Reference: Findlay, J. M., & Walker, R. (1999). A model of saccade generation based on parallel processing and competitive inhibition. Behavioral and Brain Sciences, 22, 661-721.

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Italic notes are notes taken directly from a previous handout by Tsunhin John Wong

Overview

1. Propose an information processing model for control of saccade movements, with parallels to physiological processing in the oculomotor system.
    1. Two pathways for spatial and temporal programming of the movement
2. Model accounts for number of well established phenomena and data in saccades.

Introduction

1. Experimental data of saccades:
    1. Metrics – direction and magnitude of saccades
    2. Latency – time to react to target onset
       Model will program these two parameters
2. Account for several robust effects that has been shown in the literatures:
    1. gap effect
    2. express saccades
    3. remote distractor effect
    4. global effect

The model

1.Overview

1. The framework (or model) is an information flow model
2. *Their framework has been considerably influenced by work in oculomotor neurophysiology*
3. *various aspects of saccade are not explored:*
   a. Learning: plasticity and adaptational processes of saccades
   b. Visual systems interaction with changes by saccadic movements
   c. Visual depth is not considered during saccadic eye movements

2. Model

1. Two parallel information and command streams
2. Hierarchal processing levels
3. Competitive interaction occurs when two regions or centers have cross connection. Its like a pull/push relation, increase activity in one will reduce the other.

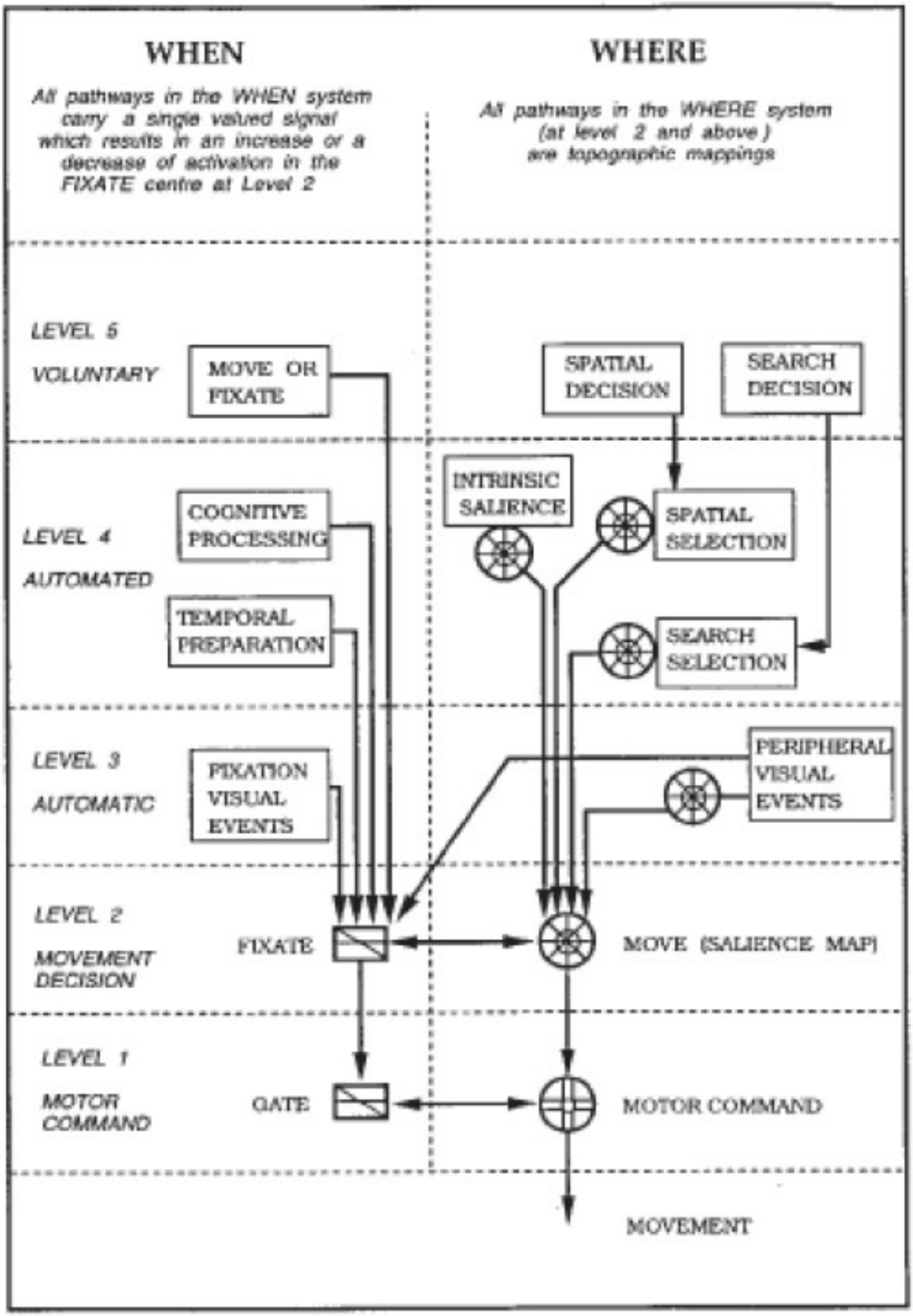

Figure 1. Diagram indicating the information flow routes and competitive pathways in saccade generation

Levels

1. Level 1 Motor command
    1. controls oculomotor muscles
    2. Saccadic movements occur when a trigger signal opens a gate in the when pathway, that leads to a spatially coded motor command being generated by the where pathway.
    3. Largely reflects the brainstem circuitry.
2. Level 2a The fixate and move balance
    1. A push-pull relation between the fixate center and the move center
    2. Focus on integrating the various competing information to decide where a saccade should move and whether or not it should be made. If activation in one center increase the other one will decline. If fixate falls below threshold move center will fire saccade.
    3. This decision process is slow, and determines the time for saccade initiation
3. Level 2b Move center and salience map
    1. Move center encodes a topographical spatial map, each points code for a different visual direction. This map could be influenced by higher cognitive level.
    2. Salience map has activity value register at each point on the map.
    3. When a saccade is triggered, the point of current maximum salience determines its metrics.
4. Level 2c Distributing mapping and the calculation of saccade metrics.
    1. Salience map use spatially distributed coding. Which maps a topographic spatial map with divergent and overlapping connections
5. Level 3 Direct visual influences
    1. Routes which visual stimulation influences the fixate-move system, directly influence level 2 processes.
    2. Turning off the central stimulation will cause disengagement (reduce fixate center activity, while onset of central stimulation will increase fixate center activity
    3. Peripheral stimulation will affect activity fixate center and move center activity
6. Level 4 and 5 automated effects and habits of cognitive control
    1. Where the model integrates high-level influences.
    2. Influence of the where pathway
        1. Spatial selection works by modifying the salience map in particular regions, in potentiating or inhibiting manner, .e.g inhibition of return signified a modification of the previous point of high salience
        2. Search selection promotes saccade to particular visual features wherever in the visual field they may occur, e..g during visual search
    3. Influence of the when pathway
        1. Temporal preparation, e.g. warning signal or predictable target onset that promote disengagement
        2. Pacing for ongoing sequential movements, e.g. during text reading

Physiological background

1. Brainstem processes
    1. *WHEN gate and WHERE motor command in level 1 of the framework resembles the flip-flop-like switching between omnipause cells and burst cells*

2. Fixate/move competition
    1. Fixate center contains representation of fovea and connects to omnipaus neurons as described in the literatures, which were activate when fixating
    2. Deeper layers in the colliculus code saccade metrics, resembles neurons that fire during fixations and saccades in the “gap effect”
3. Distributed processing
    1. The salience map are distributed as receptive fields in the superior colliculus
4. Competitive interaction within the salience map
    1. *A possible neurophysiological substrate for their conflict resolution mechanism within the salience map may be implemented in the system of reciprocal inhibitory connections between the collicili, i.e. intercollicular inhibition*
    2. *Excitation and in particular inhibition interactions through the collicular cross-connections also contribute to target selection for the oculomotor system*
    3. *Search selection works as an excitatory-inhibitory interaction also as demonstrated in frontal eye field neurons of monkeys by a simple color search task*

Data

1. The gap effect
    1. Recall chapter 6, gap effects is theat when fixation is gone, that speeds up saccades
    2. The critical stage in determining saccade release is the resolution of fixate/move in level 2. Visual events at the fixation have direct connection from level 3 to the fixate system. Offset the fixation reduces the fixate activity make saccade triggering more likely
2. Remote distractor effect
    1. The effect: When two widely separated simultaneous stimuli are presented, there is a latency in saccade (Levy-Schoen 1969)
    2. The model suggests that the onset of a remote distractor at other locations will affect the fixate system, this increase activity in the fixate system and slow down the saccade triggering
3. Express saccades
    1. Recall chapter 6, express saccades are saccades with very short latencies observed under the gap effect.
        1. If the fixate system is already in a mode of disengagement (not activated), saccade can happen immediately as a result of increase activation in the move system
4. Antisaccades
    1. Antisaccades are saccades look away from the onset target
    2. Level 5 saccadic programing can top-down influence the saccade generation in this model

Metrics

1. Metrics of the saccade is calculated separately and subsequent to the decision of trigger a saccade. Following triggering, a saccade is made to the point of greatest salience in the salience map.
2. In the model, triggering stage is non-spatial.
3. Two-target paradigm: subject is presented with more than one target at the same time.
    1. Subject usually make their first saccade in some intermediate location - global

effect
    2. *Their notion is also having a physiological foundation: in the collicular fixation system, it is shown that the system is accessed by stimulation from an extended central region of the visual field*
4. Influence of higher processes on the WHEN system
    1. Saccade can be speed up by prior information, the model attributes these effects to their temporal mechanism
5. Influence of higher processes on the WHERE system
    1. The model predicts that spatial selection operates in the WHERE pathway (only via the fixate / move equilibrium level 2) and effects of latency from spatial selection would be small
    2. Latency found in the precueing studies are related to conflict resolution within the move centre
    3. They suggested that search selection is a natural mode of operation of the various retinotopically mapped areas that map in turn onto the salience map in the move centre
6. Overt and covert attention
    1. *The author thought that it is not necessary for them to make use of the attention capacity notions in their framework and appropriate attentional mechanisms should be adopted domain-specifically*
    2. *Visual attention is generally covert while attentional deployment of eye movement is overt and the authors tend to forge affinities to both notions: they made use of spotlight and zoom lens models as well as the distributed processing model*
    3. *Their saccade model has no role for an internal attentional scanning process*
7. Unilateral neglect
    1. The authors found patients made more ipsilesional saccades in the gap condition than in the overlap condition
    2. *Their conclusion for these patients is there are increase in a nonspatial attention caused by warning signal effects of fixation offset*
    3. *They further proposed that at some level the spatial channels for L and R saccades are separate*
    4. *Unilateral brain damage appears to result in an imbalance in the system that affect the level 3 automated processes in the spatial channel on the same side of as the brain damage*