Attention and Eye Movements

(Kustov, A.A. and Robinson, D.L. (1996), "Shared neural control of attentional shifts and eye movements", *Nature*, Vol. 384, pp 74-77)

There is an increasing body of evidence being accumulated that suggests that attention and motor activity are linked.

It has been suggested that attentional processes evolved as part of the motor system (i.e. the pre-motor theory of attention).

Kustov and Robinson generated saccades in monkeys by electrical stimulation of the superior colliculus motor map.

They found that exogenous and endogenous attentional shifts caused deviations in the direction of the electrically evoked saccades.

These deviations even occured when the monkey makes hand movements in response to the cue. Thus these deviations cannot be ascribed to conscious preparation of an eye movement.

Psychophysical Evidence

(Henderson, J.M. (1992), "Visual attention and eye movement control during reading and scene perception" in **Eye Movements and Visual Cognition**, Rayner, K. ed., Springer-Verlag, pp 260-283)

An experiment done by Henderson demonstrates that attention is allocated to the specific location about to be fixated.

Task was to name a word presented on a display. This word was either presented at the fixation mark (NO MOVE) or in the periphery (MOVE).

A preview of the word was also presented, some time before the actual display of the word. The preview was presented either near the fixation mark (NEAR), in the periphery (FAR) or was not presented (CONTROL).

The most preview benefit was obtained when:

FAR condition - eyes moved

NEAR condition - eyes stationary

The Gap Effect

(Saslow, M.G. (1967), "Effects of components of displacement-step stimuli upon latency for saccadic eye movement", *Journal of the Optical Society of America*, Vol. 57, pp 1024-1029)

(Reulen, J.P.H. (1984a), "Latency of visually evoked saccadic eye movements. I. Saccadic latency and the facilitation model", *Biological Cybernetics*, Vol. 50, pp 251-262)

The *Gap Effect* refers to the reduction in *saccadic latency* when there is a temporal gap between the offset of a fixation stimulus and the onset of a peripheral target stimulus.

Saccadic latency is the amount of time from the appearance of a target to the beginning of the saccadic eye movement to that target. This latency is typically 100msec and higher, usuall more than 200msec.

The actual saccadic movements take much less time, on the order of 10-40msec, depending on the distance the eye travels.

The Global Effect

(Findlay, J.M. (1982), “Global visual processing for saccadic eye movements”, *Vision Research*, Vol. 22, pp 1033-1045)

(Coëffé, C. and O’Regan, J.K. (1987), “Reducing the influence of non-target stimuli on saccade accuracy: predictability and latency effects”, *Vision Research*, Vol. 27, No. 2, pp 227-240)

The *Global Effect* refers to the tendency of the eye to move to the centre of mass of a target-distractor ensemble when saccadic latencies are short.

When saccadic latencies are long, eye movements are accurately made to the target, and ignore distractors.

The experiments done by Coëffé and O’Regan demonstrate that when people move their eyes to look at a cued letter in a string of letters, their eye movements are made accurately to the cue letter only when latencies are long. When latencies are short, the eye movements are shifted towards the centre of the string of letters.

Pre-Motor Explanation of the Gap Effect

The gap and global effects can be explained by the pre-motor theory of attention.

In the pre-motor theory, eye movements and attention shifts are linked.

One component of saccadic latency is therefore the time taken for attention to shift to the target location.

If we use a Winner-Take-All model of attention, the time needed for attention shifts will depend on the relative strengths of the fixation and target stimulus.

GAP condition - fixation has died away, the WTA shifts quickly to the target location

OVERLAP condition - fixation competes with the target for control of the WTA.

Pre-Motor Explanation of the Global Effect

In the early parts of the visual system, cells can be divided into two types:

Fast response, low spatial resolution

Slow response, high spatial resolution

The target of saccades could be represented as the centre of mass of the activity of a population of neurons (as in the colliculus).

At a short time after the appearance of a target the reponse of feature detectors to the target are mainly of the low spatial resolution variety.

If this response is strong enough to trigger a saccade, the target will be at a low resolution. Hence the saccade will be to the centre of mass of the salient features.

Otherwise, the saccade will be more accurately localized.