Is the critical print size for reading linked to letter recognition?

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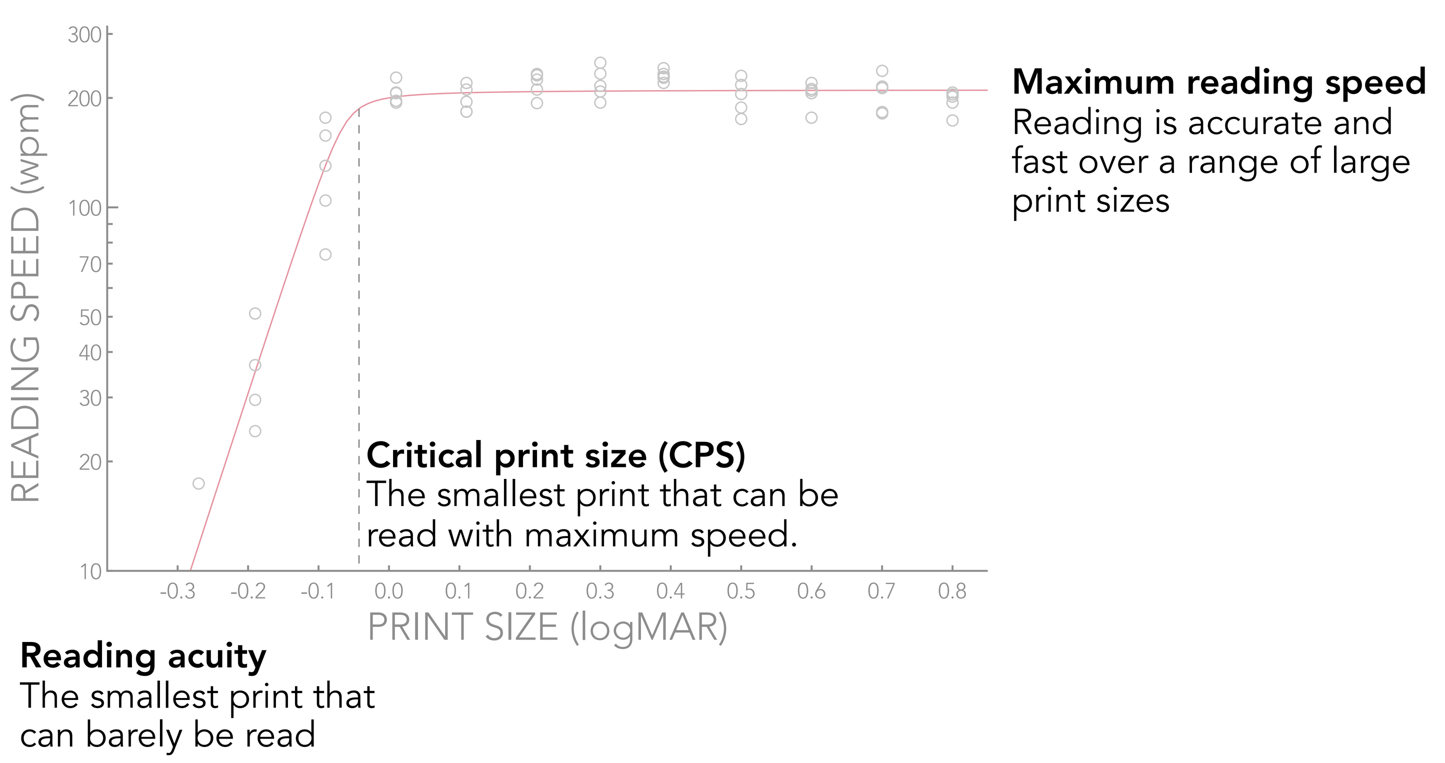
RATIONALE

Plots of reading speed as a function of print size show the following features:



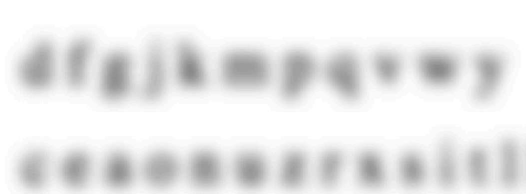
The critical print size is an important transition point between easy and effortful reading. But what determines this size?

Reading acuity is likely determined by the size at which the letters become too small to recognize. The critical print size is about twice as large as this acuity size, but is it also determined by letter recognition?

STUDY 1

To explore this question, we took advantage of the fact that at small sizes some letters are easier to recognize than others:

easy	d f g j k m p q v w y
hard	a b c e h i l n o r s t u x z



Based on recognition errors for individual blurred Times letters for 250ms exposures (Mansfield and West, 2017).

Hypothesis: Sentences containing many of these *easy* letters will have a smaller critical print size than sentences containing fewer easy letters.

METHOD

We selected sentences from our corpus of 116,000 computer-generated MNREAD sentences (Mansfield and Lewis, 2017).

We created two pools of sentences:

- *Easy:* containing many (*M*=14.3, *SD*=0.81) easy letters
- *Hard:* containing fewer (*M*=4.7, *SD*=0.56) easy letters

We measured reading speed as a function of print size using a computer based version of the MNREAD acuity chart.

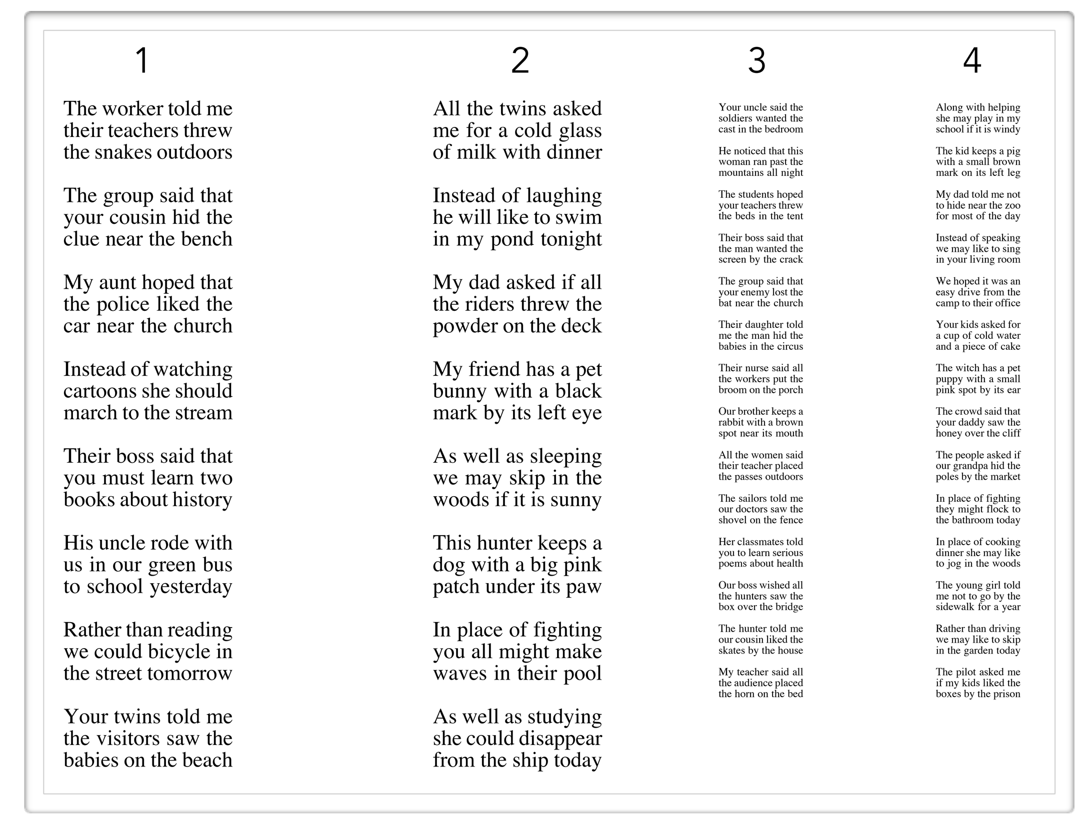
Print sizes ranged from -0.3 to +0.8 logMAR.

Data were collected from 36 college students with normal vision (or wearing their normal visual correction).

Each participant read 5 versions of the MNREAD chart for each type of sentence.

TRY IT!

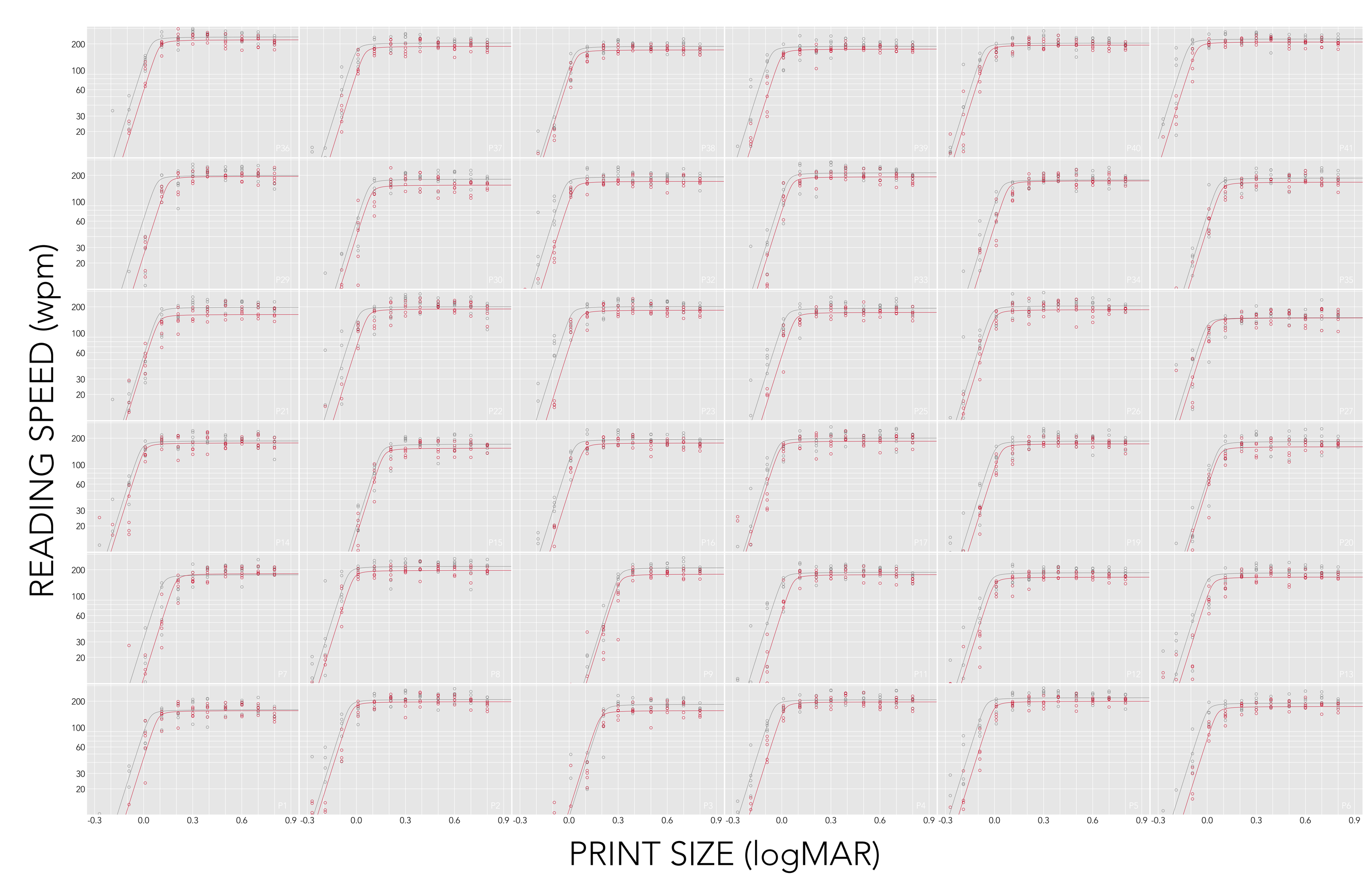
Stand at arms length (~80cm). How quickly can you read these sentences?



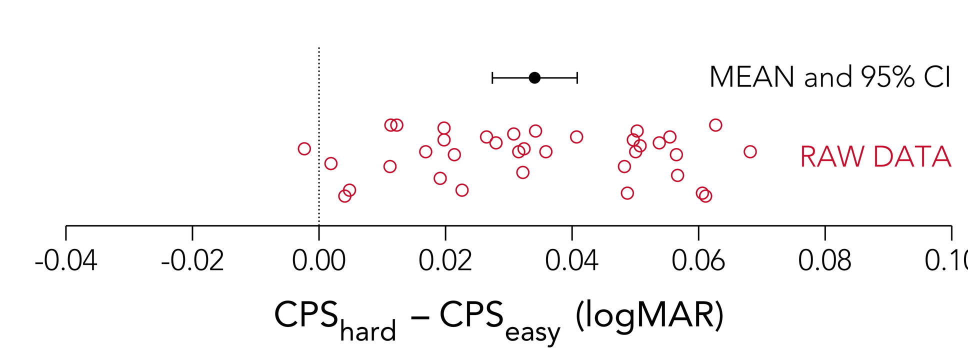
Columns 1 & 2: Print size = 0.3 logMAR — There is little difference in reading speed for the left (hard) versus right (easy) sentences. Columns 3 & 4: Print size = 0.0 logMAR. Reading is slower, but which column is easiest to read?

RESULTS

We estimated the critical print size (CPS) from curve fits to the reading-speed versus print-size data.



Reading speed versus print size for easy (gray) and hard (red) sentences. Curves have the form: $y = \mathrm{MRS} + \frac{\alpha}{2}\left[x - \mathrm{CPS} - \sqrt{(x - \mathrm{CPS})^2 + \lambda}\right]$, where y is $\log_{10}$ reading speed (in wpm), MRS is the maximum reading speed, α is the slope of the rising portion of the curve (and was set to 6.0), x is logMAR print size, CPS is the critical print size, and λ controls the sharpness of the roll-over (and was set to 0.001) (Cudeck & Harring, 2010).



On average, the CPS was 8.1% larger for the *hard* sentences than for the *easy* sentences [95% CI: 6.5, 9.8], (t_{35} = 10.3, p < 0.001).

STUDY 2

Study 1 shows that the CPS is larger for sentences that contain more hard-to-recognize letters. This is consistent with the critical print size being linked to letter recognition.

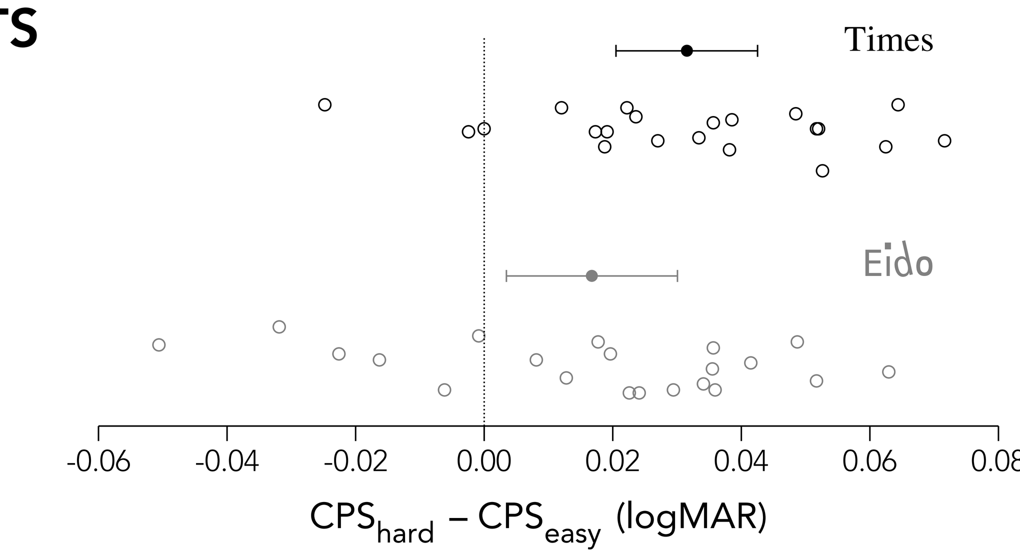
Our sentences were selected to exploit the letter confusions found with the *Times* font. The difference in CPS for our hard versus easy sentences should diminish if we use a font that has different letter confusions — we chose *Eido* (Bernard, Aguilar, & Castet, 2016), which is designed to reduce similarities between letters.

a b c d e f g h i j k l m n o p q r s t u v w x y z

METHOD

Reading speed versus print size curves were collected from 21 students with normal vision, for *easy* and *hard* sentences printed using either *Times* or *Eido*.

RESULTS

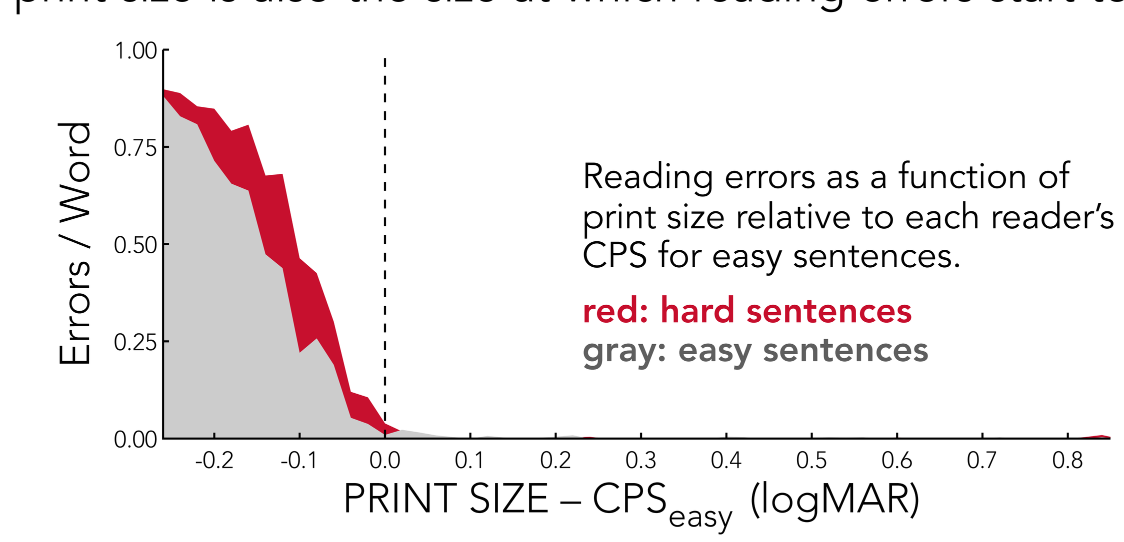


For *Times*, the CPS was 7.5% larger for the *hard* sentences than for the *easy* sentences. For *Eido*, the CPS was only 3% larger for the *hard* sentences than for the *easy* sentence. This difference is significant (one-tailed, t_{20}=1.87, p=0.038).

DISCUSSION

We propose that, with large print, letter recognition is accurate and reading is fast. But when print size is smaller than the critical print size, letter recognition becomes error prone and the reader is required to infer the identity of words that contain misidentified letters — this produces slower reading speeds, and/or reading errors.

Indeed, the critical print size is also the size at which reading errors start to become common.



References

Bernard, J-B,. Aguilar. C., Castet, E. (2016) A New Font, Specifically Designed for Peripheral Vision, Improves Peripheral Letter and Word Recognition, but Not Eye-Mediated Reading Performance. *PLoS ONE 11(4): e0152506.* https://doi.org/10.1371/journal.pone.0152506

Cudeck, R., & Harring, J. R. (2010). Developing a random coefficient model for nonlinear repeated measures data. In S.-M. Chow, E. Ferrer, & F. Hsieh (Eds.), The Notre Dame series on quantitative methodology. Statistical methods for modeling human dynamics: An interdisciplinary dialogue (pp. 289-318). New York, NY, US: Routledge/Taylor & Francis Group.

Mansfield, J. S., and Lewis, A. (2017). Computer-generated MNREAD sentences for measuring acuity and reading-speed: A comparison of Times and Courier. *Annual Meeting of the Association for Research in Vision and Ophthalmology*, Baltimore, MD, USA. May 2017

Mansfield, J. S., and West, T. (2017). Can we use lexical knowledge to help identify words when letter recognition is difficult? *Annual Convention of the Association for Psychological Science*, Boston, MA, USA. May 2017