Impact of Motor Impairment on Full-Screen Touch Interaction

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Outline

1. Touchscreens and Accessibility
2. Study Description
3. Results and Observations
4. Summary and Conclusions

Touchscreen Prevalence

- First appeared in 1960s and 1970s
  (Johnson; Beck and Stumpe; Hurst)
- In mobile devices since 1990s (IBM Simon)
- Popularity exploded in 2007 w/ iPhone
- Apple sold 1.12+ million iPhones in 2007
- Now in almost every mobile device

Touchscreen Accessibility

- Motor impairment from MS, MSA, MD, etc.
- Can rebind gestures or create new ones
- Adjust click timing; enable switch control
- Avoid touch interaction (e.g. Siri or Now)

Common Limitations

- Programmatically prohibited from toggling or adjusting sliding functionality

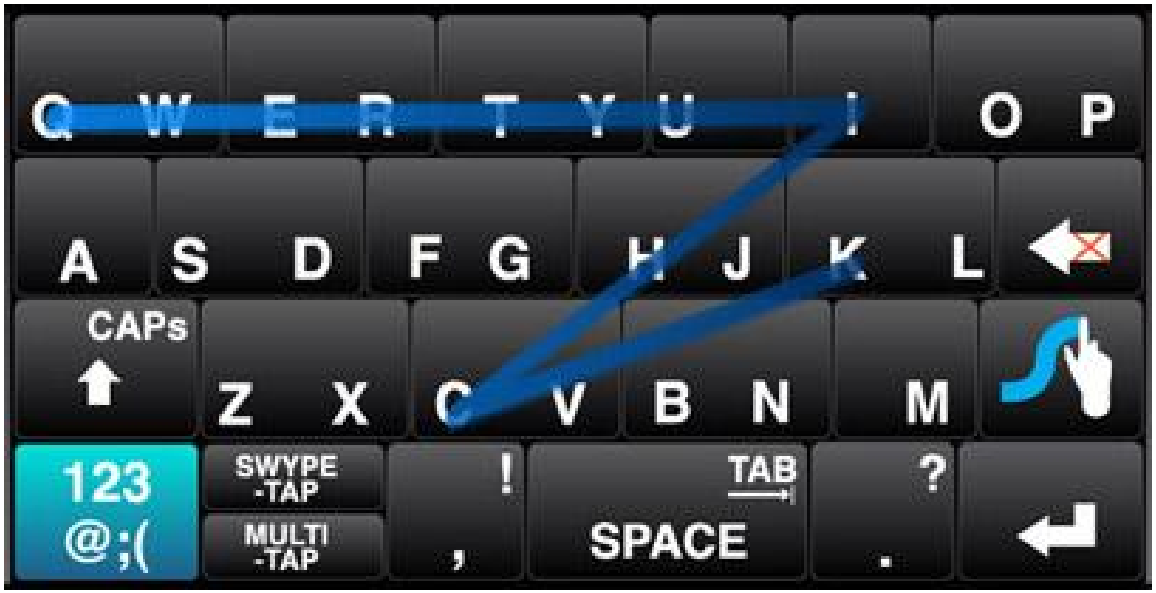
- Users are prevented from modifying the location, size, shape, and orientation of many toolbars and buttons

★ Difficult to quantify the effects of these limitations on users and purchasing

Motivating Example: Swype

- Originally conceived as an interface for assistive communication

- Well-received by non-disabled users



Motivating Questions

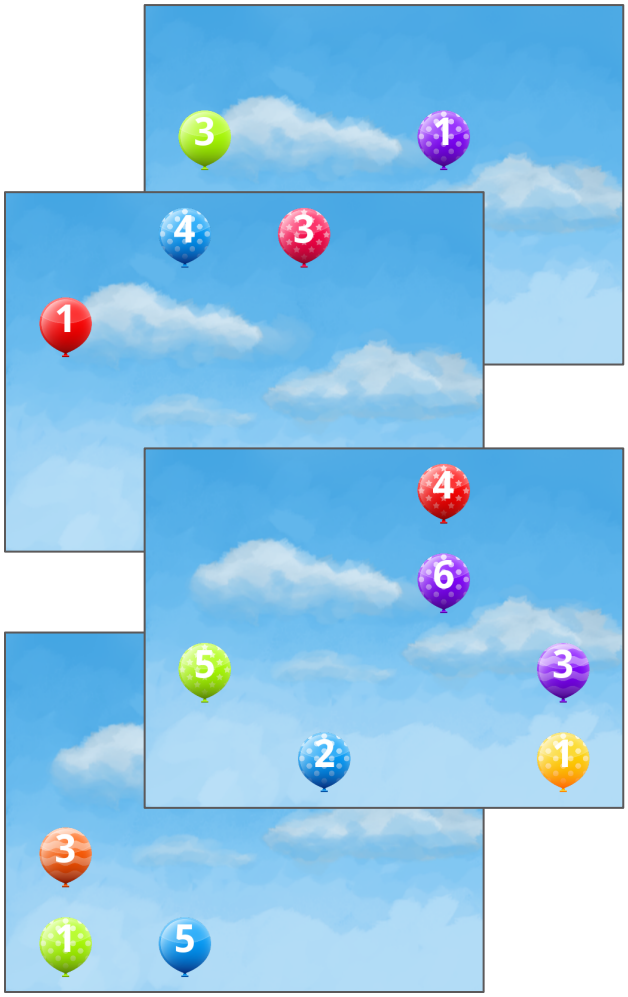
- Most mobile devices now have touchscreens
- Increasing research on accessibility
  - Fitts and Steering Laws [Fitts, 1954; Accot and Zhai, 1996]
  - Swabbing/sliding is easier [Wacharamanotham et al, 2011]
  - Buttons need to be bigger [Chen et al, 2013]

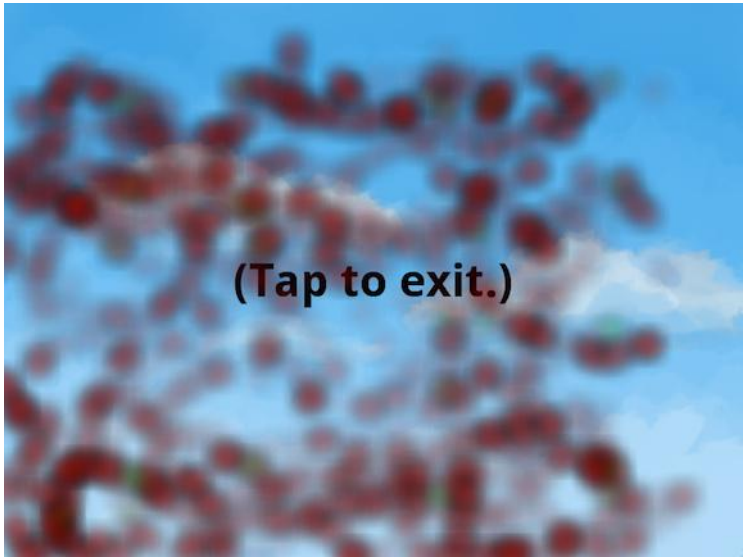
★ What about functional compensation?

★ Can we learn realistic, layout-agnostic interaction patterns for an individual user?

Motor Optimization GUI (MoGUI)

MoGUI Example





Study Overview

- 2 cross-balanced sessions: taps vs. slides
- 4x4 grid = 16 locations
  - Pseudo-random shuffling (a la Latin Squares)
- 10 levels of 3 rounds each
- 1, 2, 3, ...10 balloons per round = 165 total
- Track all hits, misses, and timing

Participants

- Residents at the Boston Home
  - Various levels of speech and motor impairments
  - 10 females and 5 males
  - Ages 35 - 71 (mean of 56)
- 8 right-handed; 7 left-handed (3 due to MS)
- All were familiar with touchscreen tablets, but only 8 regular users (7 iPads, 1 Kindle)

Method

- 10.1" Android tablet (ASUS Transformer)
- Comfortable, landscape position s.t. all areas were fully reachable
  - 9 users preferred a 45-degree angle on a table
  - 1 user preferred a lowered table and flat tablet
  - 2 users preferred the tablet in a wheelchair mount
  - 2 users preferred the tablet in their lap
  - 1 user cradled the tablet in one arm
- Choice of finger or stylus
  - 6 wanted stylus, but needed it positioned

Interview Questions

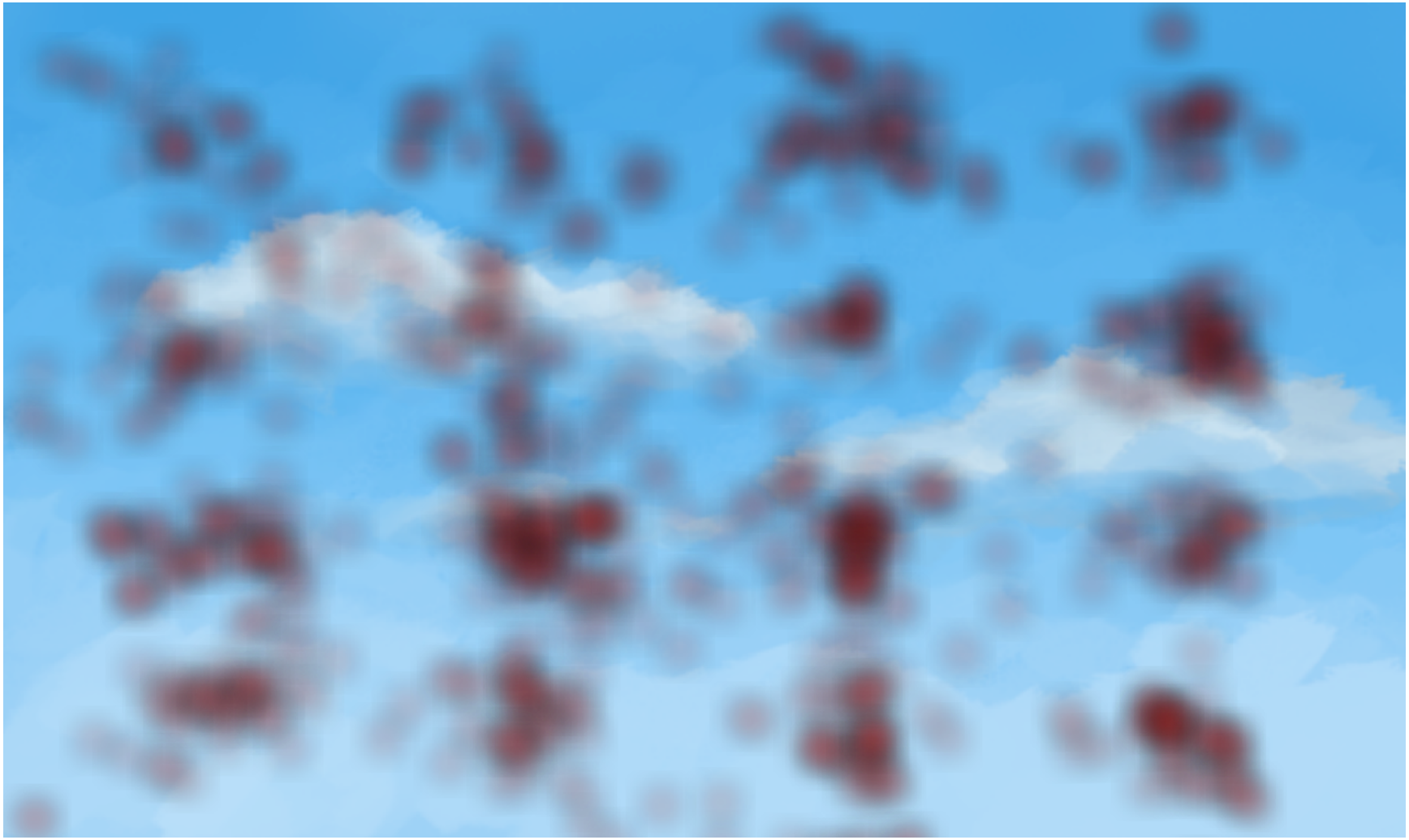
1. Did you find any areas of the screen easier or more difficult to reach than others?

2. Did you prefer tapping, sliding, a combination of both, or neither?

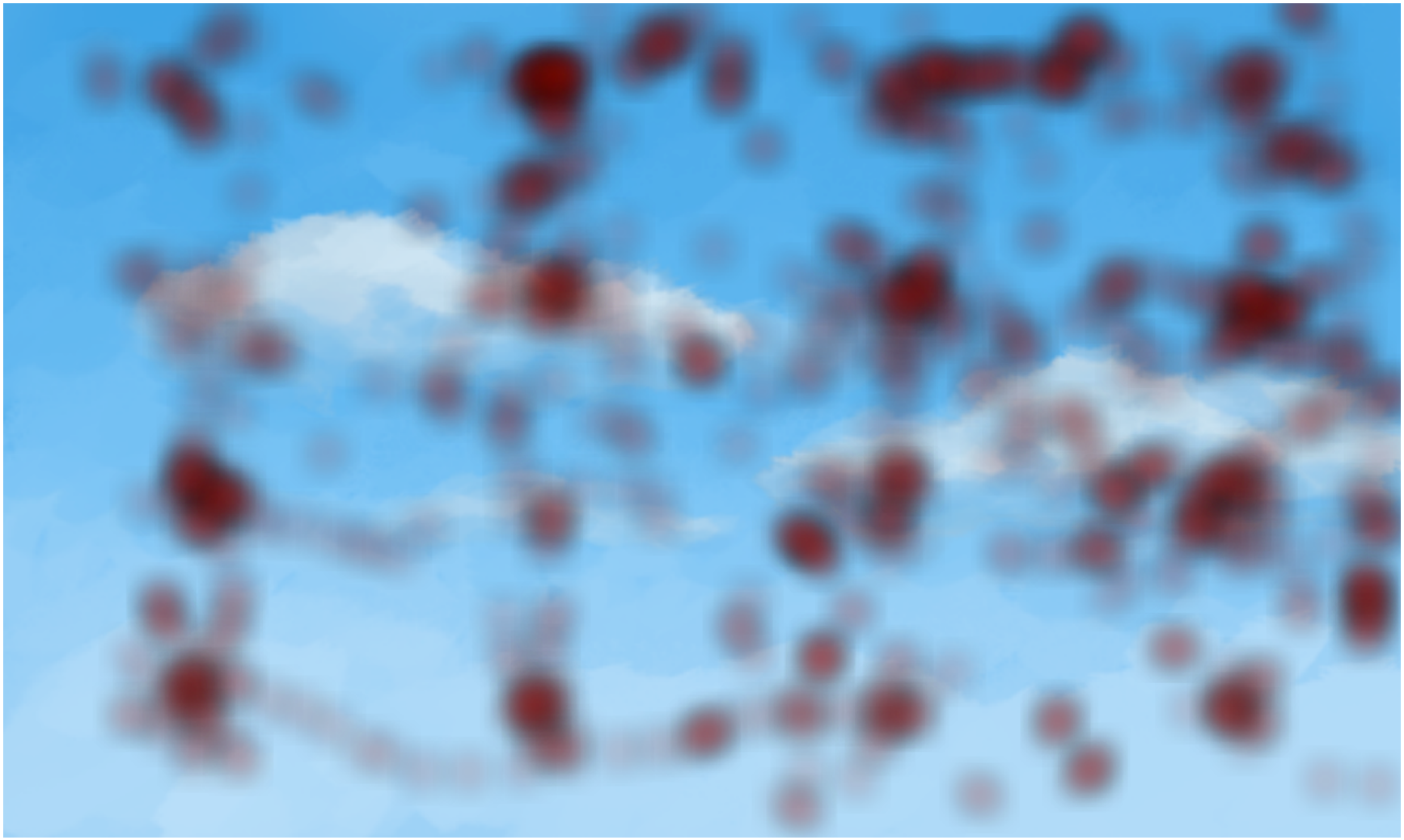
3. Were the balloon targets too big or small?

4. What would you like to see improved in touchscreen tablets?

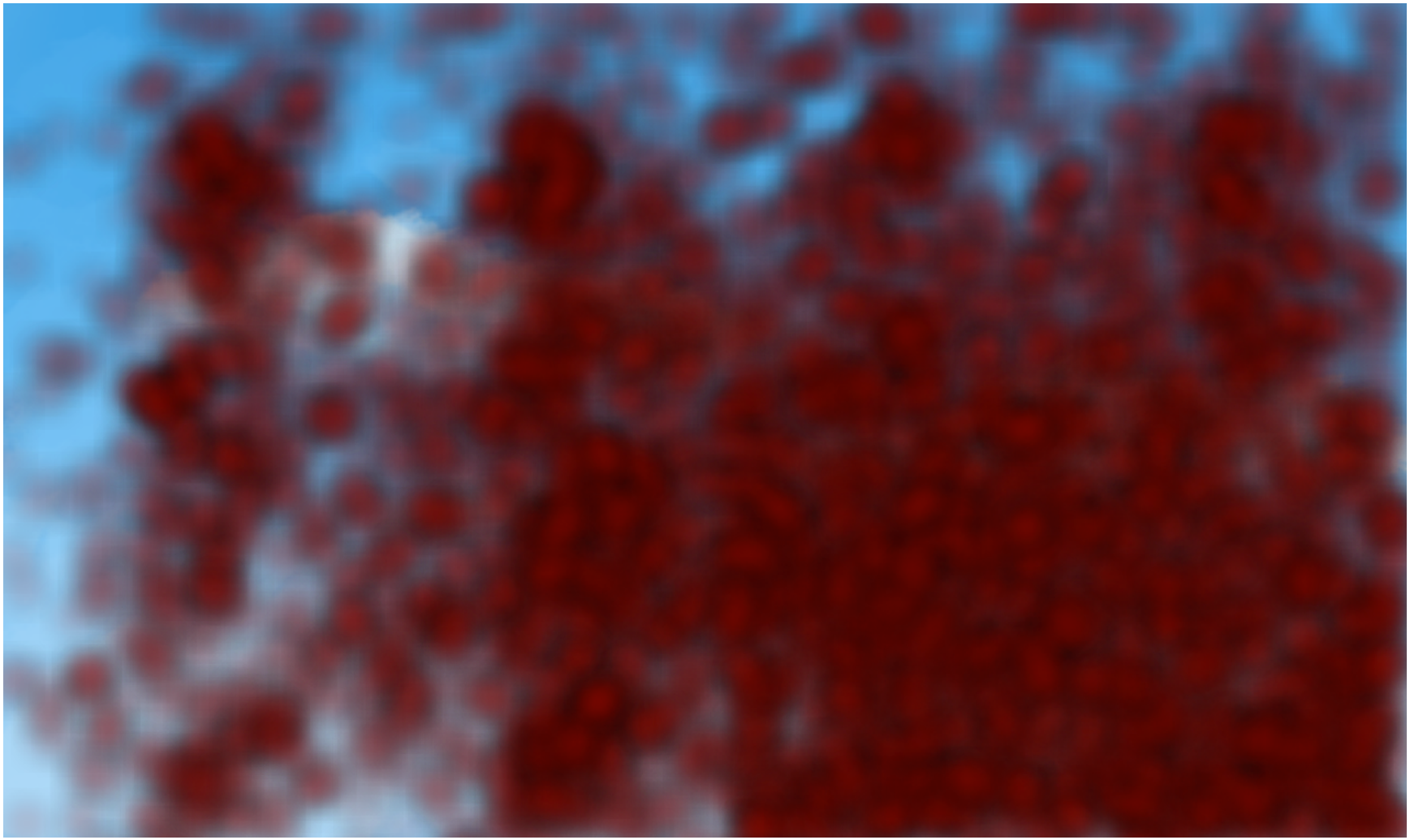
Variability: Multiple Taps (LH)



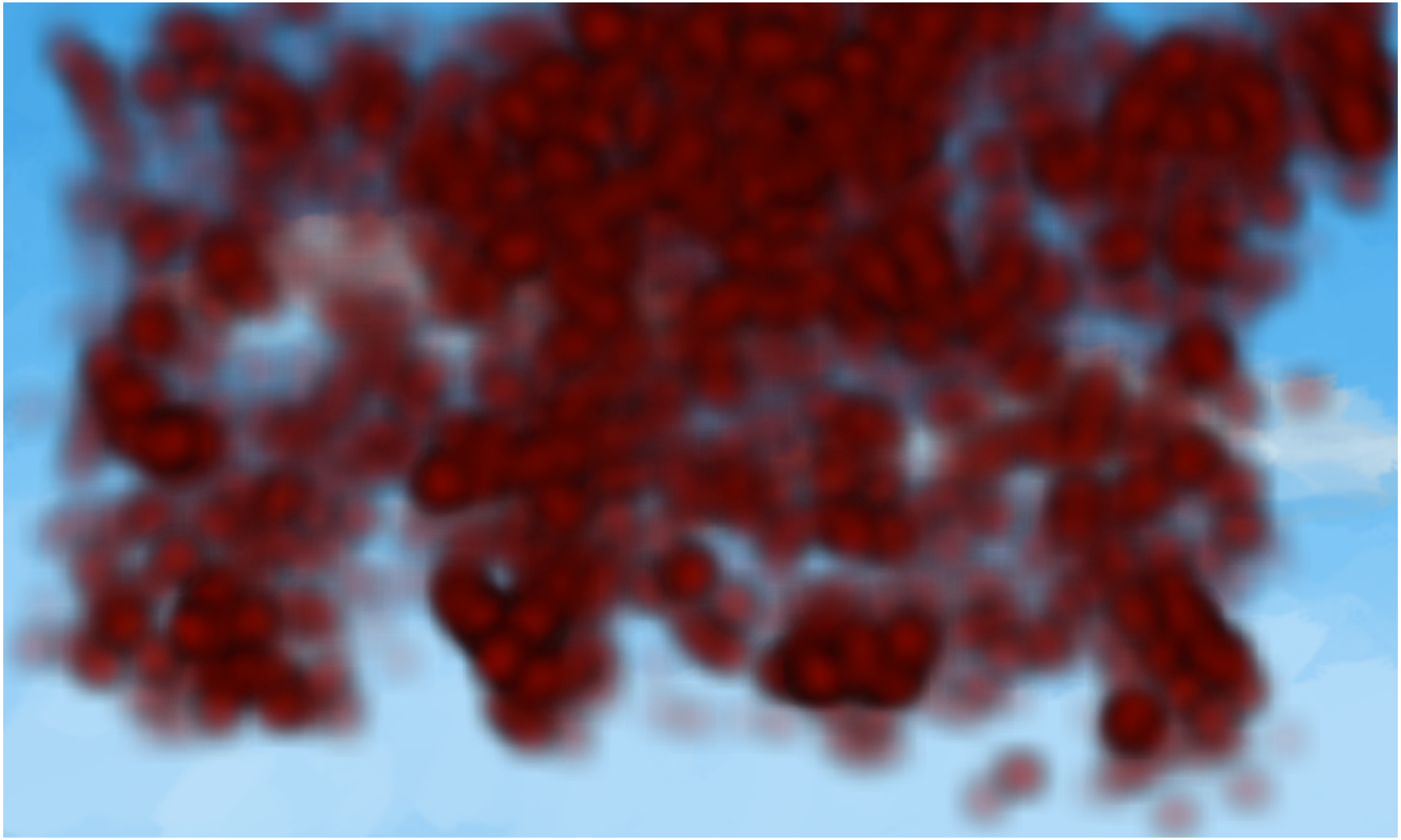
Variability: Finger Dragging (RH)



Variability: Hand Resting (RH)

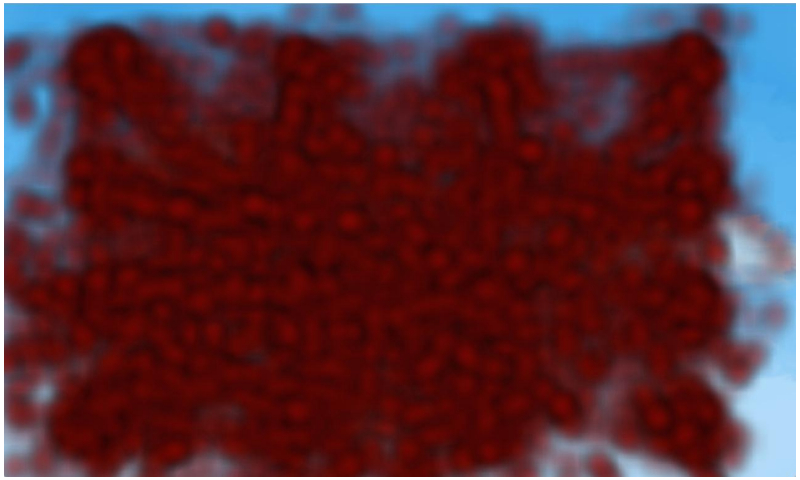


Variability: Thumb Usage (RH)

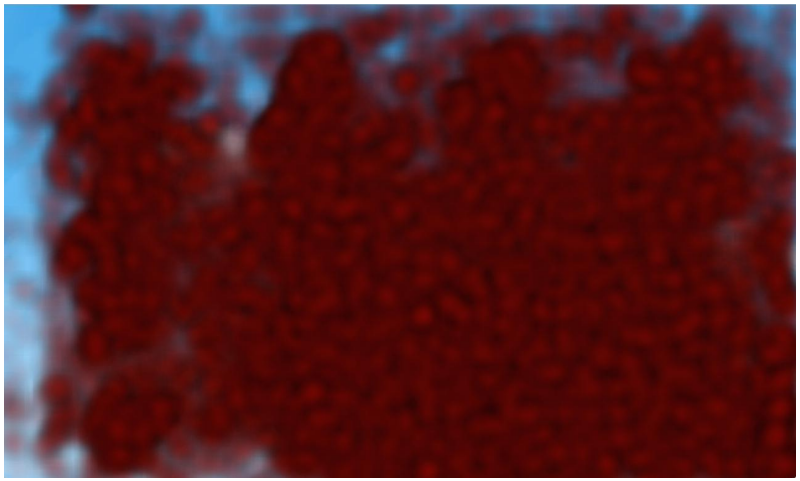


Results: Misses by Handedness

Left

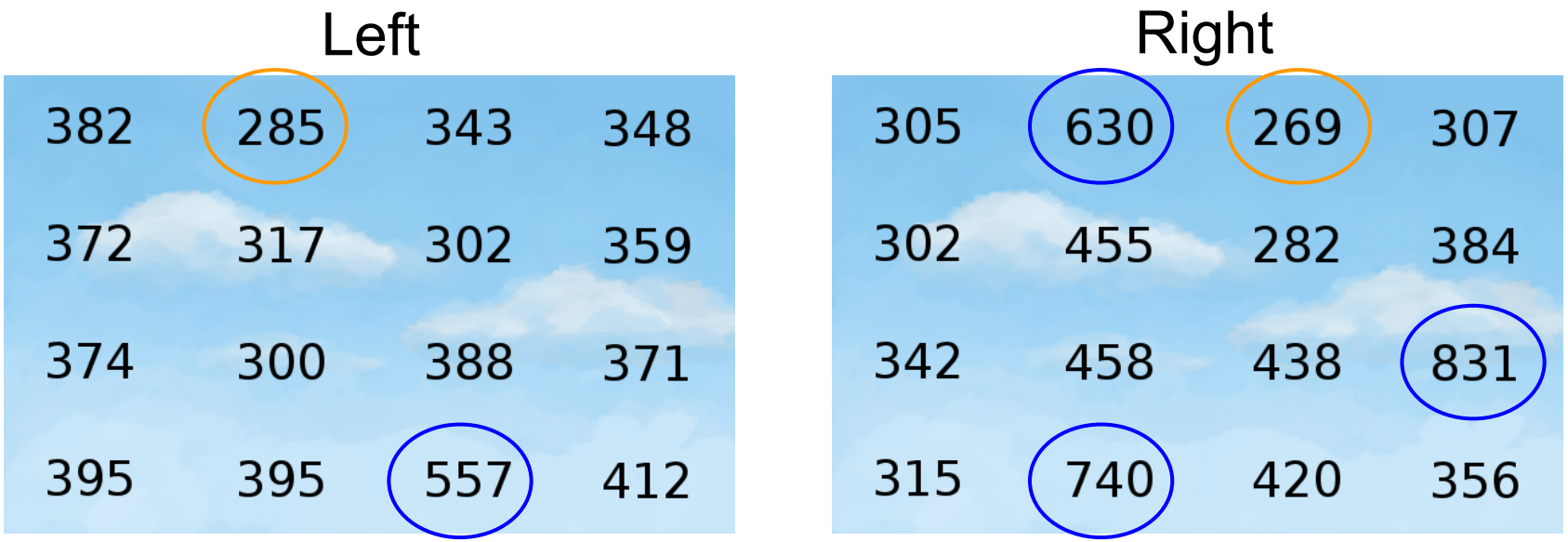


Right



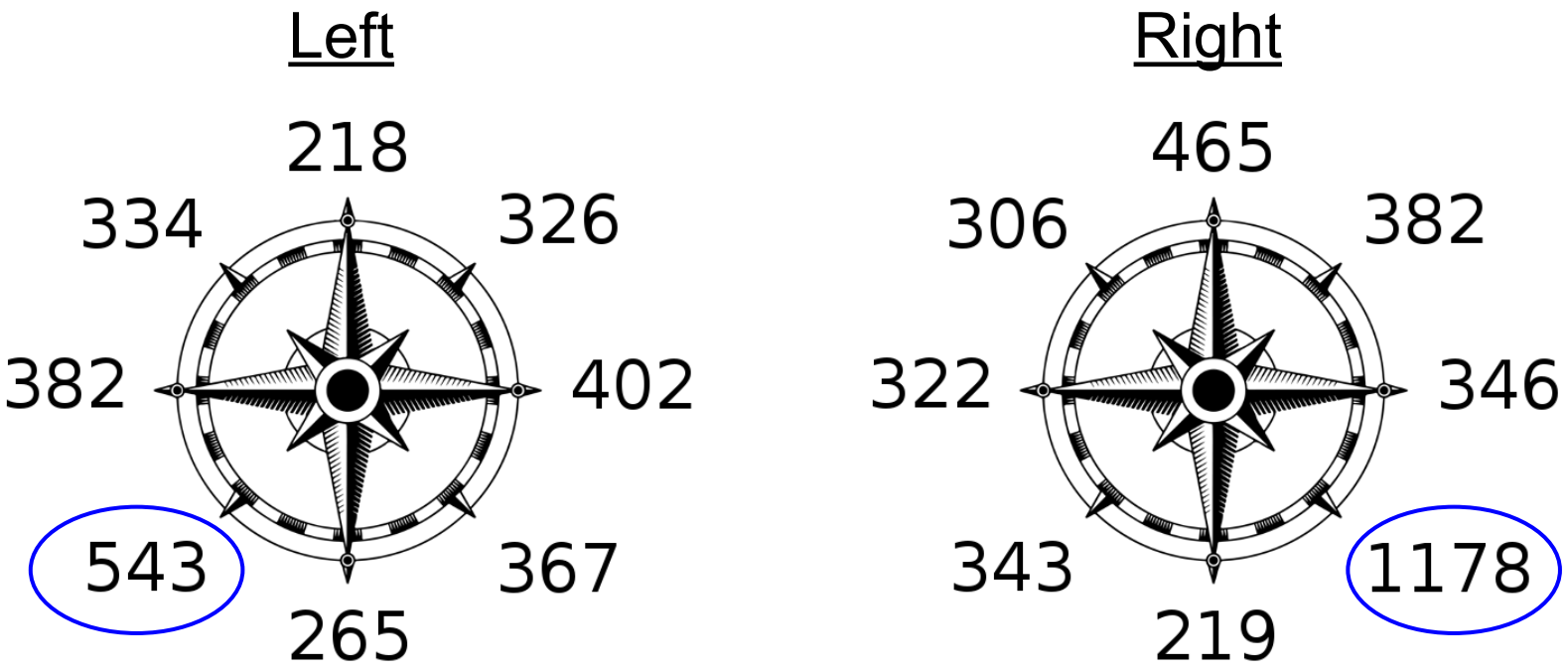
Overlays from all sessions

Results: Locations by Handedness



Mean speed-to-target in pixels/second

Results: Directions by Handedness



Mean speed-to-target in pixels/second

Participant Feedback

- 3 users preferred tapping; 5 preferred sliding; 5 preferred a combination of both; and 2 had no preference
- 10 users noted that sliding required planning
- Overall, 8 participants felt that sliding felt "faster" and "easier," but for short distances
- Randomness prevented motor learning

Study Observations

- Varied tablet and hand/arm positions
  - Tablet being held, flat/tilted on lap, on desk, tilted on table, held in wheelchair mount
  - Needed to disable auto-rotation for 1 user
  - Use of fingers, thumb, stylus, and knuckles
- Ghost tapping, spastic tapping, stylus friction, and finger humidity
- Repeated margin activation and triggering of Google Now functionality

Summary

- Sliding not significantly faster than tapping for arbitrary targets; no motor learning
  - 16% accidental slides; 43% accidental taps
- High variance in individual motor patterns; weak correlations by handedness
  - Gamified calibration
- Static improvements through personas:
  - Handedness → margins, button locations
  - Tap/slide preferences → input sensitivity

Thank you for listening!

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