The role of saccadic eye movements in visual perception

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INTRODUCTION

• Saccades are darting eye movements used to sample important visual information from our environment

• Despite our experience of perceptual stability, we make roughly three saccades a second

• Past studies have demonstrated changes at the perceptual level leading up to saccades

• In this study, we used transcranial magnetic stimulation (TMS) to alter neural activity in the early visual cortex (V1) of human participants, during a psychophysical discrimination task at various points leading up to a saccade

• In doing so, we attempted a leap in our understanding of V1's contributions to these saccade-based perceptual changes

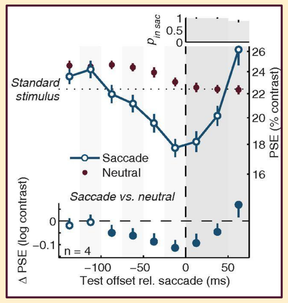
BACKGROUND

• Carrasco et al. 2012 demonstrated that we perceive higher contrast right before initiating saccades

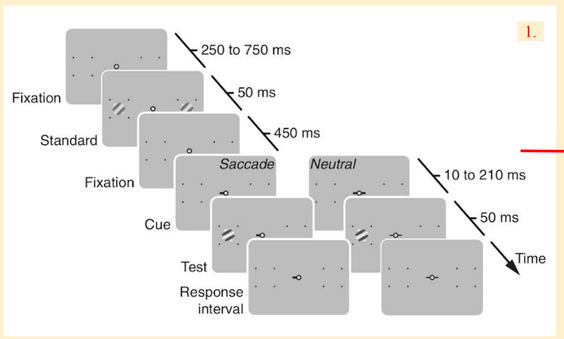
• Past studies have proposed the existence of an internal copy of the saccadic motor signal, or 'efference copy', which is thought to inform the visual system of these approaching, rapid changes to visual input

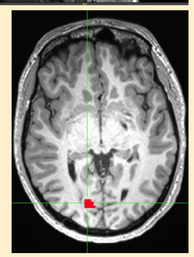
• The efference copy hypothesis dates back to von Helmholtz (1866), yet few studies have identified candidate signals in visual cortex

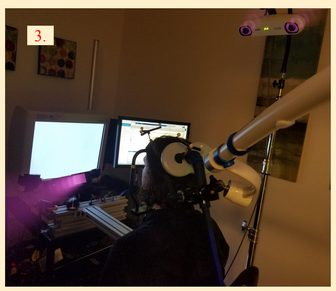
• We propose that perceptual changes are driven by the efference copy and can be offset by well-timed TMS delivery

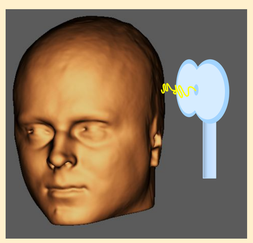


METHODS









RESULTS

Confirming pre-saccade perceptual changes

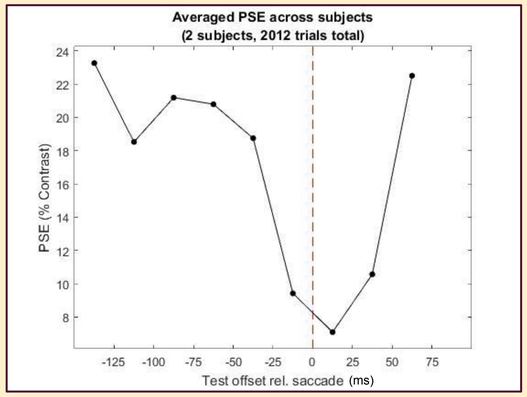


Fig.1: Averaged PSE across subjects for the non-TMS trials. Note the similarity with figure 6 from Carrasco et al. 2012. Actual PSE values may vary due to poor gamma correction of display, or due to a possibly differing metric of determining contrast for the gabors

Using TMS to abolish perceptual changes

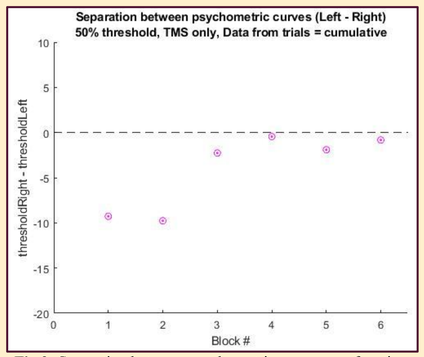


Fig.2: Separation between psychometric curves as a function of block number (TMS trials). Note: the data are cumulative

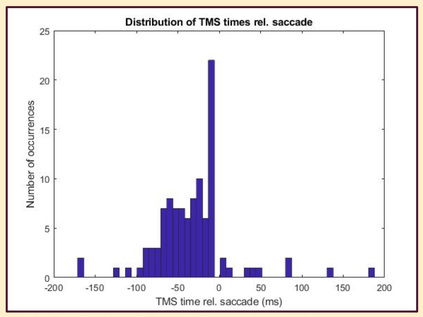


Fig.3: Distribution of TMS delivery times relative to the saccade initiation. Note: distribution engulfs the -75ms mark, which is when we hypothesize V1 receives the efference copy

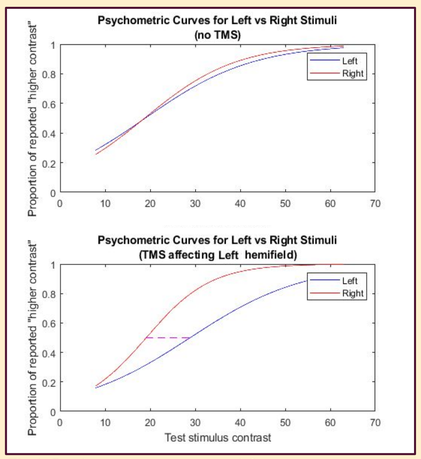


Fig.4: Psychometric were generated for contrast reports across all trials in non-TMS (n=800) and TMS (n=200) conditions. A marked shift is seen in the affected hemifield for the TMS trials, indicating that the subject perceived contrasts as lower than reality

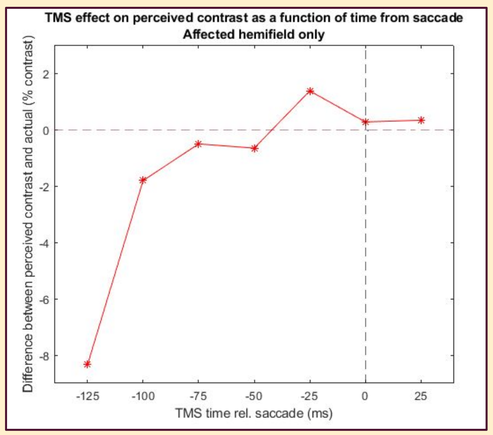


Fig.5: Temporal dependence of the TMS effect, specifically demonstrating that contrast was perceived as lower than actual for all trials where the subject was given a TMS pulse about -125ms prior to the saccade initiation. Points were generated using sliding windows of size 50ms with increments of 25ms.

CONCLUSION

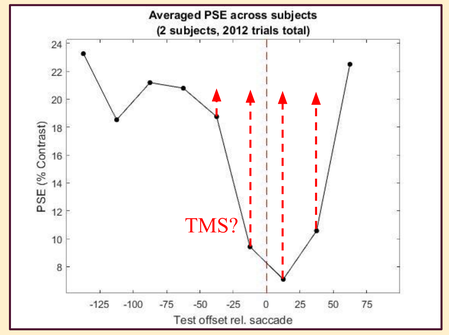
• We were able to successfully replicate the results of Carrasco et al. 2012, demonstrating that contrast sensitivity increases prior to a saccadic eye movement

• However, our preliminary TMS data show no significant difference between the PSE values of the two conditions

• Further investigation is warranted to conclusively state the contributions of V1 to these perceptual changes

FUTURE DIRECTIONS

• We hope to conclusively show that well-timed interference of V1 activity with TMS can allay the perceptual changes that precede saccades



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