

# Orbicularis Oculi Volume Relates to Resting Parasympathetic Activity and Facial Movement During Positive Emotion

University of California  
San Francisco



Department of Neurology  
Memory and Aging Center

Eena L. Kosik<sup>1</sup>, Nikolas R. Block<sup>1</sup>, Samir Datta<sup>1</sup>, Lorenzo Pasquini<sup>1</sup>, Isabel J. Sible<sup>1</sup>, Gerd F. Volk<sup>2</sup>, John Neuhaus<sup>1</sup>,  
Joel H. Kramer<sup>1</sup>, Howard J. Rosen<sup>1</sup>, Bruce L. Miller<sup>1</sup>, William W. Seeley<sup>1</sup>, Virginia E. Sturm<sup>1</sup>

<sup>1</sup> Memory and Aging Center, Department of Neurology, University of California, San Francisco, USA

<sup>2</sup> Jena University Hospital, Jena, Germany



## INTRODUCTION

### Parasympathetic activity promotes variability in heart rate and positive emotions

- The parasympathetic system decreases arousal via the inhibitory influence of the vagus nerve
- Respiratory sinus arrhythmia (RSA)** is a measure of vagally-mediated heart rate variability that is linked to the breathing cycle
- Higher resting RSA is associated with trait positivity (e.g., optimism and agreeableness) and positive emotions (e.g., compassion)
- According to the polyvagal theory, a myelinated branch of the vagus in mammals influences the heart and the face and promotes socioemotional expression
- How the parasympathetic system interacts with the facial musculature during emotions, however, is not well understood

## STUDY OBJECTIVES

- We examined whether resting RSA was associated with the size of any facial muscles that are pertinent for emotional expression
- We expected that parasympathetic activity would nuance facial movements, just as it nuances the activity of the heart, and hypothesized that higher RSA would be associated with more nuanced emotional facial expressions

## METHODS

### Participants

- 23 healthy controls (9 male, 14 female); mean age: 68.1 (± 5.8)

### Tasks

#### Resting Baseline Physiology

- Participants sat quietly during a 90-second resting baseline period

#### Emotional Reactivity Task

- Participants viewed a 90-second block of six photographs that elicited nurturant love

### Laboratory Measures

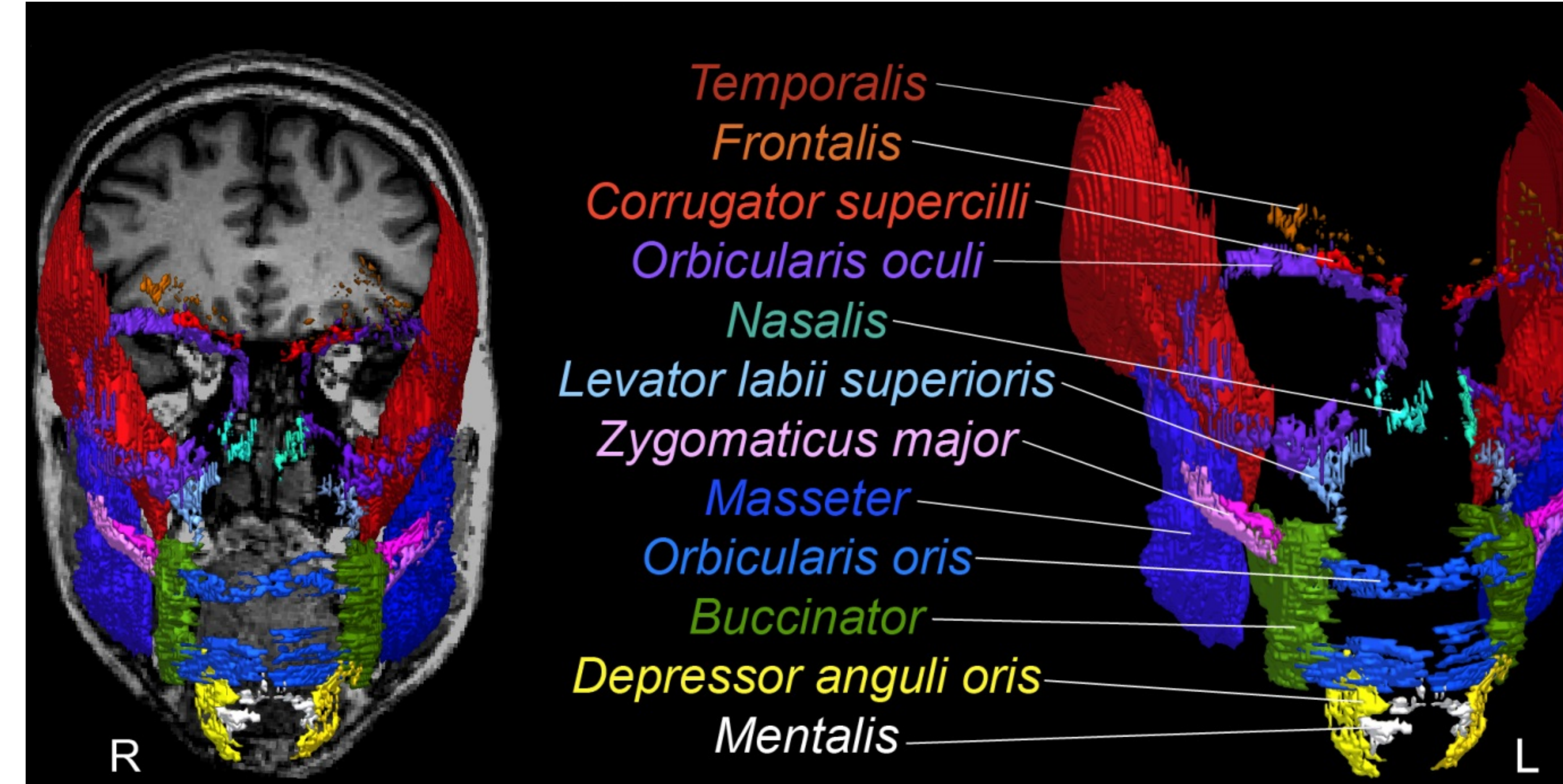
#### Autonomic Nervous System Activity

- Heart and respiration rates were measured continuously
- Mean baseline RSA was computed using the peak-valley method

#### Facial Coding

- Smiling behavior (behaviors that activated action unit 12) was coded on a 1-5 intensity scale during the nurturant love trial
- A score of 1 was given to each second in which smile intensity changed from that of the previous second, and a score of 0 was given to each second in which smile intensity remained the same
- Smile variability was quantified by summing these intensity change scores across the trial

## METHODS: Facial Muscle Segmentation

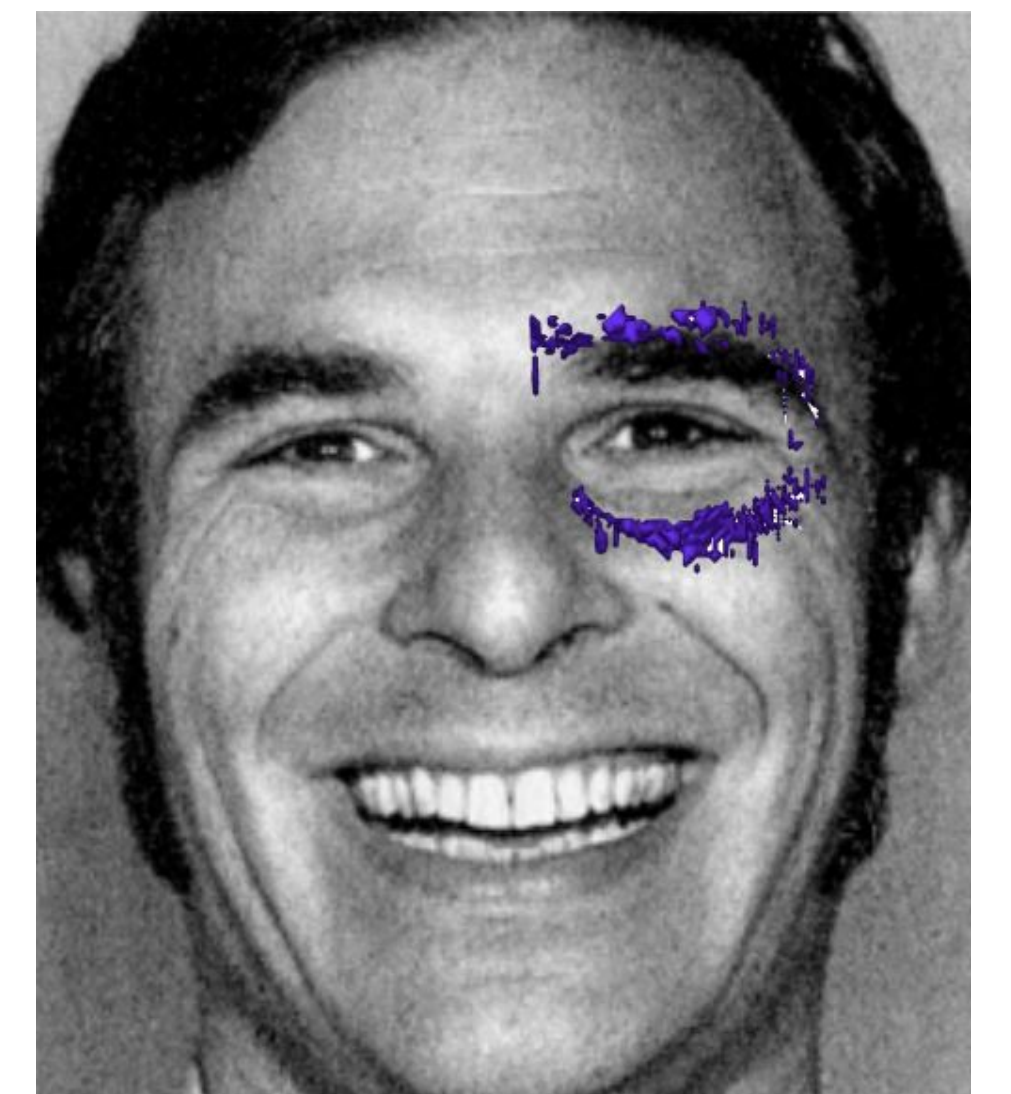


- We segmented the raw T1 and traced images by tracing each muscle of interest
- Volumes of 8 emotion-relevant muscles of facial expression were quantified

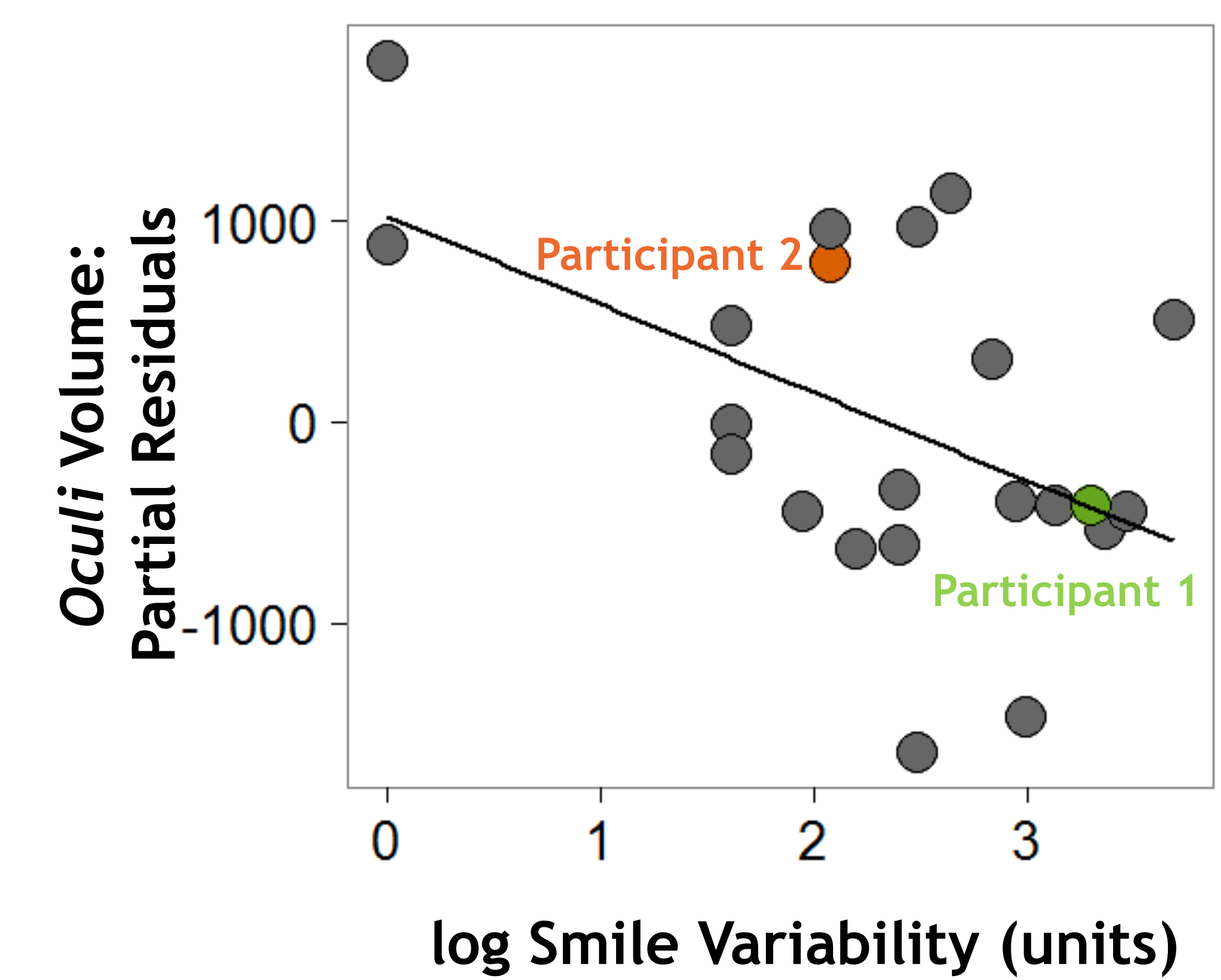
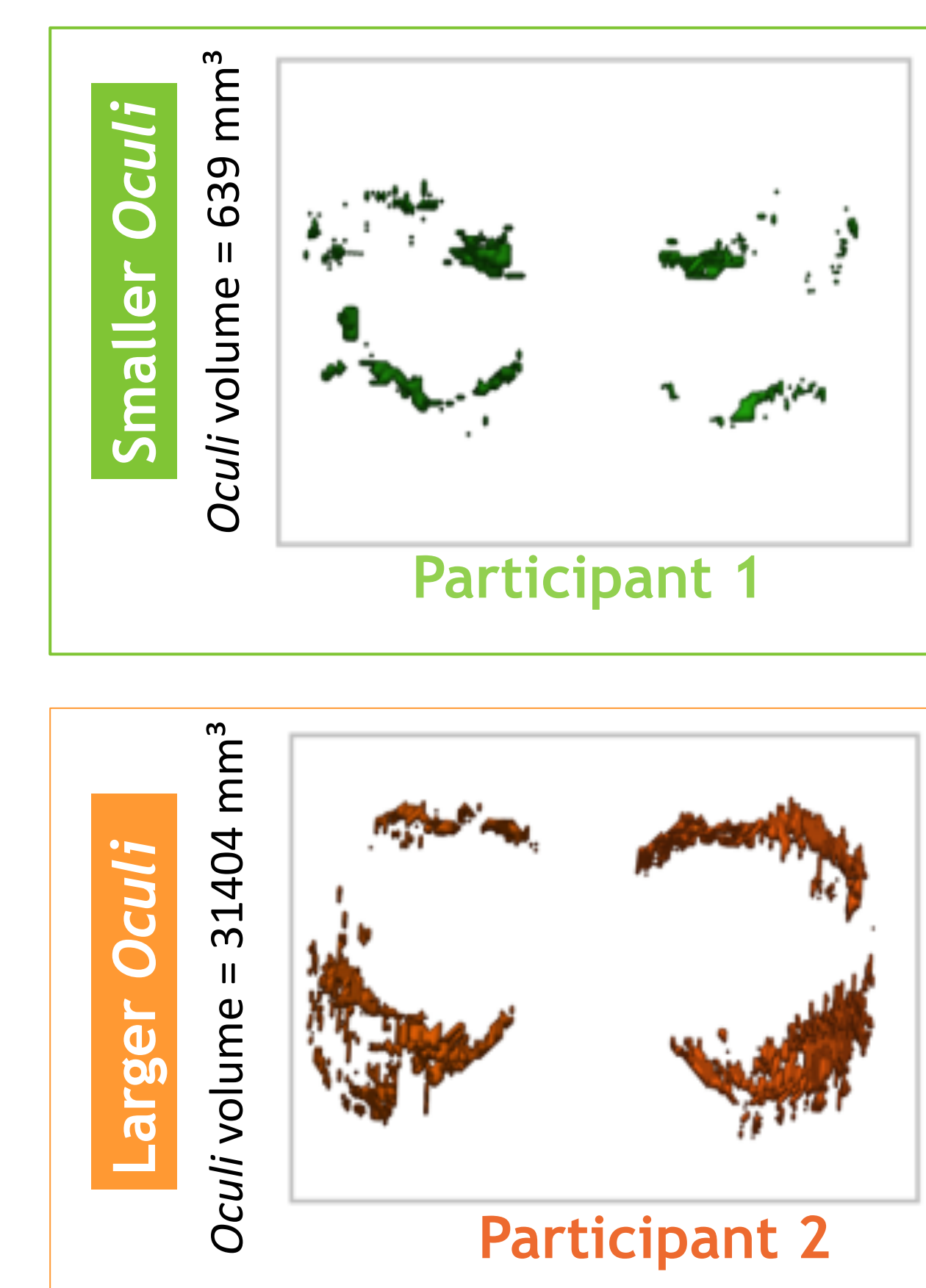
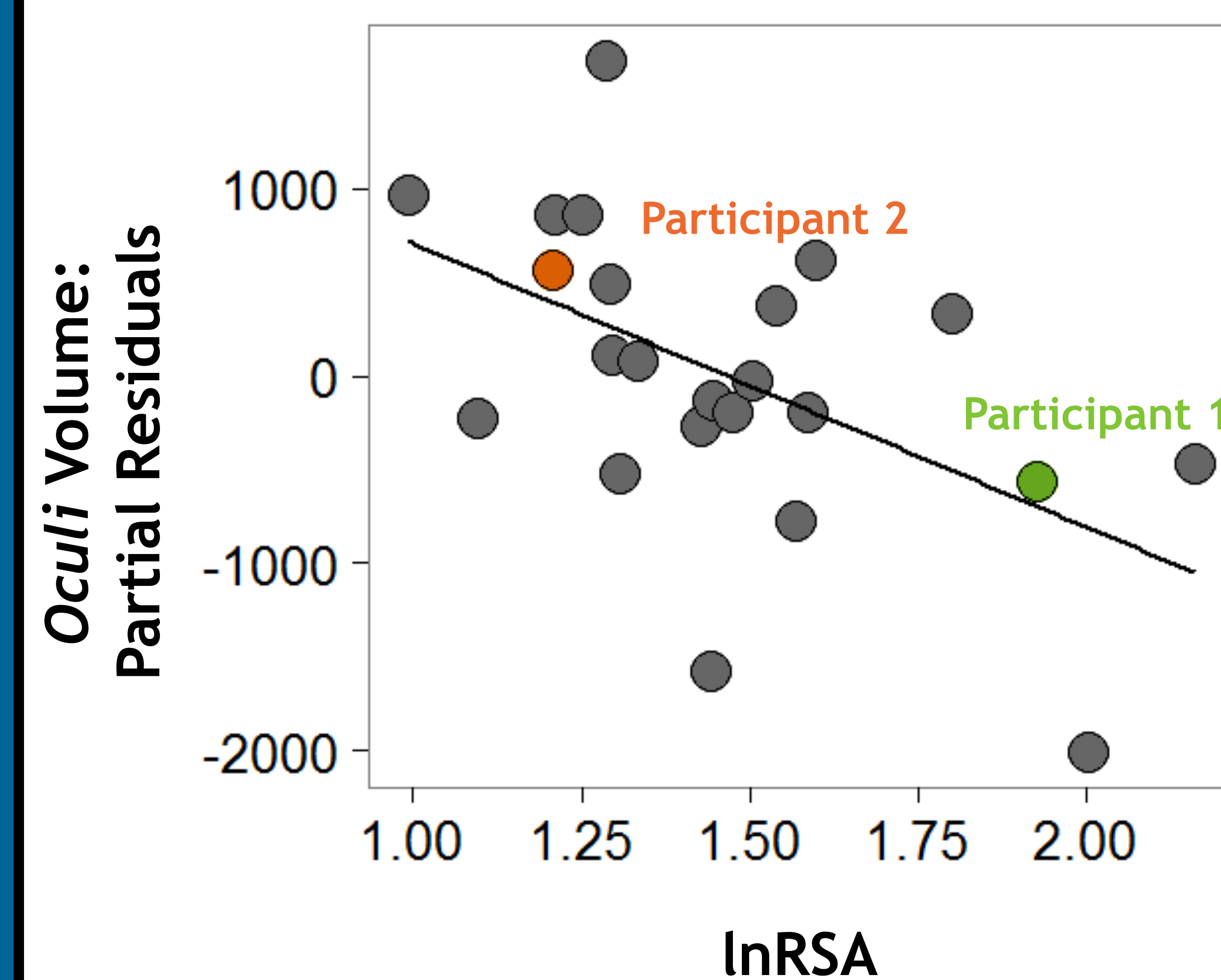
## DISCUSSION

### Orbicularis oculi volume is associated with resting parasympathetic activity and smiling behavior

- Orbicularis oculi* is a muscle that surrounds the eyes and is important for many facial expressions, including genuine (“Duchenne”) smiles
- In mammals, the vagus nerve has two branches, which influence the heart and face
- We found that smaller *orbicularis oculi* volume was associated with higher resting RSA and more variable smiling behavior
- We speculate that tonic vagal inhibition may influence either the size of *orbicularis oculi* (keeping it small and capable of nuanced movements) or the movement of *orbicularis oculi* (keeping it agile)
- A facial muscle control system that promotes flexible movements can produce a wide range of emotional expressions
- This study offers evidence that the parasympathetic nervous system links the heart and the face and is important for emotional expression



## RESULTS: Smaller Orbicularis Oculi is Associated With Higher Resting RSA and Greater Duchenne Smile Variability



Smaller *orbicularis oculi* volume was associated with:

- Higher resting RSA,  $\beta = -1375.0$ ,  $R^2$  Change = .15,  $p = .03$  (but not any other facial muscles)
- Greater Duchenne smile variability during nurturant love trial,  $\beta = -510.7$ ,  $R^2$  Change = .15,  $p = .03$  (controlling for age and sex)

## REFERENCES

- Porges, S.W. The polyvagal theory: phylogenetic substrates of a social nervous system. *International Journal of Psychophysiology* 42, 123-146 (2001).
- Oveis, C., Cohen, A. B., Gruber, J., Shiota, M. N., Haidt, J. & Keltner, D. Resting respiratory sinus arrhythmia is associated with tonic positive emotionality. *Emotion* 9, 265-270 (2009).
- Stellar, J. E., Cohen, A., Oveis, C. & Keltner, D. Affective and physiological responses to the suffering of others: Compassion and vagal activity. *J Pers Soc Psych* 108, 572-585 (2015).