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Measuring Irregularity Via Approximate Entropy: How Does Perceived Human Instability Affect One's Own Stability?

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Research Questions and Implications

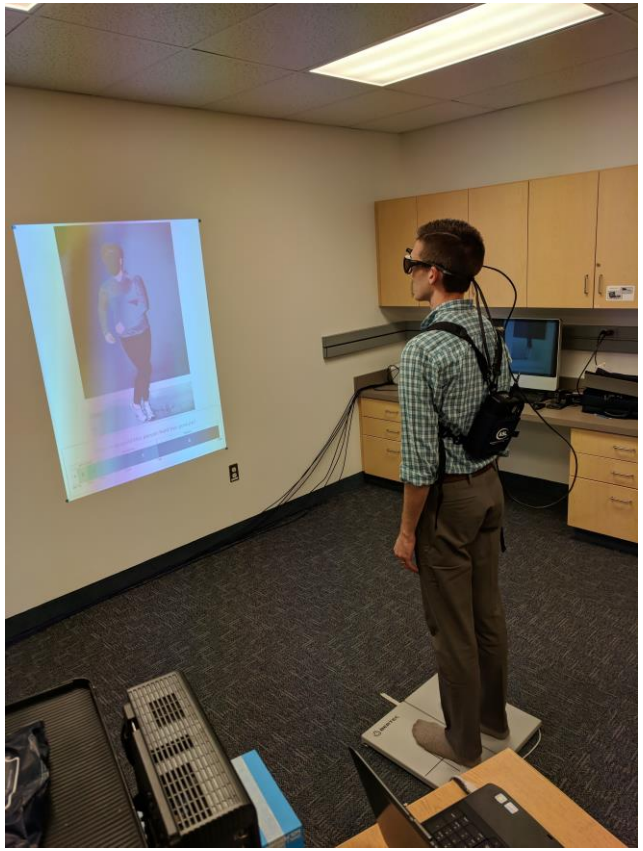
Can external factors affect an individual's stability?

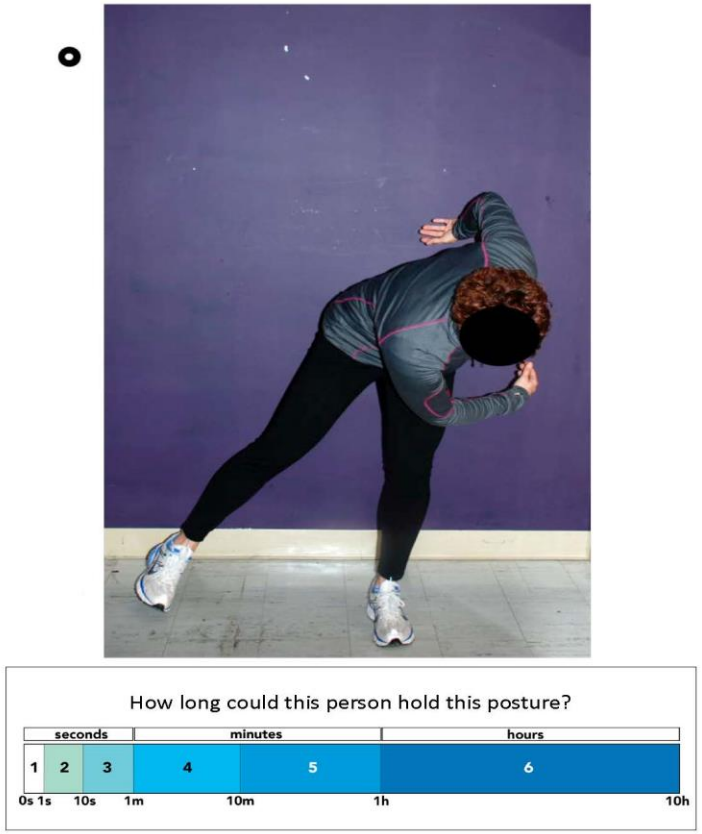
How do we measure irregularity in human movement?

<u>Implications:</u>

Project Overview

USU Human Posture Study





52 participants

Viewed 25 postures

Previous work focused on eye-tracking data

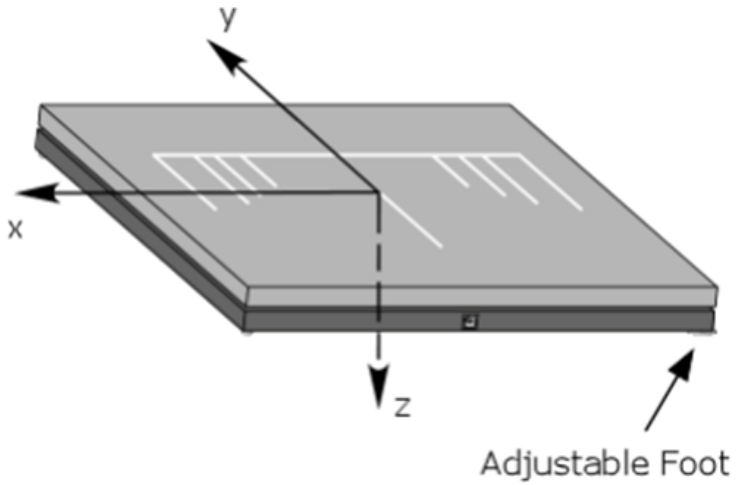
My focus is on force plate data

Coltrin, J., McKinney, E., Studenka, B., & Symanzik, J. (2020). Defining Areas of Interest for Eye-Tracking Data: Implementing a Systematic Approach. In: 2020 JSM Proceedings. American Statistical Association, Alexandria, VA, 1144–1153.

Force Plate

Two force plate readings per subject:

- Calibration
- Judging Process



Produces a large amount of data

Center of Pressure, Force, Moment (rotations)

Pincus, S.M. (1991). Approximate Entropy as a Measure of System Complexity, Proc. Natl. Acad. Sci. USA 88(6), 2297–2301.

Methods

Approximate Entropy (ApEn)

Measure of irregularity

- Time series statistic
- Value between 0 and 1

Research suggests is has applications in measuring stability

- Ex: Athletes recovering from concussions

Pincus, S.M. (1991). Approximate Entropy as a Measure of System Complexity, Proc. Natl. Acad. Sci. USA 88(6), 2297–2301.

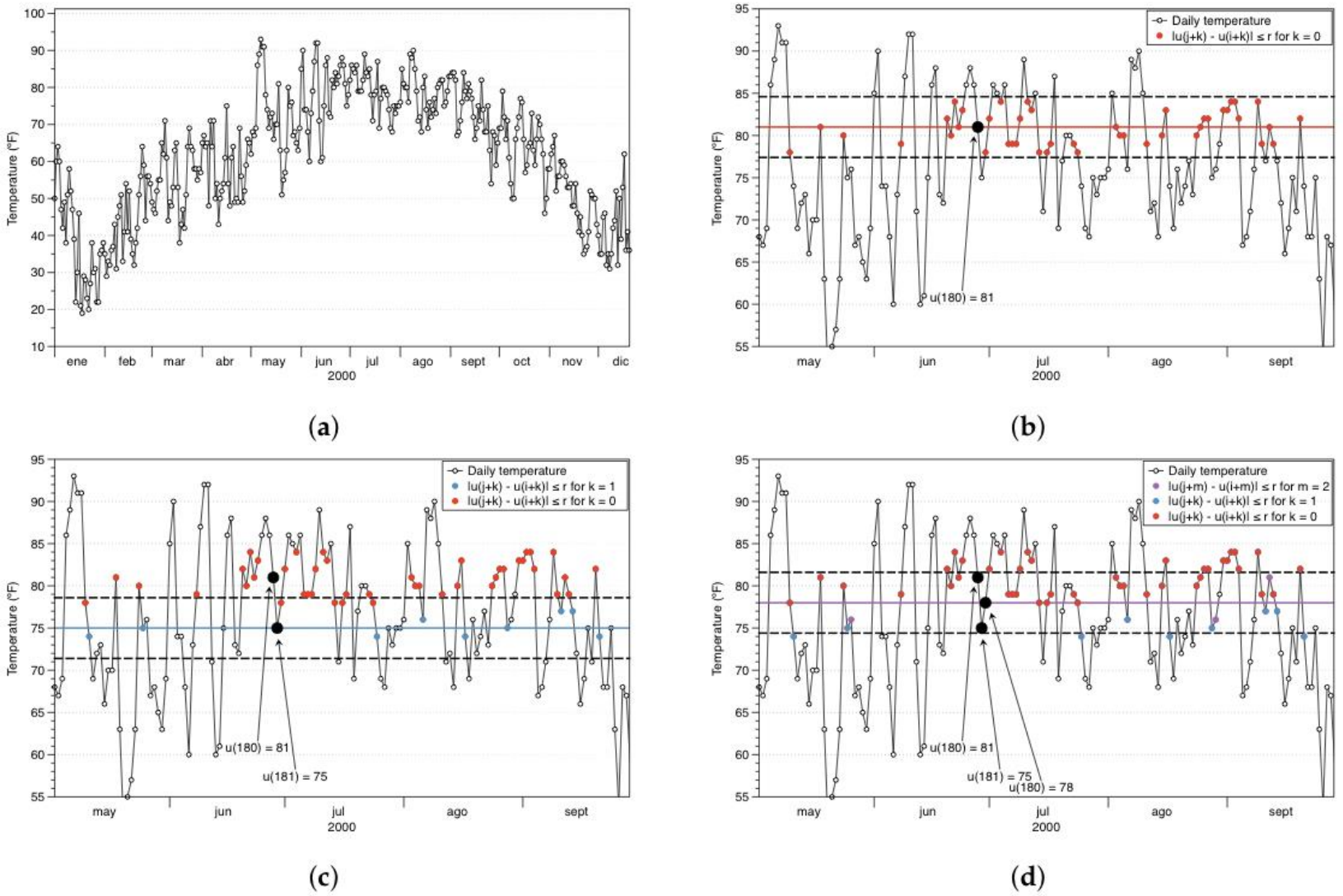
ApEn (Cont.)

m: embedding dimension

r: noise filter

N: length of sequence

Conditional probability = possible matches / confirmed matches



Pincus, S.M. (1991). Approximate Entropy as a Measure of System Complexity, Proc. Natl. Acad. Sci. USA 88(6), 2297–2301.

ApEn (Cont.)

Altogether:

$$ApEn(m, r, N) = -\frac{1}{N-m+1} \sum_{i=1}^{N-m+1} log\, C_i^m(r)$$

FastApEn fuction in R Package TSEntropies

Tomcala, J. (2018). TSEntropies: Time Series Entropies. R package version 0.9.

Optimal Movement Variability (OMV) Theory

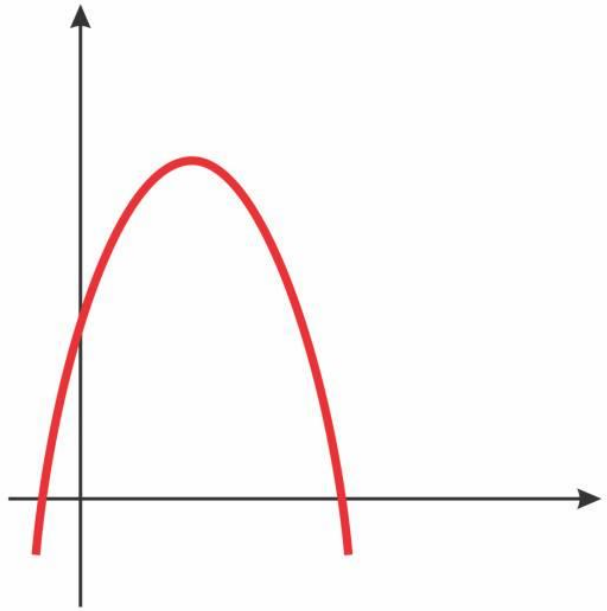
Goldilocks approach

Certain amount of variability maximizes stability

Resembles an inverted “U”

Accounting for OMV

- Compare using initial ApEn



Stergiou, N., & Decker, L. M. (2011). Human Movement Variability, Nonlinear Dynamics, and Pathology: Is There a Connection?. Human Movement Science, 30(5), 869–888.

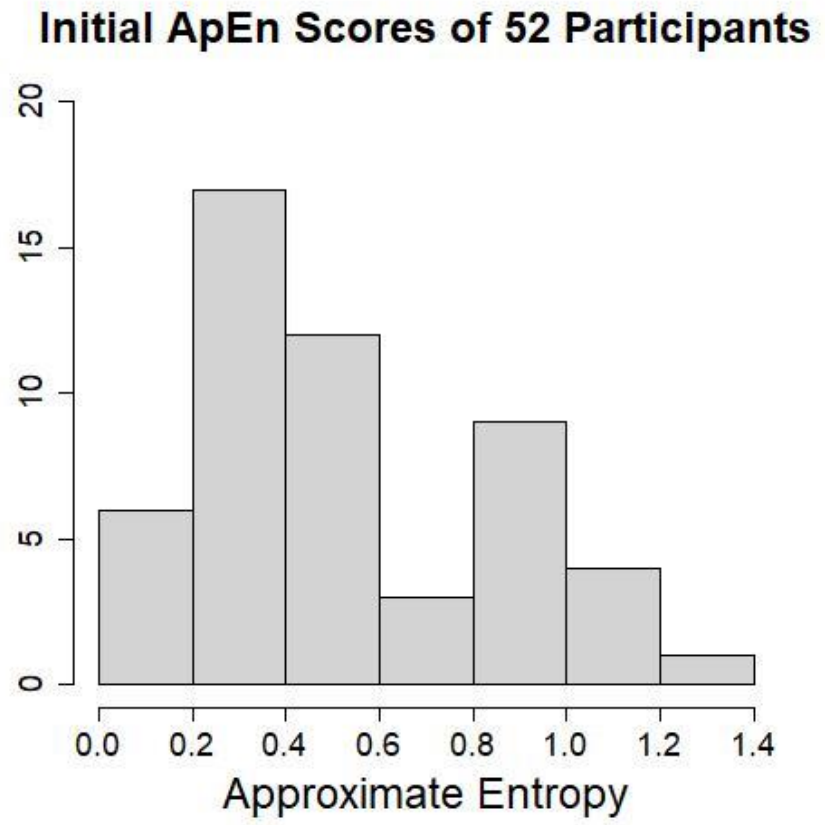
Preliminary Results

Distribution of initial ApEn values

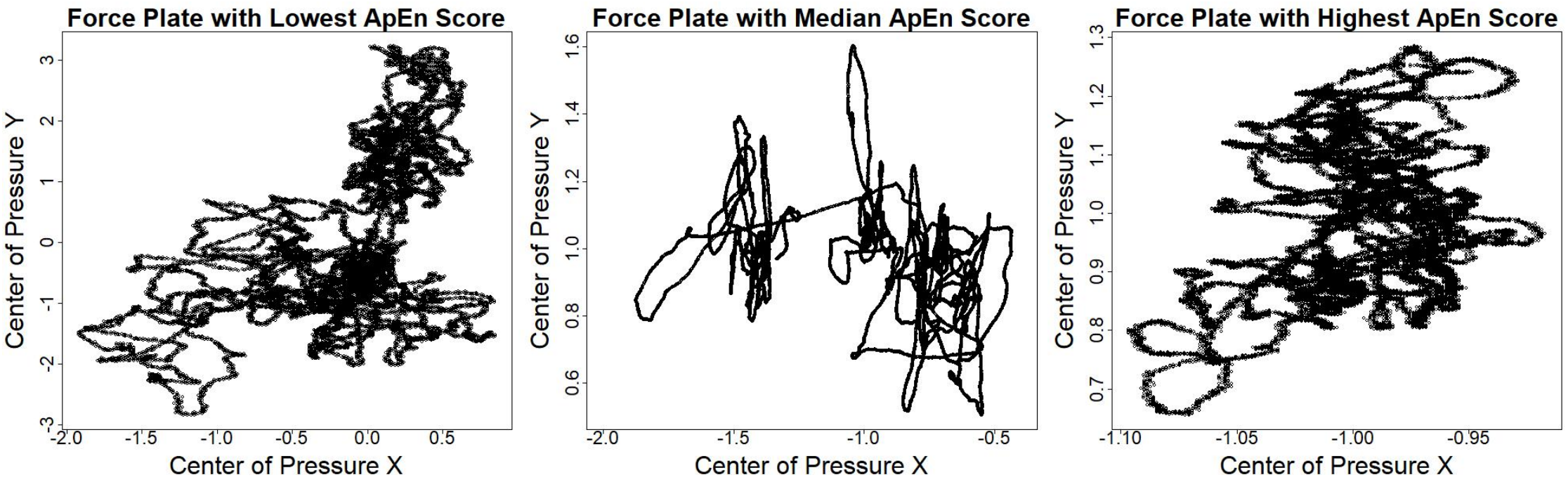
Spans all possible values

Bimodal

Median occurs at .4



Center of Pressure Plots



Plots have ApEn scores of 0.072, 0.410, and 1.245, respectively

Future Work

Next Steps

Transform data:

- Account for biological processes

Analyze force plate data during the judging process:

- Requires much data processing
- Compare ApEn scores at each pictured posture
- Test for significance

Contact Info

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Questions?

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- Lab director: Breanna Studenka

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