Analyzing the Articulation Features of Children's Touchscreen Gestures

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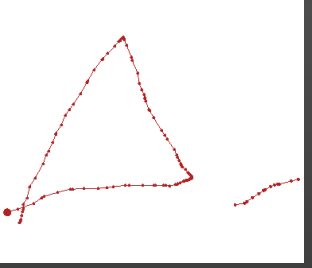
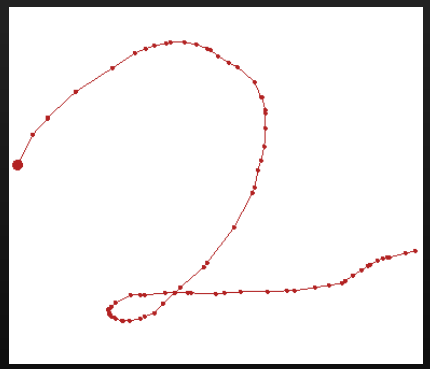
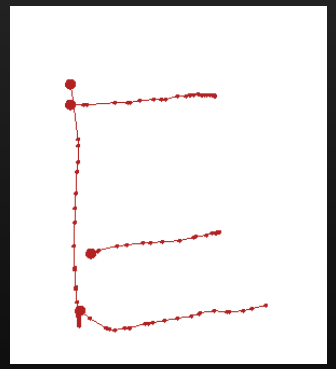
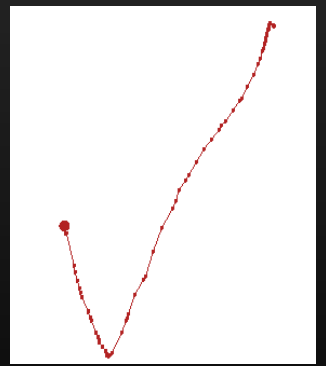
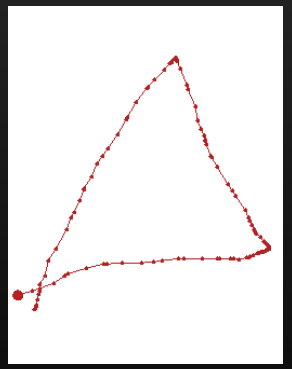


Defining Gestures and Features

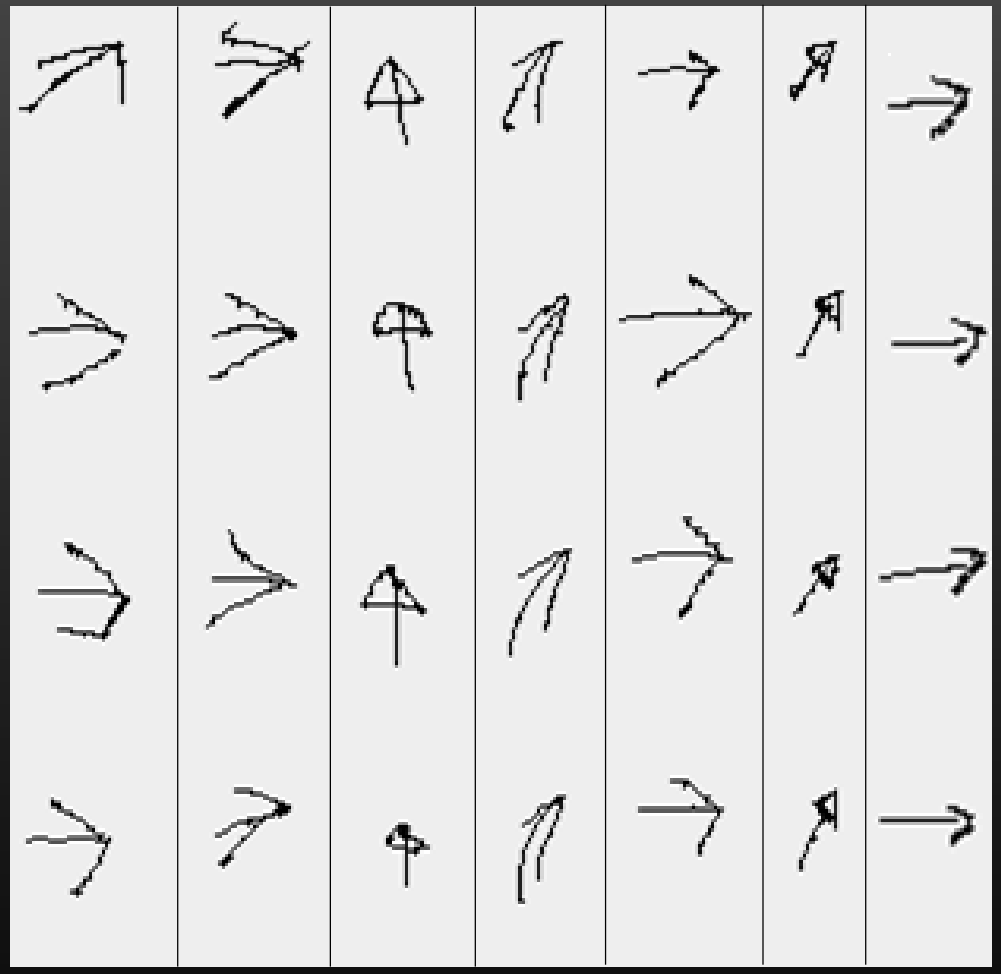
- Gesture – a series of one or more strokes to create a letter, number, symbol, or shape on a touchscreen
- Feature – a quantitative measure of some aspect of an elicited gesture, generally geometric or kinematic in nature

Four examples of different gestures from the corpus in our analysis

Motivation and Impact

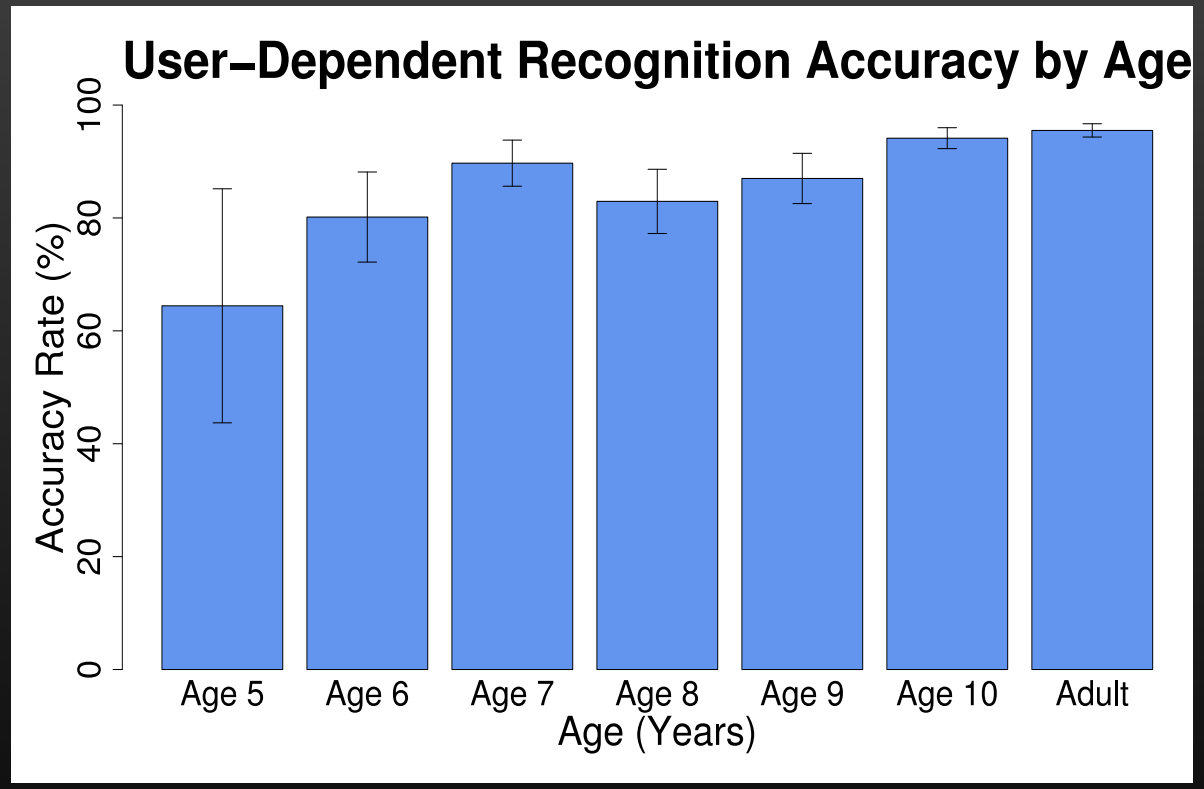
- **Children** use touchscreens differently than **adults**
- Kids' gestures are inconsistent



"Arrowhead" gestures from the corpus in our analysis

Motivation and Impact

- **Children** use touchscreens differently than **adults**
- Kids' gestures are inconsistent
- Recognition rates for children's gestures are low



Recognition rates from Woodward et al. using $P recognizer – CHI '16

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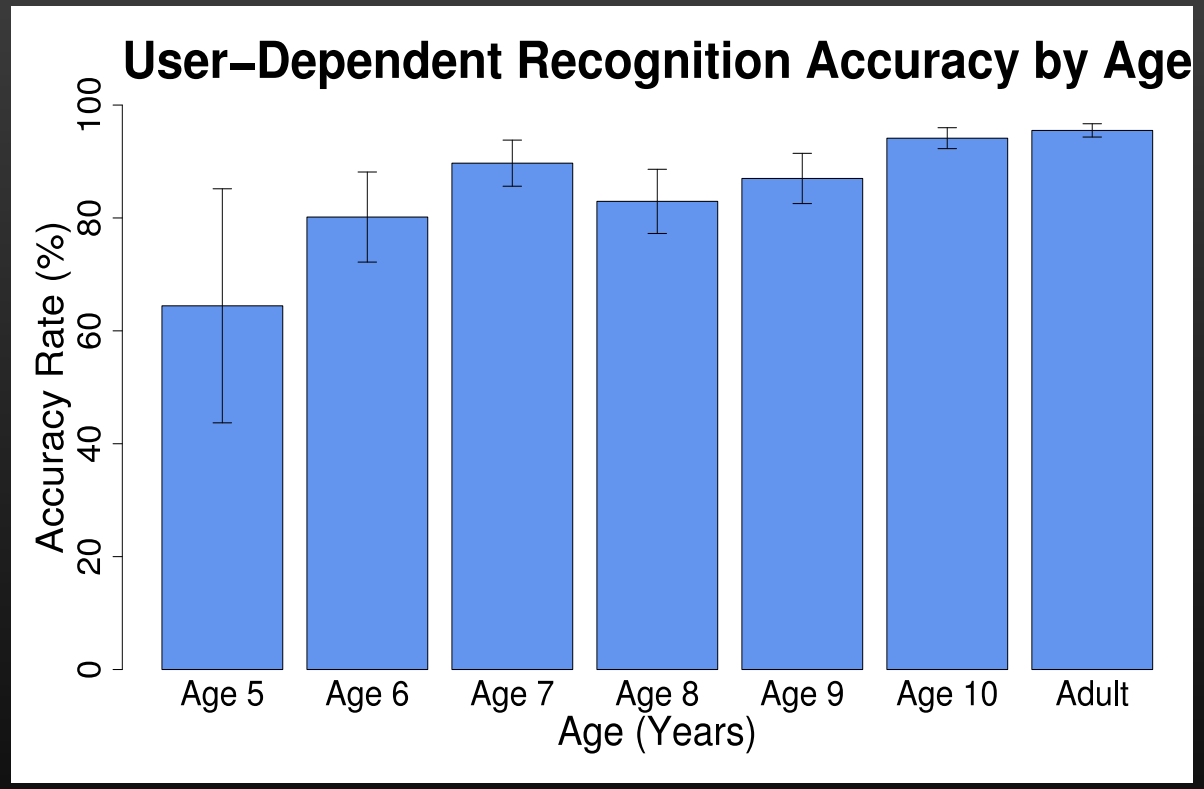
Background

- Characterizing adults' gestures
  - Anthony et al. – GI '13
    - Examined 12 dynamic and kinematic features
  - Vatavu et al. – ICMI '13
    - Introduced 12 relative accuracy measures
- Characterizing children's gestures
  - Anthony et al. – IJCCI '16
    - Computed effect of age on 9 simple features (ages 10+)



Recognition rates from Woodward et al. using $P recognizer – CHI '16

Analysis

- 22 Features (Quantitative measures)
  - 10 Simple features (Anthony et al. – GI ‘13)
  - 12 Complex features (Vatavu et al. – ICMI ’13)
- For each feature, one way ANOVA testing effect of age group on feature
  - Post-hoc tests with Bonferroni correction

Data Collection

- Gestures collected in work by Woodward et al. – CHI ‘16
- 51 participants (24 children + 27 adults) x 20 gesture types x 12 repetitions per type = 12,240 gestures
  - Participants ages 5 to 10 and 18+
    - Seven 5-6 year-olds
    - Seven 7-8 year-olds
    - Ten 9-10 year-olds

The gesture set used in our analysis – from Anthony et al. – ITS ‘12

Analysis

Simple Features (Anthony et al. – GI '13)
1. Number of Strokes
2. Path Length
3. Area of Bounding Box
4. Line Similarity
5. Global Orientation
6. Total Turning Angle
7. Sharpness
8. Curviness
9. Production time
10. Average Speed

Relative Accuracy Features (Vatavu et al. – ICMI '13)
1. Shape Error
2. Shape Variability
3. Length Error
4. Size Error
5. Bending Error
6. Bending Variability
7. Time Error
8. Time Variability
9. Speed Error
10. Speed Variability
11. Stroke Count Error
12. Stroke Ordering Error

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* $p < 0.05$

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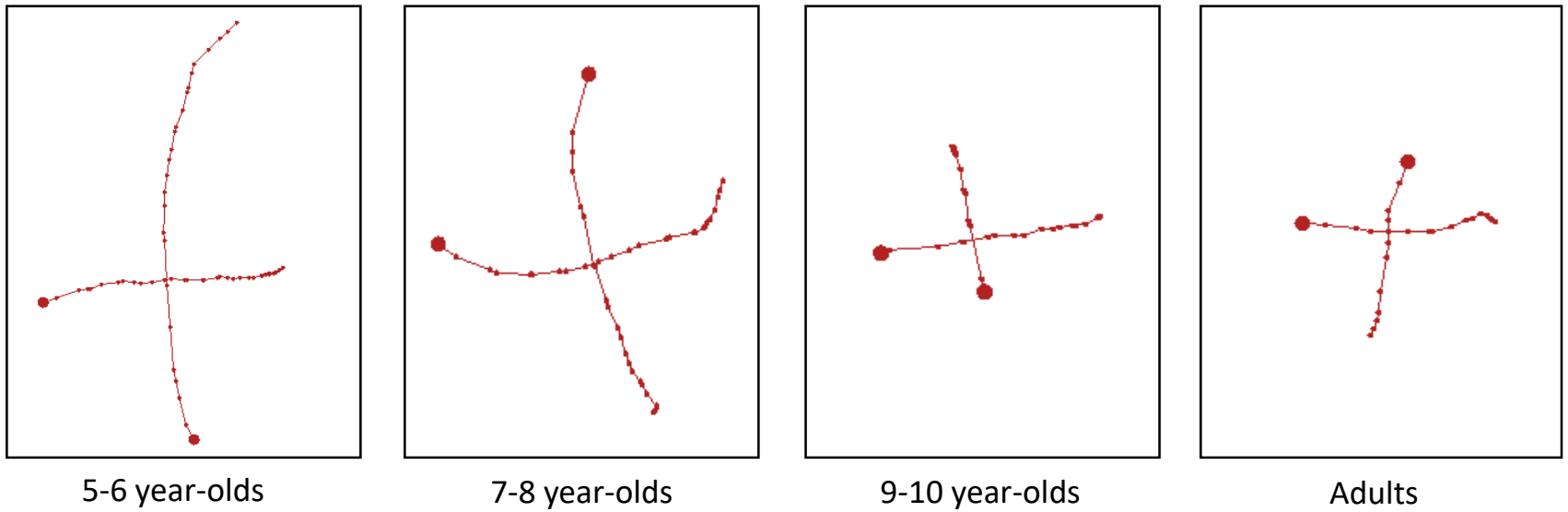
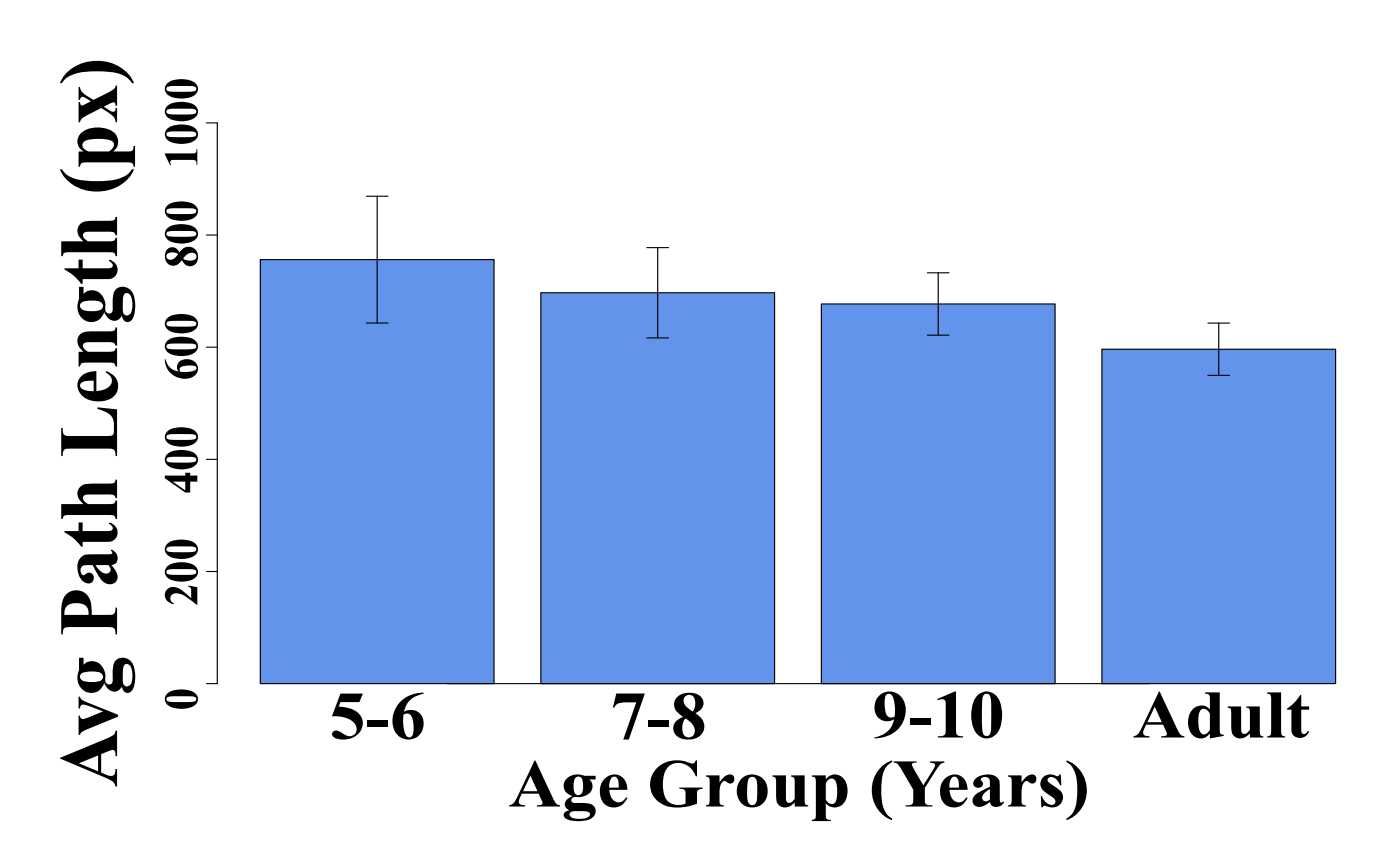
Simple Features – Path Length



"Plus" gestures representative of each age group in the corpus

Path Length – Sum of Euclidean distance between adjacent points of a gesture

Simple Features – Path Length

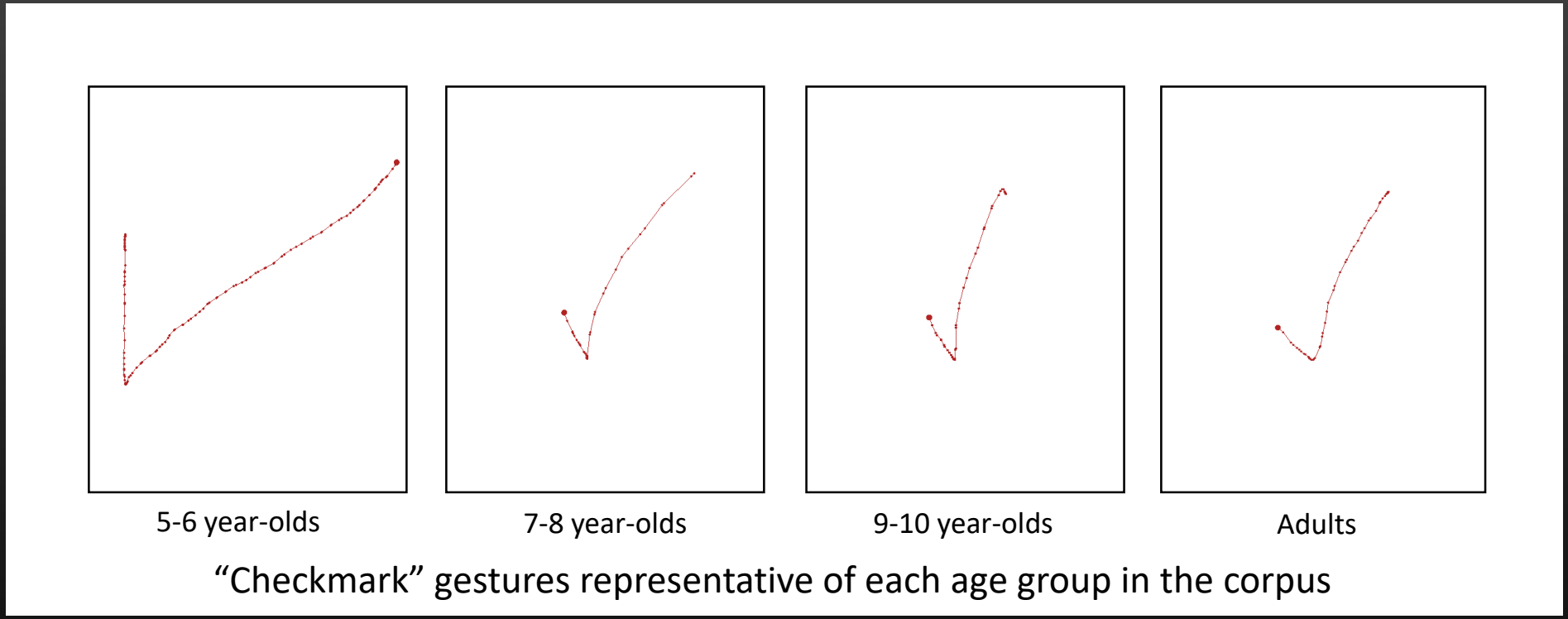


- Significant effect of age group ($p < 0.05$)

Post-hoc Tests

	Adult	9-10	7-8
5-6	$p < 0.05$	-	-
7-8	-	-	
9-10	-		

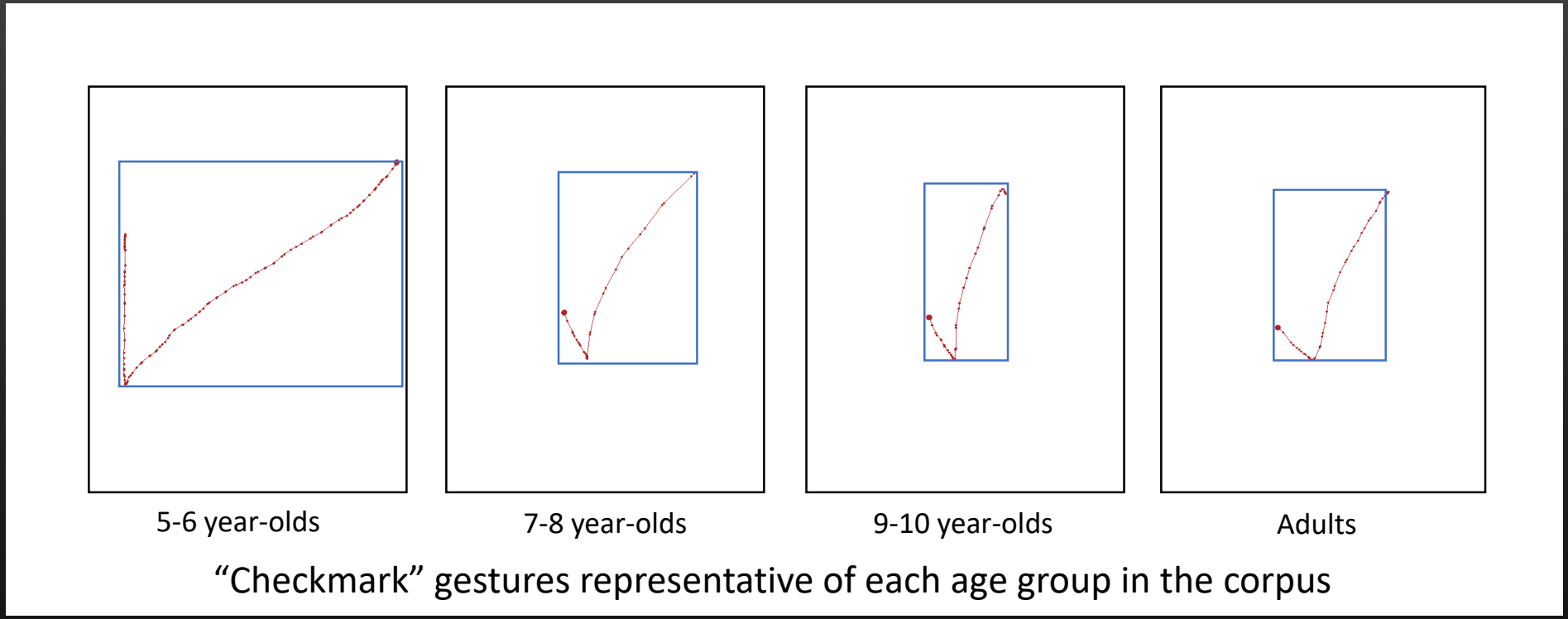
Simple Features – Global Orientation



"Checkmark" gestures representative of each age group in the corpus

Global Orientation – Angle of diagonal of gesture's bounding box

Simple Features – Global Orientation



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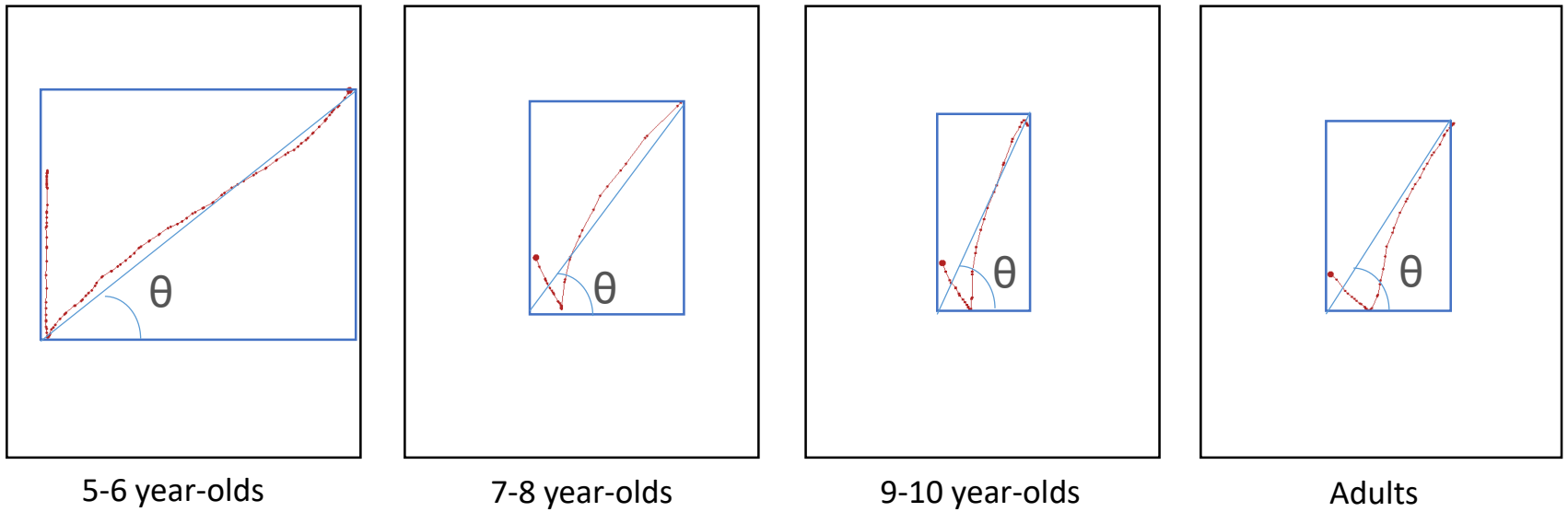

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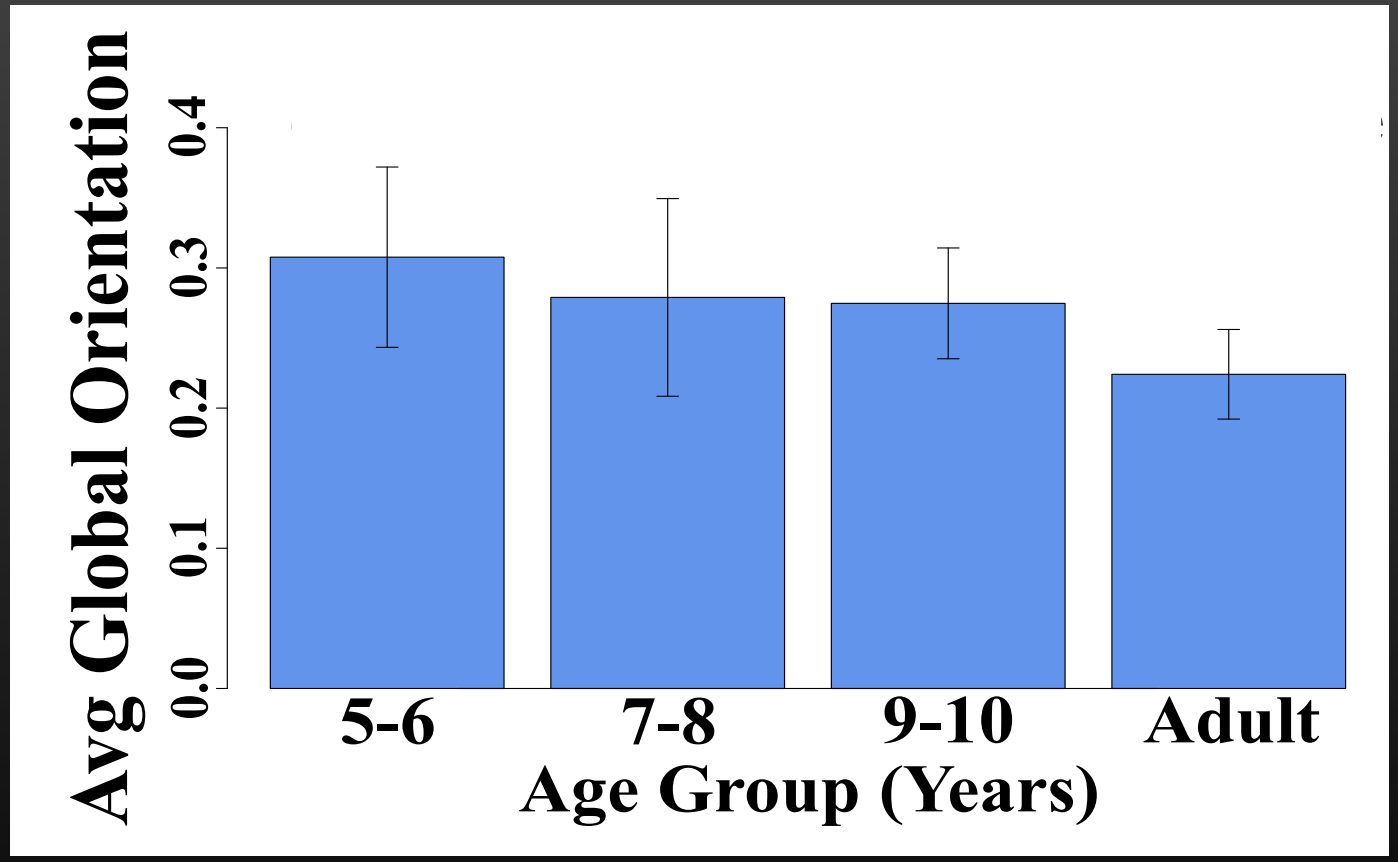
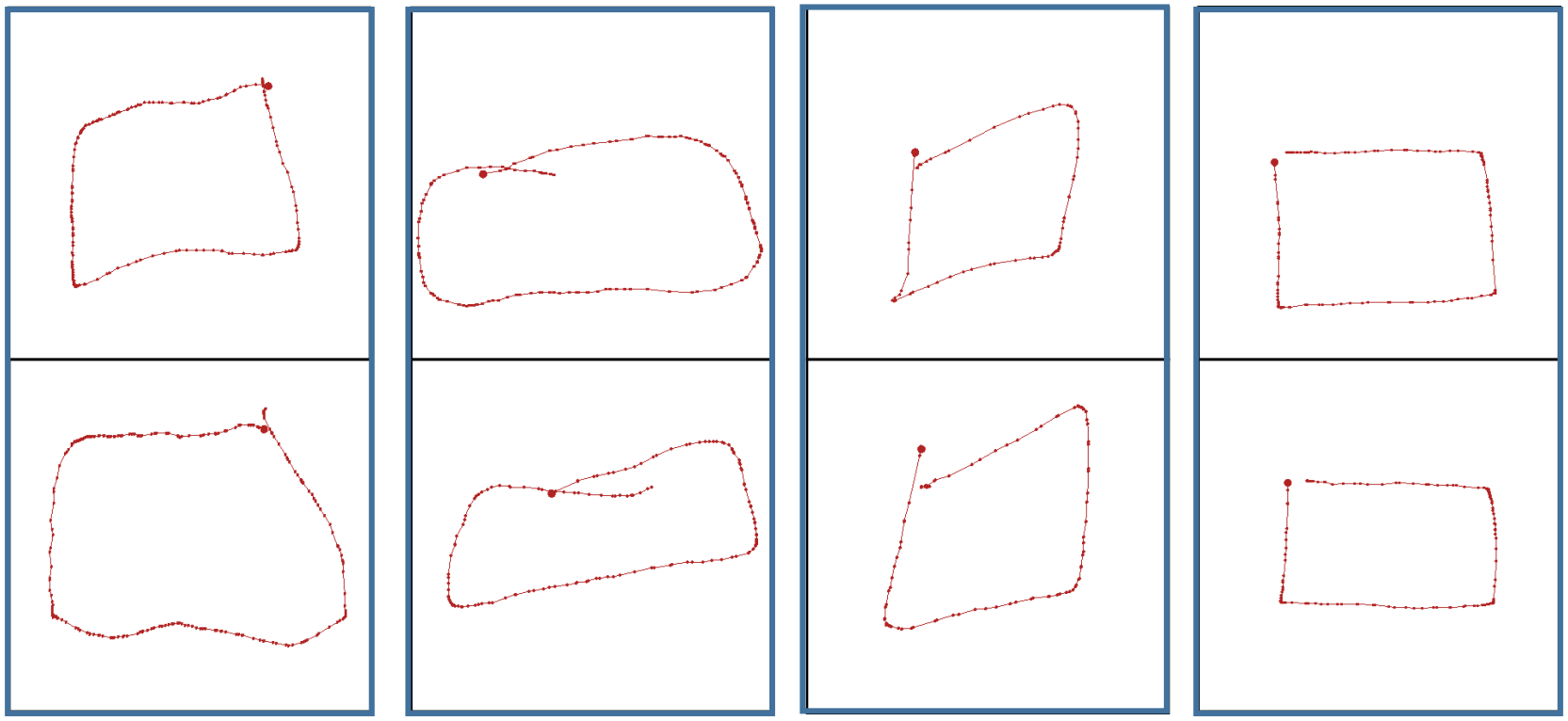


- Significant effect of age group ($p < 0.05$)

Post-hoc Tests

	Adult	9-10	7-8
5-6	$p < 0.001$	-	-
7-8	$p < 0.05$	-	
9-10	$p < 0.05$		

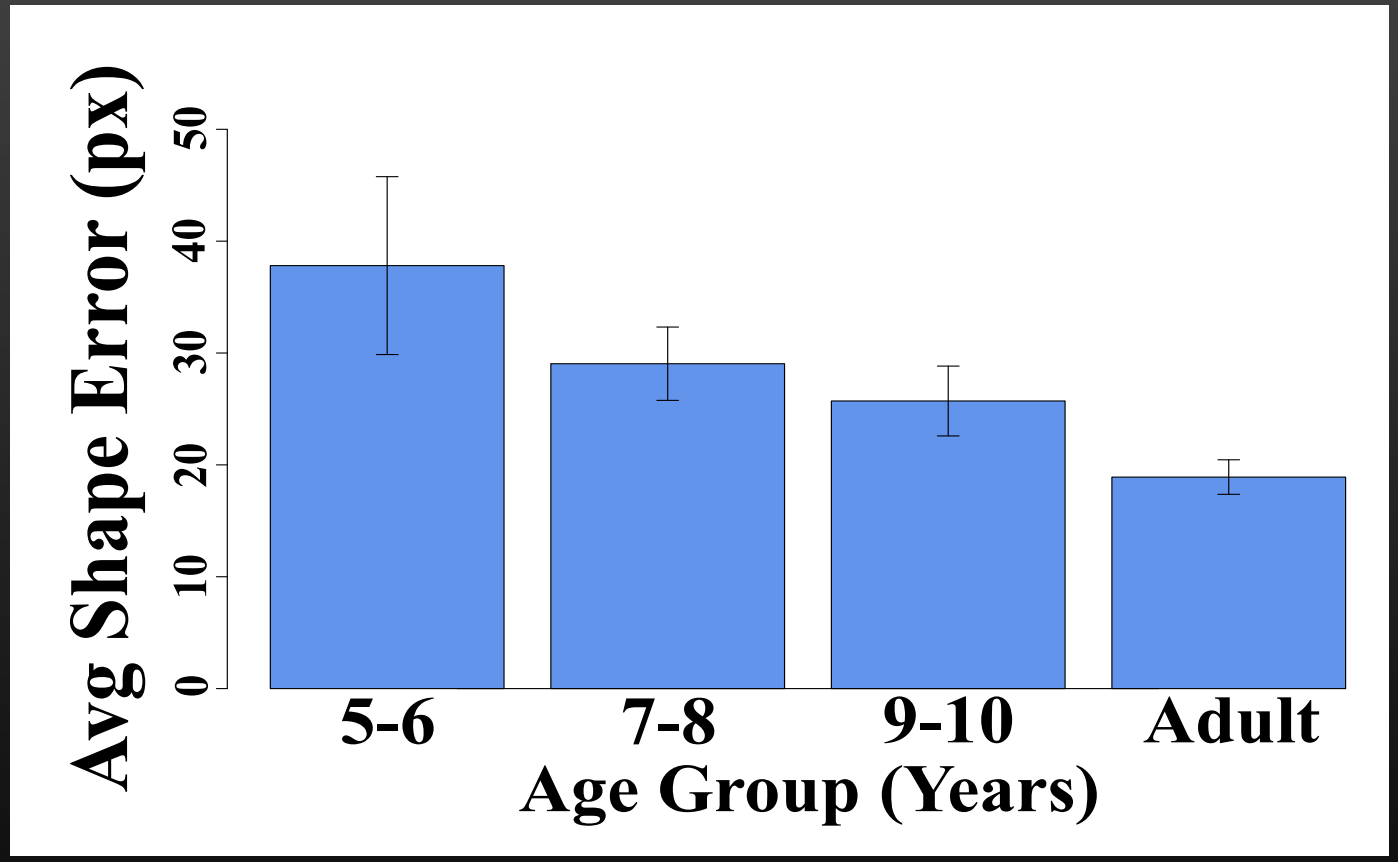
Relative Accuracy Features – Shape Error



Two “Rectangle” gestures representative of each age group in the corpus

Shape Error – Average distance between corresponding points of two gestures

Relative Accuracy Features – Shape Error

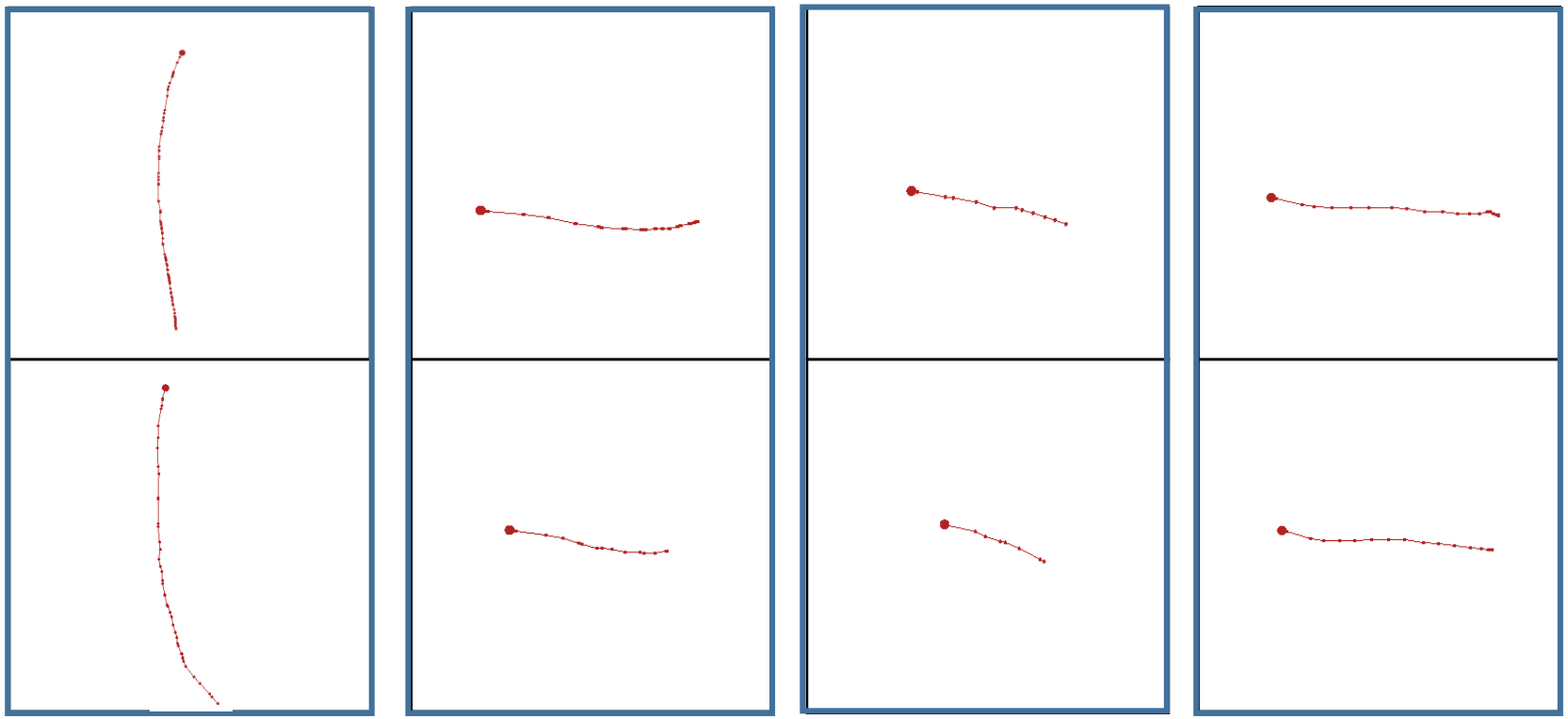


- Significant effect of age group ($p < 0.05$)

Post-hoc Tests

	Adult	9-10	7-8
5-6	$p < 0.001$	$p < 0.001$	$p < 0.05$
7-8	$p < 0.001$	-	
9-10	$p < 0.05$		

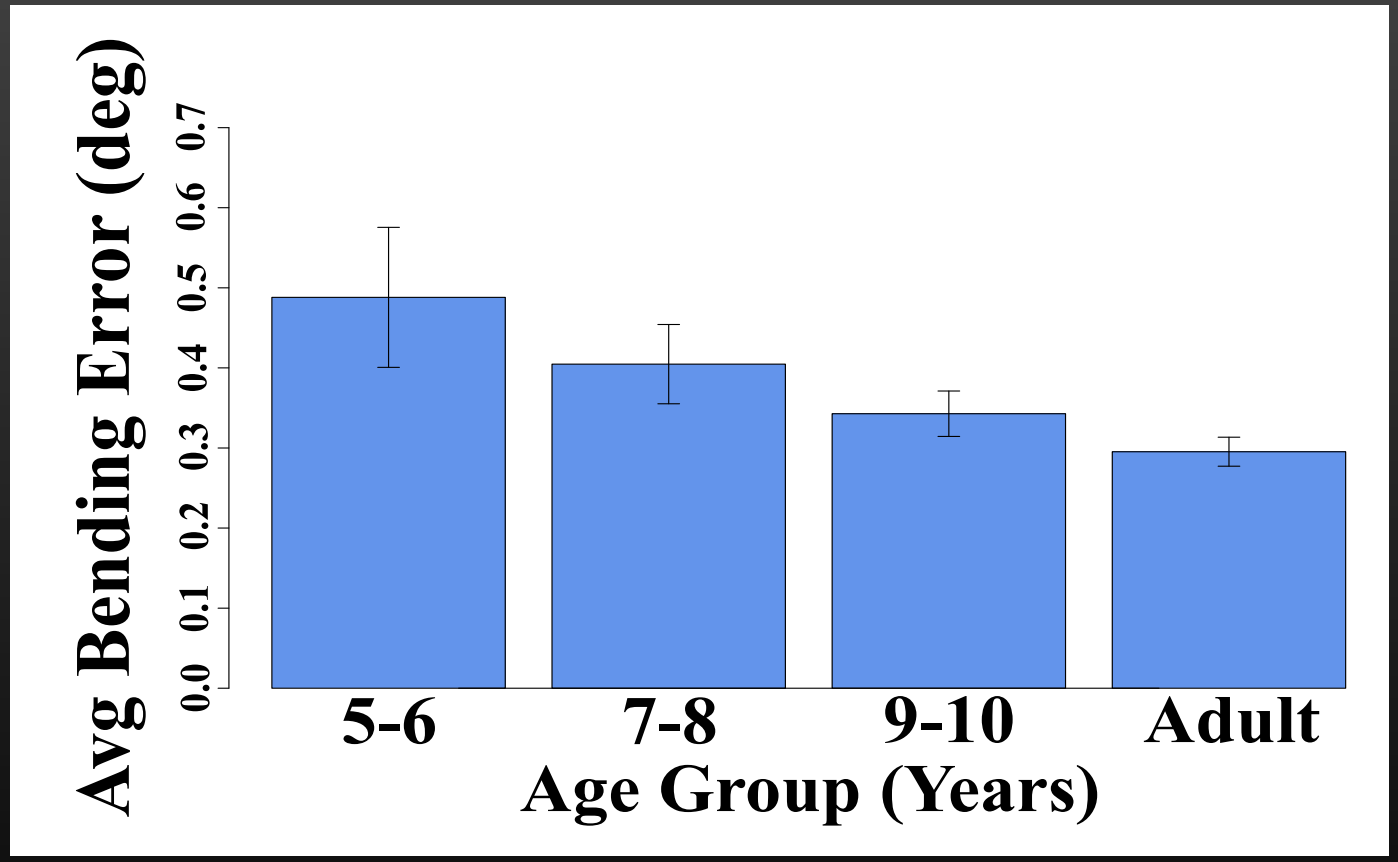
Relative Accuracy Features – Bending Error



Two “Line” gestures representative of each age group in the corpus

Bending Error – Average difference between corresponding angles of two gestures

Relative Accuracy Features – Bending Error



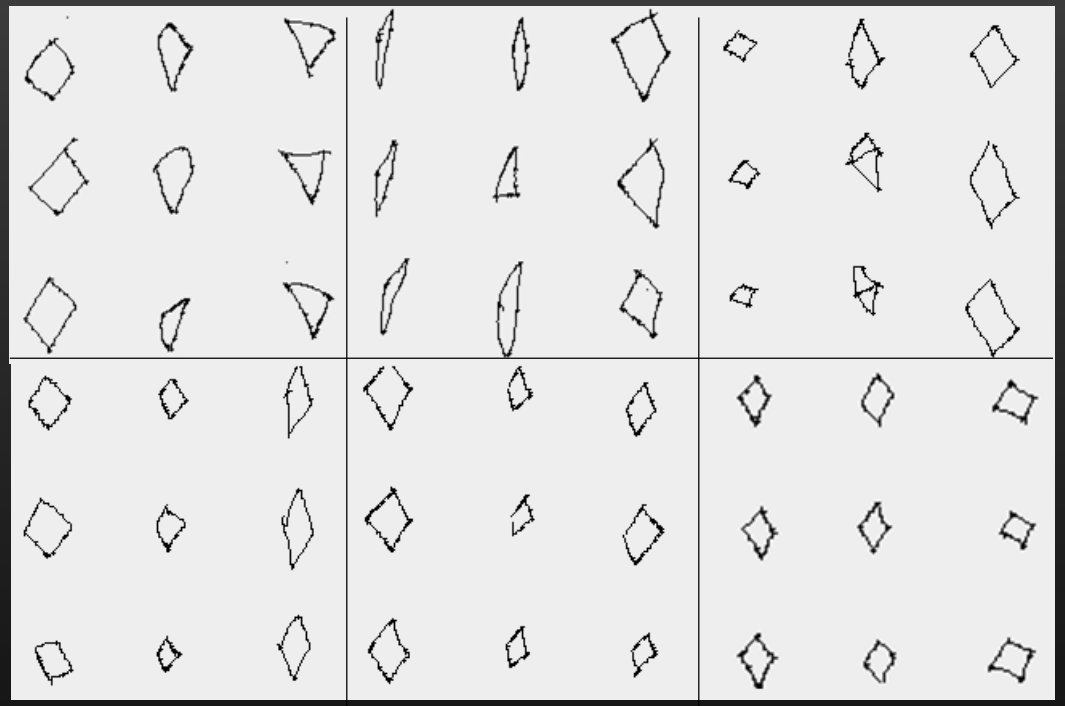
- Significant effect of age group ($p < 0.05$)

Post-hoc Tests

	Adult	9-10	
5-6	$p < 0.001$	$p < 0.001$	$p < 0.05$
7-8	$p < 0.001$	-	
9-10	$p < 0.05$		

Discussion

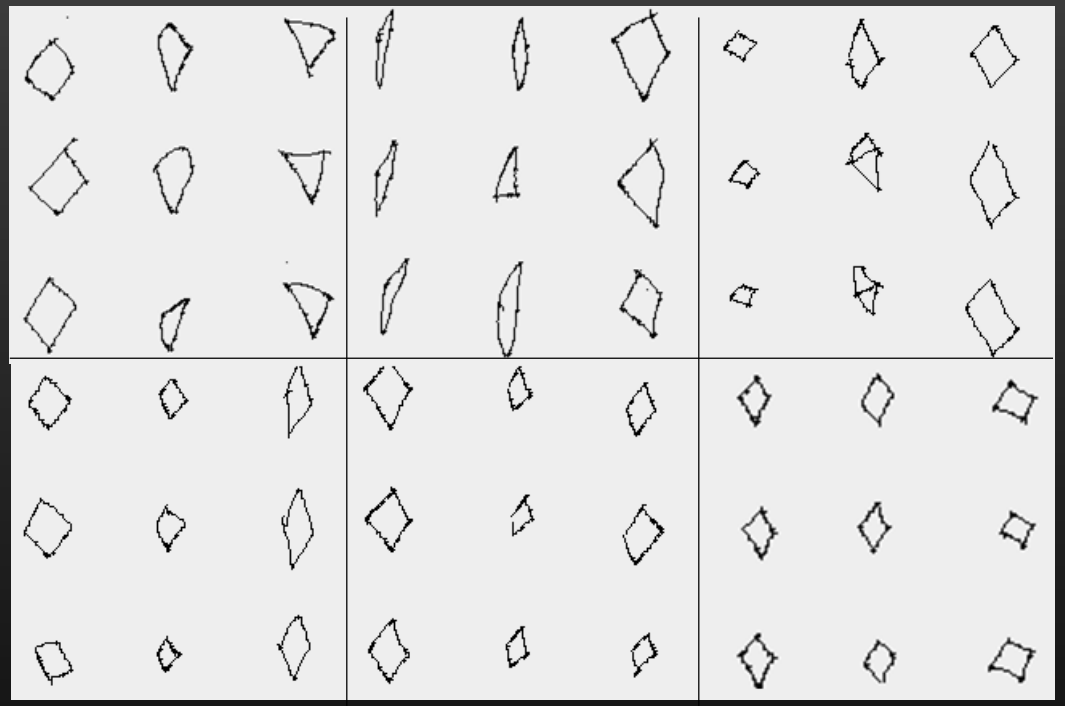
- Relative accuracy measures were more discriminative among age groups than simple ones
  - 12/12 (100%) relative features with $p < .05$ vs. 6/10 (60%) simple



“Diamond” gestures from users of various ages in our study

Discussion

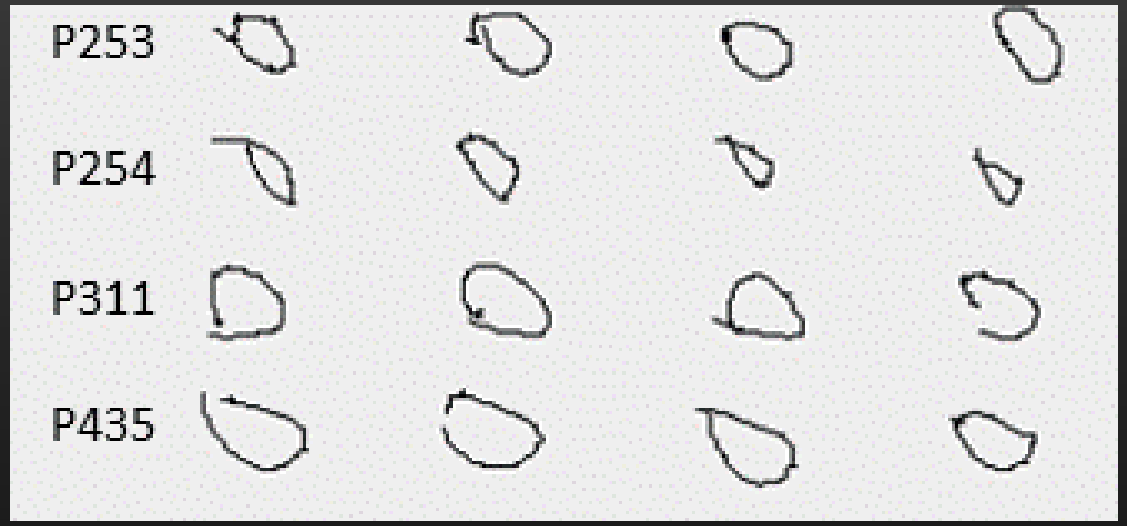
- Time, distance, & size metrics highly correlated with age



“Diamond” gestures from users of various ages in our study

Future Work

- New metrics to support better characterizations
- Other types of recognizers
- Improved recognition algorithms based on new metrics
- Younger populations
- Children with motor impairments



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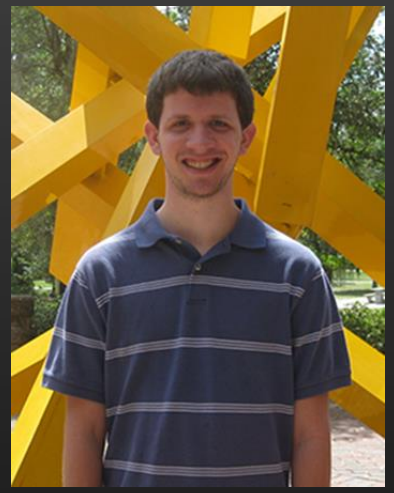

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