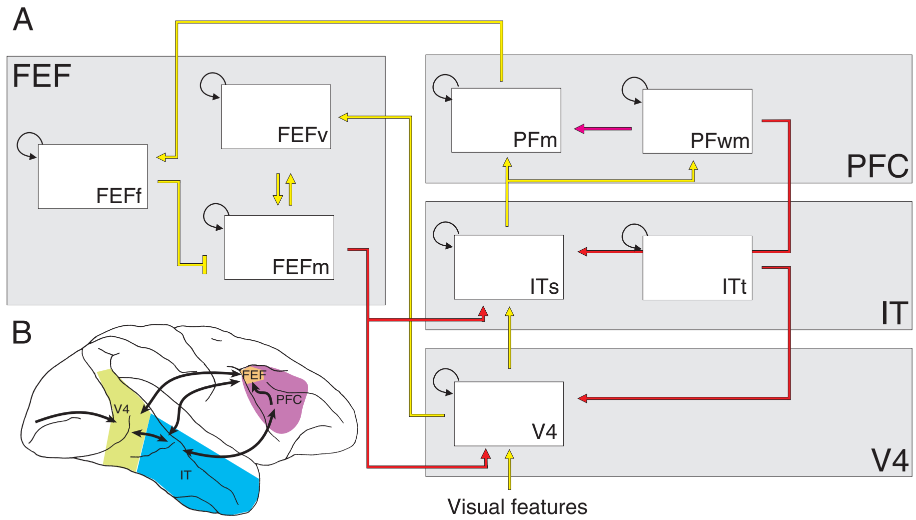

Figure 1. A. Sketch of the simulated areas. Each box represents a population of cells. The activation of those populations is a temporal dynamical process. Bottom-up (driving) connections are indicated by a yellow arrow and top-down (modulating) connections are shown as a red arrow. B. Outline of the minimal set of interacting brain areas. The model areas are restricted to elementary but typical processes and do not replicate all aspects of these areas.

We propose feature-specific top-down connections similar to those suggested within the feature-similarity (Treue & Martínez Trujillo, 1999; Saenz, Buracas, & Boynton, 2002) and biased competition (Chelazzi et al., 1993) frameworks. The idea is that feature-specific feedback emphasizes relevant features throughout the ventral pathway, so a specific interpretation of the scene becomes dominant at all levels of perception (Hamker, 1999).

The first question is then, how does visual perception affect the eye movement? The frontal eye field is in an ideal position to control eye movements because it has connections to occipital, temporal, and parietal areas, the thalamus, superior colliculus, and prefrontal cortex (Schall, Morel, King, & Bullier, 1995a). The projections from V2 and V3 are weak, from V4 intermediate, and heavy from TEO. The neurons in the FEF can be categorized based on their responses to visual stimuli or saccade execution into visual, visuomovement, fixation, and movement cells (Schall, Hanes, Thompson, & King, 1995b).

In the model, PFwm cells modulate visual processing via feedback into ITs according to the current goal of the task. The resulting local increase of firing in ITs cells is directed further downward by feedback from ITt cells to V4 cells. Increased local activity in V4 enhances the visually responsive neurons in the frontal eye field, so these cells reflect the task-relevance of a location. We consider visuomovement (v), fixation (f), and movement (m) cells in the model (Figure 1). The FEFv neurons receive convergent afferents from features in V4 at the same retinotopic location. FEFf cells generally inhibit FEFm cells unless threshold detection of the PFm cells indicates that the target is in the search array. In this case, the input into the FEFf cell is removed so that FEFm cells are disinhibited, and thus the mapping from sensory to motor is facilitated. FEFv cells activate FEFm cells by feedforward excitation and surround inhibition. Because there is evidence that saccades are elicited when movement-related activity in the FEF reaches a particular level (Hanes & Schall, 1996), a fixed threshold in model FEFm cells initiates a saccade.

The model as outlined above can explain how knowledge about features of an object of interest might influence eye movement selection so an eye movement is goal directed. We now address the question of how a saccadic decision determines perception. According to our reentry hypothesis, activity in the movement planning areas is sent back to extrastiate visual areas and sensitizes cells within their movement field, so the object of interest gets dominant even before it is foveated. Recent evidence points toward the FEF as a possible origin of a reentry signal (Moore & Armstrong, 2003). In the model, the FEFm cells send a spatially organized signal to V4 and IT stimulus cells, which enhances the sensitivity of particular V4 and IT cells (Figure 1). What could be the effect of the enhancement of the sensitivity in V4 and IT? We have shown earlier that a spatially organized feedback signal into model V4 can account for known attention effects (Hamker, 2003): If the receptive field contains just one stimulus, then spatial feedback results in a multiplicative gain increase. This has been observed in the middle temporal (MT), medial superior temporal (MST), and V4 (Treue & Maunsell, 1999; McAdams & Maunsell, 1999). If two stimuli are presented within the same receptive field, then the model V4 reproduces the data of Reynolds, Chelazzi, and Desimone (1999): A bias toward one stimulus reduces the influence of the other stimulus