Recruitment of Small Synergistic Movement Makes a Good Pianist

Beth Jelfs[1,2] Shengli Zhou[1,2,3] Bernard K.Y. Wong[1]
Chung Tin[2,4] Rosa H.M. Chan[1,2]

[1]Department of Electronic Engineering
City University of Hong Kong

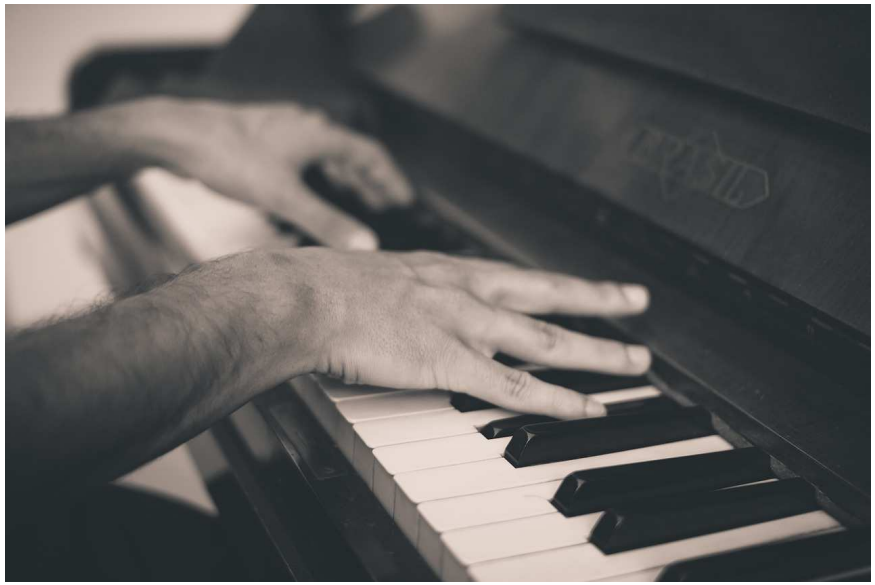
[2]Centre for Biosystems, Neuroscience & Nanotechnology
City University of Hong Kong

[3]School of Astronautics
Northwestern Polytechnical University

[4]Department of Mechanical & Biomedical Engineering
City University of Hong Kong

What Can We Learn From Pianists?

- Interested in coordination
- How does practice manifest in experienced pianists?



What Can We Learn From Pianists?

Are There Differences in How the Fingers Move ...

- Individually? - joints
- Together? - simultaneous movement
- Independently? - sequential movement

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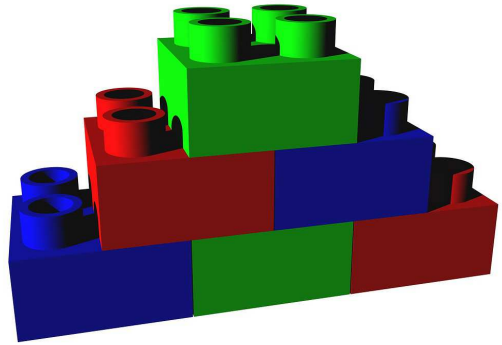
Subjects:

- 5 novices - little or no experience
- 5 experienced - either grade 8 (1-8) or concert level

Movement Synergies

- Fundamental patterns of movement
- Serve as building blocks
- Reduce complexity (degrees of freedom) to be controlled
- Requires few components to explain variance in movement



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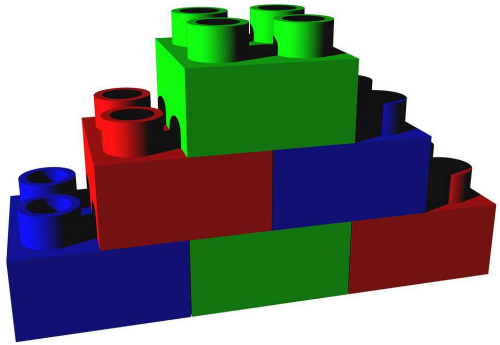
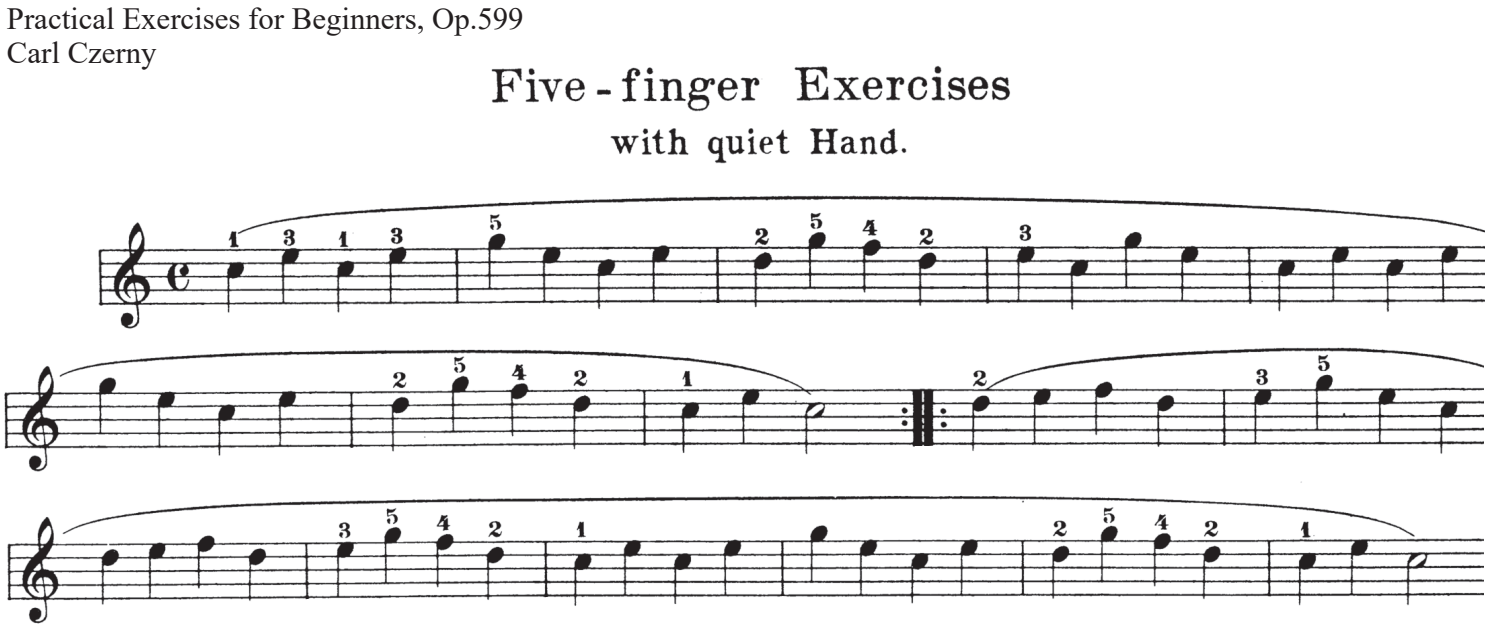


Kinematics

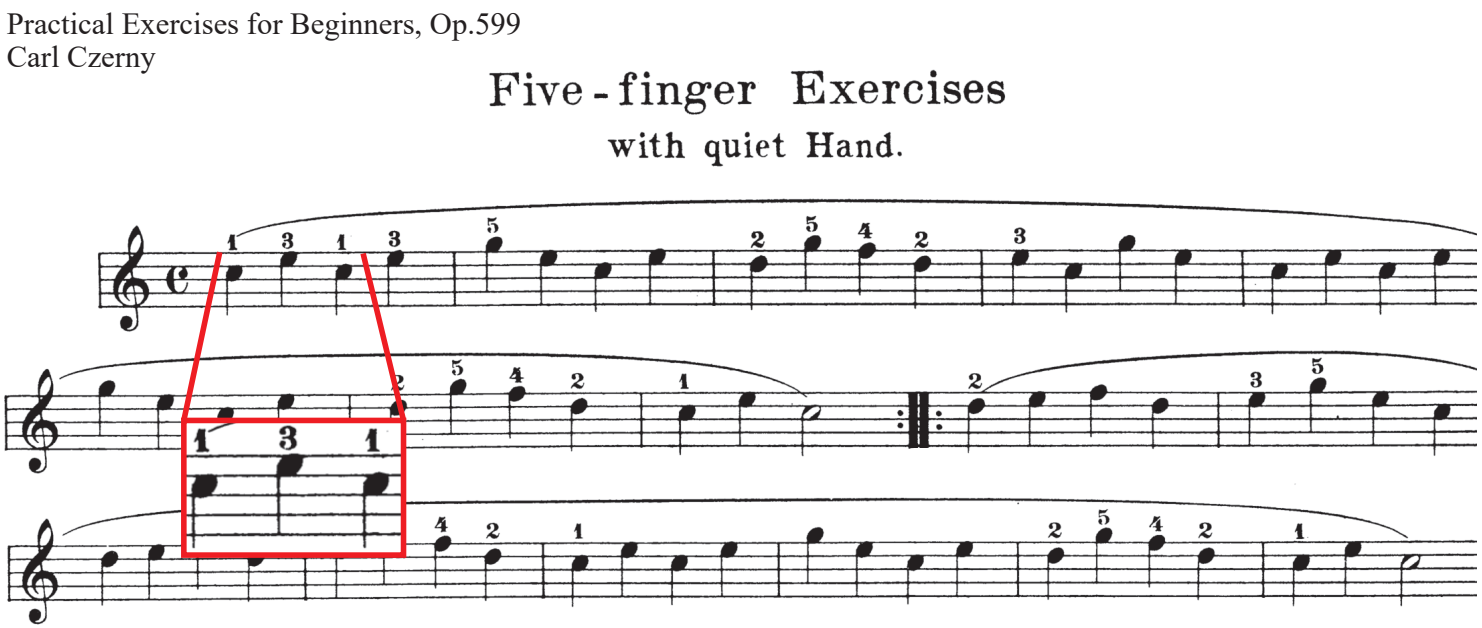
- Movement recorded using data glove
- 14 sensors
  - 2 per finger (MCP, PIP)
  - 4 abduction
- Rate of flexion analyzed

Music



- Taken from Czerny Op. 599 - designed to improve fingering of novice pianists
- Static hand using all 5 fingers

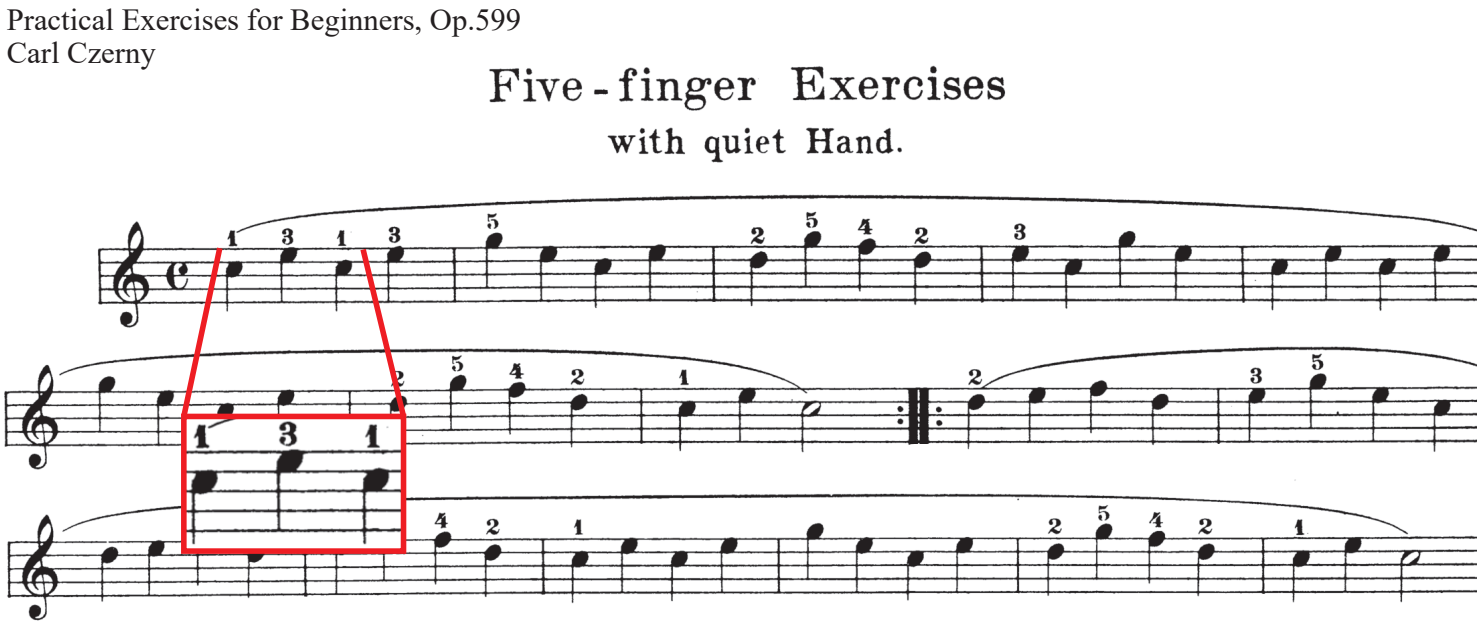
Music



For analysis:

- Select 3 consecutive notes
- Capture transitions before & after the key press of interest

Music



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- Identify finger playing middle note

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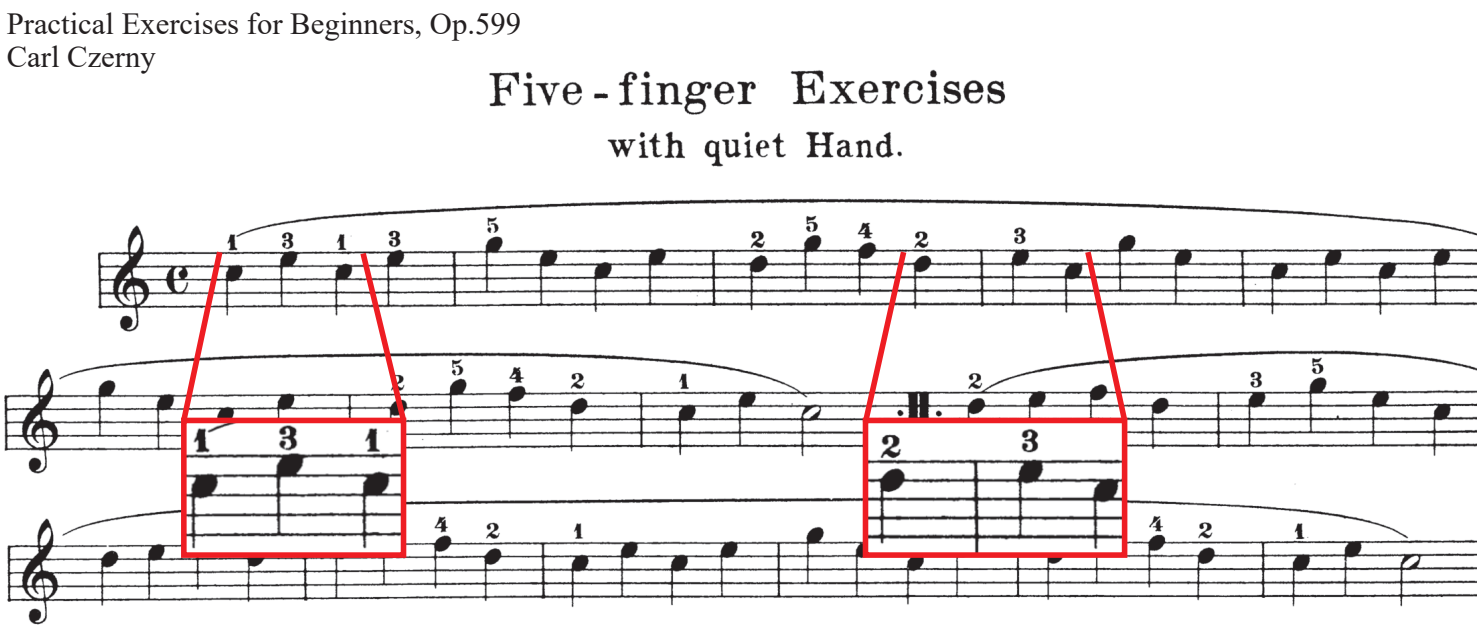

For analysis:

- Select 3 consecutive notes
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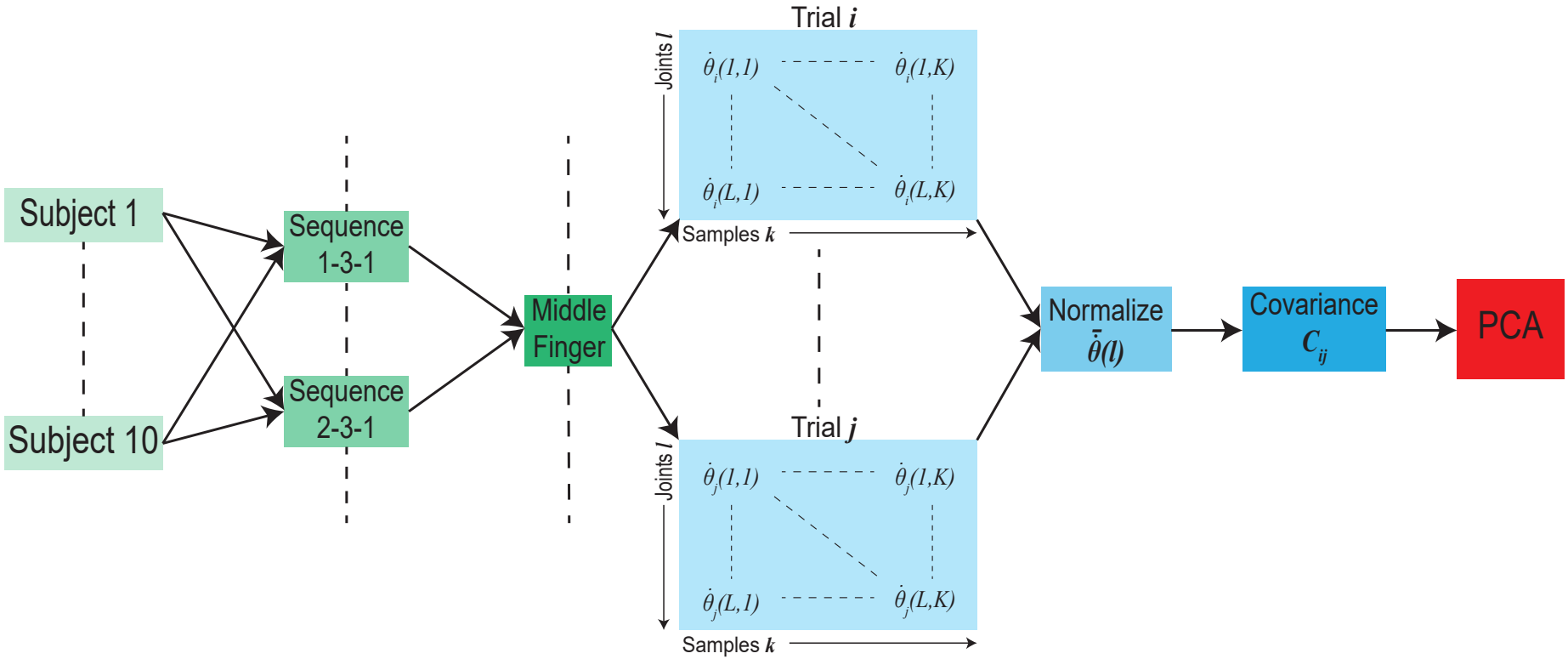
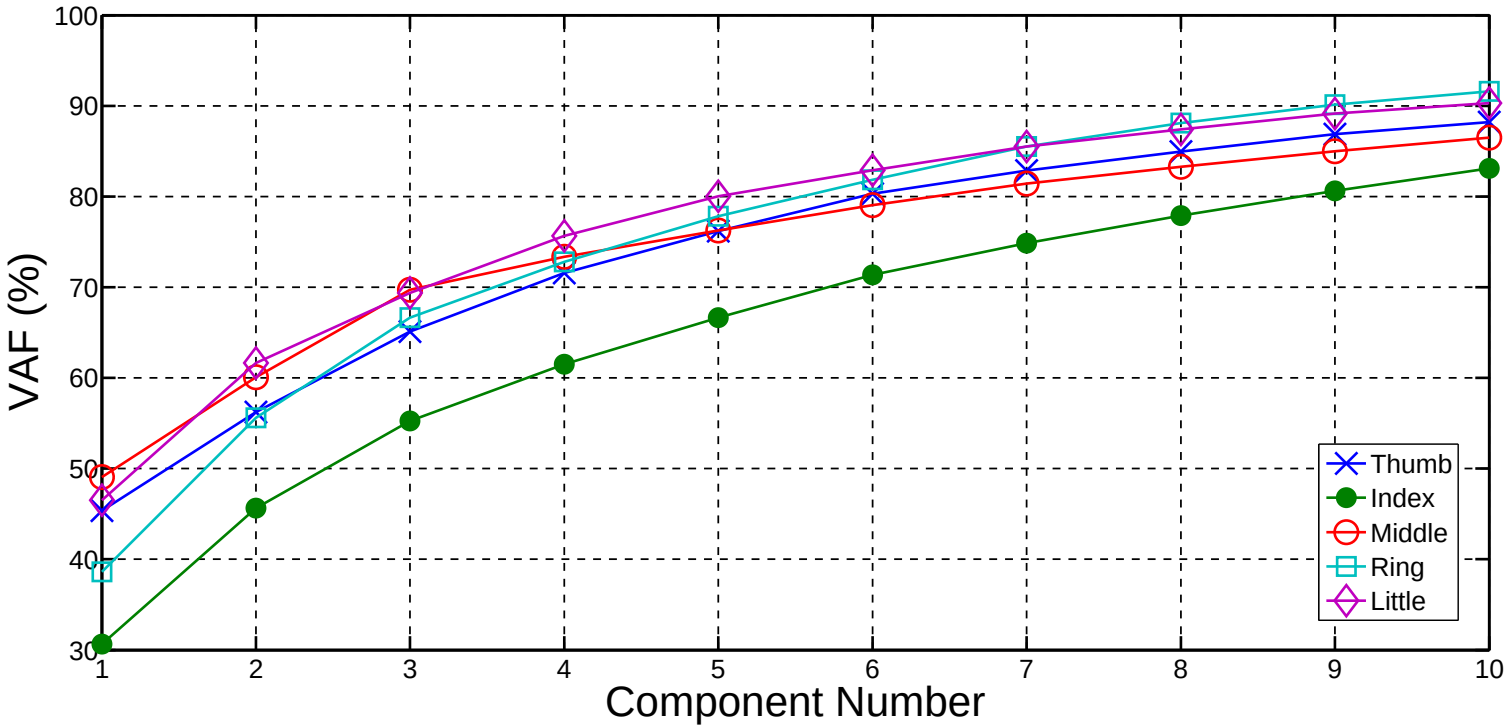
- Identify finger playing middle note
- Group all sets of 3 notes by the finger playing the middle note

Synergy Extraction via Principal Component Analysis



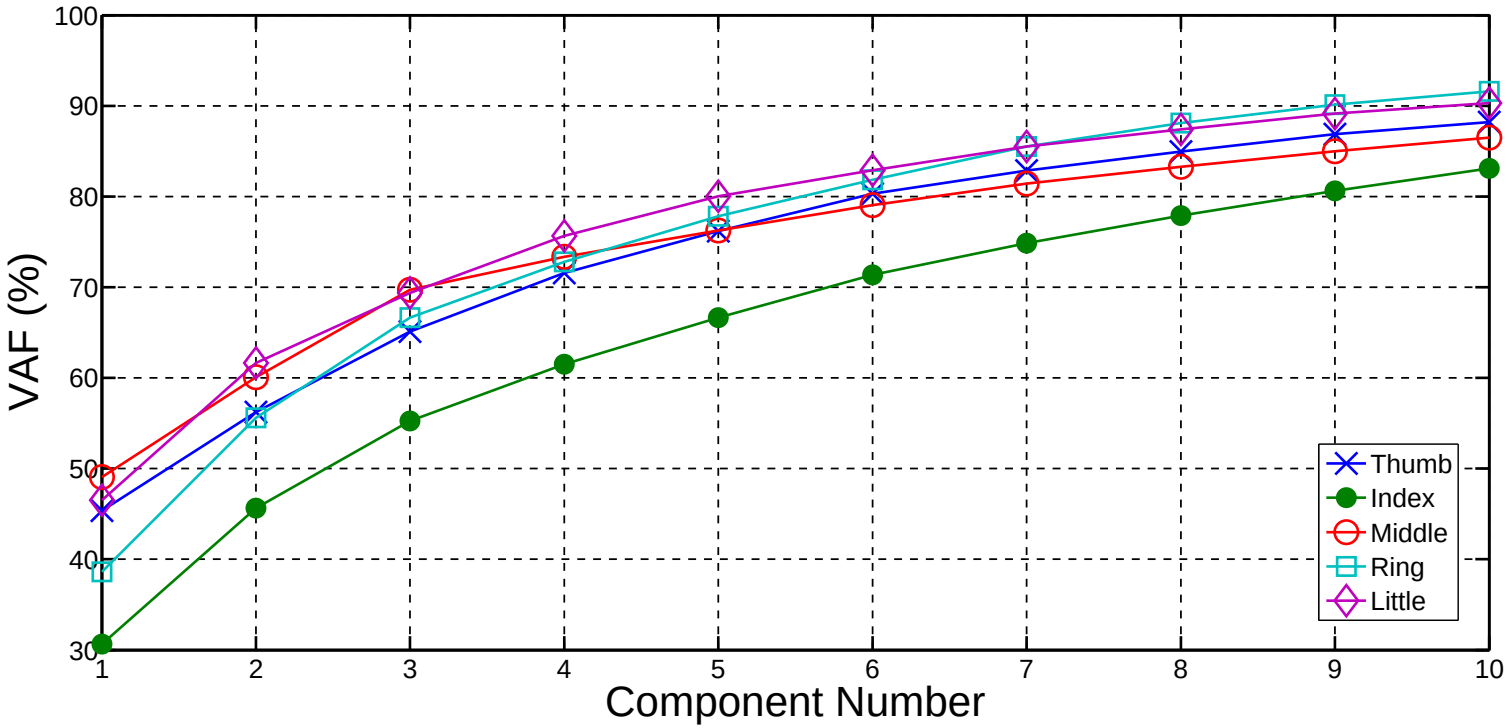
- Extraction performed on all subjects simultaneously
- 1 data set per finger
- Extract time varying synergies with fixed weighting coefficients

Variance Accounted For



- First 4 components account for more than 60% of the variance for all fingers

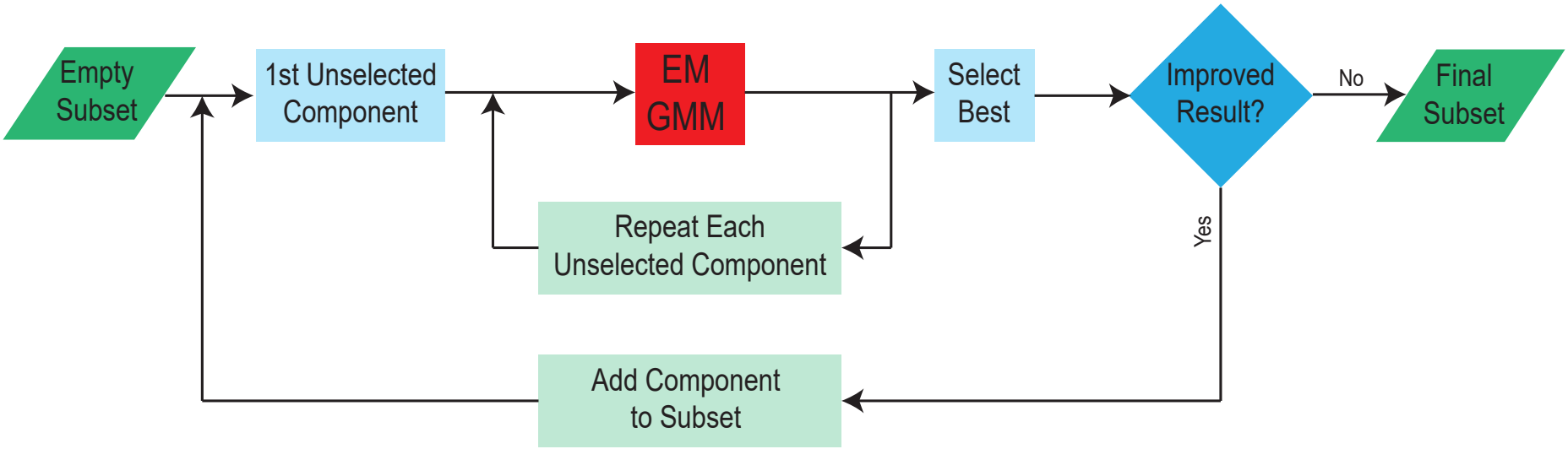
Variance Accounted For



What about the differences?

- We can successfully identify fundamental patterns in the motion of all subjects
- But what can we learn from the differences between experienced & novice pianists?

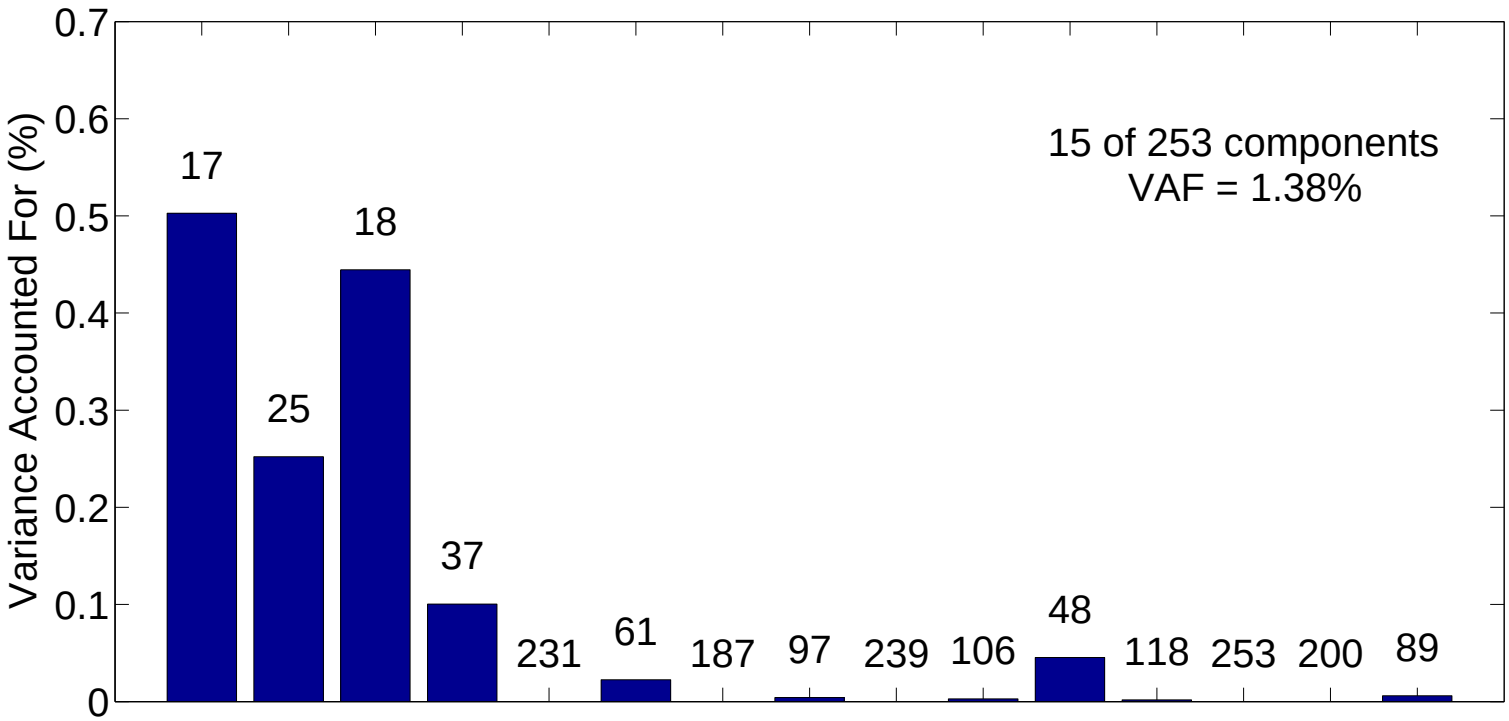
Classification



- Classify the weightings of the PCs
- Expectation Maximization algorithm
  - Fit a 2 class Gaussian Mixture Model
- Iterative forward selection of components

Classification Accuracy

Finger	Accuracy (%)	No. Components	VAF (%)
Thumb	93.68	15/253	1.38



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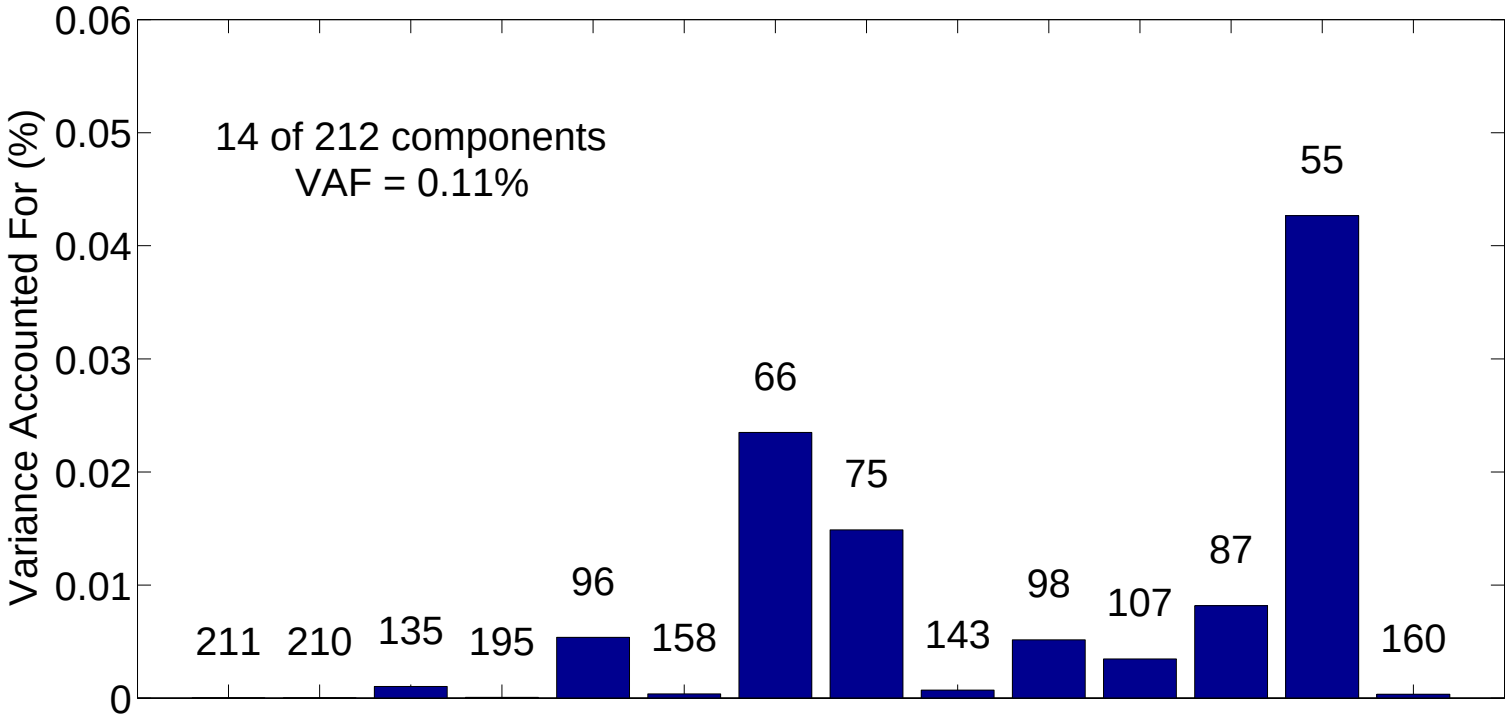

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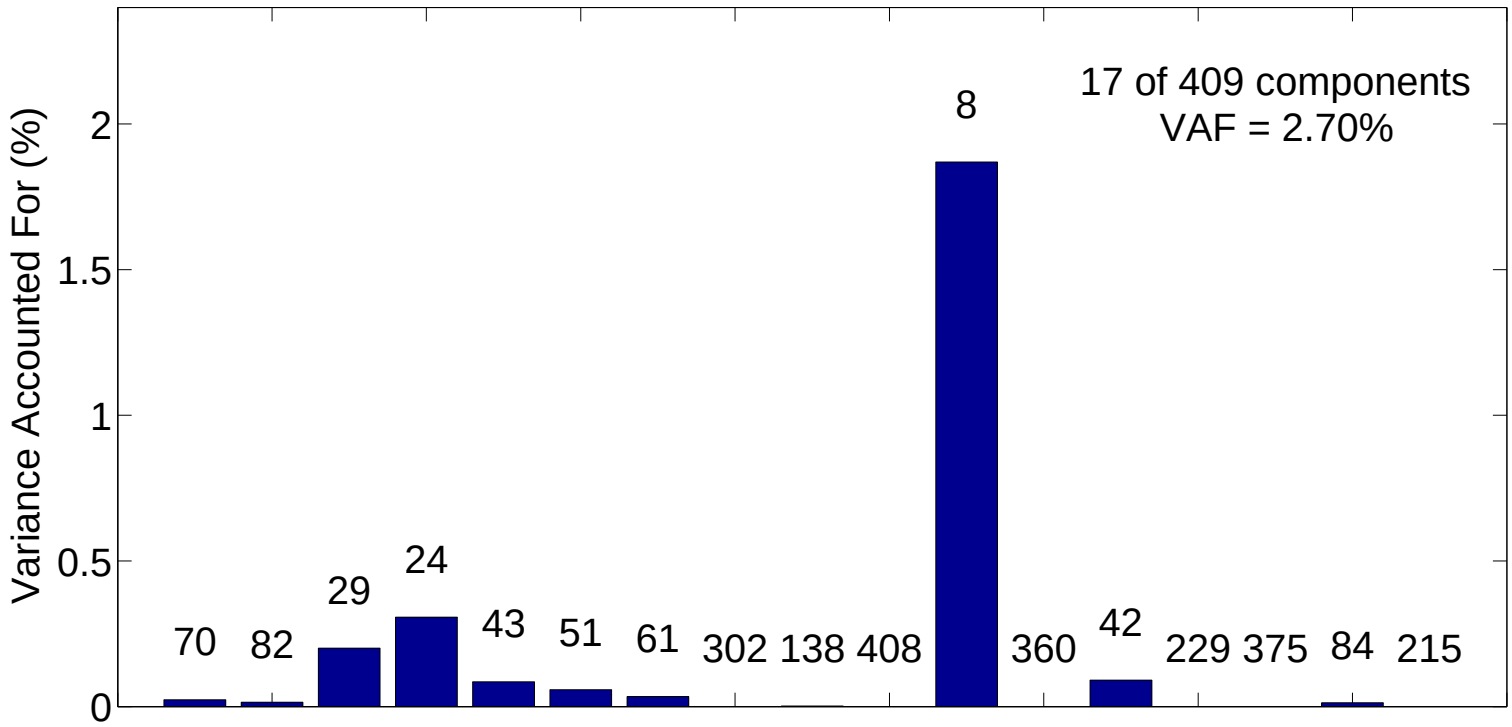

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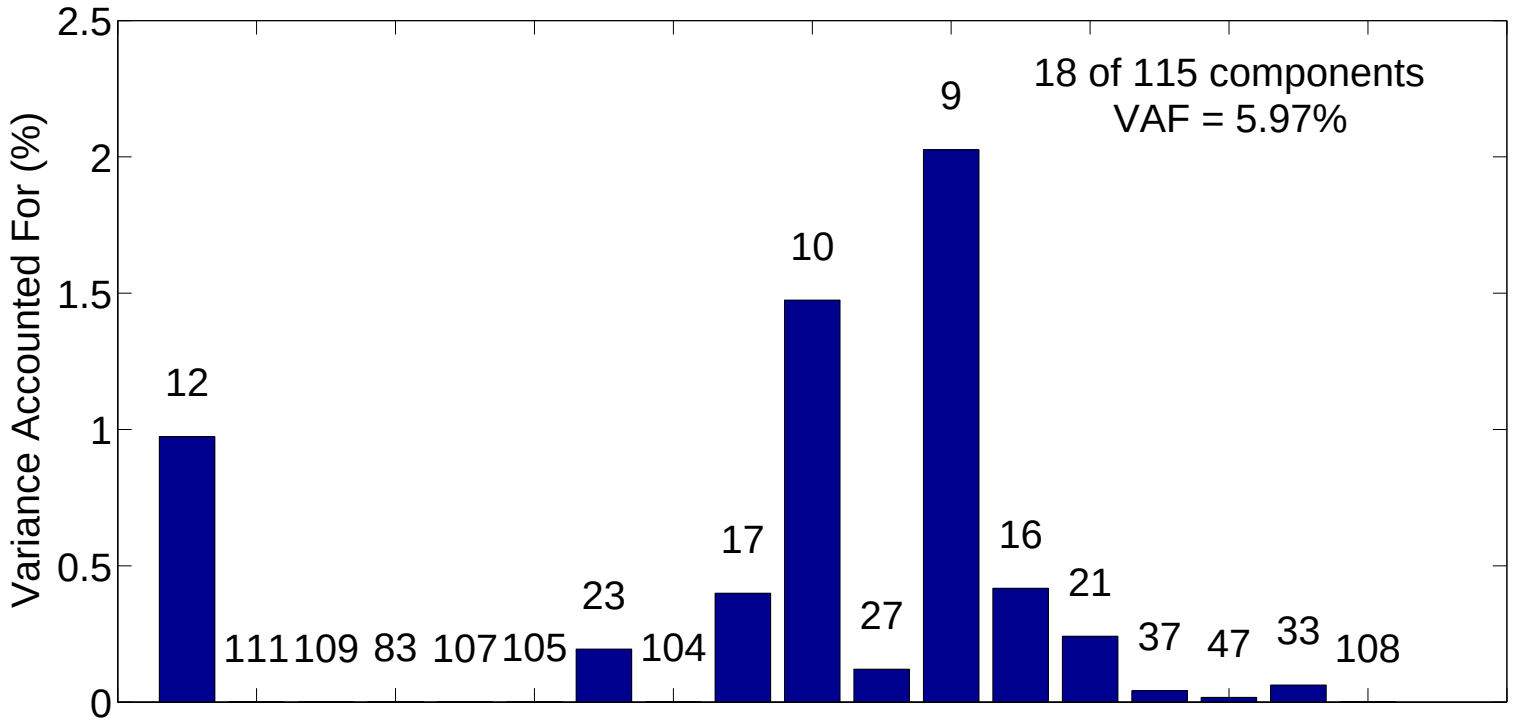

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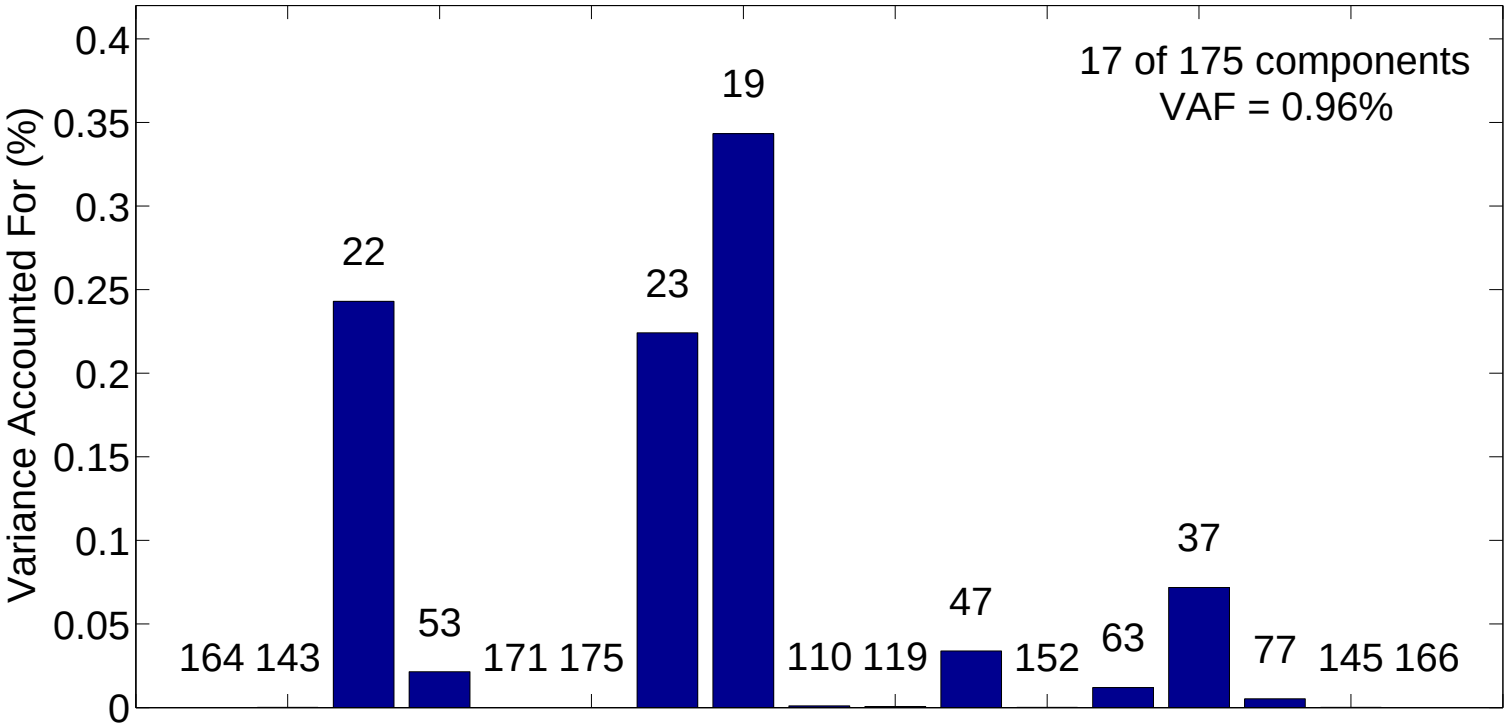
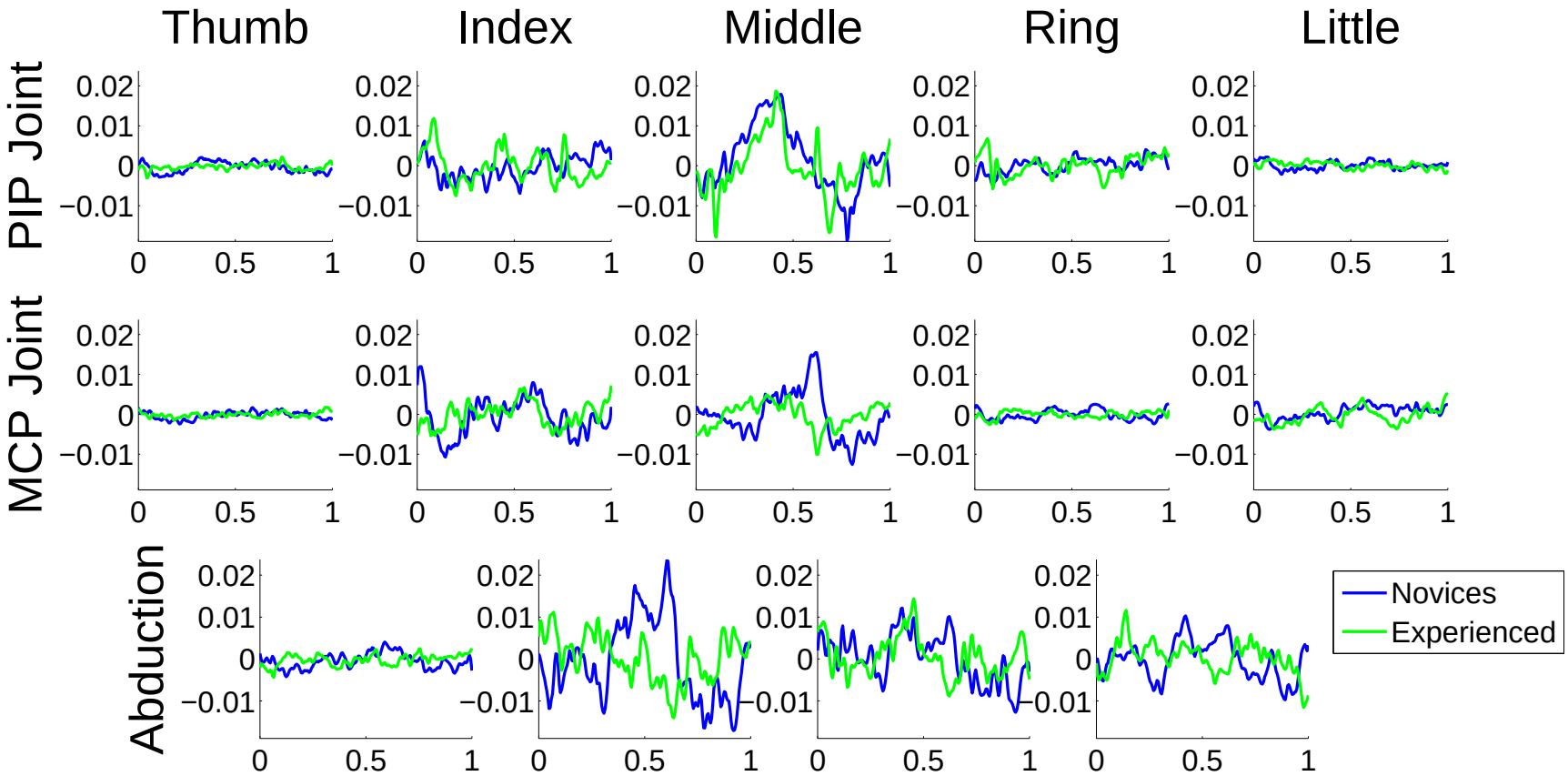
Middle	93.40	17/409	2.70
Ring	96.52	18/115	5.97
Little	98.29	17/175	0.96

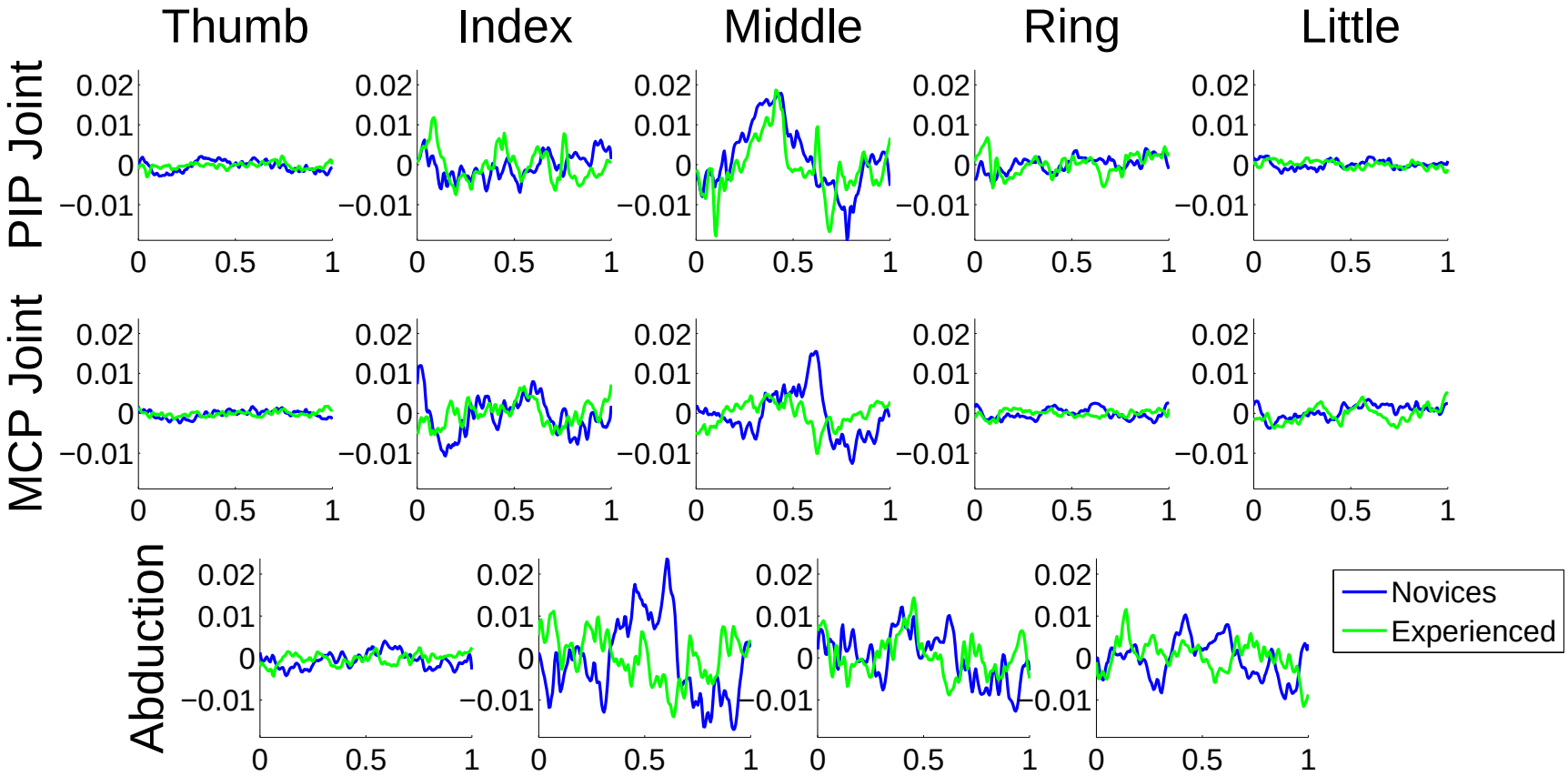


Reconstructed Signals for Middle Finger



- Reconstructed signals using only the selected components
- The movement relating to the greatest separability

Reconstructed Signals for Middle Finger

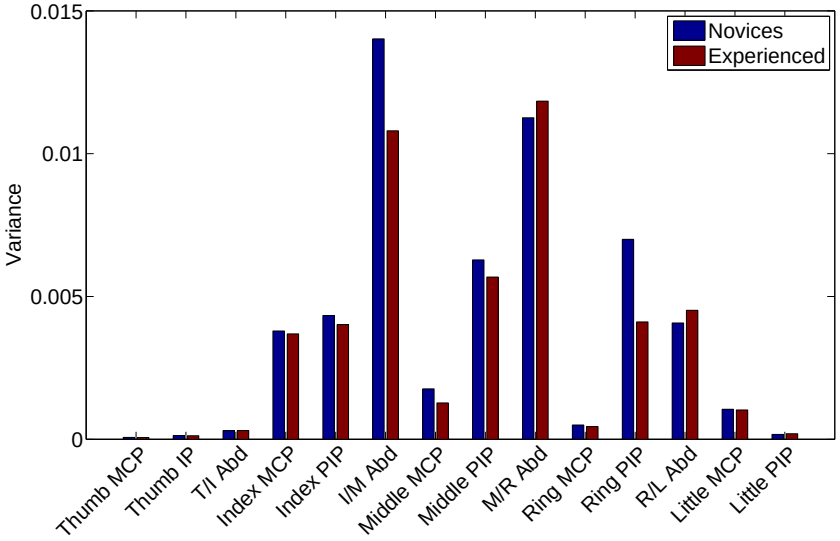


Comparison:

Focus on four long fingers as movement of thumb is different

Variability in Reconstructed Signals

Index Finger



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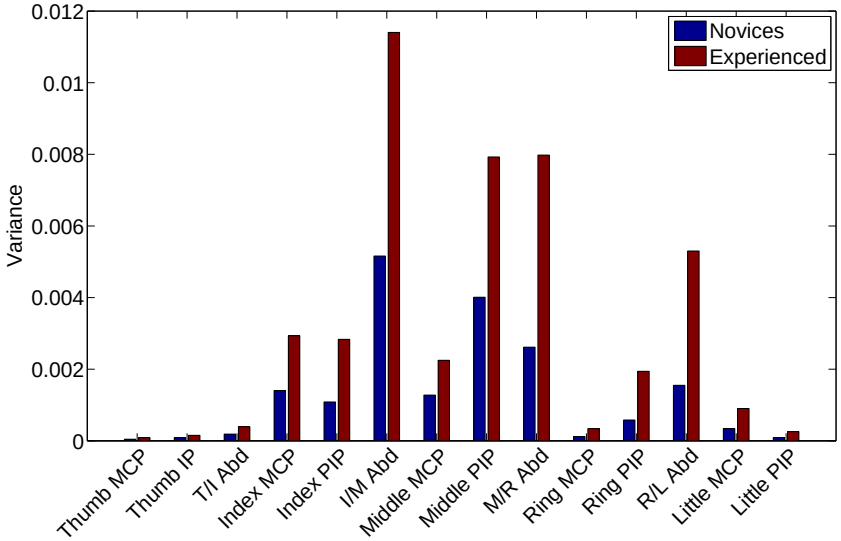
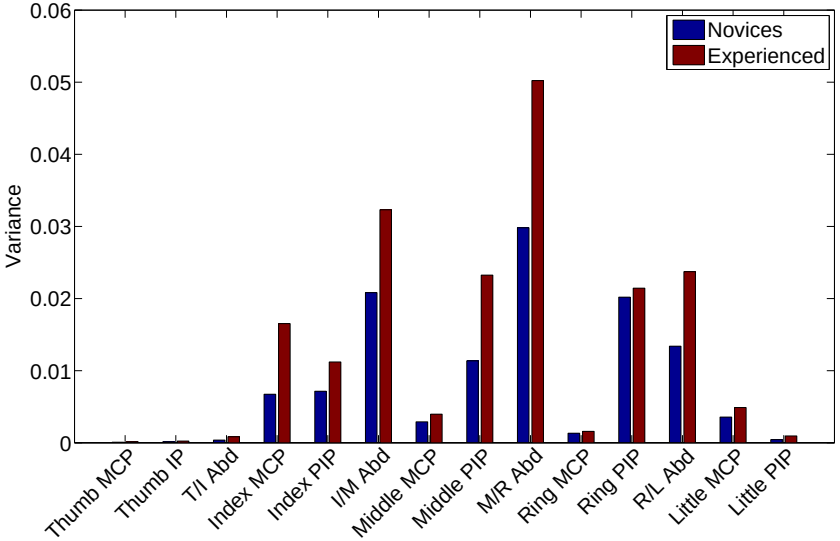
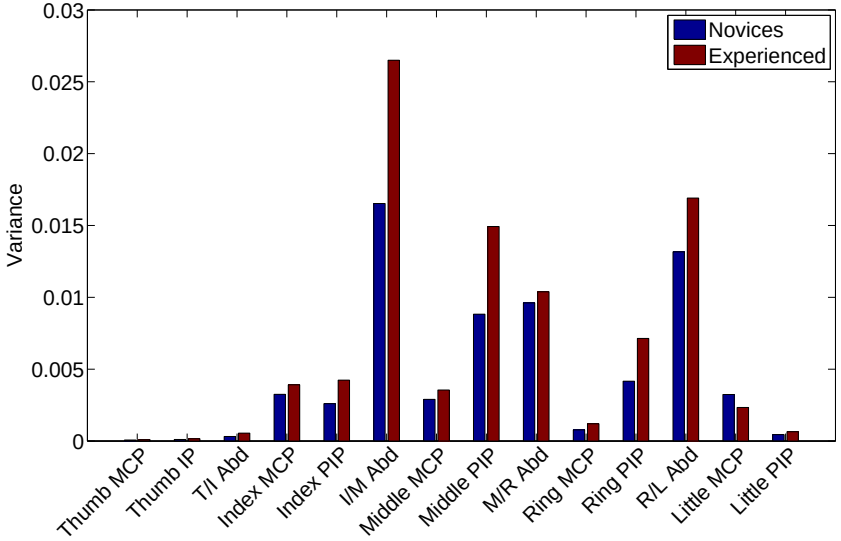


Ring Finger



Little Finger



In summary...

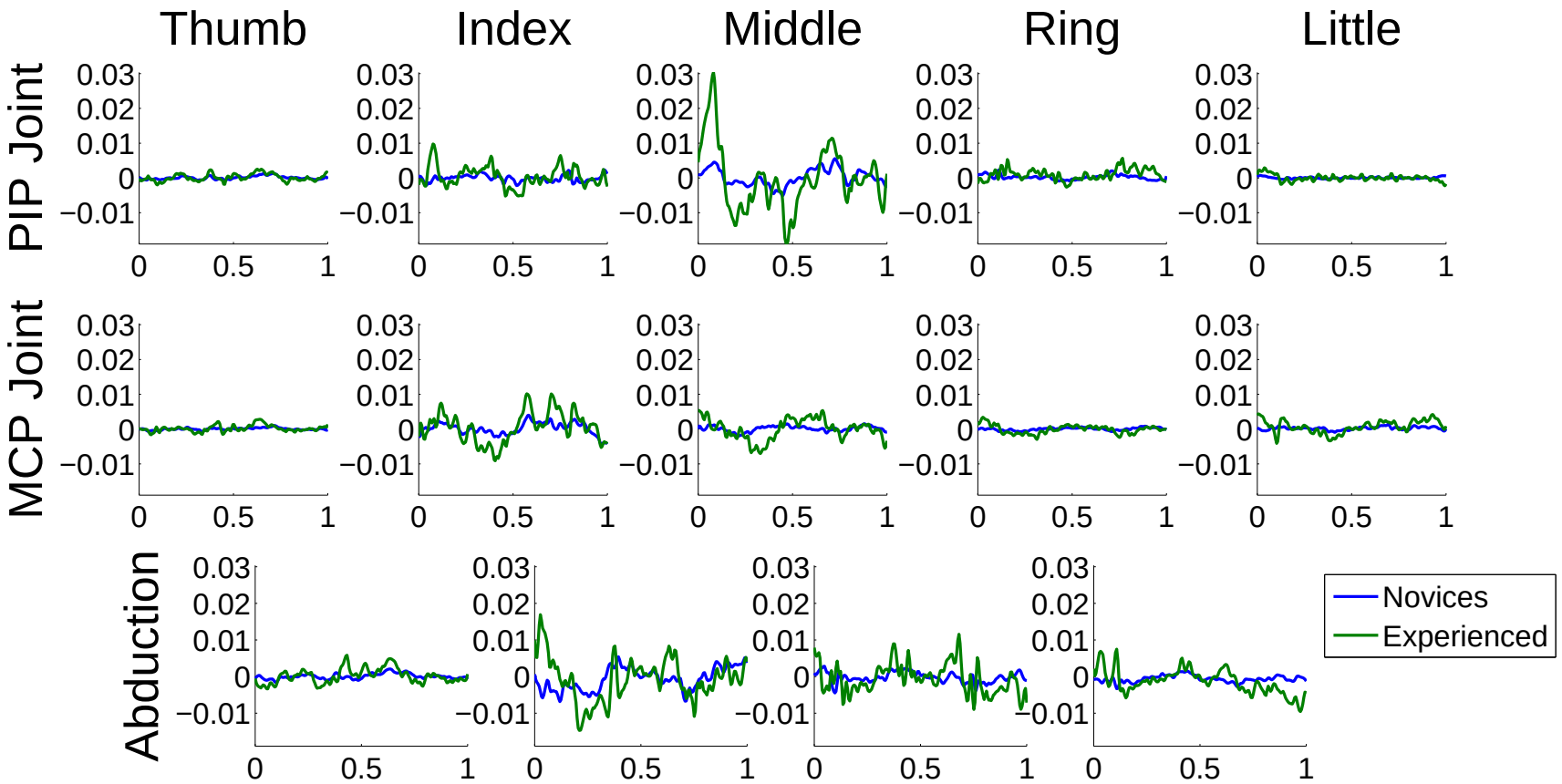
Conclusions

- Patterns of movement common to all our subjects
- Differences between novice & experienced pianists in components accounting for smaller variance
- Distinctions between groups seem to be in how fingers interact with each other
- Is variance accounted for a sufficient measure for coordinated movement?

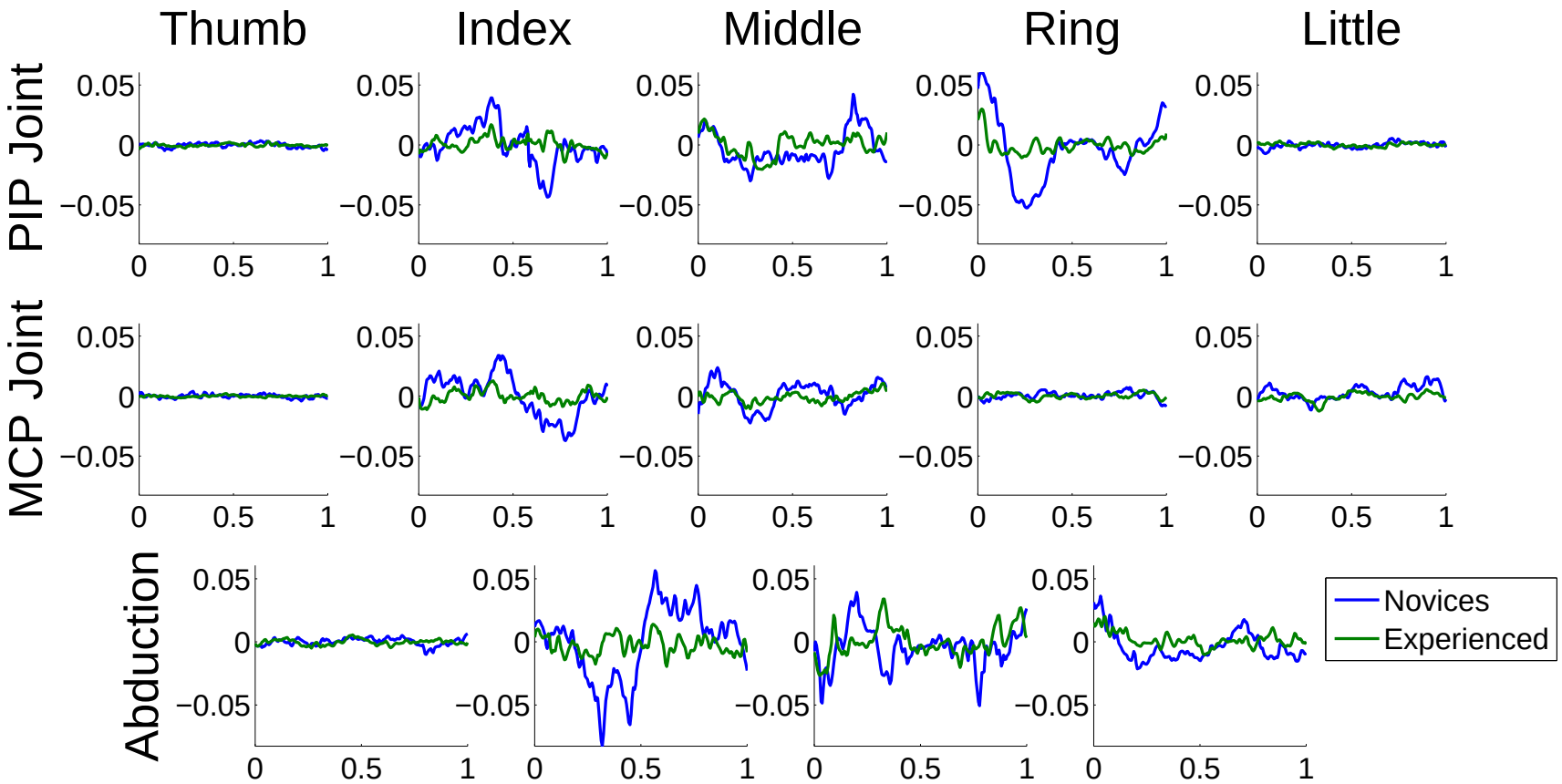
The End

Thank you for listening

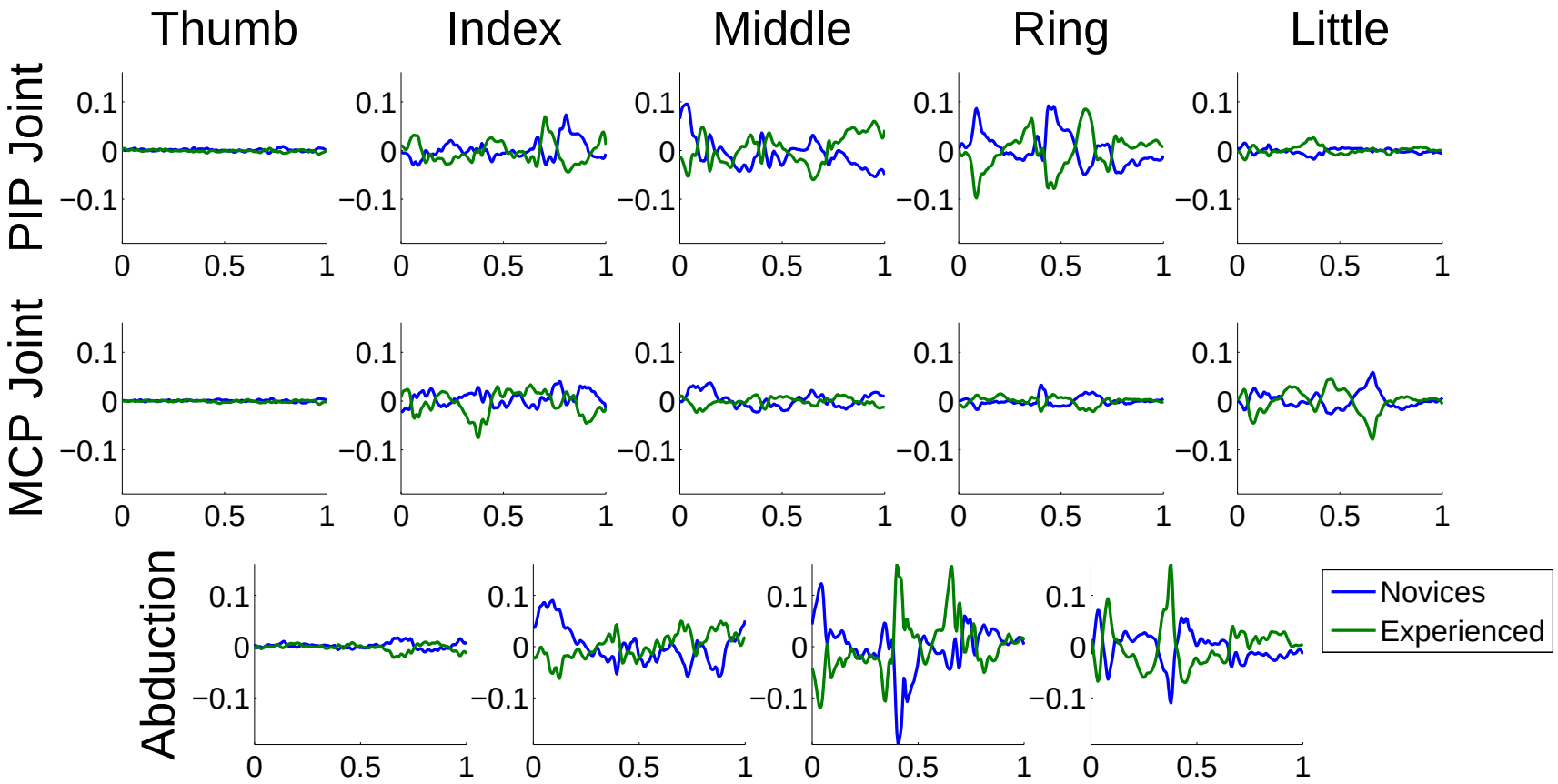
Thumb Reconstruction



Index Finger Reconstruction



Ring Finger Reconstruction



Little Finger Reconstruction