P2465 Attention Reading Review

Reference: Wright & Ward (2008) Chapter 6 Eye Movements and Attention Shifts
Reviewer: Kai Hwang E-Mail: khwang@cnbc.cmu.eud
Date: 10-02-2008 **File Name: EyeCh6.pdf**

Overview
Goal of this chapter is to review the relationship between attention and eye movements when covert attention orienting occurs.
Key terms: Covert orientation - orienting attention without explicit eye movements. Overt orientation - orienting attention with eye movements.

Oculomotor System

1. **Fovea has smaller receptive fields with higher acuity, but decrease sensitivity to stimulus onsets and motion.**
2. **Peripheral retina has larger receptive field with decrease acuity, but increase sensitivity to stimulus onsets and motions (sudden changes in visual scene).**
3. **Sometimes overt orienting accompanies body movement (head turning), when orienting across large distance.**

Types of eye movements

1. **Saccades: fast, jump-and-rest foveats, also impressively accurate. Occurs during scanning a scene or reading.**
    1. **Mostly voluntary controlled but could be stimulus driven (Figure 6.3)**
    2. **Typical saccade magnitude is 18º to 20º, but could be as large as 40º. Velocity range from 600º/sec to 1000º/sec, but at the beginning could be up to 40000/sec.**
    3. **During saccades, about 90% of viewing time is fixation (stops). Before each saccade, there is a fixational pause called saccadic refractory period that lasts about 150 – 600 ms. It is assumed that during this period the next saccade trajectory from origin to the destination is calibrated and oculomotor program is programed.**
    4. **Saccades are ballistic, once a trajectory has been fired it can not be stopped. The cutoff time of modifying a saccade movement is about 70ms before the start of the movement, after that it can not be changed.**
2. **smooth pursuit eye movements: Maintain foveation of moving objects, with no abrupt starts and stops.**
    1. **Considerably slower and less accurate than saccades. Velocity around 30º/sec.**
    2. **Tends to under-pursue a rapidly moving object.**
    3. **Not ballistic, to provide constant update of moving object location.**
    4. **Pursuit is a learned skill, accuracy could improve with practice.**

Attentional Engagement during Saccades and Pursuits

Saccades	Pursuits
Peak velocity of 600°/sec to 1000°/sec and acceleration can reach 40,000°/sec^2	Peak velocity of 30°/sec and acceleration much slower than saccades
Movement is ballistic	Movement requires feedback
Target foveation is very accurate, but latency of about 220 ms associated with calibration usually occurs	Target foveation is less accurate, and depends on observer's skill level for tracking moving objects
Smaller saccades (less than 6°) executed by newborns	Long learning period required to execute with peak efficiency
Similar to *discrete* attention shifts because attention is disengaged during movement	Similar to *analog* attention shifts because attention remains engaged during movement

Table 6.1 Properties of Saccadic and Smooth Pursuit Eye Movements

Change blindness – large changes to a visual scene are likely to go noticed if occur during saccades.

Eye-Movement Programming

1. **Superior colliculus contributes to eye-movement target selection for both saccades and smooth pursuits (with interaction with frontal and pareital regions). This info is then send to brainstem to generate oculomotor eye movement.**
2. **Superior colliculus has layers, upper layers receive inputs from retina. Intermediate and deep layers receive inputs from cortical visual areas and send inputs to saccade generation region. Each layer contains topographic space.**
3. **There are also several types of neurons in superior colliculus:**
    1. **Build-up cells**
    2. **Burst cells**
    3. **Pause cells**

How to track eye movemnts

Historically many methods have been developed to track eye movements, based on contact lens movements, photography, EOG recordings and corneal reflection. Now the most common method is to use computer image processing to detect changes in infrared light reflected of cornea as the eyes change position.

Disengaged Attention and Saccades

1. **The question: is disengagement of attention required for saccade execution?**
2. **Gap effect: the saccade latency is faster when fixation point disappeared before target onset**

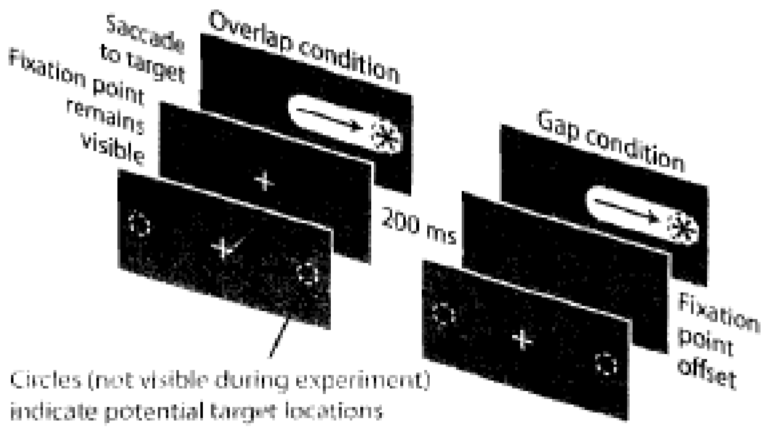

Figure 6.8 Example of the type of display in Saslow's (1967) experiment on the effect of a blank field on saccade latency. In the overlap condition, the fixation cross remains visible throughout the trial. In the gap condition, the fixation cross disappears and the display is empty prior to saccade target onset.

3. **Express saccades are faster saccades compare to regular saccades. Occur when fixation disappears. Express saccades do not occur if still engage on**

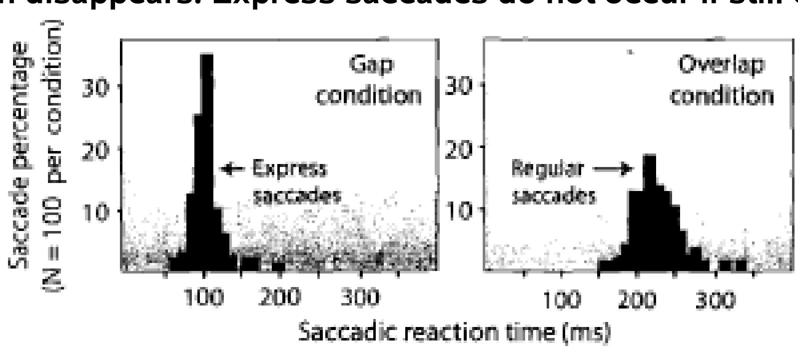

Figure 6.9 Data from Fischer's (1998) report of express saccades. In the gap condition, the modal saccade latency was approximately 100 ms (express saccades). In the overlap condition, the modal saccade latency was approximately 220 ms (regular saccades).

fixation. That is, to generate express saccade, attention must first be disengage.

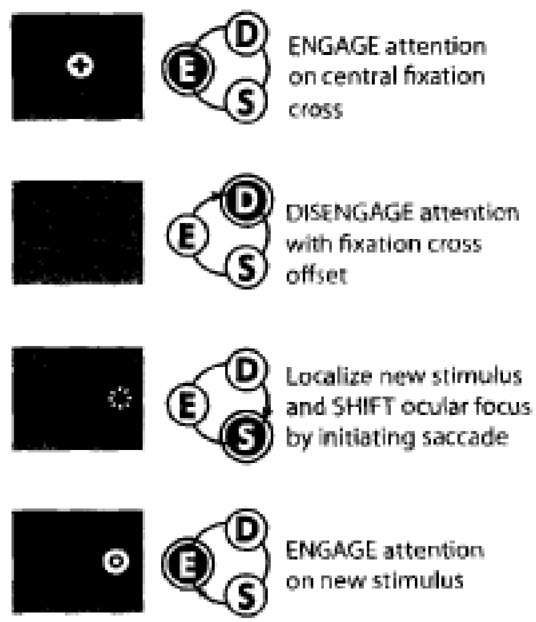

Figure 6.10 Fischer's attentional predisengagement explanation of express saccades based on Posner et al.'s (1988) proposal. Initially, attention is engaged on the central fixation point, but is then disengaged with fixation point offset. The disengagement process is completed during the 200-ms blank interval and, when the target appears, the saccade can be executed immediately. Attention is then engaged on the target.

4. **Express saccades do not occur during anti-saccade task. Because attention must remain engage on target to prepare to perform anti-saccade.**
5. **Superior colliculus plays a critical role in mediating express saccade. During the gap period, fixation neurons cease fire, movement neurons increase activity during gap period even when no eye-movement occurs. Damage to superior colliculus could reduce or eliminate express saccades.**

Relationship Between Attention and Eye Movements

Three possible forms of functional relationship between covert orienting and eye movements: Independent system proposal, common system proposal, interdependent system proposal.

1. **Independent system proposal: saccade and attention shift mechanisms are entirely different and separate system. Prediction is that locations of attention shift and saccade destinations can be simultaneously encoded and even be at opposite direction.**
    1. **Speculate that covert and overt orienting could be mediated by functionally independent mechanisms.**
    2. **Not physiological independence, as imaging studies found same activated regions for both overt and covert orienting. (Fig. 6.13)**
2. **Common system proposal: Saccades and attention shift are mediated by the same mechanism.**

1. **If physiologically overlap, they must be the same system?**
2. **Pre-motor theory holds that covert orienting is mediated by motor system responsible for generating saccades, but the actual eye movement is withheld. Covert-orienting is the by-product of oculomotor effect. Evidence: meridian effect.**

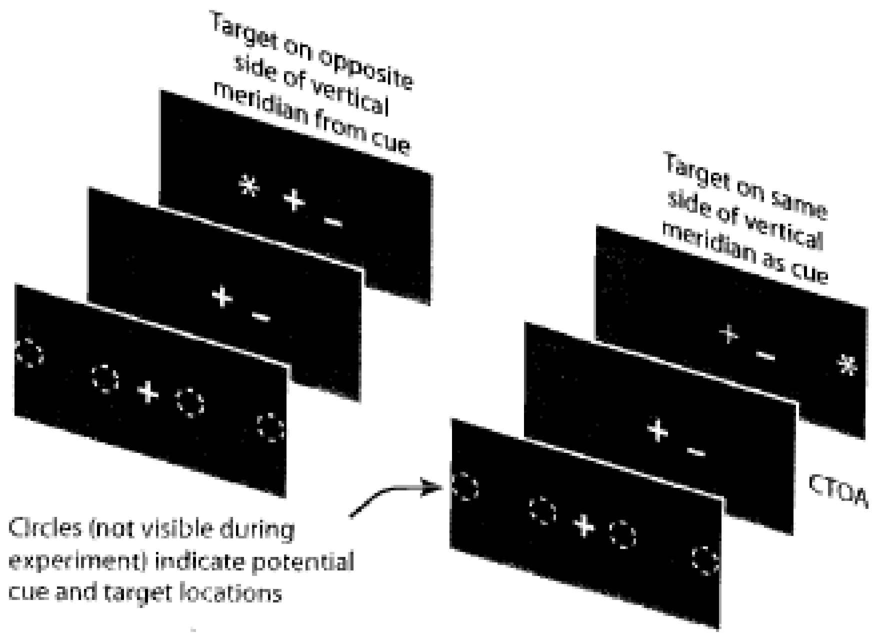

Figure 6.14 Example of a display used to study the meridian effect. Following the presentation of an invalid cue, a target appears on the same side of the vertical meridian dividing the display but at an even greater eccentricity than the cue; or an equal distance away from the cue but on the opposite side of the vertical meridian. Despite the equivalence of cue-target distance in both cases, response times are longer when the target and invalid cue are on opposite sides of the meridian.

3. **Challenging evidences: Some frontal and parietal regions are not 100% overlapped.**
   Other challenges to meridian effect: did not occur in direct cue (stimulus driven) condition.

3. **Interdependent systems proposal: Saccades and attention shift mechanisms are not mediated by a common system but do share resources or computations at some stage.**
   1. **Partially overlap with important differences: a. Not all attention shifts involve activation of superior colliculus. b. Attention and saccade mechanisms may be different because eye movements are always made to a peripheral target, while attention shift could be from peripheral to center.**

Saccade Preparation and Attention

1. **Accuracy correlated with direction of first eye movement, indicating that the potential target location may be processed during preparation of a saccade.**

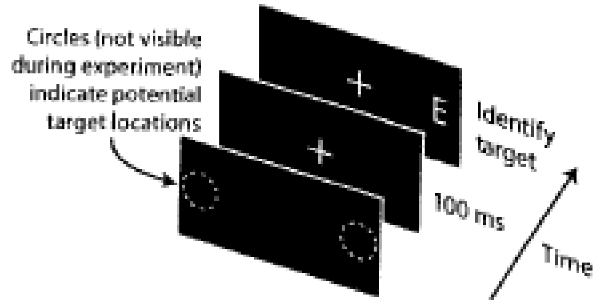

Figure 6.15 Example of the type of stimulus display in Crovitz and Davies' (1962) experiment. Each trial began with a blank field, followed by a central fixation point for 100 ms, and then the presentation of a target to be identified.

2. **In Posner's cuing paradigm (but with overt eye movement toward target onset), when CTOA is between 50-100ms, targets were detect faster when they appeared at cue location. 50-100ms is not fast enough for saccade movement, therefore the facilitation of target detection must be related to saccade preparation to the cue location.**

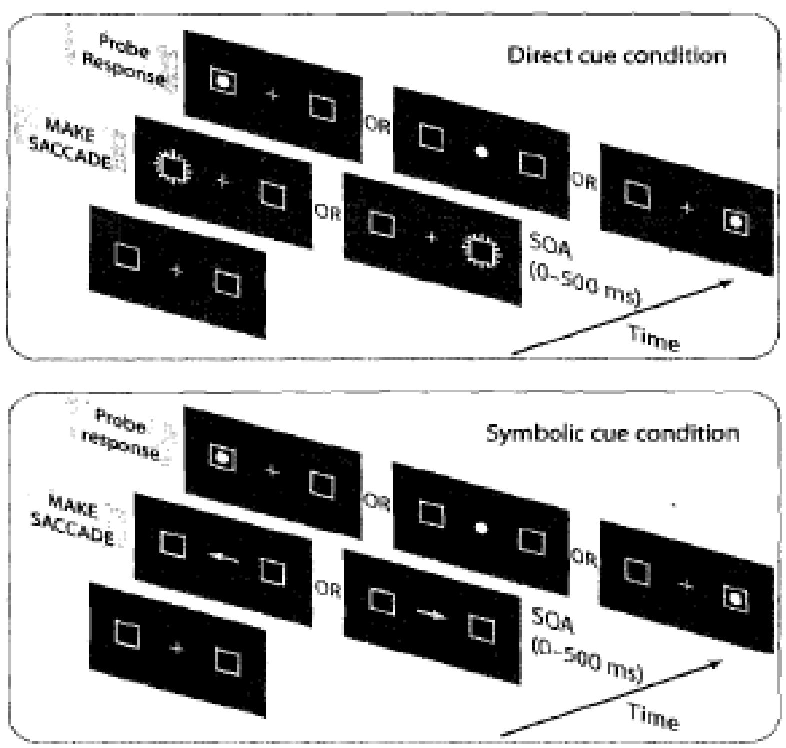

Figure 6.16 Example of the type of displays in Remington's (1980) experiment. Subjects made a saccade to the location indicated by a direct cue or a symbolic cue. Also, on 50% of trials, subjects detected the onset of a target (probe dot) at cued or uncued locations.

3. **When manipulate direct or symbolic cue (goal driven, stimulus driven) and CTOA, there is an interaction. For direct cue, target detection was facilitated at shorter CTOA before saccade and also at longer CTOA after saccade. For symbolic cue, target-detection was facilitated only at longer CTOAs after saccade was made. Attentional focus may precede ocular focus, to locations indicated by direct cues, but does not precede ocular focus to locations indicated by symbolic cues.**
4. **Theory: eye movement oculomotor system act as a slave of attention system. Attention act as an advance scout to guide eye movements.**

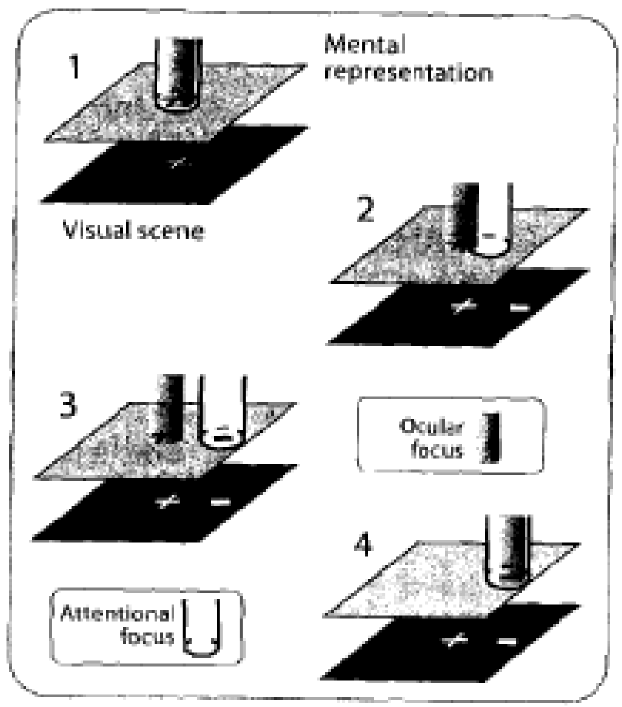

Figure 6.17 Depiction of the advance scout hypothesis about the relationship between attentional and ocular focus. The attentional focal point is said to be oriented to the saccade destination prior to saccade execution in order to facilitate eye-movement programming.

5. **In a due task (goal driven saccade and letter identification), accuracy was best when symbolically cued location for the primary task is the same as the secondary letter identification task. Suggest that attention shift to the location that the saccade was prepared to.**

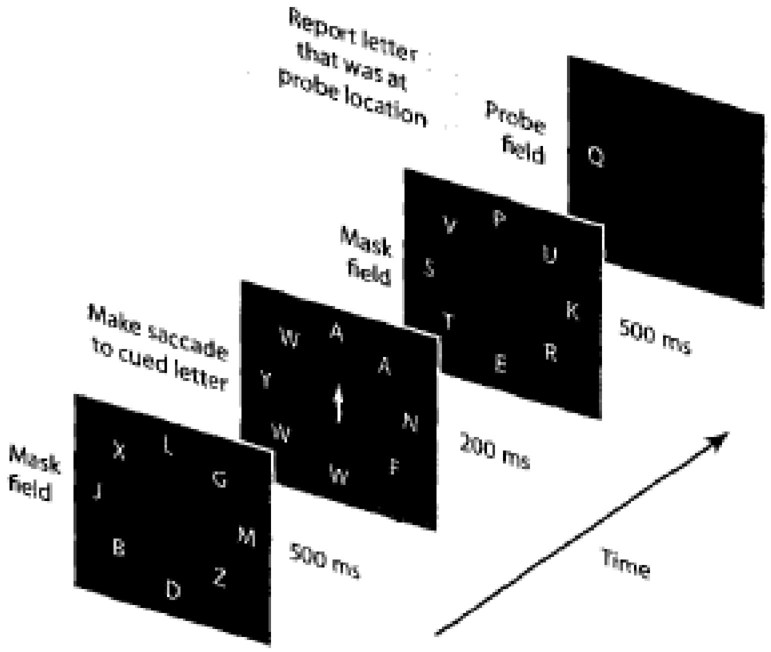

Figure 6.18 Example of the type of display used in Kowler et al.'s (1995) experiment. The primary task required subjects to make a saccade to a letter indicated by a symbolic arrow cue. The secondary task required subjects to identify the letter that was at the position indicated by a postmask probe symbol (i.e., the letter Q). Secondary-task response accuracy was highest when the letter to be identified was also the letter that subjects made a saccade to when performing the primary task.

6. **In temporal-order judgments task. When attention is allocated to a saccade destination before the saccade, then an object appearing at that location immediately afterwards should be attend to first and judge by the subject to appear first.**

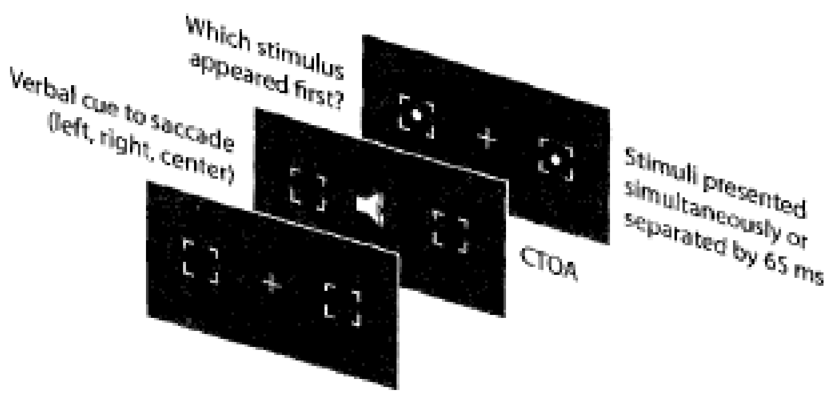

Figure 6.19 Example of the type of display used in Stelmach et al.'s (1997) experiment. A verbal cue instructed subjects to make a saccade and then, a short time later, two stimuli were presented. Subjects were required to judge which appeared first.

However no advantage was found at the location that saccades were prepared to. Therefore did not support the idea that attention direct to the saccade location prior to execution.

7. **There are also evidence showing that more than one saccade can be prepared at the same time. Therefore the attention scout theory is only valid if attention can be applied to 2 locations simultaneously.**

In summary, when attention is shift to the same location to which a saccade is made, the attention shift will happen first. However, the causal relationship between attention shift and saccade is under debate. It could be that they simply share the same destination and a common goal of facilitating sensory identification, but have functional independence.

Saccade Destination Encoding and IOR

1. **IOR effect occurs at the saccade destination. While shifting attention alone won't produce IOR, saccade will. Given that IOR may be mediated by spatial indexing, this implies that saccade destinations may be spatially indexed during saccade preparation.**
2. **The relation between saccade and IOR is further studied with developing infants. 6 months old infants showed IOR at but 10 and 30 degrees of eccentricity, while 3 months old only showed IOR at 10 degrees of eccentricity. As 30 degree is outside of 3months old infants' saccade range, this suggests that saccade preparation involves allocation of spatial index to a saccade destination.**
3.

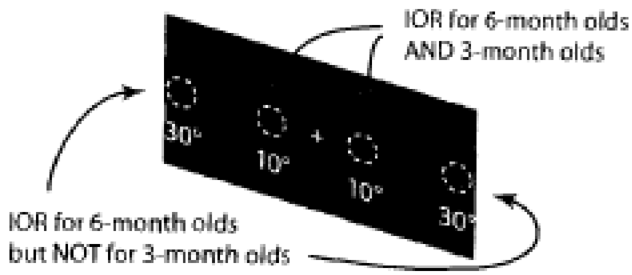

Figure 6.21 The eccentricities of direct location cues in Harman et al.'s (1994) experiment with 3-month-old and 6-month-old subjects.