Supplemental Information

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Vibrotactile masking experiments reveal accelerated somatosensory processing in congenitally blind Braille readers

Supplemental Methods

Here we derive the formula for the masking decay time constant, τ, and the predicted masking amplitude at zero ISI, m_0.

We model masking at ISI (t) as:

$$m_t = m_0 e^{-t/\tau} \qquad \text{(Eqn. 1)}$$

We divide the expressions for masking at 50 ms ISI and 100 ms ISI to obtain:

$$\frac{m_{50}}{m_{100}} = \frac{e^{-50ms/\tau}}{e^{-100ms/\tau}} = e^{50ms/\tau} \qquad \text{(Eqn. 2)}$$

Taking the natural logarithm of both sides and rearranging, we obtain:

$$\tau = \frac{50ms}{\ln\left(\frac{m_{50}}{m_{100}}\right)} \qquad \text{(Eqn. 3)}$$

Note that, if we were to redefine time, t, as stimulus-onset asynchrony (SOA) rather than inter-stimulus interval (ISI), this would add a constant to each time entered in the derivation of Eqn. 2. The added constant (25ms for BM tasks, 100 ms for FM tasks) would cancel out in the derivation. Therefore, the formula for τ would not change.

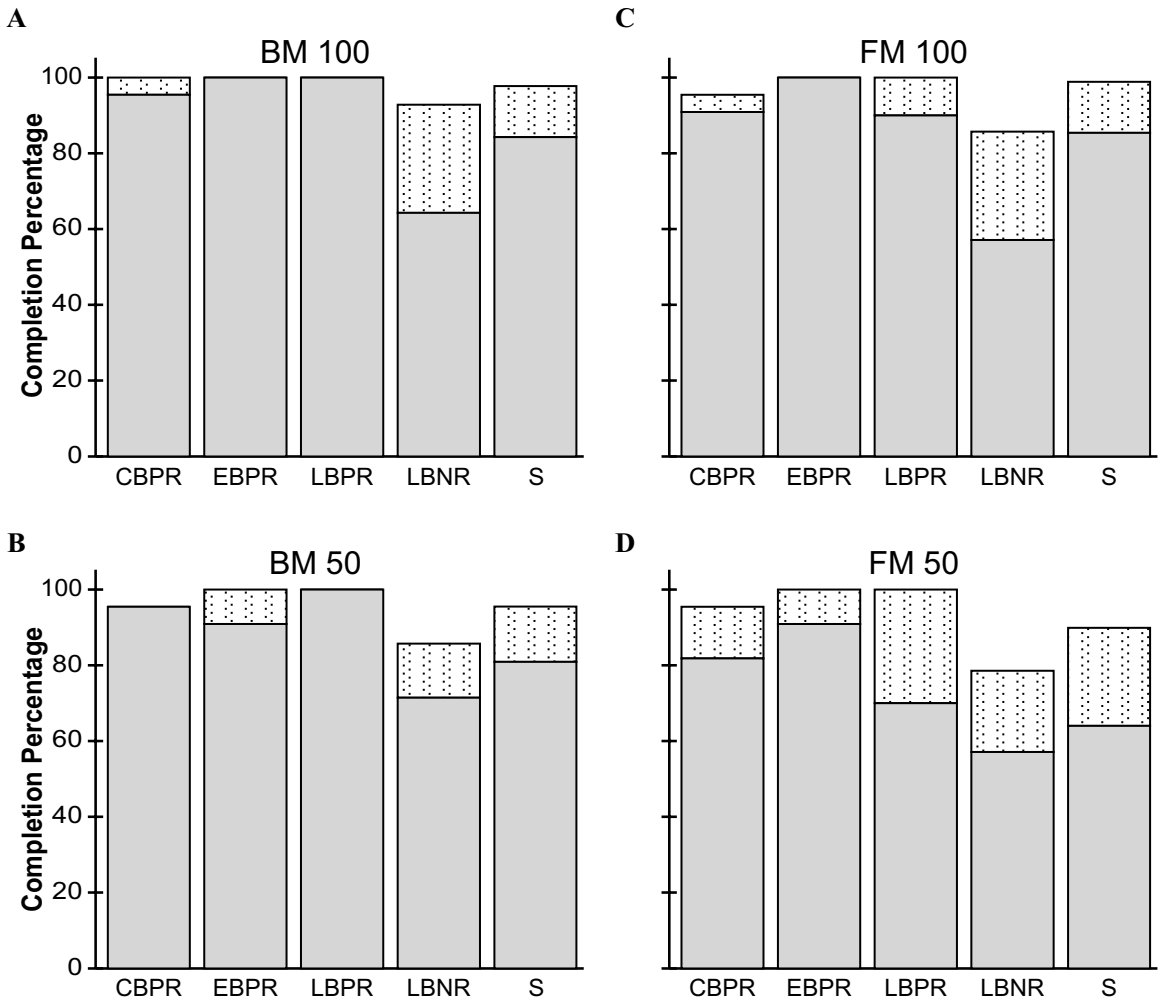
To derive m_0, we rearrange Eqn. (1) then substitute in the expression for τ (Eqn. 3):

$$m_0 = m_t e^{t/\tau} = m_t \exp\left[(t/50ms)\ln\left(\frac{m_{50}}{m_{100}}\right)\right] = m_t\left(\frac{m_{50}}{m_{100}}\right)^{t/50ms}$$

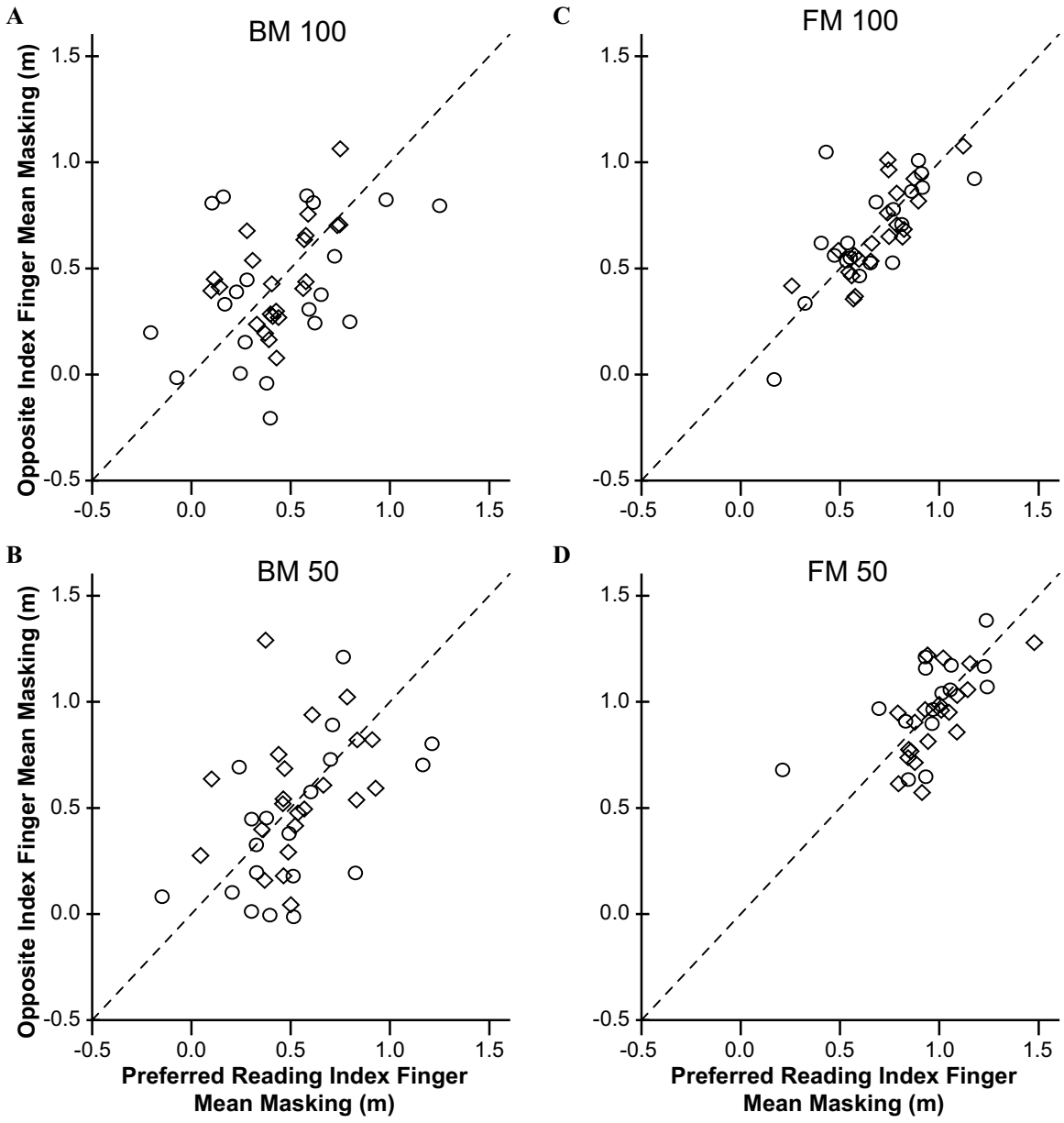
Therefore,

$$m_0 = \frac{(m_{50})^2}{m_{100}}$$

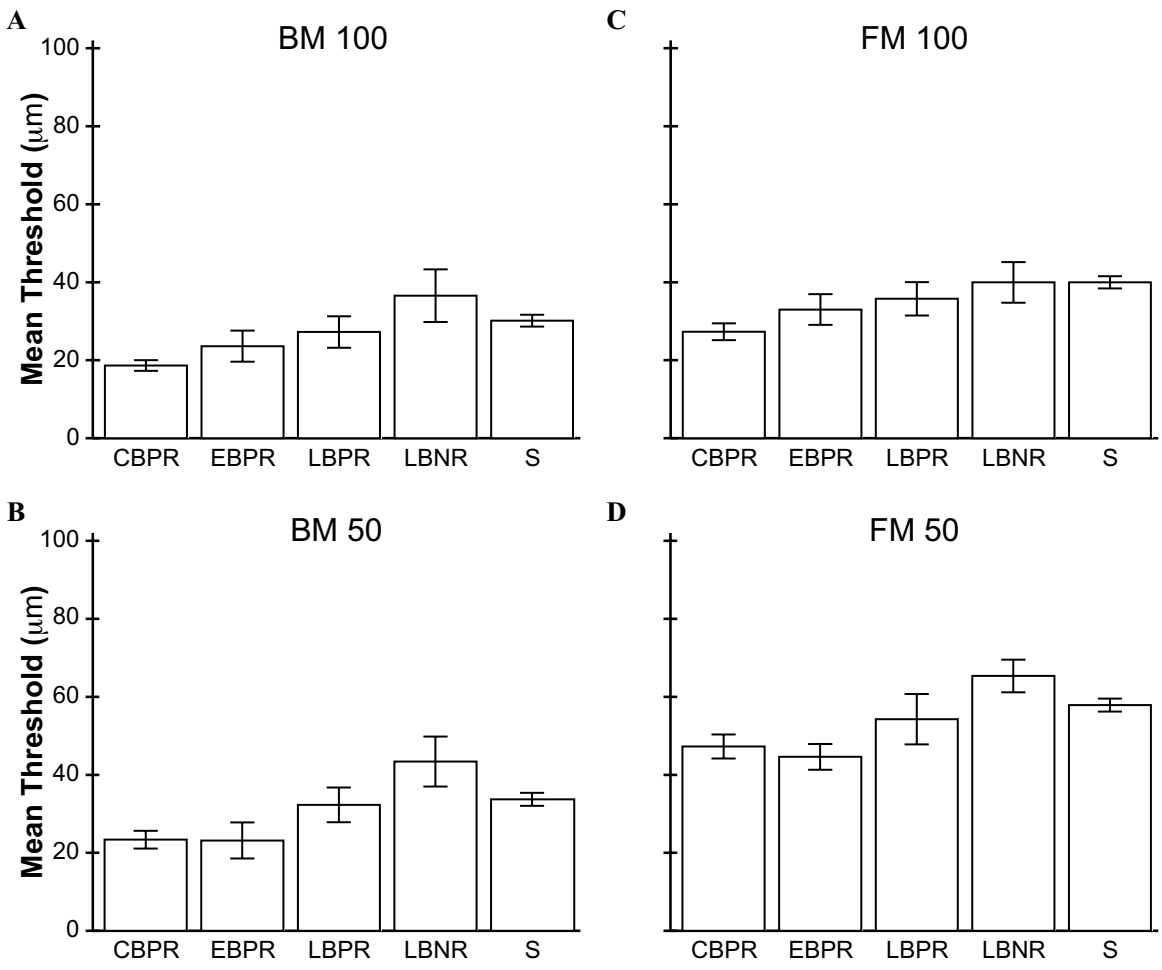
Supplemental Figures



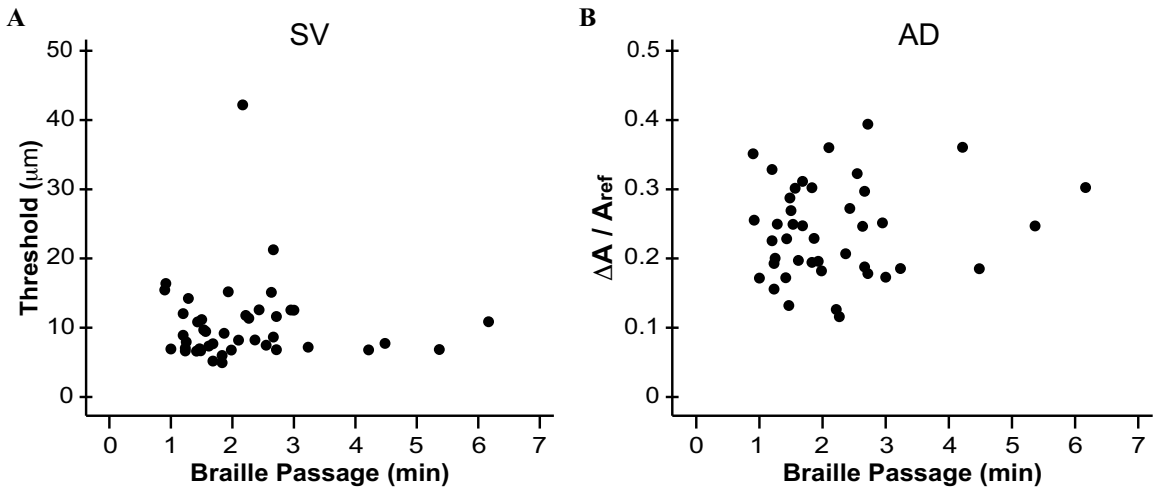
Supplemental Figure 1. Masking task completion percentages for the five participant groups. **A-D,** Backward masking 100ms, 50ms, forward masking 100ms, 50ms. Grey bars: percent of participants who completed the task with both hands. Stippled bars: percent of participants able to complete with one hand only. CBPR: congenitally blind proficient Braille reader. EBPR: early blind proficient Braille reader. LBPR: late blind proficient Braille reader. LBNR: late blind novice or nonreader. S: sighted.



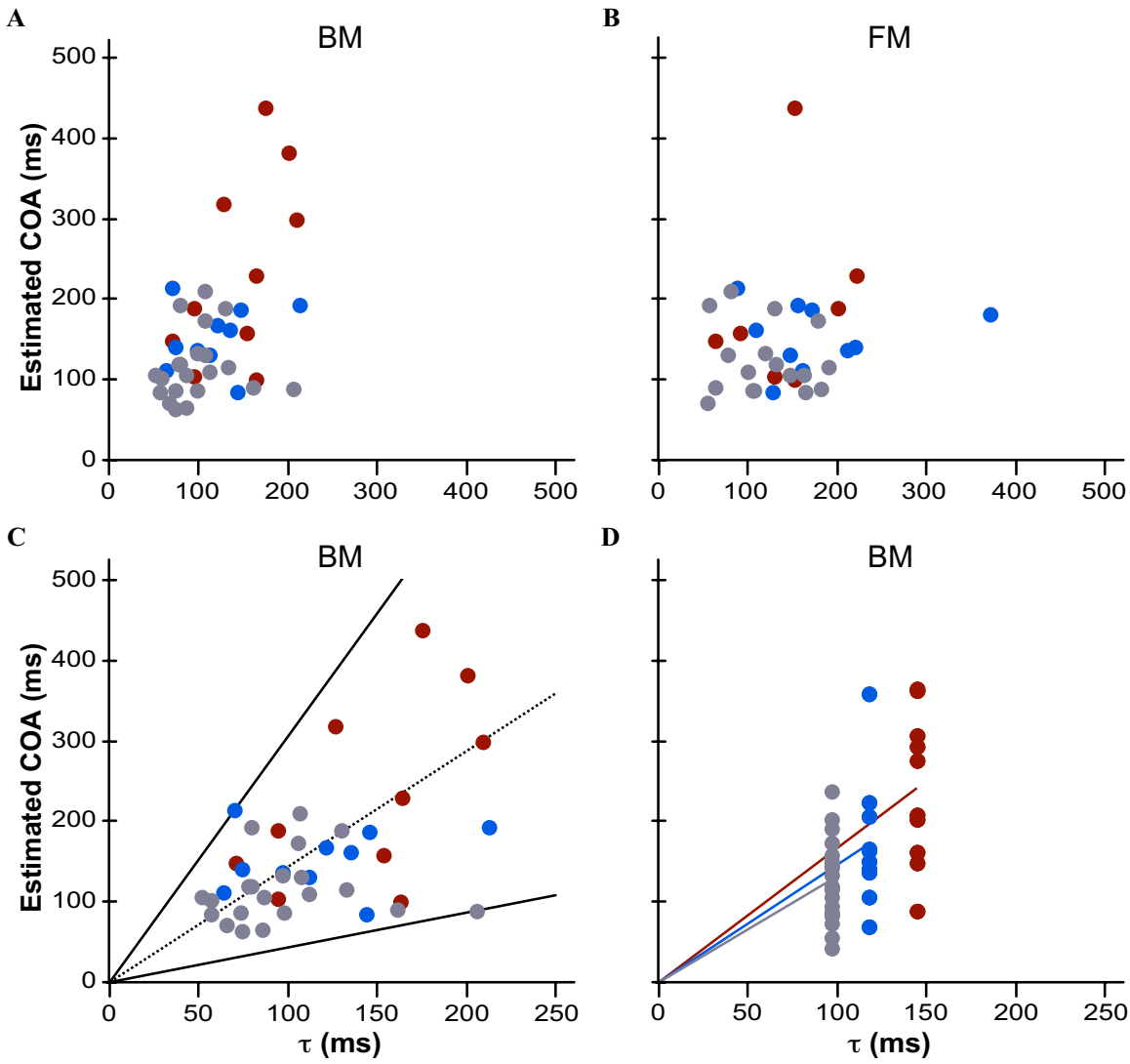
Supplemental Figure 2. Proficient Braille readers' performance metric on the four masking tasks with the index finger preferred for reading versus the index finger of the opposite hand. **A-D,** Backward masking 100ms, 50ms, forward masking 100ms, 50ms. Diamonds: one-hand readers. Circles: two-hand readers. Performance on the two hands was statistically equivalent (see paired-t test p-values given in main text) and significantly correlated (All proficient readers: BM100 Pearson's $r = 0.43$, $p = 0.005$; BM50 $r = 0.45$, $p = 0.003$; FM100 $r = 0.74$, $p < 0.001$; FM50 $r = 0.62$, $p < 0.001$. One-hand readers: BM100 $r = 0.52$, $p = 0.013$; BM50 $r = 0.31$, $p = 0.16$; FM100 $r = 0.79$, $p < 0.001$; FM50 $r = 0.69$, $p = 0.001$. Two-hand readers: BM100 $r = 0.39$, $p = 0.085$; BM50 $r = 0.57$, $p = 0.011$; FM100 $r = 0.71$, $p = 0.001$; FM50 $r = 0.64$, $p = 0.011$).



Supplemental Figure 3. Mean detection thresholds (target amplitude, microns) of the five participant groups on the masking tasks. **A-D,** backward masking 100ms, 50ms, forward masking 100ms, 50ms. Error bars: ±1 SE. Thresholds are averaged across the two hands. Compare to Fig. 5 of the main text, which plots the same performance data using the masking metric, *m*. The two plots show very similar trends.



Supplemental Figure 4. Performance of the proficient Braille readers on non-masking tasks, plotted against Braille test passage reading time. **A,** Simple vibrotactile detection. **B,** Amplitude discrimination. Thresholds are averaged across the two hands.



Supplemental Figure 5. Estimated character onset asynchrony during Braille reading plotted against masking decay time constants. Data points are color-coded according to proficient reader group: CBPR (grey), EBPR (blue), LBPR (red). **A,** Backward masking decay time constant. **B,** Forward masking decay time constant. **C,** The mean COA-to-BM τ ratio was 1.4 (dotted line); the maximum ratio was 3.1 (upper solid line); and the minimum ratio was 0.4 (lower solid line). **D**, Each participant's data point was regressed along the line connecting it with the origin, in order to adjust the participant's BM τ to the average BM τ for the group to which the participant belonged, while maintaining the participant's COA-to-BM τ ratio. Interestingly, the mean COA-to-BM τ ratio increased slightly but systematically across the three groups of proficient readers (mean ± SE: CBPR, 1.3 ± 0.1; EBPR, 1.5 ± 0.2; LBPR, 1.7 ± 0.2), although this increase was not statistically significant (ANOVA, $p = 0.285$).