***Surround Suppression in Post-Traumatic Headache – a Pilot Study***

**Aims and Motivations**

Patients with post-traumatic headache suffer from significant visual symptoms, including difficulty with motion tracking. Consistent with prior work suggesting cortical hyperexcitability in headache, one proposed mechanism is that these motion tracking deficits result from impaired surround suppression.

We are devising an experiment to measure motion tracking in order to quantify surround suppression effects in patients using a continuous psychophysics paradigm. The purpose of this initial study is to establish the feasibility of this approach. Specifically, we aim to determine the tolerability of the experimental protocol in patients and the shape of the data to help refine our analysis protocol. If, however, data collection is successful with the experiment in its current iteration, we would consider using these data as part of a larger study to examine differences in motion tracking in headache.

**Subjects**

We will collect data from youth between the ages of 13 years and 21 years within 28 to 365 days of concussion with post-traumatic headache with migraine-like features. Migraine-like features will be defined as a Post-Concussion Symptom Inventory (PCSI) score of at least 3/6 for headache with a score of at least 1/6 for either both light AND sound sensitivity OR nausea alone. We will compare them to youth without a history of concussion who have a total PCSI score of less than or equal to 7. We will also collect additional demographic and clinical information, including Visio-vestibular exam, PCSI score, and past medical history.

As part of this initial pilot testing, we plan to collect 10 case subjects and 10 control subjects. Based on pilot data, we will expand this number to reach a sample size for appropriate statistical power.

**Experiment Protocol**

We are using a continuous psychophysics protocol to assess motion tracking and surround suppression in patients. In this experiment, a gabor will move horizontally across a screen and subjects will be tasked with tracking this gabor with their mouse.

Specifics of the visual stimulus were motivated from prior work from Tadin intended to operate in a stimulus regime in which surround suppressive mechanisms are most apparent (Tadin 2005). The main target is a gabor or vertically-oriented visual grating that varies in terms of size (1.5, 3, 6, 12 degrees visual angle) and contrast (2 and 99% Michelson contrast). The grating has a spatial frequency of 1 cycle per degree. Movement of the target is determined by a random walk, in which the frame-to-frame velocity is drawn from a normal distribution with width selected to provide an average speed of 4 degrees per second.

One trial will consist in tracking a given stimulus for 20 seconds. One block will consist of 3 repetitions per stimulus condition (4 stimulus sizes x 2 contrast levels gives 8 stimulus conditions, for 24 trials total). One session will consist of two consecutively-acquired blocks.

**Analysis**

The main analysis approach to quantify motion tracking performance is adapted from Bonnen et al (Bonnen 2015). Briefly, for each trial a cross-correlogram is calculated between target position and the subjects’ position estimate (as determined by mouse position). These cross-correlograms are averaged across all trials of the same type and fit with a Gaussian. Performance metrics are summarized from these fits, including the Gaussian’s peak, width, and lag. Note that we may explore other models to more robustly capture the shape of these cross correlograms. Prior work suggests that these 3 summary metrics are fairly equivalent in quantifying tracking performance (Bonnen 2015). We will initially plan to base subsequent analyses on the “peak” as it is most intuitive, but part of the role of this piloting is to determine how these different metrics relate to one another.

In general, our analysis goal is to more broadly understand the shape of these data in patients. We will look to determine how performance varies as a function of size and stimulus contrast in patients with headache relative to headache free controls. We are also interested in measures of trial-to-trial variability, to ensure our overall signal-to-noise is reasonable or we need to collect additional data per participant.

We will take several approaches to quantify surround suppression in these data. Most simply will be in terms of a suppressive index, where for a given contrast level we will quantify tracking performance relative to that of the smallest stimulus. In addition, we will look to employ a more mechanistic model. Although the shape of this model is still to be determined, we will take for inspiration those published by Tadin et al (Tadin 2005, Tadin 2019).

**Hypothesis**

Our primary hypothesis is that patients with headache will have reduced surround suppression relative to headache free controls. We would expect to see this effect in terms of 1) a reduced suppressive index and 2) reduced surround suppression summary parameter from a mechanistic model (i.e. a reduced beta/alpha ratio as in Tadin 2019).

**References**

Bonnen, K., Burge, J., Yates, J., Pillow, J., & Cormack, L. K. (2015). Continuous psychophysics: Target-tracking to measure visual sensitivity. *Journal of vision*, *15*(3), 14-14.

Tadin, D., & Lappin, J. S. (2005). Optimal size for perceiving motion decreases with contrast. *Vision research*, *45*(16), 2059-2064.

Tadin, D., Park, W. J., Dieter, K. C., Melnick, M. D., Lappin, J. S., & Blake, R. (2019). Spatial suppression promotes rapid figure-ground segmentation of moving objects. *Nature Communications*, *10*(1), 2732.