does this organization stand at the end of the course? For example, do the ideas of access in Huang and Pashler require one to reconsider the meaning of capacity?

Object-Based Attention

6. Object boundaries? Most theories we have discussed have tacitly assumed that objects are selected using of their physical boundaries. How are these boundaries defined within more complicated objects? For example, consider stimuli that are colored boxes containing a letter. When participants perceives this stimulus as one object, does this mean that they are ignoring the boundaries of the "X" in order to select the box? What if they are trying to perceive the letter instead of the box? Do they then use the boundaries of the "X"? In short, how does one get from selecting an object to selecting a region of space? Ian Rasmussen

7. Task-based attention? We have discussed theories of attention that are object-based, space-based, and variations therein such as the grouped array and Boolean maps. Is it instead possible that attention is allocated based on current task demands? In situations where it is efficient to focus on objects, attention might be object-based; when space is more efficient, attention might be space-based; and so on. Keith Apfelbaum

8. Alternative hypotheses for attentional effects on perception. One of our most extended discussions was the alternative accounts of attentional effects on perception in variations of the Egly paradigm. These were summarized in a tree diagram repeated below. Given our further discussion, how would we revise this set of alternatives?



Attention Effects on Perceptual Organization

9. It is all perceptual organization? What if perceptual organization and attention are highly intertwined, and they can't be studied separately? Let's assume that, as proposed by Gestalt psychologists, each time we group together different elements of a visual display we perceive them configurally instead of as the sum of the individual elements. Consequently, processing the group together becomes easier and tearing them apart becomes more difficult. Given this view, then object-based attention phenomena are granted because the structure of objects makes their parts easy to be grouped together. How much of what we know about attention can be explained as a product of perceptual interaction between different elements of a visual display? Do we still need the concept of attention? Fabian Soto

10. New paradigms. Our discussion of attention and perceptual structure contrasted a paper by Moore and Egeth with a paper by Freeman and colleagues. Can we design new versions of both paradigms that take advantage of other ideas discussed in the seminar. First, can we introduce the use of cues from Freeman into the inattention paradigm to show effects of attention that satisfy the requirements for inattentive processing? For example, attending to colored lines might change the effect of colored context lines. Second, can we use tricks from

Duncan and other studies using superimposed stimuli to determine if the effects found in Freeman et al. are space or object based?

Control of Attention

11. Understanding capture. What aspects of attentional capture are based on object-based, rather than depending on space and time? Are they mutually exclusive? Ben Dow

12. The development of attentional control. Recently, we discussed von Muhlenen's talk at Psychonomics about practice effects and attention capture by color singletons. Over the course of a session, subjects learn that color singletons are irrelevant to locating the target, so it seems that their attention is tuned to ignore that irrelevant property. Might a similar process also be occurring at the timescale of developmental time? Is the development of attentional control a process of learning to ignore or one of learning to attend? Lynn Perry

Other Topics

13. Moving Boolean maps? Consider attention over space and time. What needs to be added to the Boolean map account so it can be applied to moving stimuli? Teresa Stephens

14. Object-based transformation tasks? Consider the spatial transformation experiments used in Huang and Pashler (2007) such as the simultaneous-sequential comparison for matching colored patterns. Can one test if these matches are object based by matching stimuli with multiple objects?

15. Conscious effort? What is the role of conscious effort on performance in the attention paradigms discussed in this class? Would high- vs. low-effort groups differ qualitatively in some paradigms but not others. For example, would processing appear more parallel in a visual search task? Marc Halusic

Attention and Perceptual Organization
Summary for Topic 11: Finale
Elisabeth Hein, Cathleen Moore and John Palmer
December 10, 2008

Discussion Summary

Overview. Cathleen Moore explained the goal of this last seminar session. Before starting to discuss the questions we collected, we will revisit the entire seminar with the help of a question-and-answer summary of the seminar made by John Palmer.

Comments to the question-and-answer summary. John wanted to know if we are happy with the summary, especially what we think about the Yes and No responses. Cathleen wondered why John was using “but” in order refer to memory mediated effects of attention in the answer to the question if objects influence divided attention (Question 1). During the course of the entire seminar we repeatedly found large attentional effects on memory and not such convincing effects on perception. John responded that his "but" was referring to the title of the seminar focusing on perceptual organization and not memory organization.

Caglar Tas asked about why separate Question 3 (Does selection affect perceptual organization?) and Question 4 (Does perceptual organization require attention?) . These two questions were discussed together in the seminar. John answered that this is one way to integrate these two conflicting papers by emphasizing that they address two distinct questions that need not have complementary answers.

Question 1: Purely attentional tasks. Caglar wondered how much one can separate memory and attention. And, in particular, are there any tasks that separate memory and attention? For example, even a typical visual search task still requires some memory and therefore the question is if it is possible to create a visual search task that does not require any memory. Marc Halusic offered that once can minimize the influence of memory but not eliminate entirely. John added that a more refined question is whether a particular manipulation affected the memory requirements for a particular task. For example, in visual search one can make the argument that set-size manipulations do not increase the memory load of the final decision and identity of the target.

Question 1 & 2: Attention as a separate process from memory and perception. Libo Zhao asked how much attention can be seen as separate from perception and memory. What exactly does attention add? Cathleen offered Pashler's suggestion in his attention book, we try not to talk about attention as a process in itself, but rather refer to capacity limits, selection effects, etc. John suggested thinking about concrete cases, in which the answer is easier. Consider theories that describe an effect of attention but without proposing a distinct attentional process. For example, in a parallel processing theory of visual search, cueing different numbers of stimuli results in a corresponding number of parallel processes. These processes are a consequence of attention but not about "attention" in themselves. Cathleen posed another possibility of thinking about the flip side of this suggestion: consider theories that do propose

attention as a distinct process. Keith Apfelbaum commented that in the papers we discussed during the seminar attention was often described as its own process.

John described an example task in which participants have to make eye movements in order to read different words in turn. Some of the words are red and others are green. The participants are instructed to attend to the red words. In this example, is attention a modulator or a different process? Keith responded that attention could be part of perception and not a separated process. John suggested that in his example the processes underlying reading the words is the same regardless of their color. Attending to red controls which stimulus is selected for the reading process. The attentional question is: what is that selection process? Is this integral to perception or is it distinct from perception? Keith asked if one would consider an attentional researcher as different from a vision researcher? Is selection part of visual processing?

Cathleen asked us to think about what counts as an attentional effect. Consider a paradigm in which attention is manipulated by an instruction to attend to something particular. The physical stimulus is always the same. Nevertheless, something is changed about how the stimulus is processed. What is it that changed? And what process allowed the change in processing in response to a particular instruction? Are those processes different from "normal" perception? What defines an attentional effect? Libo offered that the perceptual system needs to connect with motivation. Thus, the perceptual system is modulated by other systems such as motivation. Cathleen asked if this other system is something outside of perception and memory? Keith added that memory is also not really separate from perception, everything is used constantly together and totally intertwined. John argued that this is a extreme position. Consider for example the case of H.M., the famous patient, who died this week. He could not learn any new things after his brain damage, even though his perception was intact. This example illustrates that memory and perception are separated entities. Furthermore, examples of other patients show that there are many different kinds of memories that can be damaged independently.

Marc presented the example of a study showing that in people that are in coma still make tracking eye movements of a rudimentary sort. What is this system that allows tracking in coma patients – is it attention or vision? John responded that attention can't be involved in this case, as there is no possibility of goal dependence. The tracking in this case is likely to be stimulus driven. Marc asked if this is separate or part of the system. Lynn Perry added that a motor system might be involved. John responded that a reflexive system might be responsible for tracking to stimuli such as a bright flash of light.

Keith asked about how attention is implemented physiologically Are there one or several brain areas particularly involved in attention or is attention integrated into areas specialized in other things, like perception and memory? Cathleen replied that most current physiological theories of attention assume that there is a distributed network involved. In addition, there are specialized brain areas involved in the control of attention. These areas are specific to the control of attention and not the attentional modification of a stimulus representation. But there is a debate in the field on how tightly interleaved are the control of attention and the effect of attention. One brain area that has something to do with attention is the frontal eye field (FEF). The FEF is thought to be involved in the control of eye movements. Activation of cells in the

FEF activates the superior colliculus, which in turn provokes an eye movement. The FEF also modulates activity in visual areas such as V4.

Caglar asks about people having Balint syndrome. These patients have difficulties disengaging their attention or switching tasks. This reminded Cathleen of the phenomenon of babies getting stuck with their eye movements, which might be evidence of an immature attentional system. John added that there seems to be a qualitative difference between infants younger than 6 months and older ones. This is, because the preferential looking paradigm only works for children younger than 6 months. After that the infants "have there own agenda". Libo worried that this difference might be explained by familiarization. John responded that this might be part of the reason for the difference, but seems unlikely to explain the qualitative difference that is observed. Marc asked if that means that one distinguishes between a top-down attentional system and a another system that might be perceptual that has his own defaults and reflexes and that is linked to eye movements. John agreed that this distinction of goal- and stimulus-driven attention is important.

Question 12: Development of attentional control. Lynn was inspired by the conversation we had about the Psychonomics' talk of von Mühlenen about practice effects in attentional capture. She wanted to know if there are changes of attention on the larger time scale of developmental time. Libo replied that, for example, children have to learn that shape is important in order to identify an object. Consequently, infants focus on shape when trying to identify objects. Cathleen emphasized that children learn to attend to a special property of an object. Lynn added, that children do not only learn to what to attend, but that they also have to learn what to ignore. Keith mentioned that in the domain of speech perception it is known that the vocal system can flexibly choose what to ignore and what to attend to (for example VOT or pitch). John described a transfer study in which participants were trained in a visual search task distinguishing a target group of letters, from a second distractor group of letters. After training, several transfer conditions were compared. In one condition, the target letter set stayed the same and the distractor letter set was changed. In another condition, the target letter set was changed and the distractor set remained the same. There were also controls where none of the categories changed or they both changed. Interestingly, the two key conditions were intermediate between the two controls. This suggests that one learns both attending to relevant targets as well as ignoring irrelevant distractors. As an alternative, Cathleen suggested that participants might have learned relations between targets and distractors.

Question 5: Selection and capacity. Cathleen made the observation that until now in today's discussion every statement was related to selection. What do we think about the distinction made by Pashler in his attention book between capacity and selection. Is this distinction really important or not? Elisabeth Hein argued that the distinction between control and effect is more important than the distinction between capacity and selection. Cathleen asked further why we are even talking about selection if there is no capacity limitation. Marc explained that we are often talking about a particular kind of task, in which people are attending to only one item and therefore there is no capacity limit. Lynn asked if capacity is not the more interesting part. Cathleen suggested that capacity questions are more straightforward and easier to examine. John disagreed.

Question 4: Capacity and the processing sequence. Libo wanted to know at which stage in the processing sequence did capacity limitations occur and whether capacity limits are specific to particular stages. Cathleen offered that the default hypothesis might be a big pool of attention "resources" that is modality and task independent and can be used up by all stages. Libo countered that there are studies showing that one can attend to multiple things at once in different modalities without any cost. Whereas there is a cost to attend to multiple things within one modality. This suggests that there is no general pool of attention. Elisabeth suggested that the answer to the question also depends on how serial or parallel are the different stages in the processing sequence. John agreed and added that Pashler sees the most significant processing bottleneck not at the early stages of processing but rather at more central stages.

Question 9: Is it all perceptual organization? Fabian Soto explained that his question is related to Keith's question about the integrality of attention and perceptual processes. Fabian made the observation that when we are talking about attention we always talks about objects that are selected. Fabian suggested that maybe attention does not exist as a separate process and pure perceptual organization can explain all the effects we are attributing to attention. For example, in line with the Gestalt principles of vision, like similarity, proximity and common fate, some things get grouped together and as a consequence represented together as a whole, which could explain effects that are usually attributed to object-based attention. Cathleen suggested thinking about the particular situation of displays that have an ambiguous organization, as for example the Necker cube. In order to change from one organization to the other don't we need something more than perceptual organization alone? Doesn't this situation fits the attentional definition we talked about earlier, that even though the physical stimulus is identical, we can perceive very different things. Fabian agrees that attention seems to be needed in order to switch from one organization to the other. However, as John adds, there are examples of perceptual states in ambiguous displays that do not always seem to be under voluntary control, as we often can not switch at will from one state to the other. Elisabeth mentions that in the case of the Necker cube, depending on what corner of the Necker cube we are attending to, we tend to see one and not the other organization of the cube, suggesting that attention could trigger a certain perceptual organization. Fabian concludes that his point is intended to be about stimulus-driven attention and not goal-driven attention.

Question 15: Conscious effort? Marc asked about the distinction between effortful, conscious control of attention and effortless, non-conscious processing. For example in a categorization task, one can learn to quickly determine if an animal is present or not. How much effort does this process need and what kind of feedback is required? Are we learning such a task with the help of an non-conscious process that picks up certain stimulus characteristics in combination with a more goal-directed, conscious and effortful system? How can we study these two kinds of processes separately? John suggested that conceptual learning might be relevant in this context. In these studies, people learn to categorize stimuli into two categories without instructions defining the categories. Under these conditions, how do people learn to categorize? There are at least two possibilities: People might form conscious hypotheses about possible categories or are they might be unconsciously recording contingencies about feature characteristics and the task feedback. Marc summarized that there seem to be two simple models, one, a non-conscious process that is picking up global statistics about the stimuli, and another one, a conscious attentional system that is task oriented. Are these distinct systems? John thinks

that they are. There is a low-level learning system in addition to an conscious control system. This conscious control system may be limited and effortful, but it is possible to achieve learning. For example we can learn how do drive a car even if it is very difficult in the beginning. Cathleen adds that this relates to the view of David Meyer, who in contrast to Pashler, assumes that the response selection bottleneck reflects the state the observer. According to Meyer's view, the bottleneck depends on the task. For the right tasks, there is no bottleneck.

Question 11: Understanding capture. Ben Dow asked about how attentional capture is different for objects and space. John responded with his Question-and-Answer summary that objects might mediate the control of attention, but probably do not always do so. Cathleen argued that there are studies that show that new objects will not always capture attention, but on the other hand there is counterevidence by Franceroni and the change detection studies we discussed during the seminar. Maybe everything is about space and time and not objects. John agreed and decided to change the answer to Question 5 in his summary to "No". Cathleen was not happy with this and argued that functionally in the real world new objects are highly related to transients in space and time.

Question 13: Moving Boolean maps? Teresa Stephens asked how something that is discontinuous such as a binary map can be made continuous in order to relate to the real world. Teresa suggested that one possibility is to use a number of snapshots of discrete Boolean maps and to integrate them over time. Cathleen asked the group to think about what needs to be added to Boolean maps so that they can be applied to time. Cathleen offered a solution, object tracking a la Boolean map, in which one can distinguish between moving and stationary objects. John clarified that this idea does not need to add object structure to the Boolean map. Motion can be simply added as another feature that can be used in order to define a Boolean map. Caglar asked how one can account for objects that change during motion in this framework. Teresa asked how the Boolean map theory deals with the object occupying a new location. In this case, an updated Boolean map is needed. Cathleen agreed and reminded us that the same is true for the quick switching between maps described by Huang and Pashler. John suggested an experiment to test this idea of a motion-defined Boolean map. He suggested presenting stimuli similar to Huang's symmetry displays, in which a number of dots of two colors define a pattern against a background. The pattern is presented with two kinds of motion (e.g. left and right rotations) and participants have to decide whether the pattern is symmetric or not. Would this motion allow the easy judgment of symmetry?

The end.

Attention and Perceptual Organization
Question-and-Answer Summary of the Seminar
Cathleen Moore and John Palmer
December 8, 2008

1. Do objects influence divided attention?

Yes. But effects are probably mediated by memory rather than perception (Duncan, 1984; Awh, et al., 2001).

2. Do objects influence selective attention?

Yes. The effects are probably perceptual but the mechanism is unclear (Egly et al., 1994; Shomstein & Yantis, 2002; Chen & Cave, 2006).

3. Does selection affect perceptual organization?

Yes (Freeman, Sagi & Driver, 2004).

4. Does perceptual organization require attention?

No (Moore & Egeth, 1997).

5. Are the limits of divided attention different for judgments of relations between objects compared to attributes on single objects?

Probably (e.g. Poder, 1999).

6. Are objects identified sequentially or in parallel?

Unknown.

7. Do objects mediate the control of selective attention?

Probably not always (Yantis & Hillstrom, 1994; Franconeri, Hollingworth & Simons, 2005).