Tablet-Based Method for Handwriting Assessment

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Introduction and Objectives

• Handwriting is one of the most important motor skills that children need to master for success in:
- Academics (not limited to composition)
- Communication
- Building self-esteem
- Independent living (Feder & Majnemer, 2007)

• Handwriting is a complex learned behavior that requires the integration of perceptual, motor, and cognitive systems, all of which are affected in autism spectrum disorder (ASD) as well as other developmental disorders.

• 37% of 2nd Graders present with dysgraphia (Overvelde & Hulstijn, 2011). Handwriting impairments are a common reason for OT referral; $100-400 per hour (Aetna medical data).

• Current manual handwriting assessments rely on labor-intensive post-hoc approaches that assess letter formation using a categorical scale, which is often subjective and fails to account for natural variations

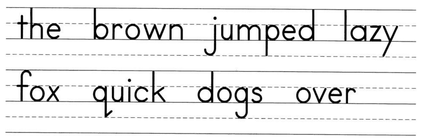
• Current automated handwriting assessments only look at handwriting kinematics without assessing letter form or spacing.

• Our novel tablet-based application aims to provide users with:
1) A reliable and accessible handwriting assessment
2) A cutting edge letter form assessment
3) Both a real-time kinematic feedback as well as a post-hoc summary of morphometric, spacing, and kinematic performance.

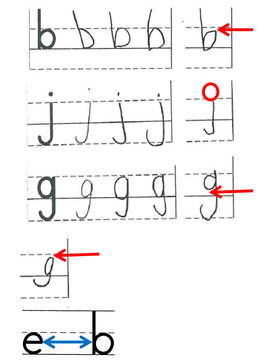
• By doing so, we hope to provide interventionists with a more accurate and reliable assessment of handwriting that also saves time scoring, allowing the therapist to spend more time with patients.

Current Manual Handwriting Assessments

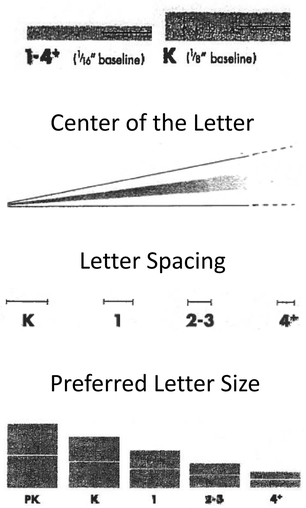
Minnesota Handwriting Assessment



MHA Subscores



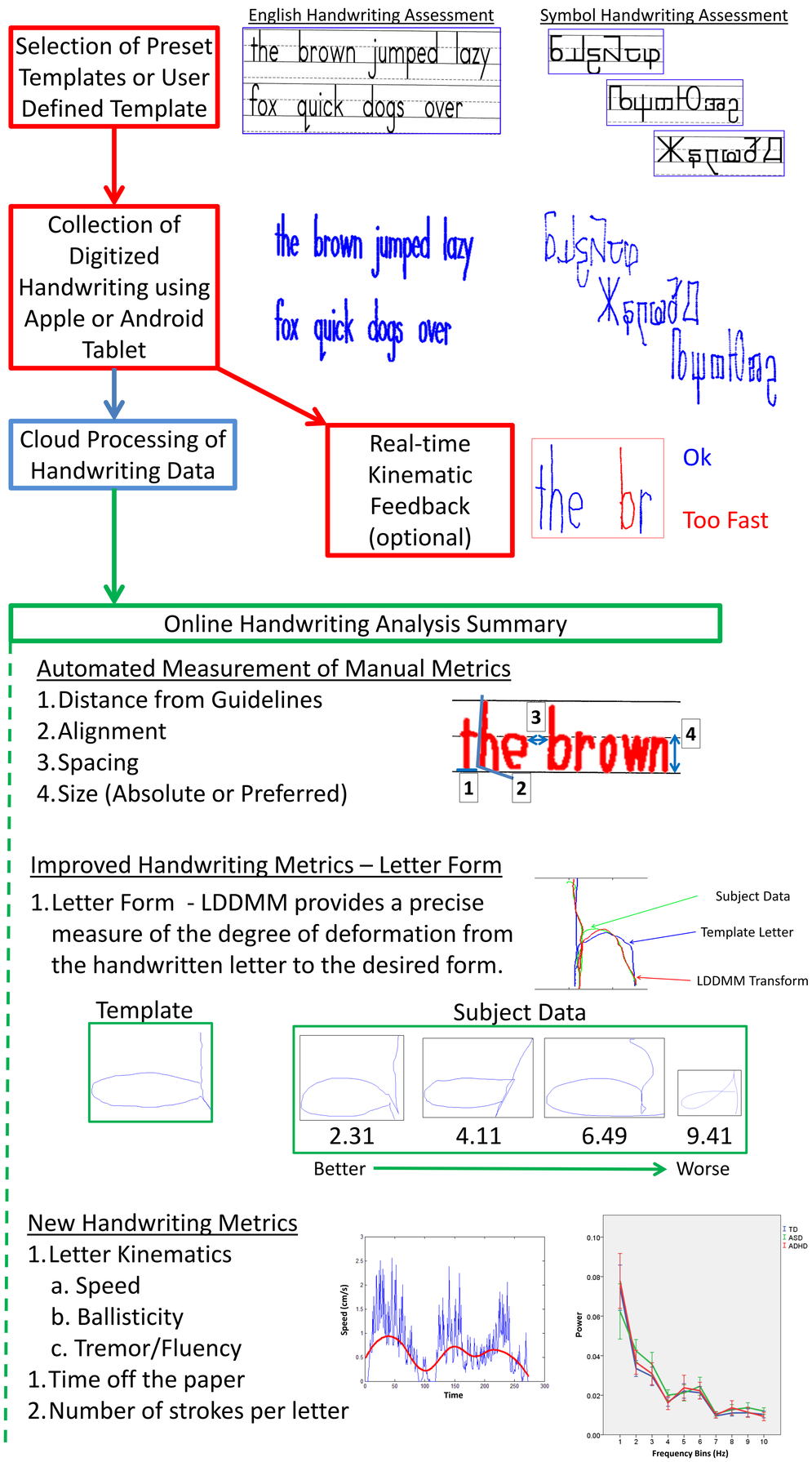
Print Tool Measurements



1) Current handwriting assessment rely heavily on painstaking post-hoc measurements, which are devoid of any kinematic analysis.

2) Categorical measures produced by the manual assessments may not be as sensitive as continuous absolute measures of letter form, spacing, and alignment.

Novel Tablet-Based Handwriting Application Processing Flow Chart



Automated Measurement of Manual Metrics

1. Distance from Guidelines
2. Alignment
3. Spacing
4. Size (Absolute or Preferred)

Improved Handwriting Metrics – Letter Form

1. Letter Form - LDDMM provides a precise measure of the degree of deformation from the handwritten letter to the desired form.

New Handwriting Metrics

1. Letter Kinematics
   a. Speed
   b. Ballisticity
   c. Tremor/Fluency
2. Time off the paper
2. Number of strokes per letter

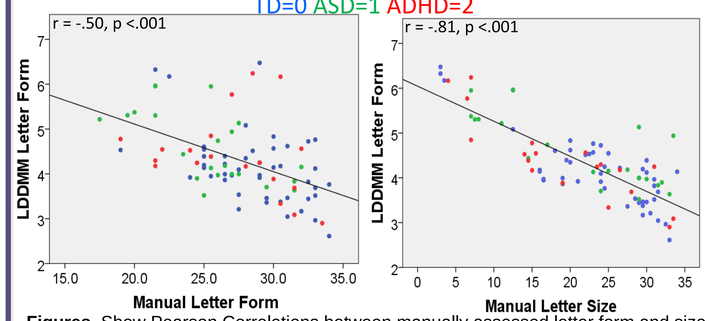
Results Using Digital Handwriting Assessment

• Participants: Both the Symbol and English Handwriting Assessment groups had partially overlapping groups.

• Symbol Handwriting Assessment (SHA): 85 subjects ages 8-12 years old: 38 TD (7F; age 10.2 ± 1.1), 20 ASD (3F; age 10.7 ± 1.4), and 27 ADHD (8F; age 10.0 ± 1.3) . Groups were matched on age, SES, and PRI (WISC-IV).

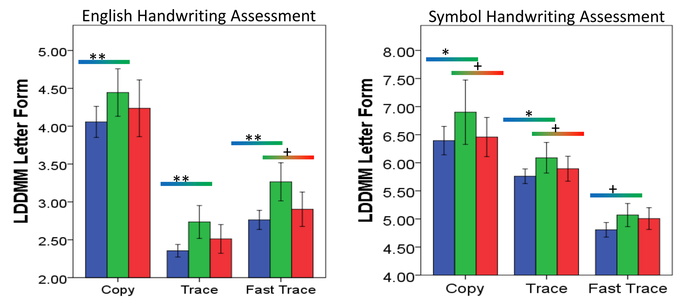
• English Handwriting Assessment (EHA; based on MHA): 92 subjects ages 8-12 years old: 49 TD (9F; age 10.2 ± 1.2), 23 ASD (2F; age 10.4 ± 1.4), and 20 ADHD (3F; age 9.7 ± 1.4). Groups were matched on age, SES, and PRI.

Automated vs. Manual Results



Figures. Show Pearson Correlations between manually assessed letter form and size (x-axis; MHA) and LDDMM letter form (y-axis). Higher scores represent in all measures indicate worse performance.

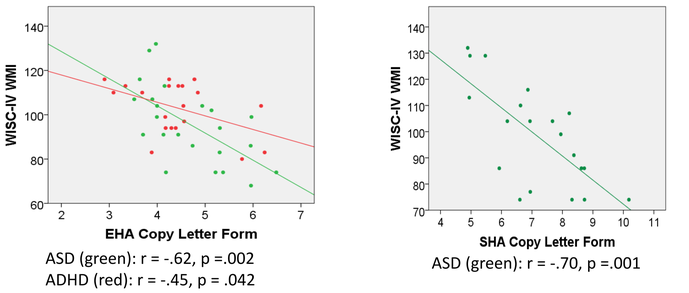
Letter Form Analysis



Figures. Standard error bars represent 2 S.E. above and below the mean. All children showed decreased performance in the copy condition compared to the trace conditions. Additionally, children with ASD showed specific letter form impairments compared to TD and ADHD children. All kinematic measures did not show an effect of diagnosis.

Symbol Legend
+ = p<.01,
* = p<.05,
** = p<.01

English and Symbol Letter Form Correlations with WISC-IV's Working Memory Index



ASD (green): r = -.62, p =.002
ADHD (red): r = -.45, p = .042

ASD (green): r = -.70, p =.001

Figures. Show Pearson Correlations between letter form (English, left; Symbol, right) and WISC-IV Working Memory Index (WMI). Higher letter form scores represent worse performance, while higher WMI scores represent better WM..

Research supported in part by Autism Speaks, the National Institutes of Health Grants R01 MH078160, R01 MH085328, R01 NS048527-07, and the Johns Hopkins University School of Medicine Institute for Clinical and Translational Research, an NIH/NCRR CTSA Program, UL1 RR025005. There are no relevant disclosures. Feder KP, Majnemer A. Handwriting development, competency, and intervention. *Dev Med Child Neurol*. 2007;49(4):312-317, Overvelde A, Hulstijn W. Handwriting development in grade 2 and grade 3 primary school children with normal, at risk, or dysgraphic characteristics. *Res Dev Disabil*. 2011;32(2):540-548.