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Modeling Word Length Effect in Lexical Decision: The Role of Visual Attention

Émilie GINESTET, Thierry PHÉnix, Julien DIARD and Sylviane VALDOIS

1st computational model simulating the word length effect in LD

Context

The word length effect in Lexical Decision (LD) has been reported in many megastudies (Ferrand et al., 2010, 2011; New et al., 2006).

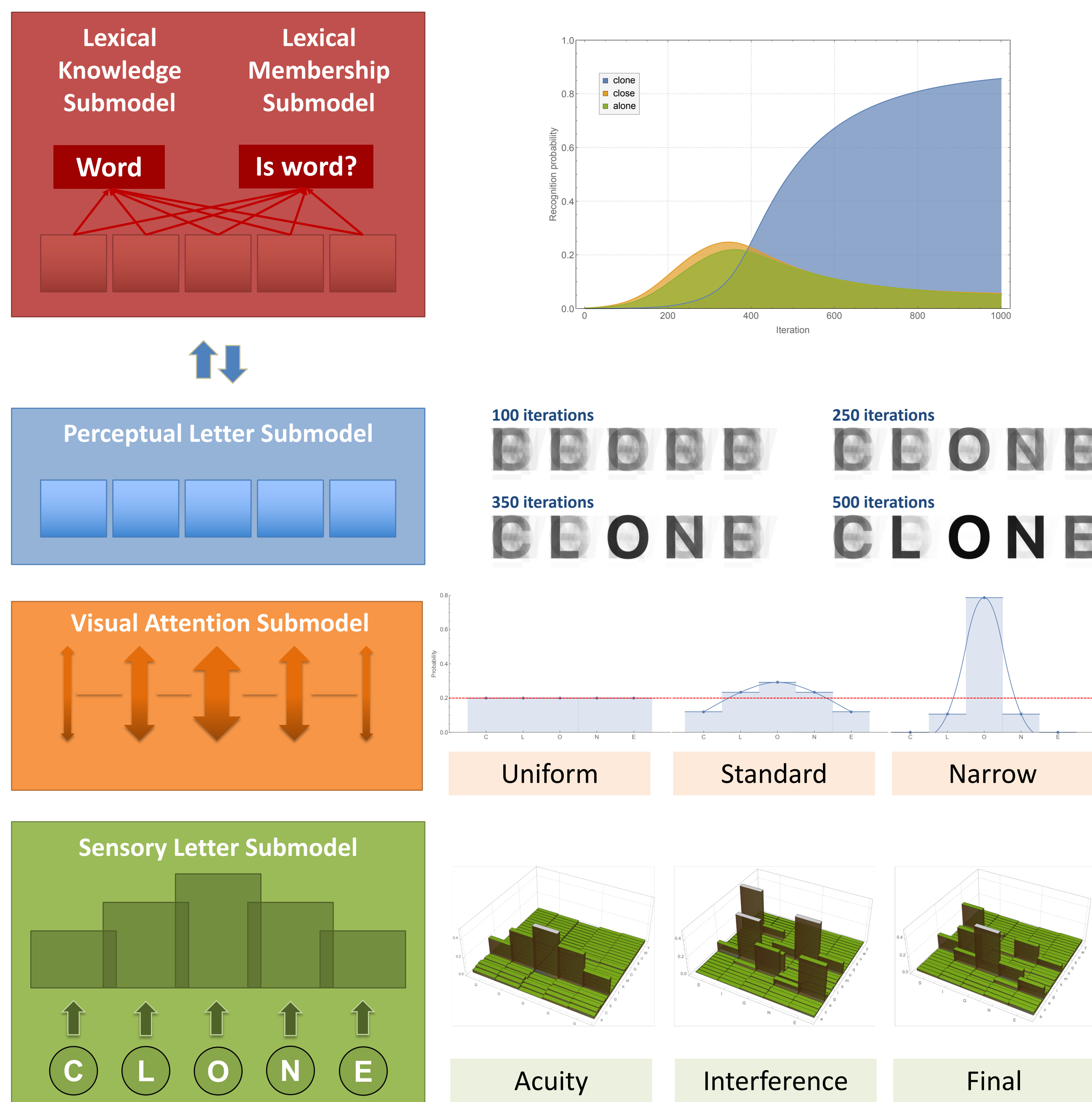
Most current models attribute length effect to serial processing during phonological decoding which can account for the effect as reported in naming but not in LD (Coltheart et al., 2001; Perry et al., 2007; Plaut, 1999). The MTM model simulated exaggerated length effects on words following a visual attention deficit but failed to account for typical word length effects in LD (Ans et al., 1998).

Our team has recently developed **BRAID**, a Bayesian word Recognition model with Attention, Interference and Dynamics, to simulate the performance of expert readers (Phénix et al., submitted; Ginestet et al., submitted). BRAID integrates an attentional component modeled by a Gaussian probability distribution, a mechanism of lateral interference between letters and an acuity gradient, but no phonological device.

Here, we simulate the word length effect in LD and we explore the role of visual attention on this effect using 1,200 French words ($f_{\text{moy}} = 57,9$; $N_{\text{moy}} = 1,9$) from 4 to 11 letters from the French Lexicon Project (FLP; Ferrand et al. 2010).

The BRAID model

BRAID is a hierarchical probabilistic model of visual word recognition composed of 5 submodels.



Word length effect simulations

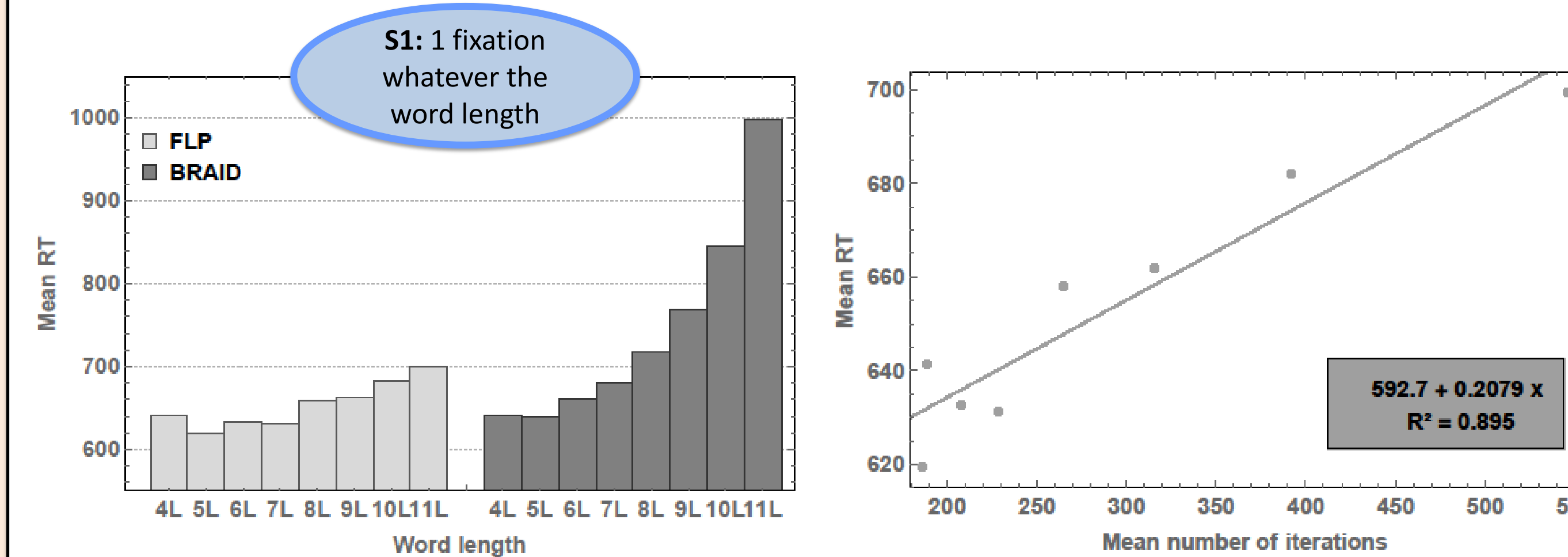
Goal: simulating the word length effect following either one attentional fixation whatever the word length or several attentional fixations for words of 7 letters or more

Method

- Simulation 1: **1 central fixation**
- Simulation 2: **several possible fixations on 2 "strategic" positions**
- Model predicts reaction times** (model is calibrated such that 1 iteration = 1 ms)

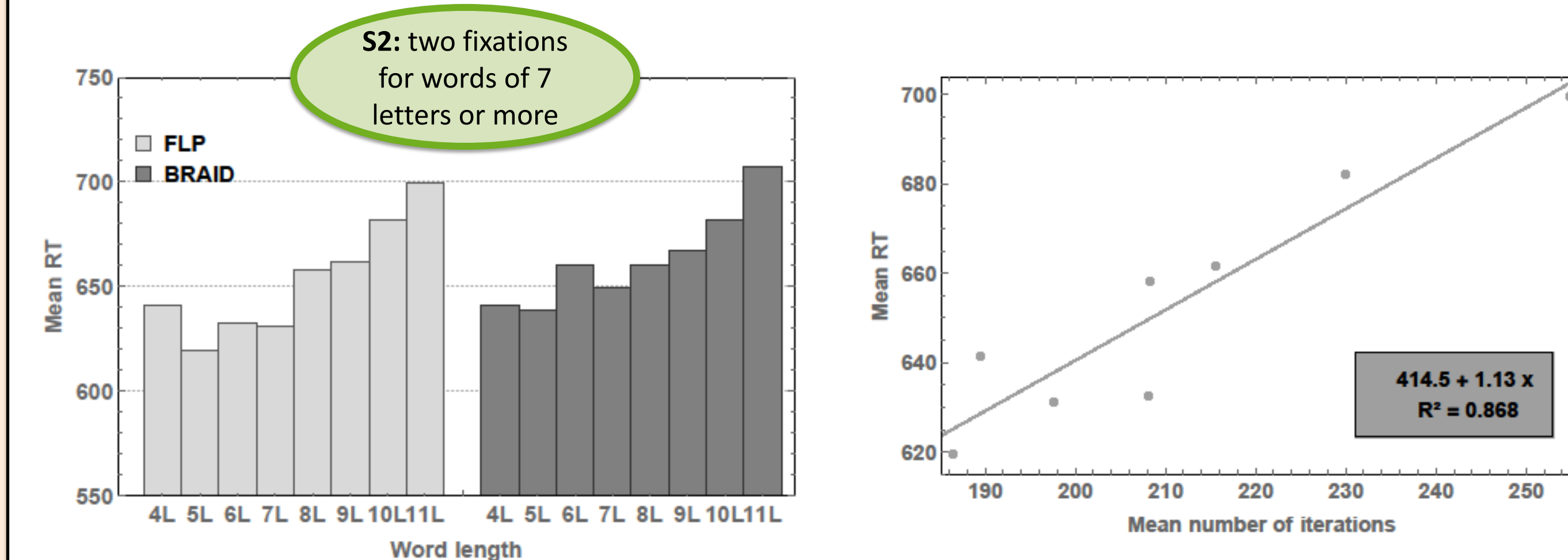
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Results



+ 44.6 iterations per additional letter in BRAID

Length effect in FLP → + 7.25 ms per additional letter



+ 8 iterations per additional letter in BRAID

Conclusion

- Exaggerated word length effect following parallel processing (1 fixation)
- Good fit of human data using serial processing for longer words (2 fixations)
- Visual attention shifts not motivated by phonological decoding but by visual limitations

References

Ans, B., Carbonnel, S. & Valdois, S. (1998) *Psychological Review*, 105 (4), 678-723. • Coltheart, M., Rastle, K., Perry, C., et al. (2001). *Psychological Review*, 108 (1), 204-256. • Ferrand, L., New, B., Brysbaert, M., et al. (2010). *Behavior Research Methods* 42 (2), 488-49. • Ferrand, L., Brysbaert, M., Keuleers, E., et al. (2011). *Frontiers in Psychology* 2, 306. • Ginestet, E., Phénix, T., Diard, J., & Valdois, S. (submitted). Modelling the length effect for words in lexical decision: the role of visual attention. • New, B., Ferrand, L., Pallier, C. & Brysbaert, M. (2006). *Psychonomic Bulletin and Review*, 13 (1), 45-52. • Perry, C., Ziegler, J. C., Zorzi, M., 2007. *Psychological Review* 114 (2), 273-315. • Phénix, T., Valdois, S., & Diard, J. (submitted). Bayesian word recognition with attention, interference and dynamics. • Plaut, D. C., 1999. *Cognitive Science* 23 (4), 543-568.

Visual attention as modulator of word length effect

Goal: modulating the distribution of visual attention to assess its impact on the predicted length effect

Method

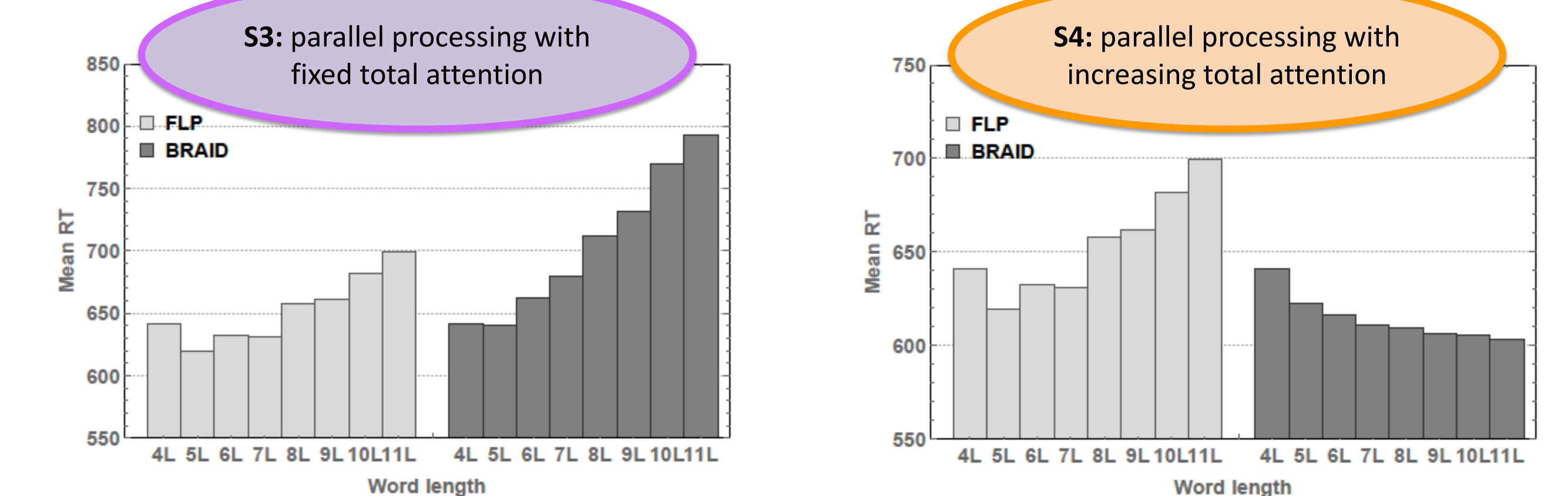
- Q_{Ai} = Quantity of visual attention allocated to a letter; N = word length
- Simulation 3: **parallel processing with fixed total attention**
1 central fixation, uniform distribution,
 $Q_{Ai} = f(N) = 1/N$ and $\sum_{i=1}^N Q_{Ai} = 1$
- Simulation 4: **1 parallel processing with increasing total attention**
1 central fixation, uniform distribution,
 $Q_{Ai} = 0.5$ and $\sum_{i=1}^N Q_{Ai} = f(N) = N/2$
- Simulation 5: **letter by letter, serial processing**
several fixations, narrow Gaussian distribution

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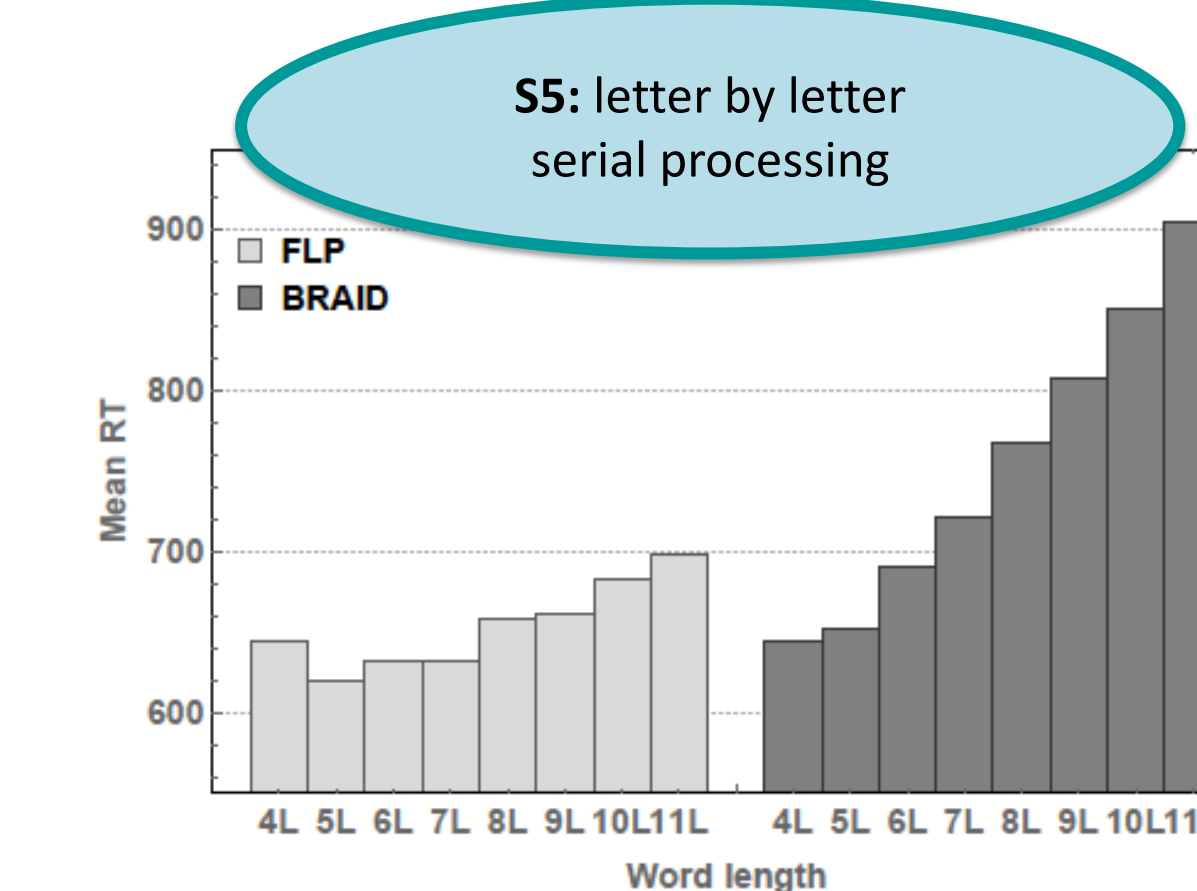
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Results



+ 19 iterations per additional letter

- 4.75 iterations per additional letter



+ 32.6 iterations per additional letter

Conclusion

- Simulations with uniform distributions of attention do not fit human data
- Varying Q_{Ai} : modulation of the magnitude and/or direction of the length effect
- Narrow distribution: exaggerated length effect

Summary and discussion

- Visual attention is critical to account for the word length effect in LD
- The BRAID model successfully simulates the LD word length effect reported for typical readers in the French Lexicon Project
- Length effects on words in LD are observed following either serial or parallel processing: the length effect is not specific to serial processing
- Serial processing is a useful strategy that follows the principles of cognitive economy by reducing processing time for longer words
- Exaggerated length effects follow from narrow distribution of visual attention; this may model impairments observed in some pathologies of reading