OMB No. 0925-0001 and 0925-0002 (Rev. 09/17 Approved Through 03/31/2020)

BIOGRAPHICAL SKETCH

Provide the following information for the Senior/key personnel and other significant contributors.
Follow this format for each person. **DO NOT EXCEED FIVE PAGES.**

NAME: **Issa, Elias Bassam**

eRA COMMONS USER NAME (credential, e.g., agency login): **eissa1**

POSITION TITLE: **Assistant Professor of Neuroscience**

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Johns Hopkins University	BS	05/2001	Biomedical Engineering
Johns Hopkins University School of Medicine	PhD	05/2008	Biomedical Engineering
Massachusetts Institute of Technology	Postdoc	08/2017	Brain & Cognitive Sciences

A. Personal Statement

My lab's long-term research goal is to study how visual cortical areas interact to support high-level visual behavior, specifically face and object recognition. I have identified recurrent feedforward and feedback interactions as a key, poorly understood mechanism in visual networks. To dissect the role of feedback, I am taking a highly interdisciplinary approach that tightly integrates new techniques and theory into my experiments. This approach is enabled by my highly technical background as a biomedical engineer with extensive training in sensory systems neuroscience labs during predoctoral (Dr. Xiaoqin Wang, Johns Hopkins) and postdoctoral (Dr. James DiCarlo, MIT) training periods. I have published broadly across auditory and visual electrophysiology (single-unit, multi-unit, LFP, and EEG), fMRI, behavioral psychophysics, and computational modeling. The integrated, highly technical approach of my lab is well complemented by the unique, interdisciplinary environment at the Zuckerman Institute at Columbia.

At the core of my research program, I am developing a new experimental platform for primate visual neuroscience that centers around the common marmoset, a small primate that has excellent visual abilities and a flat lissencephalic cortex that allows adoption of the latest functional imaging and optogenetic techniques that have been mainly developed and applied in the rodent animal model. I am uniquely qualified to develop a marmoset experimental platform since I have worked extensively with marmosets in both my PhD (neurophysiology) and postdoc (behavior) before starting my own lab. Situated between the traditional rodent and primate models, the marmoset allows cross-cutting collaboration between my lab and groups from both communities. My long-term research program investigates the function of primate cortical circuits in online perception and offline learning of visual objects.

B. Positions and Honors

Positions

2008	Postdoctoral fellow, Department of Biomedical Engineering, Johns Hopkins University School of Medicine, Baltimore, MD (**Advisor: Prof. Xiaoqin Wang**)
2008-2016	Postdoctoral fellow, Department of Brain & Cognitive Sciences, Massachusetts Institute of Technology, Cambridge, MA (**Advisor: Prof. James DiCarlo**)

2017 Assistant Professor, Department of Neuroscience, Columbia University, New York, NY

Honors

2002-2006	Whitaker Foundation Graduate Student Fellowship in Biomedical Engineering
2007	Murray B. Sachs Research & Travel Award, Johns Hopkins University, Baltimore, MD
2008	Paul Ehrlich Award for Dissertation, Young Investigator's Day, Johns Hopkins University, Baltimore, MD
2010	Cosyne Conference Gatsby Travel Fellowship, Salt Lake City, UT
2009-2012	NIH NRSA Postdoctoral Fellowship (F32)
2012-2014	NIH Pathway to Independence Award (K99)
2017-2020	NIH Pathway to Independence Award (R00)
2019-2022	Klingenstein-Simons Fellowship Award in Neuroscience
2020-2022	Sloan Research Fellowship

C. Contributions to Science

1. My PhD thesis work examined responses to sounds in naturally sleeping marmosets. This study challenged the prevailing idea that the cortex is shut off from the external world during sleep. Rather, by performing stable recordings of well-isolated single neurons across multiple sleep cycles, I was able to show that spiking activity in both primary and secondary auditory cortex in response to sounds was similar between wakefulness and sleep. The robustness of sound-evoked responses in cortex was found during both slow-wave sleep and rapid eye movement phases of sleep. This primary finding led to two follow-up studies testing neural properties besides mean activity levels. These studies revealed that responses to quiet sounds were diminished during slow-wave sleep compared to wakefulness and that correlations between neurons were increased during slow-wave sleep. Remarkably, rapid eye movement sleep resembled wakefulness in its responses to quiet sounds and in neural correlations suggesting relatively preserved sensory processing in this phase of sleep as compared to slow-wave sleep.

(a) **Issa EB** & Wang X (2008). Sensory responses during sleep in primate primary and secondary auditory cortex. *Journal of Neuroscience* 28: 14467-14480.
(b) **Issa EB** & Wang X (2011). Altered neural responses to sounds in primate primary auditory cortex during slow-wave sleep. *Journal of Neuroscience* 31: 2965-2973.
(c) **Issa EB** & Wang X (2013). Increased neural correlations in primate auditory cortex during slow-wave sleep. *Journal of Neurophysiology* 109: 2732-2738.

2. fMRI of object-selective cortex has revealed functional organization in both humans and macaques (e.g. face, object, and scene selective areas). However, fMRI lacks the spatial and temporal resolution to adequately study spatial organization at the neural scale. In my postdoctoral work, I used a novel, stereo microfocal x-ray system to localize neural recordings at high accuracy and co-registered these reconstructed 3D neural maps to fMRI maps collected in the same subjects. This work demonstrated a direct quantitative relationship between 3D neurophysiology and fMRI spatial maps at the macroscale (>2 mm) providing much needed validation of human imaging studies. At a microscale (<1 mm), the measured fine-grain neural organization within the fMRI-identified middle face patch revealed that instead of being a uniform module this region contained a graded enrichment of face-selective cells with a hot spot of selectivity in the center that fell toward the edges. These highly detailed neurophysiological maps are important for guiding any future circuit-level manipulations of IT subregions.

(a) **Issa EB,** Papanastassiou AM & DiCarlo JJ (2013). Large-scale, high-resolution neurophysiological maps underlying fMRI of macaque temporal lobe. *Journal of Neuroscience* 33: 15207-19.
(b) *Aparicio PL, ***Issa EB** & DiCarlo JJ (*2016*). Neurophysiological organization of the middle face patch in macaque inferior temporal cortex. *Journal of Neuroscience* 36:12729-45.

3. As a postdoc, I revealed the precise dynamics of how faces are processed in IT. In contrast to typical neurophysiology studies where firing rates are averaged over hundreds of milliseconds, I chose to focus on the fine-scale temporal dynamics of the first and second 30 millisecond phases of neural response leading to two

important discoveries. In the first 30 ms of neural responses in posterior IT, I showed that the eye region, and not other face features, was critical for driving the initial feedforward response edge. Given this finding, I then showed that the next phase of the response, occurring within tens of milliseconds, signaled errors in face detection for distorted faces when the eye was misplaced. In collaboration with a computational neuroscientist (Dr. Charles Cadieu), we built dynamical models that captured the observed neural phenomena and made novel, testable predictions about feedforward and feedback phases of processing. This work on the dynamics of posterior IT responses motivates my future research program examining how error signals are generated through recurrent interactions between cortical areas.

(a) **Issa EB** & DiCarlo JJ (2012). Precedence of the eye region in neural processing of faces. *Journal of Neuroscience* 32: 16666-82.
(b) **Issa EB,** Cadieu CF & DiCarlo JJ (2018). Neural dynamics at successive stages of the ventral visual stream are consistent with hierarchical error signals. *eLife* 7: e42870.
(c) Kar K, Kubilius J, Schmidt K, **Issa EB** & DiCarlo JJ (2019). Evidence that recurrent circuits are critical to the ventral stream's execution of core object recognition behavior. *Nature Neuroscience* 22(6): 974-983.

Link to Complete list of Published Work:
http://www.ncbi.nlm.nih.gov/pubmed/?term=issa+eb

D. Additional Information: Research Support and/or Scholastic Performance

Ongoing Research Support
Sloan Research Fellowship   Issa (PI)   09/15/2020 – 09/14/2022
Understanding the role of cortical feedback in vision
Develop behavioral and imaging paradigms for studying feedback in the visual cortex.

Klingenstein-Simons Fellowship Award in Neuroscience   Issa (PI)   07/01/2019 – 06/30/2022
Imaging cortical feedback during visual face recognition and learning
Utilizing viral methods to label feedback neurons for cellular imaging experiments studying the visual response properties of feedback neurons.

R00 EY022671   Issa (PI)   07/01/2017 – 06/30/2020
The role of cortical feedback in visual face processing
Circuit-level manipulations of feedback pathways to examine their effects on downstream neural populations observed with multielectrode recording and cellular imaging.

Completed Research Support
K99 EY022671   Issa (PI)   09/01/2012 – 08/31/2014
The role of cortical feedback in visual face processing
The goal of this work was to measure the dynamics of IT neural response during face processing and to examine how inactivation of one cortical area affects responses in an adjacent cortical area. This work has resulted in two publications.

F32 EY019609   Issa (PI)   03/17/2009 – 03/16/2012
The neural organization of face and object patches in inferotemporal cortex
Large-scale, high resolution neural maps of the inferotemporal cortex were constructed in two animals. This work has resulted in three publications.

Whitaker Foundation Graduate Student Fellowship   Issa (PI)   2002-2006
Modulation of neural responses in auditory cortex during sleep
I studied how sounds are processed in auditory cortex during sleep and found that auditory neurons are as strongly responsive to sounds during sleep as during wakefulness; however, receptive field properties and population correlations were altered during slow-wave sleep, but not rapid eye movement sleep, compared to wakefulness. This work has resulted in three publications.