

The haptic kinematics of two-handed braille reading in blind adults



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Introduction

Braille is a haptic modality for blind readers based on a system of raised dots to represent text. It shares some functional properties with visual reading, such as regressive movements elicited by degraded text.

Bimanual braille reading raises the question of each hand's contributing role, and the possibility of perceptual mechanisms distinct from visual reading.

Research questions

Sensitivity to stimulus quality: We asked whether stimulus quality (i.e. dot height) affected two-handed reading speed and regressive movements similarly to previous analyses of 1-handed reading (Lei et al., 2019).

Parallel text reading: We asked whether some readers are able to pick up text in parallel with hands over different portions of the text, i.e. "simultaneous disjoint reading" (Bertelson & Mousty, 1985).

Methods

Stimuli, participants, task

Stimuli: Braille passages adapted from IReST texts, equated for approximate length (~150 words), complexity, word frequency, 6 distinct texts + 1 practice text per subject; embossed at low, medium, or high dot height (0.04 mm, 0.18 mm, 0.38 mm)



Layout of example stimulus paragraph, topic "grey," as presented (left); annotated (right) with word boundaries and visual print text

Participants: Blind adult proficient braille readers (Present sample: N=10, age 22-70 y)

Task: Read braille prose passage aloud; using 1 or 2 hands at 3 dot heights = 6 unique trials per subject

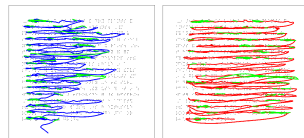


Data acquisition, analysis

Recording: Index & middle finger positions measured (3DG TrakStar, 240 Hz, 1.4 mm accuracy)

Behavior: Inclusion in analysis contingent on accurate verbal reading; reading speed measured via completion time; no other explicit task

Regressions: Defined as backward index finger movements over text of at least 1 character (0.25")

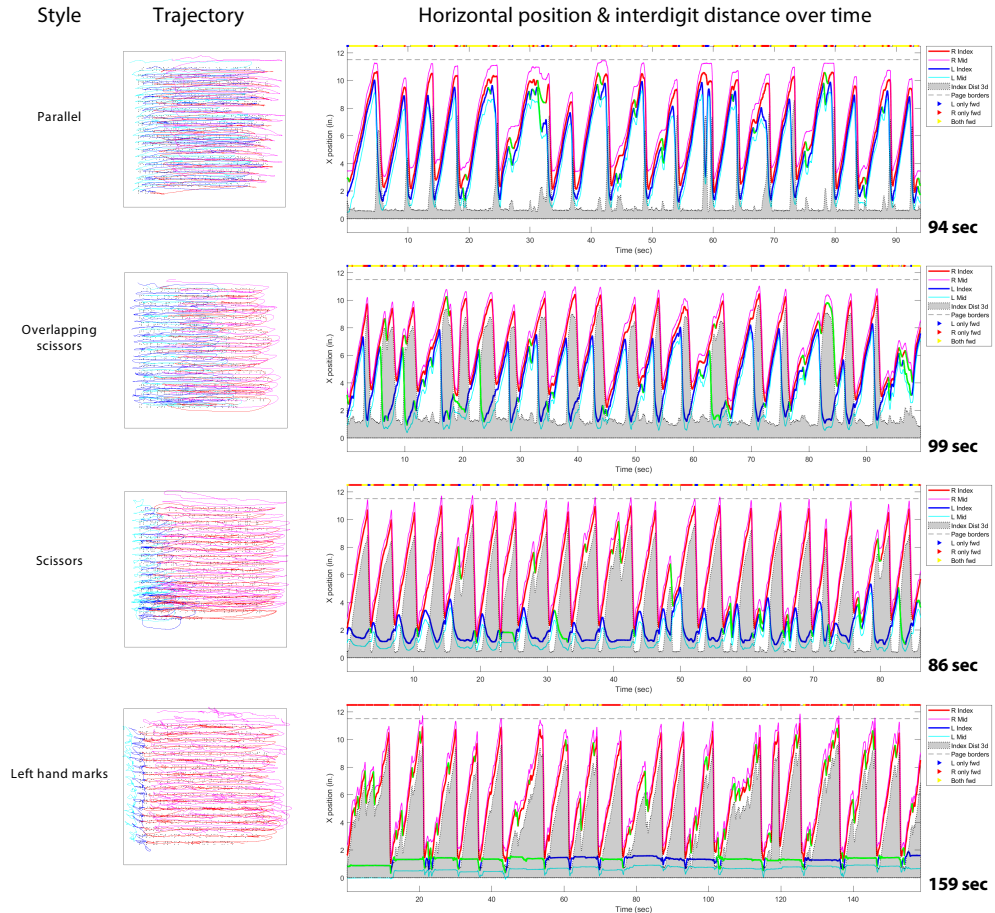


Example trial showing regressions (highlighted in green) for left (blue) and right (red) finger trajectories

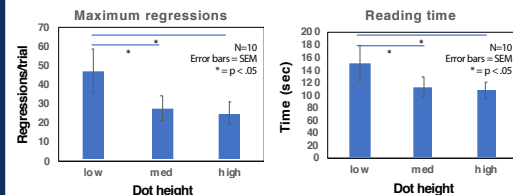
Finger kinematics: x-position (horizontal position on the page) and interdigit (3d Euclidean) distance between index finger positions vs. time

Results

Reading styles influence bimanual kinematics (representative individual trials shown)



Dot height modulates regressions and speed

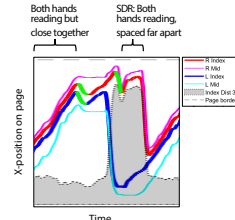


- Subjects made significantly more regressions (measured by hand with more regressions) and took longer to complete a passage when reading low vs. medium or high dots. Similar pattern to 1-handed reading (Lei et al., 2019)
- Handedness did not affect reading rates
- Preliminarily, 2-handed reading conferred a ~27% speed advantage over 1-handed reading, measured for high dots

Evidence of simultaneous disjoint reading

Parallel reading: Time points during which both index fingers advanced over text (marked yellow at top edge of individual plots above). To identify simultaneous disjoint reading (SDR), we excluded text covered by both hands at any time

Example SDR identification



- Preliminarily, episodes of SDR were found in two readers, lasting ~1 sec (0.7 - 1.8 sec across both).
- This corresponds to parallel acquisition of about 1 word
- Further analyses are ongoing

Summary and Conclusions (in progress)

Stimulus quality: As with 1-handed reading, 2-handed readers' speed and regressive movements were influenced by quality, with decrements at lowest dot height.

Parallel reading: Many readers showed simultaneous 2-handed reading, but only a few individuals exhibited *disjoint* parallel reading of separated text. This may suggest a parallel reading "buffer" of about 1 word in some readers.

Effect of reading styles: In addition to present analyses, we may consider the effect of bimanual reading styles on speed and efficiency, potentially informing training interventions.

Bimanual dissociations: Future analysis of disparate regression patterns between the hands may indicate different perceptual mechanisms based on reading style.