BIOGRAPHICAL SKETCH

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NAME: Krishna Vaughn Shenoy, PhD

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POSITION TITLE: (1) Investigator, Howard Hughes Medical Institute (HHMI) and (2) Hong Seh and Vivian W. M. Lim Professor, Depts. of Electrical Engineering and, by courtesy, Bioengineering, Neurobiology & Neurosurgery. Wu Tsai Neurosciences and Bio-X Institutes. Neurosciences PhD Program, Stanford University

EDUCATION/TRAINING

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
UC San Diego	---	9/1986 – 6/1987	Electrical Engineering and Computer Science (EECS)
UC Irvine	B.S.	6/1987 – 6/1990	EECS, Prof. GL Shaw
MIT	S.M.	8/1990 – 6/1992	EECS, Prof. CG Fonstad, Jr
MIT	Ph.D.	6/1992 – 6/1995	EECS, Prof. CG Fonstad, Jr
Caltech	Postdoc Senior PD	7/1995 – 6/1998 7/1998 – 7/2001	Neurobiology, Division of Biology, Prof. RA Andersen

A. Personal Statement

I have trained in both electrical engineering and computer science (MIT PhD) and in systems neuroscience (Caltech postdoc). I joined Stanford as an Assistant Professor in 2001, and since then I have directed the Neural Prosthetic Systems Lab (**NPSL)** and co-directed the Neural Prosthetics Translational Lab (**NPTL).** My teaching is focused on interdisciplinary neuroscience, neuroengineering, neurocomputation and signal processing. To date I have trained 21 postdocs, 1 research scientist, 21 PhD students and 8 MS students. I was elected to the National Academy of Medicine in 2022.

NPSL focuses on systems and computational neuroscience questions regarding how populations of individual premotor and motor cortical neurons prepare and generate movements and participate in decision making. Approaches include linear and non-linear dynamical systems data analysis and modeling (e.g., single-trial methods, dimensionality reduction, real-time interventions, LDSs and RNNs; in collaboration with Adjunct Prof. David Sussillo here and Prof. Maneesh Sahani at the Gatsby Computational Neuroscience Unit, UCL), rhesus and squirrel monkey neurophysiology (e.g., NeuroPixels, Utah arrays, head-mounted wireless systems) and optogenetics and 2-photon GCaMP optical imaging (in collaboration with Prof. Karl Deisseroth), and closed-loop brain-computer interface (BCI) design and demonstrations (e.g., new-science based neural decoding algorithms, validated in full end-to-end systems).

Since 2009, Prof. Jaimie Henderson MD (Chief of Functional Neurosurgery here) and I have co-directed **NPTL** which is a human clinical-trial based research group that translates innovating BCI systems to clinical trial participants with tetraplegia (e.g., ALS, upper spinal cord injury, brainstem stroke). We work closely with Profs. Hochberg, Cash, Donoghue and their groups at Brown U and MGH as part of the BrainGate clinical trial consortium (we are the 2nd site; there are now 4 sites). We focus on basic and applied systems and computational neuroscience questions regarding how populations of individual human premotor and motor cortical neurons prepare and generate movements (e.g., arm/hand movements, decision making, speech, handwriting). This is enabled by the chronic implantation of electrode arrays, which record from populations of individual neurons, in people with tetraplegia. Approaches include dynamical systems data analyses and modeling, neurophysiology from people with tetraplegia, power-constrained fully-implantable wireless system design and BCI design for high-performance and high-robustness real world operation with commercial off-the-shelf interfaces (e.g., iPhones, iPads, laptops). All of these activities are either directly or indirectly relevant to the current research proposal.

Regarding the important goal of increasing diversity: (1) I co-chair the Neurosciences PhD Program's Diversity, Equitability, Inclusion and Belonging (DEIB) committee, and (2) help lead the Dept. of EE's DEI efforts, to advance the recruitment, retention, and delivery of an extremely high-quality experience for URM, BIPOC and FLI students, postdocs and staff and faculty. (3) I have also chaired the Dept. of EE's Student Life Committee for multiple years.

Regarding the important goal of trying to provide student and postdoc mentorship excellence, the majority (two thirds) of my trainees pursue research as faculty members at universities and a minority (one third) do so in industry. **PhDs.** Twenty-one (**21**) PhDs have trained and graduated. **7 of these 21 (33%)** went on to industry: Afsheen Afshar MD PhD; Nir Even-Chen PhD; Justin Foster PhD; Werapong Goo PhD; Rachel Kalmar PhD; Zuley Rivera Alvidrez PhD; Gopal Santhanam PhD. **14 of these 21 (67%)** became postdocs and/or tenure-track faculty members. To break down these data a bit more, regarding the **5 of the 14 (36%)** that are now postdocs: Daniel O'Shea PhD Stanford U; Xulu Sun PhD UCSF; Eric Trautmann PhD Columbia U; Saurabh Vyas PhD Columbia U; Megan Wang PhD Princeton U. Regarding the **8 of the 14 (57%)** that are now tenure-track / tenured Profs: Cynthia Chestek PhD Assoc Prof U Michigan; John Cunningham PhD Full Prof. Columbia U; Vikash Gilja PhD Assoc Prof UCSD; Jonathan Kao PhD Assist Prof UCLA; Matthew Kaufman PhD Assist Prof U Chicago; Paul Nuyujukian MD PhD Assist Prof Stanford U; Sergey Stavisky PhD Assist Professor UC Davis; Byron Yu PhD Full Prof CMU. And **1 of 14 (7%)** is now in industry: Cora Ames PhD **Postdocs.** Nineteen **(19)** postdocs have completed their training and are now independent investigators.**14 of these 19 (74%)** went on to tenure-track and tenured professorships. To bread down these data a bit more, regarding the **5 of 13 (38%)** that are now pre-tenure Assist Profs: Chand Chandrasekaran PhD (Boston U.); Jonathan Kao PhD (UCLA); Matthew Kaufman PhD (U Chicago); Chethan Pandarinath PhD (Emory U & Georgia Tech); Paul Nuyujukian PhD Stanford U; Sergey Stavisky PhD UC Davis. Regarding the **3 of the 13 (23%)** that are now tenured Assoc Profs: Cynthia Chestek PhD U Michigan, Vikash Gilja PhD UCSD; Mark Churchland PhD Columbia U. Regarding the **4 of 13 (31%)** that are now tenured Full Professors: Aaron Batista PhD U Pittsburgh; John Cunningham PhD Columbia University; Ilka Diester PhD U Freiburg; Byron Yu PhD CMU. The remaining **1 of 13 (8%)** is sadly now deceased: Paul Kalanithi MD. Returning to the **5 of 19 total postdocs (26%)** that went on to other medical / corporate opportunities: **1 of 5 (20%)** is now a neurosurgeon at California Pacific Medical Center (CPMC, San Francisco, CA) and in neurotech industry (Neuralink Corp., Fremont, CA): Matthew MacDougall MD. **1 of 5 (20%)** is now Chair of the Department of Neurosurgery at Palo Alto Medical Foundation (PAMF, Palo Alto, CA) and an Adjunct Prof of Electrical Engineering and Neurosurgery at Stanford: Stephen Ryu MD. **1 of 5 (20%)** is now at CTRL-Labs (Burlingame, CA), which was acquired by the Reality Labs division of Facebook (now Meta Platforms) in Fall 2019 and Adjunct Prof of Electrical Engineering at Stanford: David Sussillo PhD. **1 of 5 (20%)** is now at Apple (Cupertino, CA): Sharlene Flesher PhD. **1 of 5 (20%)** is now a postdoc at Western U: Jonathan Michaels PhD.

Ongoing projects (1) NIH NIDCD R01-DC014034 Henderson (contact) & **Shenoy (Multi-PDs/PIs)** 9/30/20-9/29/25 *Advanced neural decoders for communication interfaces in humans***,** (2) NIH NIDCD U01DC019430 Henderson (contact) & **Shenoy (Multi-PDs/PIs)** 9/1/21-8/31/26 *Single-neuron population dynamics in human speech motor cortex for a speech prosthesis*, (3) NIH NINDS U01NS123101 Henderson (contact) & **Shenoy (Multi-PDs/PIs)** 10/1/21-9/30/26 *Cortical basis of complex motor sequences in humans for neural interfaces***,** (4) NIH NINDS UH2NS095548 Hochberg & Nurmikko (Multi PDs/PIs), **Shenoy (Co-I)** 9/1/15-8/31/23 *High bandwidth wireless interfaces for continuous human intracortical recording,* (5) NIH NIDCD U01DC017844 Hochberg (PI), **Shenoy (Co-I)** 4/1/19-3/31/24 *Intuitive, complete neural control of tablet computers for communication*, (6) NIH NINDS R01NS121097 Kao (PI), **Shenoy (Co-I)** 4/1/21-3/31/26 *An open-source simulator for multi degree-of-freedom brain-machine interfaces,* (7) NIH NINDS BRAIN R01NS116623 Moore, **Shenoy**, Wallis **(Multi-PDs/PIs)** 9/30/20-9/29/25 *Large-scale recordings in primate prefrontal cortex: Mechanisms of value and attention*, (8) NIH NIMH R01MH086373 Deisseroth (PI), **Shenoy (Co-I)** 12/1/20-11/31/25 *Brain-spanning and scale-crossing circuitry mediating motivational drives*, (9) NIH NINDS BRAIN U19NS112954 Deisseroth & Giocomo (Multi-PDs/PIs), **Shenoy (Co-I)** 9/1/21-8/31/26 *Triggering, updating, and maintaining neural population states: cellular-level interaction of external inputs and internal dynamics,* (10) Simons Foundation (SCGB) 543045 **Shenoy (PI)** 7/1/17-8/31/23 *Computation through dynamics*, and (11) Howard Hughes Medical Institute (HHMI), Investigator **Shenoy (PI)**, renewable 9/1/15-8/31/28 *Motor cortical dynamics and brain-computer interfaces.*

Completed projects (1) ONR N000141812158 **Shenoy (PI)** 12/1/2017-7/31/21 *Dissecting the causal role of neural dynamics in supporting computation and behavior*, (2) NIH NIDCD R01-DC014034 (renewed) Henderson (PI), **Shenoy (Co-I)** 4/1/15-8/31/20 *Advanced neural decoders for communication interfaces,* (3) NIH NINDS UO1-NS098968 Cash (PI), **Shenoy (Co-I)** 9/1/16-08/31/20 *Understanding the neural basis of volitional state through continuous recordings in humans* and (4) DARPA BTO W911NF-14-2-0013 Deisseroth (PI), **Shenoy (Co-PI)** 12/23/13-4/1/20 *NeuroFAST: Neurosci.s: Function, Anatomy, Science, and Technology*

Citations

1. Paulk AC, Kfir Y, Khanna A, Mustroph M, Trautmann EM, Soper DJ, Stavisky SD, Welkenhuysen M, Dutta B, **Shenoy KV**, Hochberg LR, Richardson M, Williams ZM, Cash SS. (2022) Large-scale neural recordings with single neuron resolution using Neuropixels probes in human cortex. *Nature Neurosci.* 25:252-263.
2. Trautmann EM*, O'Shea DJ*, Sun X*, Marshel JH, Crow A, Hsueh B, Vesuna S, Cofer L, Bohner G, Allen W, Kauvar I, Quirin S, MacDougall M, Chen Y, Whitmire M, Ramakrishnan C, Sahani M, Seidemann E, Ryu SI, Deisseroth K**, **Shenoy KV**** (2021) Dendritic calcium signals in rhesus macaque motor cortex drive an optical brain-computer interface. *Nature Communications*. 12:1-20.
3. Trautmann EM, Stavisky SD, Lahiri S, Ames KC, Kaufman MT, O'Shea DJ, Vyas S, Sun X, Ryu SI, Ganguli S, **Shenoy KV** (2019) Accurate estimation of neural population dynamics without spike sorting. *Neuron*. 103:1-17.
4. **Shenoy KV**, Yu BM (2021) Brain Machine Interfaces, Chapter 39. Principles of Neural Science, 6th edition. Editors: Kandel ER, Koester JD, Mack SH, Siegelbaum SA. McGraw Hill.

B. Positions, Scientific Appointments, and Honors

Positions and Employment

2017-	Hong Seh and Vivian W. M. Lim Professor of Engineering (endowed chair), Stanford Univ.
2015-	Investigator, Howard Hughes Medical Institute
2001-2017	Assistant (2001-2008), Associate (2008-2012) and Full (2012-2017) Professor, Stanford Univ.
1995-2001	Postdoc (1995-1998), Senior postdoc (1998-2001), Neuroscience, Caltech (Prof RA Andersen)
1995-1998	Postdoc, Division of Biology (systems neuroscience), Caltech (Prof. R. A. Andersen)
1990-1995	MS (1990-1992), PhD (1992-1995) Research Assist., Dept. of EECS, MIT, Prof CG Fonstad Jr.
1989	Summer Intern, Rockwell Semiconductor Products Division, Newport Beach, CA
1988-1990	NSF REU, Research Assistant, Neurobiology Center, UC Irvine (Prof. Gordon L. Shaw)

Other Experiences and Professional Memberships

2018-	Scientific Advisory Board, Inscopix Inc., Palo Alto, CA (inscopix.com)
2018-	Scientific Advisory Board, MIND-X Inc., Bethesda, MD (mind-x.io)
2017-	Co-Founder & Consultant / Advisor, Neuralink Inc., Fremont, CA and Austin, TX (neuralink.com)
2019-	Consultant / Advisor, CTRL-Labs, Reality Labs, Meta Platforms Inc. (NYC & Burlingame)
2016-	Scientific Advisory Board, Heal Inc., Los Angeles, CA (heal.com)
2016-2019	Founding Scientific Board, CTRL-Labs (NYC)
2016-2021	Scientific Advisory Board, NSF ERC CNSE, U. Washington, Seattle, WA (csne-erc.org)
2008-2013	Editorial Board, Journal of Neurophysiology
2006-	Member, American Physiological Society
2005-2009	Elected Member, Defense Science Research Council, DARPA
2003-2005	Elected Fellow, Defense Science Research Council, DARPA
2000-	Member, Neural Control of Movement
1995-	Society for Neuroscience
1989-	Elected President (1989-1990) and Member, Tau Beta Pi (ΤΒΠ), UC Irvine chapter
1988-	Elected Member, Eta Kappa Nu (ΗΚΝ), national EE honor society and IEEE

Honors

2022	Elected Fellow of the Institute of Electronics and Electrical Engineering (IEEE)
2022	Elected member of the National Academy of Medicine
2018	Carnegie Prize in Mind and Brain Sciences, Carnegie Mellon University & Carnegie Corp.
2015-	Elected Fellow, American Institute for Medical and Biological Engineering (AIMBE)
2015	Elected Member, Hall of Fame, Henry Samueli School of Engineering, UC Irvine
2013	UC Irvine Distinguished Alumnus Award, Henry Samueli School of Engineering
2012	North American Konkani Association Sammelan, Award of Excellence in Research
2010	Stanford University Postdoctoral Mentoring Award
2009-2016	NIH Director's Pioneer Award
2009-2012	NIH EUREKA Award
2008-2011	Charles Lee Powell Faculty Scholar, School of Engineering, Stanford University
2007-2009	McKnight Technological Innovations in Neurosciences Award
2002-2004	Alfred P. Sloan Research Fellow
2001-2008	Robert N. Noyce Faculty Scholar & William George Hoover Faculty Scholar, SOE, Stanford
2006-	Elected Senior Member, Institute of Electrical and Electronics Engineers
1999-2004	Burroughs Wellcome Fund Career Award in Biomedical Sciences
1996-1999	F32 Postdoctoral Fellowship, National Eye Institute, National Institutes of Health

1996 Doctoral Thesis Prize, Fannie and John Hertz Foundation
1995-1996 Alcott Postdoctoral Fellow, Division of Biology, Caltech
1992-1995 Graduate Fellowship, Fannie and John Hertz Foundation
1990-1995 Graduate Research Fellowship, National Science Foundation
1989-1990 Presidential Undergraduate Fellowship & Hembd Memorial Scholarship, UC Irvine

C. Contributions to Science (>140 peer-reviewed journal papers)

1. The role of primary motor (M1) and premotor (PMd) cortex is still poorly understood and quite debated. Reasons for this center on the large variety of single-neuron responses making it possible for individual cells to be interpreted as relating to numerous different movement parameters. Motor cortex has been studied in this way for decades due to the paradigm setting way in which primary visual cortex represents parameters of the outside world. But motor cortex need not represent anything in particular; rather, it must generate movement to allow the organism to survive and thrive. Creating new theories, experiments and computational methods for understanding large (electrode array) datasets is a core focus of our basic neuroscience research. It leads to a so-called "dynamical systems perspective" with fundamental implications beyond the motor system. We have reported evidence of a simple, yet powerful, dynamical system in motor cortex which also involves other cortical and subcortical areas. Four papers include:

1. Pandarinath C, O'Shea DJ, Collins J, Jozefowicz R, Stavisky SD, Kao JC, Trautmann EM, Kaufman MT, Ryu SI, Hochberg LR, Henderson JM, **Shenoy KV**, Abbott LF, Sussillo D (2018) Inferring single-trial neural population dynamics using sequential auto-encoders. *Nature Methods.* 15:805-815.
2. Sussillo D, Churchland MM, Kaufman MT, **Shenoy KV** (2015) A neural network that finds a naturalistic solution for the production of muscle activity. *Nature Neuroscience*. 18:1025-1033. PMCID:PMC 5113297.
3. Churchland MM*, Cunningham JP*, Kaufman MT, Foster JD, Nuyujukian P, Ryu SI, **Shenoy KV** (2012) Neural population dynamics during reaching. *Nature*. 487:51-56.
4. Churchland MM*, Yu BM*, …, Newsome WT, …, Movshon JA, …, Moore T, …, Snyder LH, Lisberger SG, Priebe NJ, Finn IM, Ferster D, Ryu SI, Santhanam G, Sahani M, **Shenoy KV** (2010) Stimulus onset quenches neural variability: a widespread cortical phenomenon. *Nature Neurosci.* 13:369-378.

2. We also ask how it is possible for a population of neurons, many of which project directly to the spinal cord and on to muscles, can be highly active without causing movement and, more generally, how one brain area can selectively and dynamically communicate with another area. This question arises naturally since preparatory activity (preceding movement) in premotor and motor cortex exists without generating movement. Having not found the prevailing postulate that cortical interneurons gate these signals such that they do not reach the muscles, we hypothesized that population preparatory activity may have certain patterns thereby preventing movement initiation. In linear algebra terminology, the neural activity resides in certain "null space" dimensions while preparing a movement, and then evolves into other activity patterns in a precise manner thereby entering dimensions "potent space" dimensions for generating movement. We found evidence that this mechanism is in operation, and that it can also account for flexible communication between cortical areas. The same mechanism appears to also be in operation during feedback control. Four papers include:

1. Vyas S, Golub MD, Sussillo D, **Shenoy KV** (2020) Computation through neural population dynamics. *Annual Review of Neuroscience.* 43:249–275.
2. Williams AH, Kim TH, Wang F, Vyas S, Ryu SI, **Shenoy KV**, Schnitzer M, Kolda TG, Ganguli S (2018) Unsupervised discovery of demixed, low-dimensional neural dynamics across multiple timescales through tensor components analysis. *Neuron.* 98:1-17. PMCID: PMC 6907734
3. Stavisky SD, Kao JC, Ryu SI, **Shenoy KV** (2017) Motor cortical visuomotor feedback activity is initially isolated from downstream targets in output-null neural state space dimensions. *Neuron.* 95:195-208. PMCID: PMC6907734.
4. Kaufman MT, Churchland MM, Ryu SI, **Shenoy KV** (2014) Cortical activity in the null space: permitting preparation without movement. *Nature Neuroscience*. 17:440-448.

3. In order to understand the role of arm-movement preparatory activity in relation to arm-movement generation activity we have necessarily focused on the so-called "instructed delayed-reach behavioral paradigm". This has led to insights regarding the interpretation of preparatory population neural activity as reflecting the initial state of a dynamical system, and the resulting evolution of this dynamical system (instantiated in neural circuits) resulting in movement population neural activity. We have also reported moving beyond this task to other behavioral paradigms – including movements without a delay period, movements redirected to new (hopped) reach targets mid-reach, and during visual-motor learning and curl field learning – thereby putting our theories and predictions to direct experimental test in more generalized behaviors. We found that our theories held up end we discovered entirely new neural population features that further advanced the theory. Four papers include:

1. Vyas S, O'Shea DJ, Ryu SI, **Shenoy KV** (2020) Causal role of motor preparation during error-driven learning. *Neuron.* 106:329-339.
2. Ames KC, Ryu SI, **Shenoy KV** (2019) Simultaneous movement preparation and execution in a last-moment reach correction task. *Nature Communications.* 10:2718.
3. Vyas S, Even-Chen N, Stavisky SD, Ryu SI, Nuyujukian P, **Shenoy KV** (2018) Neural population dynamics underlying motor learning transfer. *Neuron.* 97: 1-10.
4. Sun X*, O'Shea DJ*, Golub MD, Trautmann EM, Vyas S, Ryu SI, **Shenoy KV** (2022) Cortical preparatory activity indexes learned motor memories. *Nature.* 602:274-279.

4. In collaboration with Prof. Bill Newsome, we have been investigating the dynamical systems perspective (that we designed and developed with the motor system), to help reveal lawful neural population behavior from prefrontal and premotor cortical activity during sensory-integration decision tasks. We saw a wonderful intellectual intersection where Bill's group was seeing the same sort of highly heterogeneous, complex single-neuron responses in prefrontal cortex that we see in motor cortex. Our approach to this problem has been to understand the dynamical structure of the neural population activity, through specific dimensionality-reduction and state-space approaches combined with recurrent neural network (RNN) modeling so that we can analytically understand the brain's solution. We discovered a new mechanism for how prefrontal cortex may select and integrate sensory information, which opens up new avenues of investigation in this area of neuroscience and in decision making, including in motor cortex. Four example papers include:

1. Peixoto D*, Verhein JR*, Kiani R, Kao JC, Nuyujukian P, Chandrasekaran C, Brown J, Fong S, Ryu SI, **Shenoy KV**, Newsome WT (2021) Decoding and perturbing decision states in real time. *Nature.* 589:1-7.
2. Chandrasekaran C, Peixoto D, Newsome WT, **Shenoy KV** (2017) Laminar differences in decision-related neural activity in dorsal premotor cortex. *Nature Communications*. 8:614.
3. Mante V*, Sussillo D*, **Shenoy KV**, Newsome WT (2013) Selective integration of sensory evidence by recurrent dynamics in prefrontal cortex. *Nature.* 503:78-84.
4. **Shenoy KV**, Sahani M, Churchland MM (2013) Cortical control of arm movements: A dynamical systems perspective. *Annual Review of Neuroscience.* 36:337-359.

5. The final focus area is applied neuroscience and neurotechnology. Regarding optogenetics and optical imaging, in this collaborative research with Karl Deisseroth's group, we were among the first to design and demonstrate a set of optogenetic constructs that work in rhesus and squirrel monkeys thereby opening up many new scientific lines of investigation. More recently, we have been developing 2-photon GCaMP-based optical imaging of single-cell resolution neural activity, and later recovering neuroanatomy via CLARITY, in rhesus making arm movements which is quite challenging (but achievable) to maintaining stable.

In our BMI research, in both monkeys and in clinical trials with people with tetraplegia, we have focused on high-performance and high-robustness control of computer cursors to restore lost communication channels (#1 below). Most recently we discovered speech-related single-neuron resolution signals in human motor cortex (#2 below), discovered a new 'compositional' organization in human premotor and motor cortex (#3 below) and designed a very high-performance handwriting-based BCI (#4 below). We were also the first to use NeuroPixel electrode arrays in rhesus (Shenoy, Moore, Shadlen, Tsao, HHMI-IMEC effort). Also see Completed Projects. Four papers include:

1. Sylwestrak EL*, Jo Y*, Vesuna S*, Wang X, Holcomb B, Tien RH, Kim DK, Fenno L, Ramakrishnan C, Allen WE, Chen R, **Shenoy KV**, Sussillo D, Deisseroth K (2022) Cell-type-specific population dynamics of diverse reward computations. *Cell.* 185:3568-3587.
2. Pandarinath C*, Nuyujukian P*, Blabe CH, Sorice B, Saab J, Willett F, Hochberg LR, **Shenoy KV****, Henderson JM** (2017) High performance communication by people with paralysis using an intracortical brain-computer interface. *eLife*. 6:e18554
3. Stavisky SD, Willett FR, Wilson GH, Murphy BA, Rezaii P, Avansino D, Memberg WD, Miller JP, Kirsch RF, Hochberg LR, Ajiboye AB, Druckmann S, **Shenoy KV****, Henderson JM** (2019) Neural ensemble dynamics in dorsal motor cortex during speech in people with paralysis. *eLife*. 8:e46015
4. Willett FR*, Deo DR*, Avansino DT, Rezaii P, Hochberg LR, Henderson JM**, **Shenoy KV**** (2020) Hand knob area of premotor cortex represents the whole body in a compositional way. *Cell*. 181:396–409. PMCID: PMC7166199.
5. Willett FR, Avansino DT, Hochberg LR, Henderson JM**, **Shenoy KV**** (2021) High-performance brain-to-text communication via imagined handwriting. *Nature*. 593:249-254. PMCID: PMC8163299.