

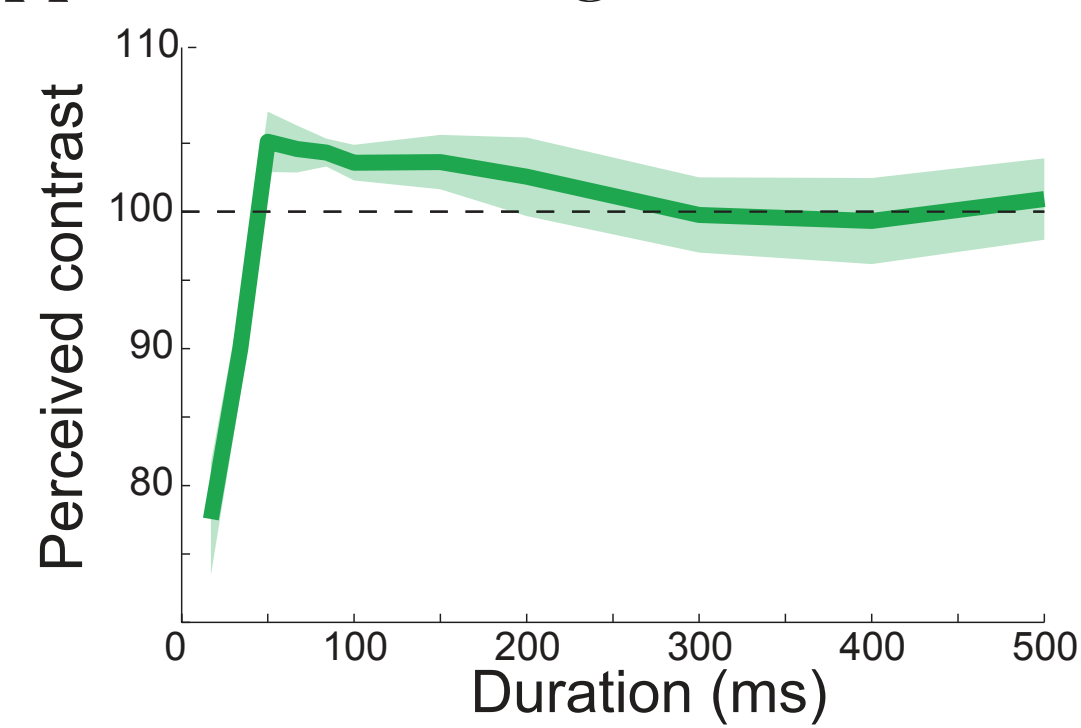
STUDY OF TEMPORAL VISION AND BLOOD FLOW REGULATION

Héctor Rieiro^{1,2}, José Luis Alba Castro¹, Stephen L. Macknik²

¹Universidad de Vigo, Vigo, Spain, ²Barrow Neurological Institute, Phoenix, USA

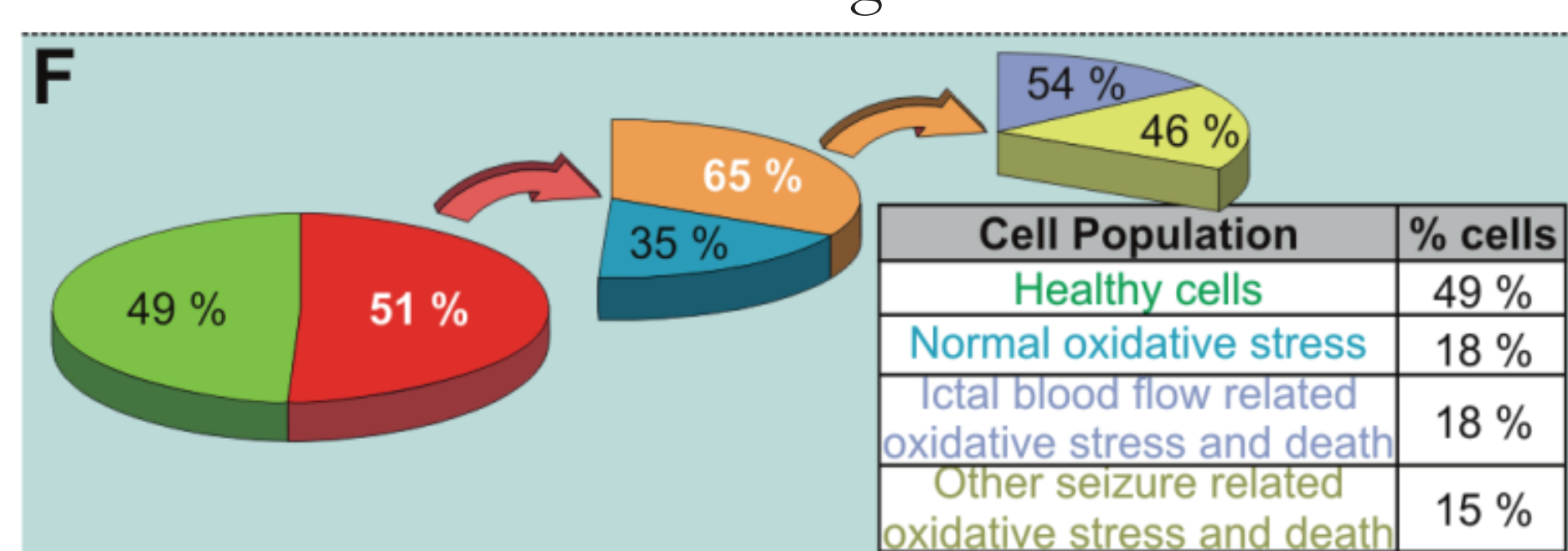
Motivation

- Light sources are not tuned to human vision
 - Temporal parameters such as stimulus timing influence important phenomena such as contrast perception (1) and flicker fusion
 - Neural mechanisms unknown
 - Immediate application to design of illumination system



- Epilepsy patients are specially sensitive to temporal factors of light stimuli

- Functional activation produces changes in blood flow
- Increased neural activity during seizures also causes changes in blood flow activity that leads to neural degeneration (2)
- Need to understand blood flow regulation mechanisms better



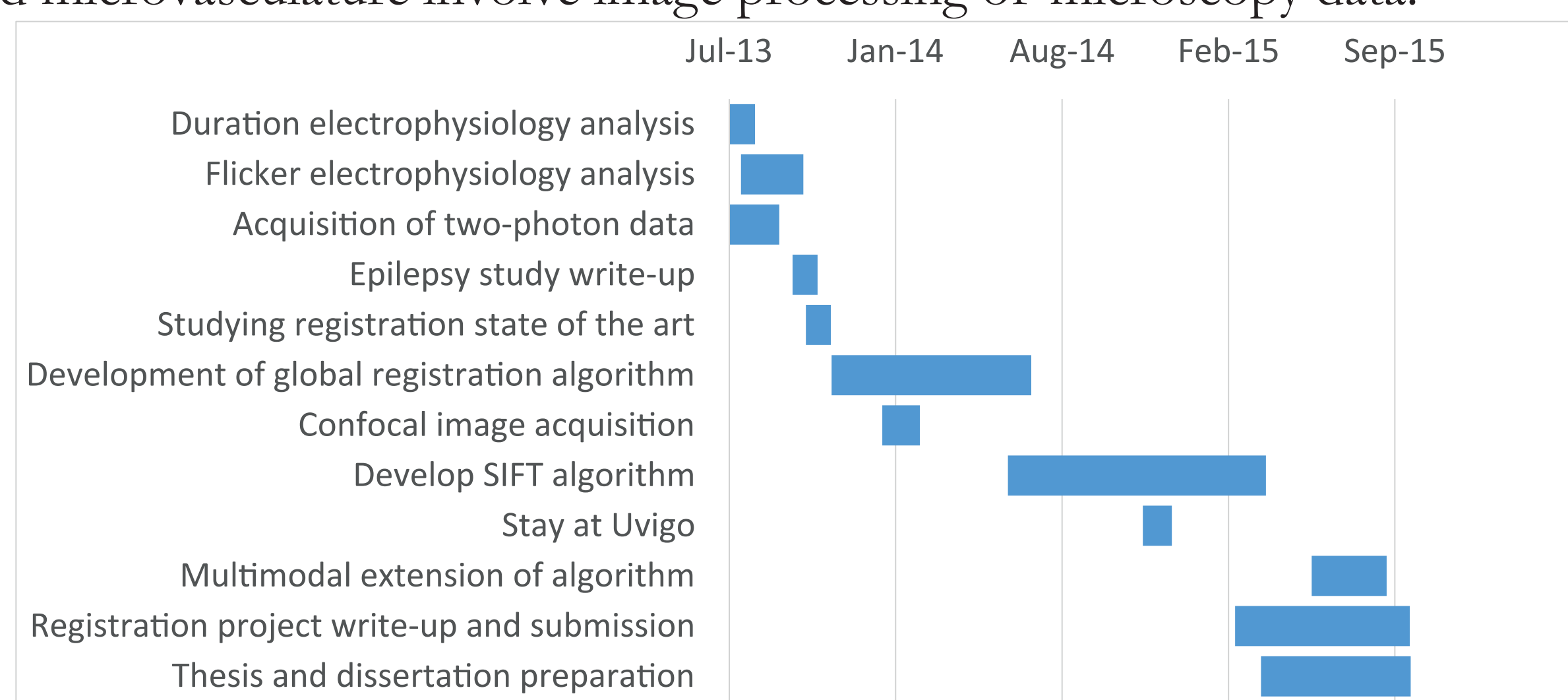
Objective

- Study temporal effects on visual perception
 - Electrophysiological studies
 - Effect on brightness perception: is there an optimal set of temporal parameters that maximizes perceived contrast? What is the neurological basis?
 - Effect on flicker fusion: why and how flicker fusion happens?
- What are the mechanisms that produce blood flow regulation?
 - Results from (2) suggest the existence of a blood flow reserve
 - This hypothesis might not be testable in vivo due to limitations of recording systems: need to study in vivo blood flow regulation and ex vivo microvasculature structure
 - Development of an algorithm that allows registration of microvasculature microscopy images, specifically those used using two different techniques: two-photon and confocal microscopy

The studies of temporal vision will provide insight in the development of novel illumination and display system. Better understanding of blood flow regulation will help understand regulation on disease conditions such as epilepsy and provide a framework to better delineate the effect of temporal factors of visual stimulation in brain activity and neural degeneration. The registration tool developed will be of help to scientists performing complex imaging experiments.

Research Plan

The thesis goals related to studies of visual perception consists on the analysis of one-dimensional signals obtained through single-cell electrophysiological recordings, and the development of mathematical models. Studies of bloodflow and microvasculature involve image processing of microscopy data.



Next Year Planning

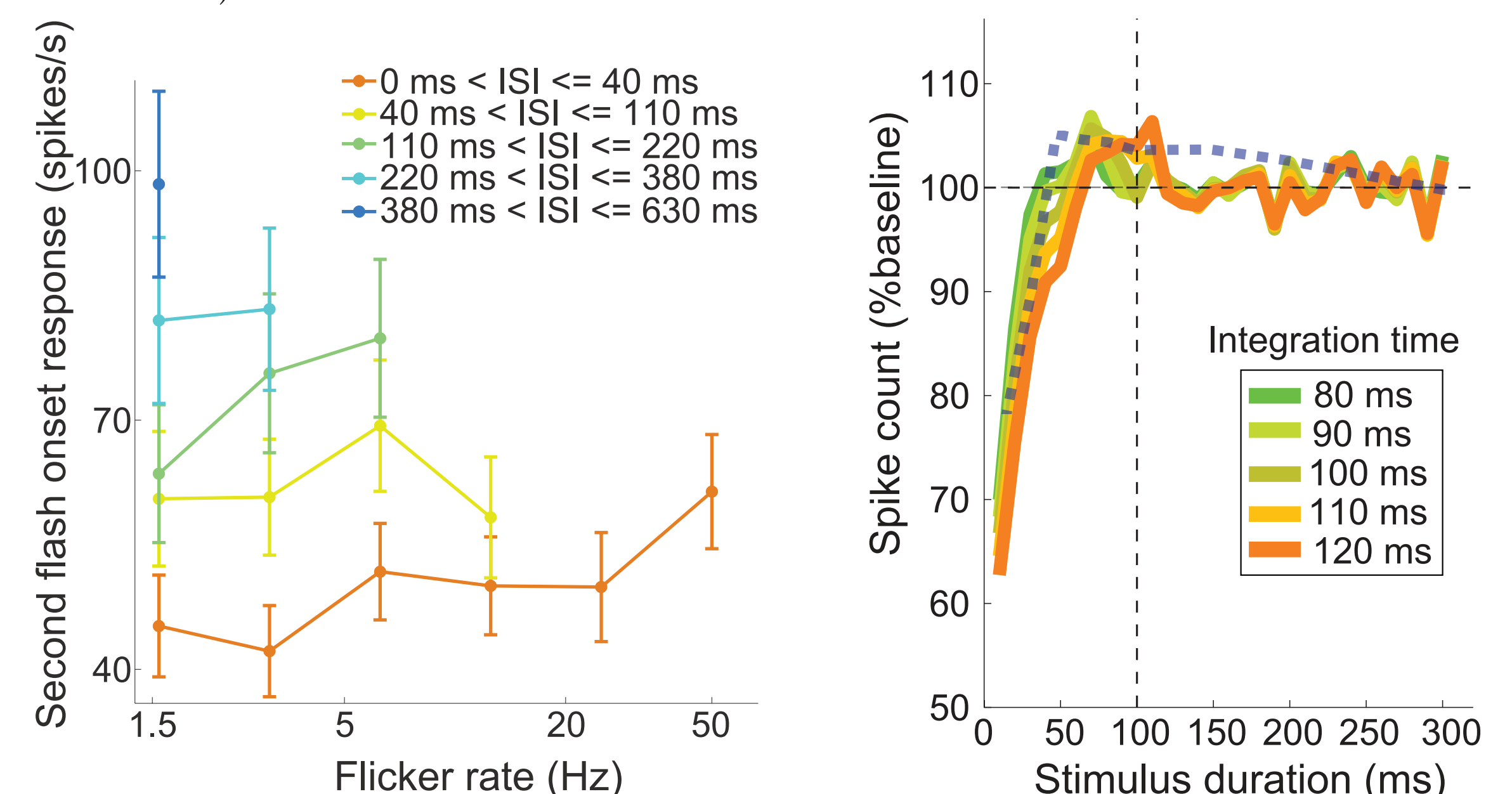
- Multimodal extension of registration algorithm
- Finish writing up all the current results and submit to journals
- Prepare thesis and dissertation

References

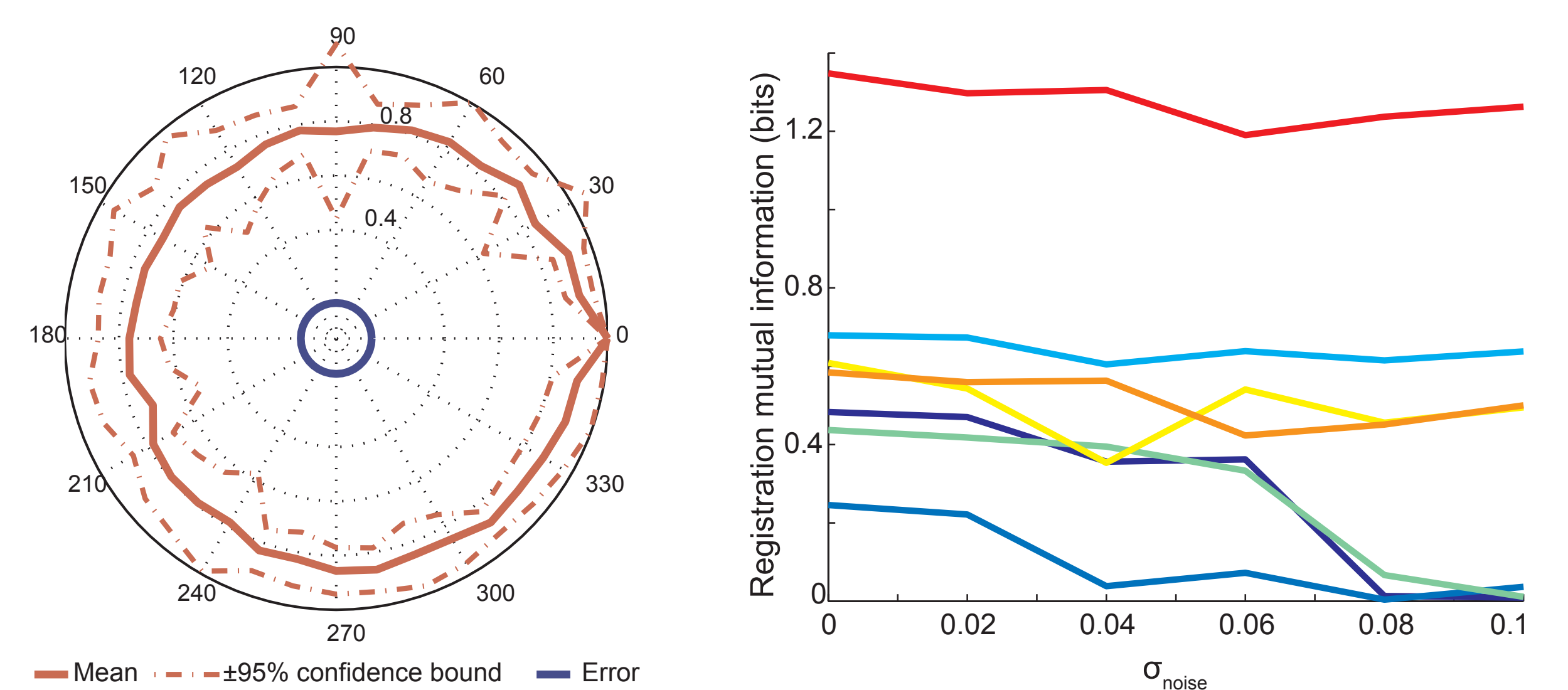
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Results and progress

- Found that flicker fusion is depending on interstimulus interval, not on rate (left). Mutual information analyses suggest that flicker fusion is caused by lateral inhibition circuits
- Found that there is a peak in brightness perception with duration, physiologically explained by the action of integrator circuits early in the visual hierarchy (right)
- Our results on temporal vision have application in the design of new, efficient illumination and display systems, since these rely in temporal properties of the visual system. Research on this applications has already been funded. The results are otherwise been presented in abstract form and are ready for submission to international journals



- Our epilepsy data (2) shows that abnormal blood flow contributes to neural degeneration in epilepsy. The development of a new biomarker points to a anomalous behavior of pericytes as a cause. These results have been submitted for publication and reviewers' response is currently being addressed
- Development of microvasculature registration algorithm:
 - Initial testing of an intensity-based global registration algorithm produced unsatisfying results. The focus has been changed to use a feature-based algorithm
 - Initial image preprocessing: used a multilocal creaseness algorithm to filter and clean background noise in microscopy images (3)
 - Added full 3-D rotational invariance to SIFT
 - Used RANSAC to do an estimation of the linear transformation
 - Tested using a mutual information metric (4) to measure the goodness of the estimation on a single mode registration problem. Method shows good rotational invariance (left) and resilience to noise (right)



- The satisfactory performance of our method in monomodal test will be followed by an extension and testing of the method using multimodal data
- Summary of activities and publications:
 - Electrophysiology results presented at Society for Neuroscience Meeting 2013
 - Performed a stay at Universidade de Vigo with director J.L. Alba Castro to finalize the registration algorithm. This stay was partially funded by a doctorate travel award from Universidade de Vigo.
 - Epilepsy results submitted to Proceedings of the National Academy of Sciences. Currently preparing resubmission
 - Author in an accepted article in PLoS ONE (5)
 - Conference abstract accepted at European Conference on Eye Movements
 - Monomodal results from registration algorithm accepted at VipImage