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Deutsches Primatenzentrum
Leibniz-Institut für Primatenforschung

Hierarchical organization of rhesus macaque behavior

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Neurobiology Lab Journal Club
Presented by: James Goodman
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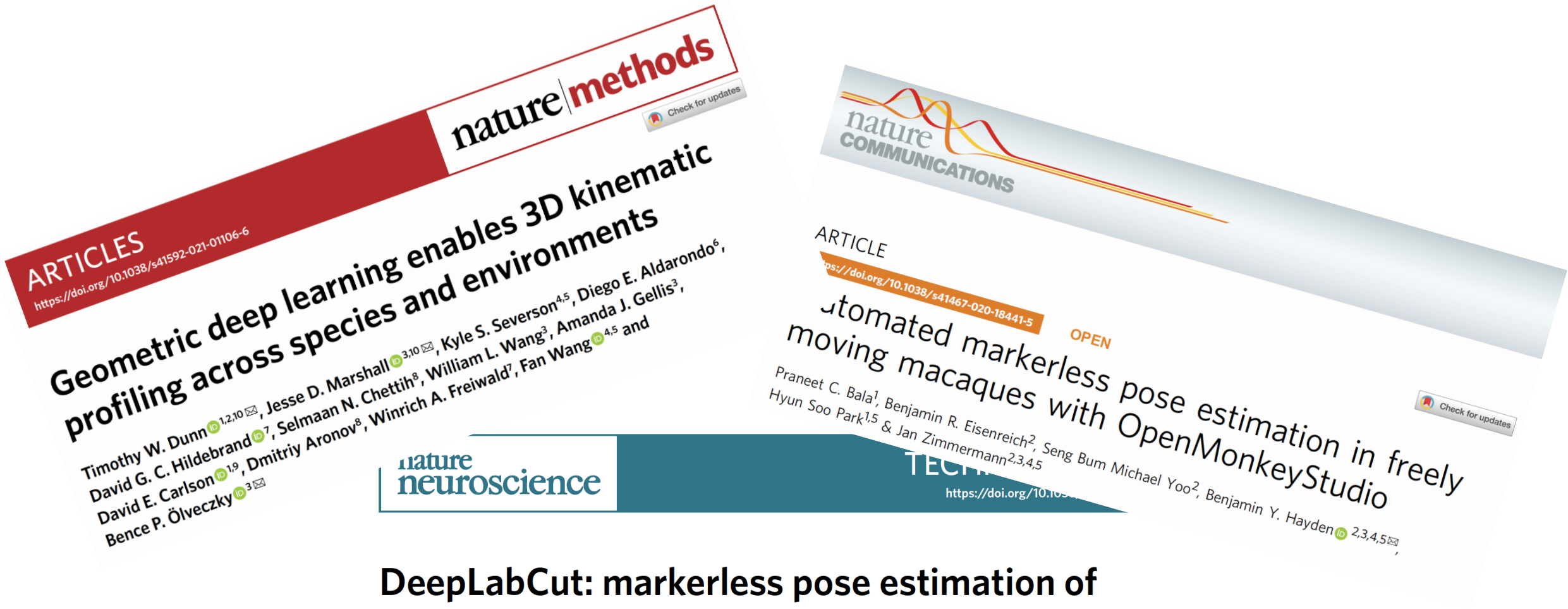
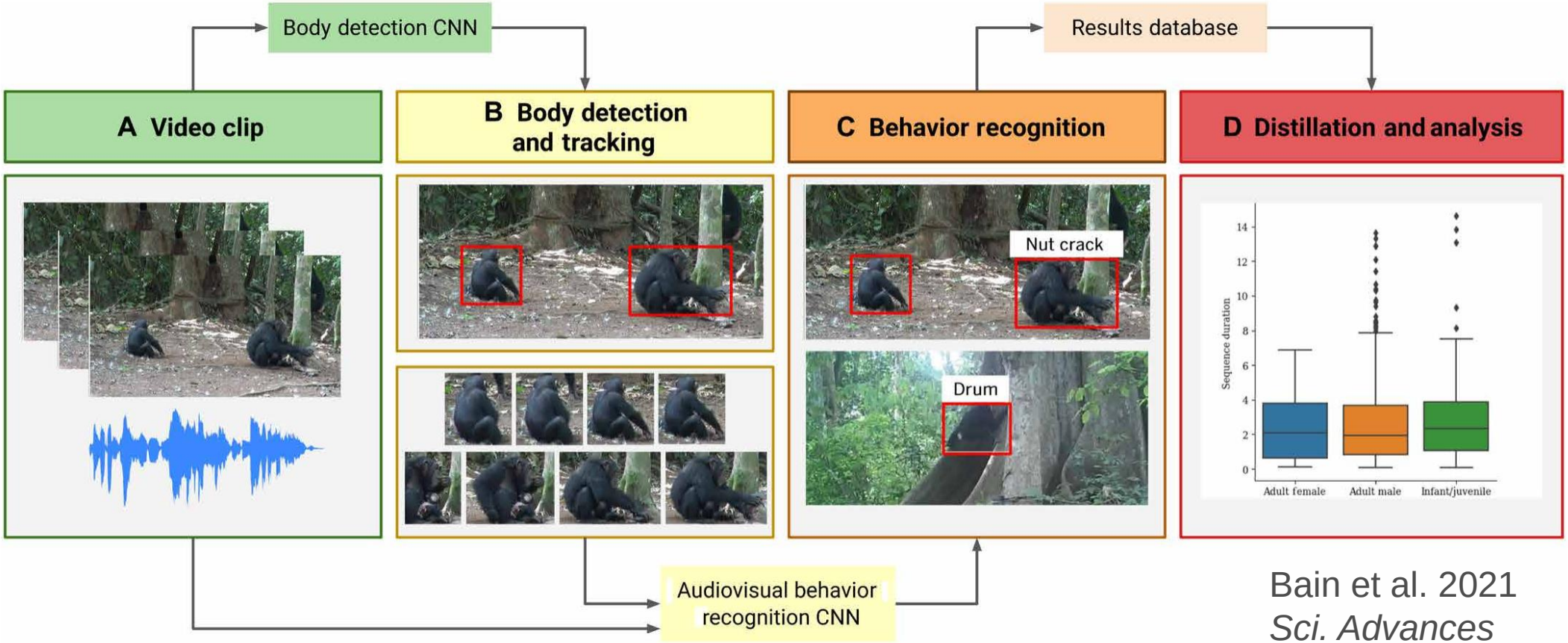
Optical Motion Tracking is Booming



DeepLabCut: markerless pose estimation of user-defined body parts with deep learning

Alexander Mathis[1,2], Pranav Mamidanna[1], Kevin M. Cury[3], Taiga Abe[3], Venkatesh N. Murthy[2], Mackenzie Weygandt Mathis[1,4,8*] and Matthias Bethge[1,5,6,7,8]

Toward the Automated Primate Ethogram (APE)

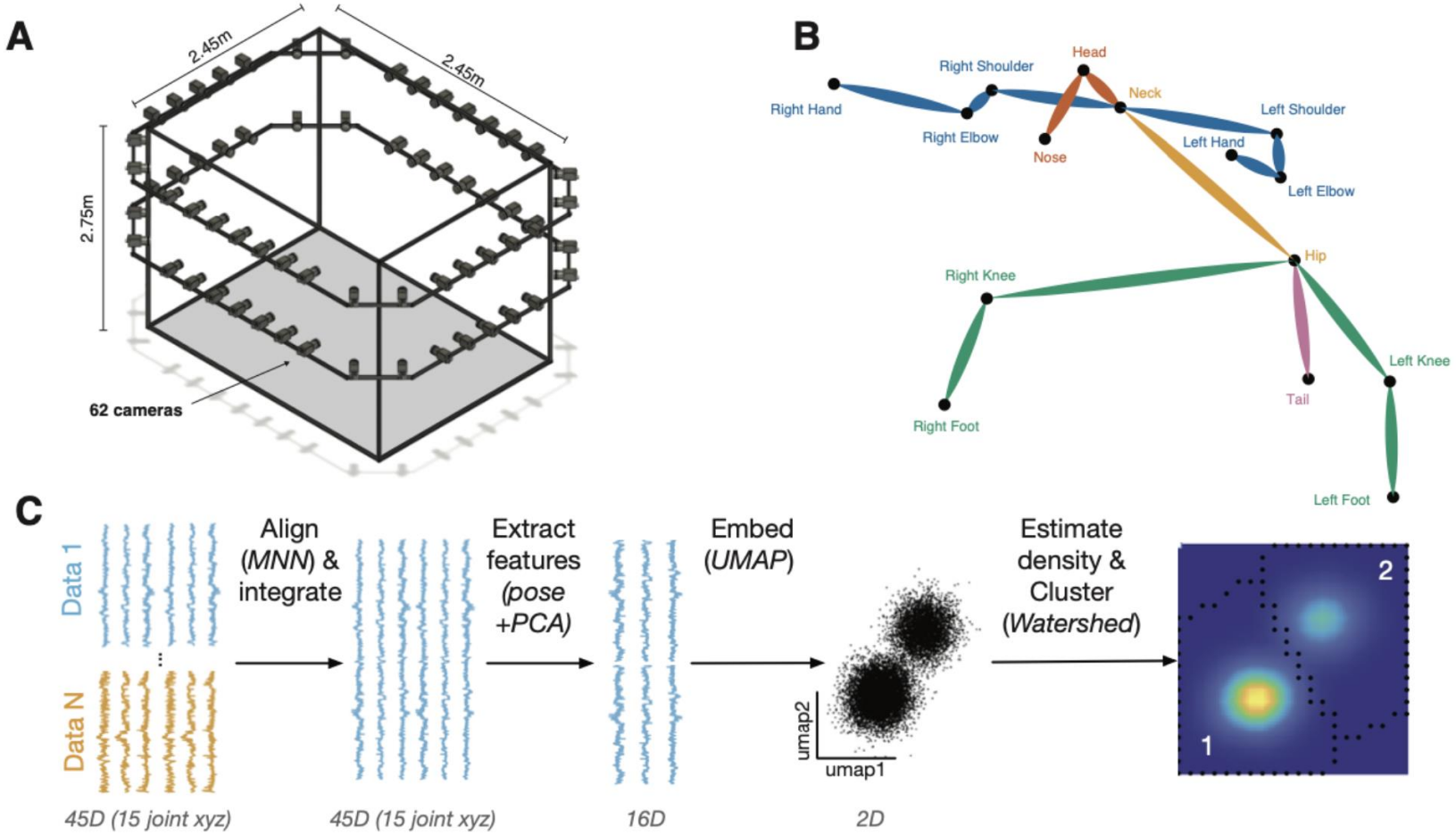


Bain et al. 2021
Sci. Advances

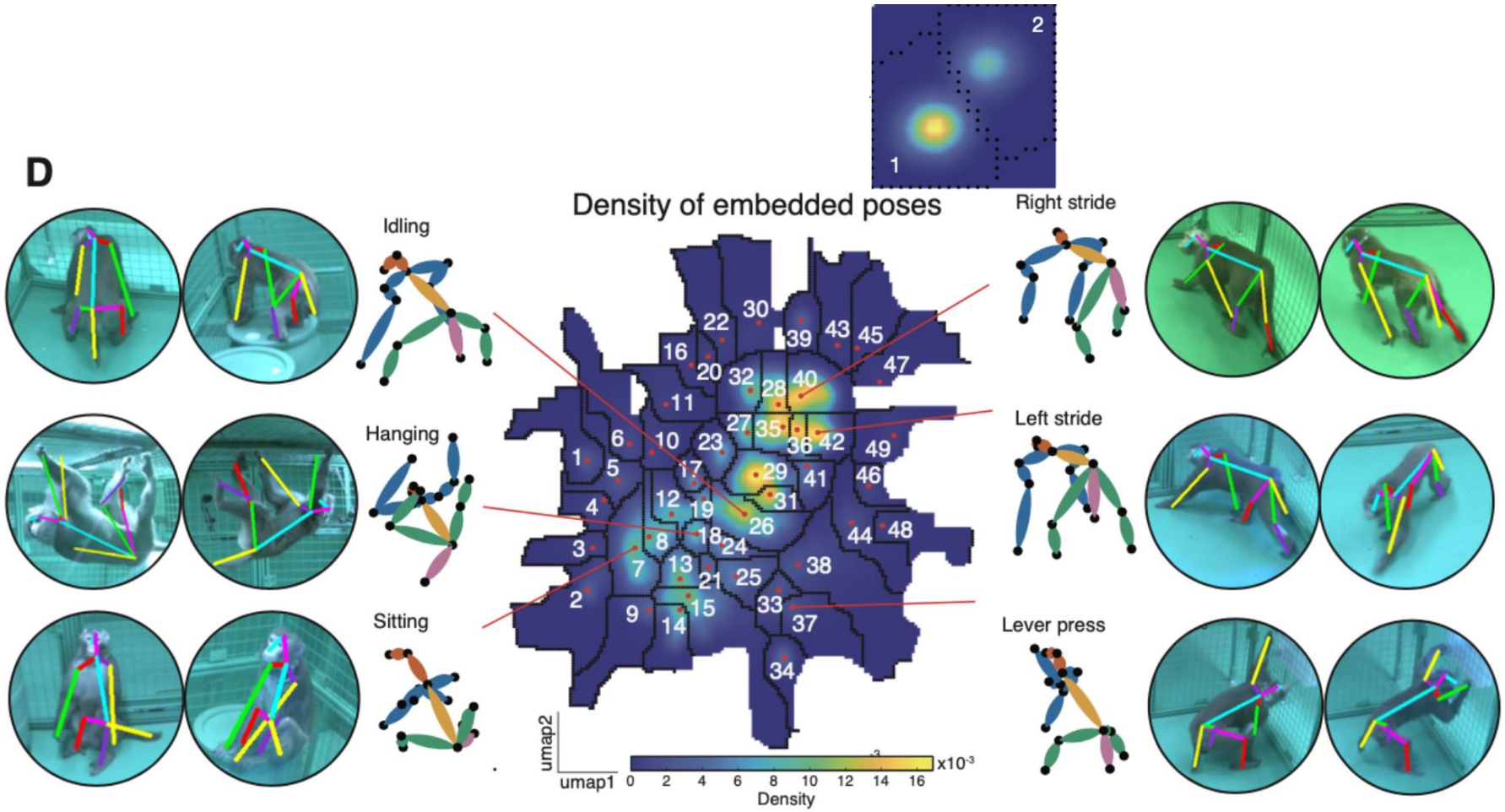
What do we hope to learn about?

- An update on a very cool whole-body primate motion tracking platform
- A deep dive into an unsupervised clustering framework for behavioral analysis
- Within this framework, how many distinct behaviors are there?
  - A lower bound on the number of contexts a primate brain must flexibly manage?
  - Contrast with frameworks where behavior is traversal of a continuum

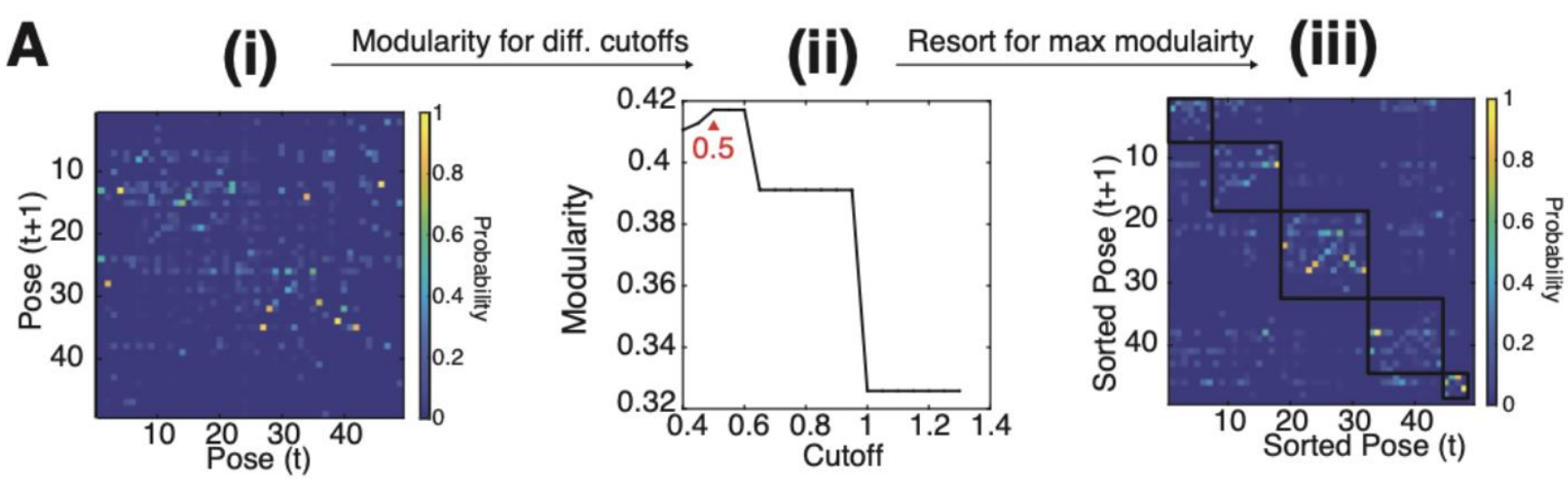
Tracking and Data Processing Methods

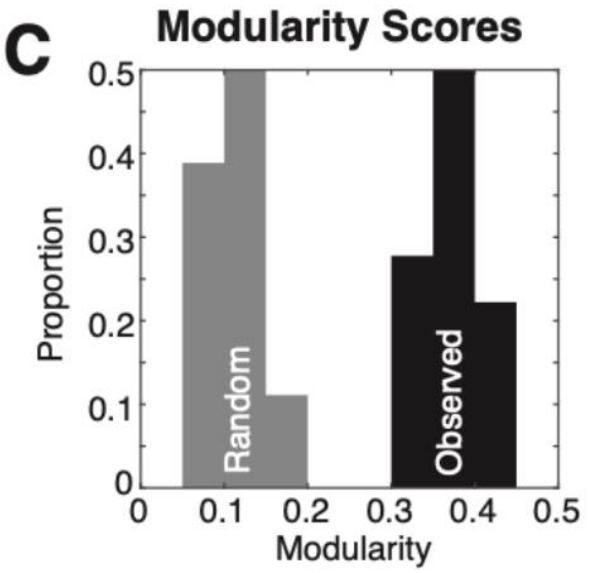


Watershed algorithm reveals 49 distinct postures



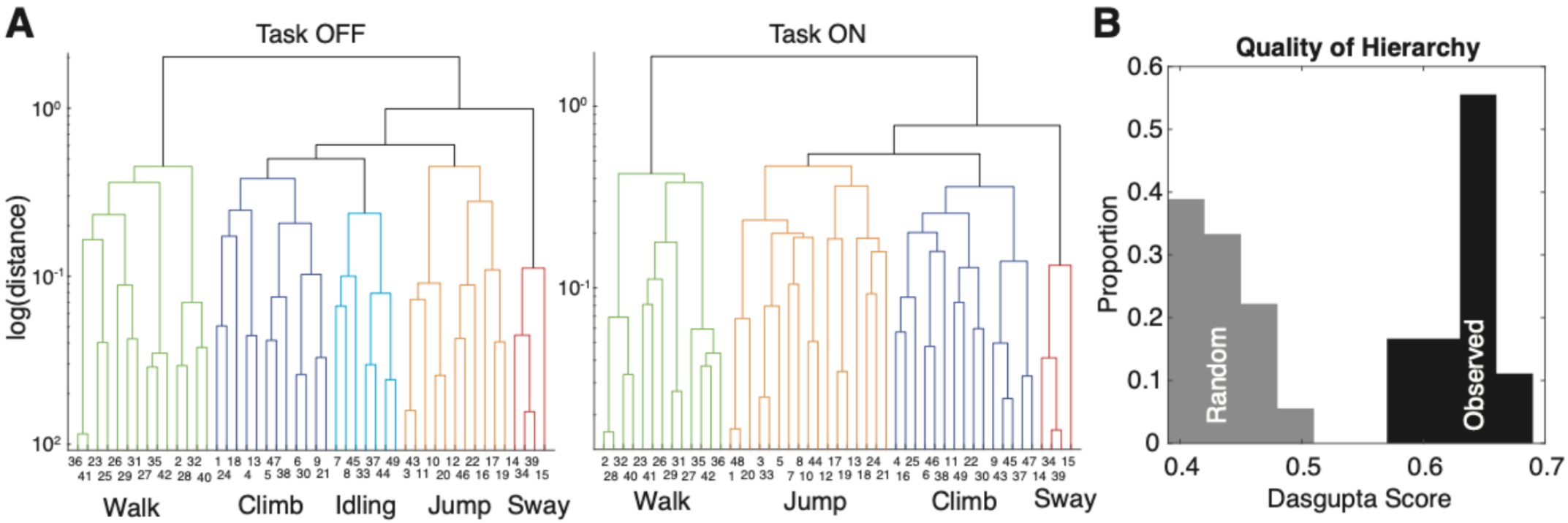
These postures show modular organization in their transitions



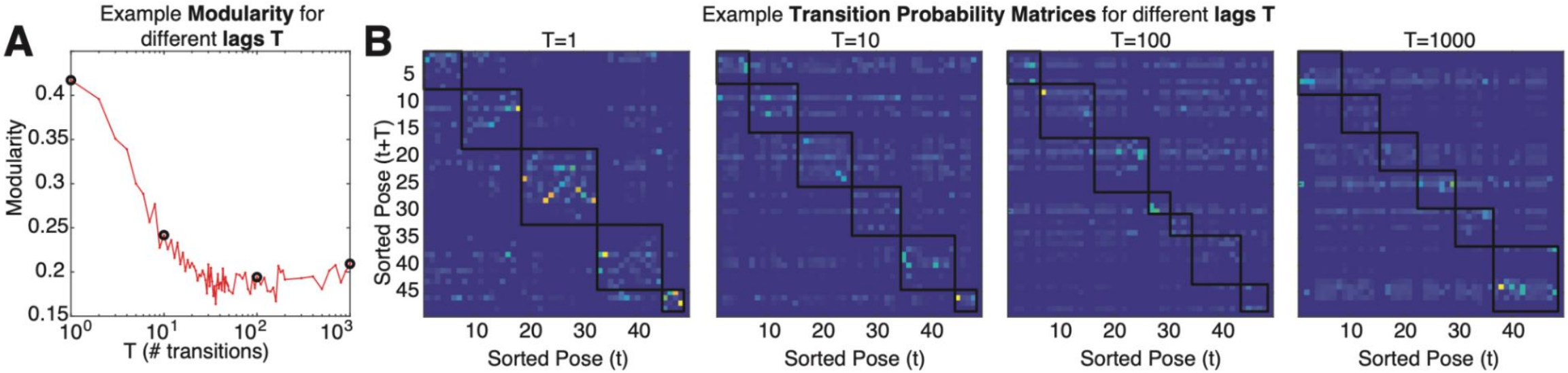


Modules correspond to intuitive semantic groups

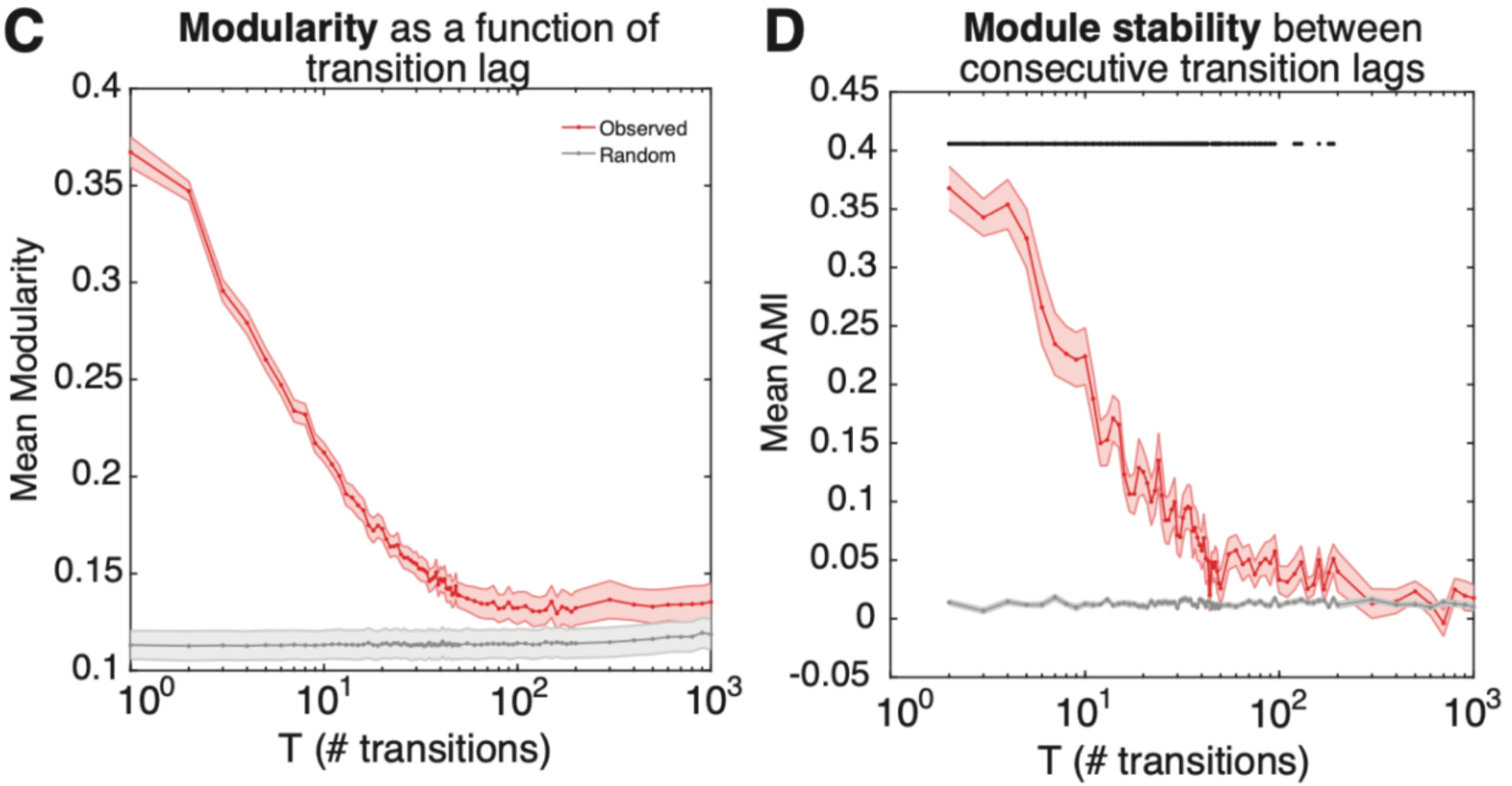
Postural modules are further hierarchically organized in their transitions



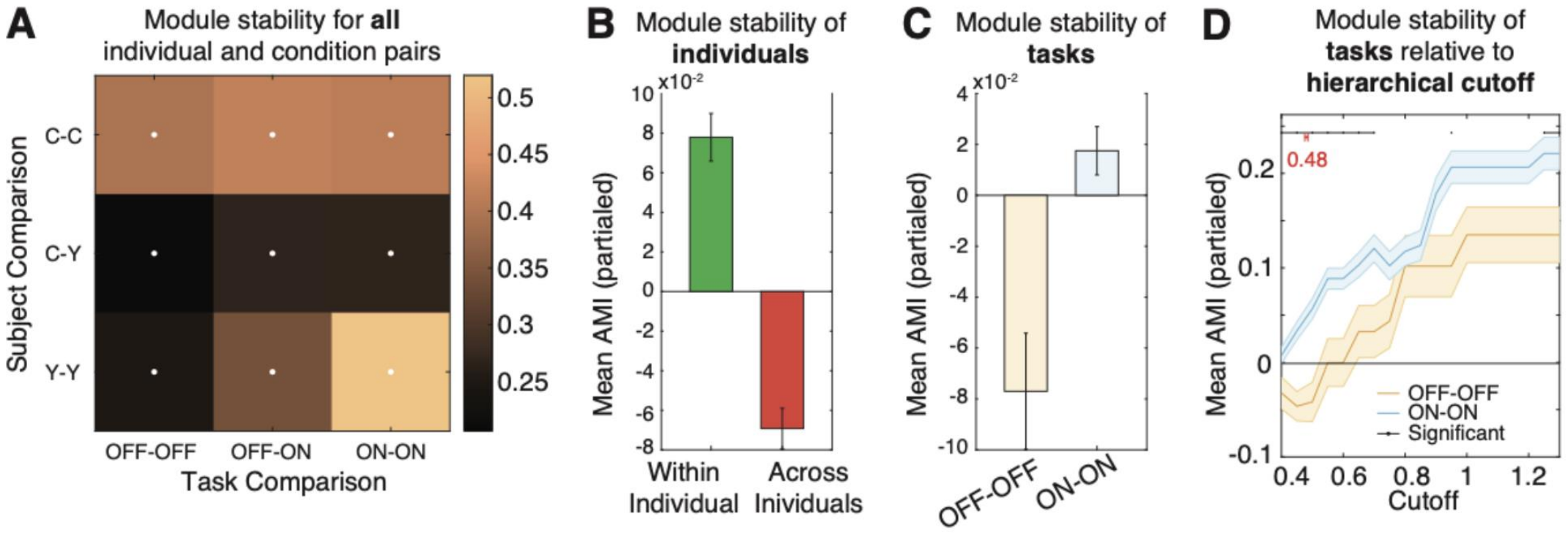
Postural clusters are stable over multiple values of a transition lag parameter



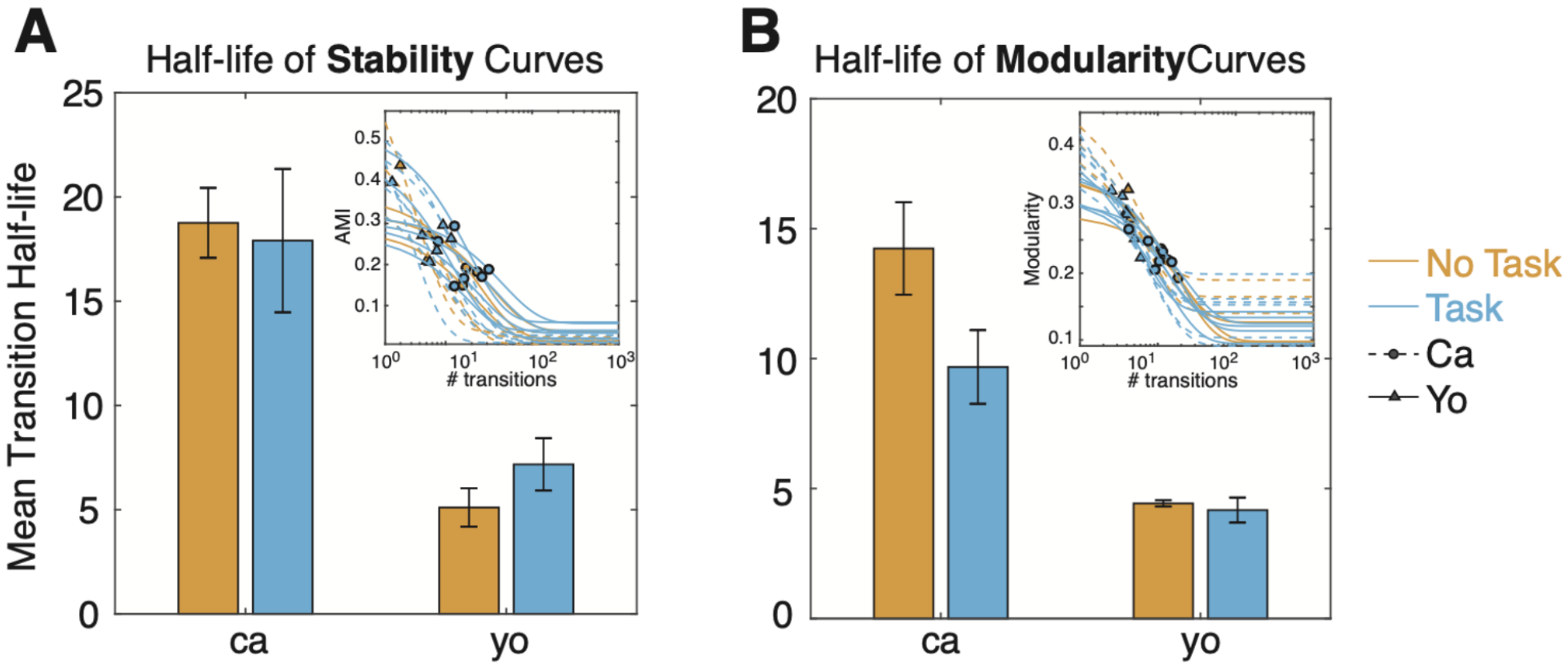
Postural clusters persist even when considering long (>3s) transition periods



Behavioral modularity is partially subject- and task-specific



Subject-, but not task-, specific differences in terms of fundamental timescale of transitions



Discussion points

- Our method is pretty cool (and it is!)
- Individual- and task-specific effects
- Specifications of our model that we think are important
  - We use kinematic information on the timescale of poses and postures
  - We perform clustering on the basis of Markovian state (posture) transitions
  - We use a totally unsupervised method, although supervised methods could wrangle the data to better fit priors
- Environmental demands (i.e., specific tasks) give rise to behavioral stabilization
  - Perhaps fewer actions are present in the repertoire under pressure
  - Perhaps there is just less variability within those action clusters
- Automated ethogramming would be pretty rad

Compare and contrast with continuous framework

- Both involve low-dimensional manifolds
- In this paper & the practice of ethogramming, one seeks behavioral "modules"
- In "synergies" framework, behaviors define a continuum without hard boundaries
  - Think Napier's observations on power & precision grips, the proto-synergies
  - Within these broader categories, there was a continuum of aperture sizes
  - There were also tasks such as rope tying with hybrid power-precision grips
- Grand unified hierarchical framework?
  - At coarse resolution, behavior is modular
  - At a fine enough resolution, behavior spans a continuum
  - Perhaps a similar reckoning to be had between "flexible" vs. "rule-based" motor learning

Forget frameworks, what did we learn about behavior *per se*?

- Not a lot, frankly
  - That there's individual variation? Yeah, of course there is.
  - That "context constrains behavioral expressivity"? Yes, there are stereotyped behaviors.
  - That there are 49 fundamental postures? I don't think anyone would buy that, not even the authors. It all depends on the level of granularity one deems useful!
- The "findings" are simply not all that surprising
- But that's kind of the point
- To sell an automated behavioral analysis framework, you need to re-demonstrate your ground truth

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End

Questions?

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