Countermanding: sometimes you should stop yourself from looking



Countermanding: stop-signal reaction time

SSRT: time required to canceled a partially prepared movement

A neuron that is involved in saccade initiation must meet two criteria:

- 1. Must respond differently for different behaviors e.g., canceled (correct) vs. non-canceled (error)
- 2. This difference must arise within the SSRT.

Allows for **causal** conclusions from physiological data. Is the signal I'm recording a command or a correlate?

Frontal Eye Field controls gaze





Time from target (ms)

Supplementary Eye Field does NOT control gaze





No Stop Signal Trial

Canceled Stop Signal Trial

Movements of the eyes



Why study eye movements?

A great model system for understanding neural control of goal-directed movements:

- only 6 muscles
- no variable load
- accurate measurement
- brain areas available to electrodes
- now playing a key role to study decision-making and attention

Dali



Yarbus, 1967



One degree from the center of the fovea visual acuity is less than half of what it is in the fovea. Acuity and sensitivity trade off.

Saccadic eye movements shift the center of gaze around the image (foveate).



Vision is an active process. Binocular vision afforded by aligning the eyes provides depth signals necessary for capturing things in the environment.





Six extraocular muscles rotate the eyes.

Types of movements of the eyes

- Gaze holding
 - Vestibular-ocular reflex
 - Optokinetic reflex
- Gaze shifting
 - Vergence
 - Pursuit
 - Saccade



Brainstem Saccade Generator





Oculomotor neuron



Brainstem Saccade Generator



100 msec

Frontal Eye Field



Visual search





Target selection in visual search



Visual search





Visual search with variable response mapping







Pro-saccade

Anti-saccade separates the location of the singleton and saccade endpoint.

Target selection

What is the neural basis of visual attention?

 One influential theory - the premotor theory of attention - claims that the neural activity underlying attention is the same activity as saccade preparation. That is, ocular motor activity reflects where attention is at a given moment. Attention is nothing more than an eye movement that hasn't been executed (i.e., motor neurons haven't reached threshold yet).

 Activity in visually-responsive cells in FEF reflects the allocation of attention. Electrically stimulating the FEF will evoke an eye movement and show you if the locus of attention is changing the evoked movement (vector averaging).



Bruce et al. (1985). *J Neurophysiology*

Dissociating target selection and saccade selection



Sato & Schall (2003). Neuron



Quantifying the deviation

Positive = towards singleton Negative = towards endpoint

Predicting outcomes





Result



Juan, Shorter-Jacobi & Schall (2004). PNAS

Conclusions

Antisaccade trials can dissociate the singleton location and the saccade endpoint.

Single-unit recordings reveal that FEF neurons select the singleton (reflecting the allocation of attention) on antisaccade trials.

Stimulation data show that evoked eye movements on antisaccade trials deviate exclusively toward the saccade endpoint, which challenges the premotor theory.

FEF is not strictly motor. Neurons can select a target, but gaze may not shift there.

Target selection and saccade preparation are two distinct processes.



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