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To cite this version:

Thierry Phénix, Sylviane Valdois, Julien Diard. Modeling Optimal Viewing Position with BRAID: The Role of Visual Attention. Annual Meeting of the Psychonomic Society, Nov 2018, New-Orleans, United States. hal-02004121

HAL Id: hal-02004121

https://hal.science/hal-02004121v1

Submitted on 1 Feb 2019

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Modeling Optimal Viewing Position with BRAID: The Role of Visual Attention

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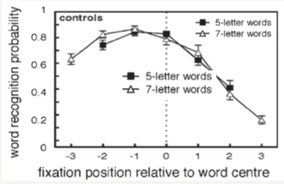
The Optimal Viewing Position Effect in typical readers

Background

Word recognition depends on the position of fixation within the word letter string.

The fixation position that is optimal for word identification (the **Optimal Viewing Position** or **OVP**) is located slightly left of the word center. Performance declines asymmetrically when deviating from the OVP, thus resulting in an inverted J-shaped curve of word recognition.

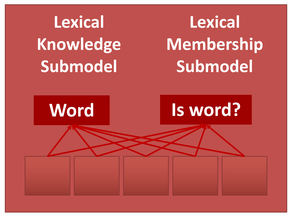


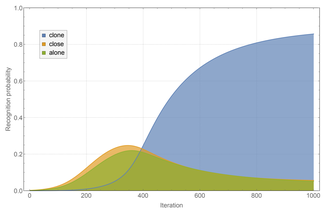
Despite being a well-documented and very robust effect in visual word recognition (Brysbaert & Nazir, 2005; O'Regan & Jacobs, 1992), the OVP effect was largely ignored by previous word recognition models.

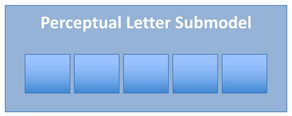
Our aim was here to assess the capacity of **BRAID, a new Bayesian model of word Recognition with Attention, lateral Interference between adjacent letters and Dynamics** to simulate the OVP effect and word recognition curves for words of different lengths.

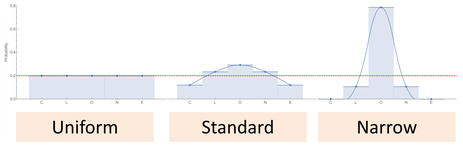
The BRAID model

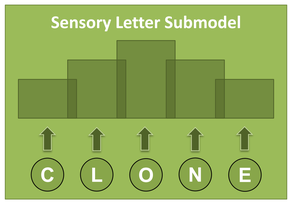
BRAID is a probabilistic model of visual word recognition composed of 5 sub-models.

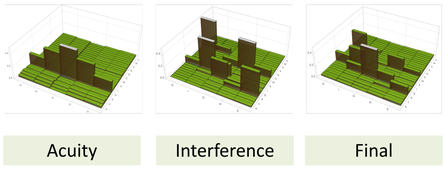








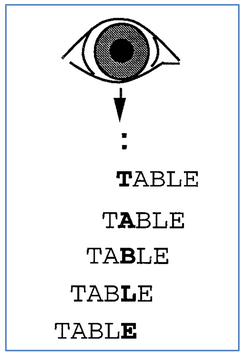




Behavioral Task and Simulation Methodology

Behavioral Experiment

Word recognition task with variable viewing position



Empirical data from Montant, Nazir & Poncet (1998)

- Word length varies from 5 to 9 letters, 250 words (50 per length)
- Short duration presentation (33 ms), avoiding any eye movement

Behavioral results:

- The OVP is slightly left of the word center
- Performance drops with eccentricity
- Asymmetry between first and last position
- Length effect: mean performance decreases with word length

Simulation with BRAID

Material:

- List of 5-to-9 letter words of Montant et al. (1998)
- Definition of five fixation zones for each word length
- Gaze position is successively set at the center of the five fixation zones for each word

Method: grid search

- The variance of visual attention (σ_A) varies between 0.5 and 3.0
- Word identification probability is recorded for the first 500 iterations
- Each word length is evaluated separately
- The mean square error (MSE) between simulated and observed performance was computed (see left column of the main Figure of simulation results)

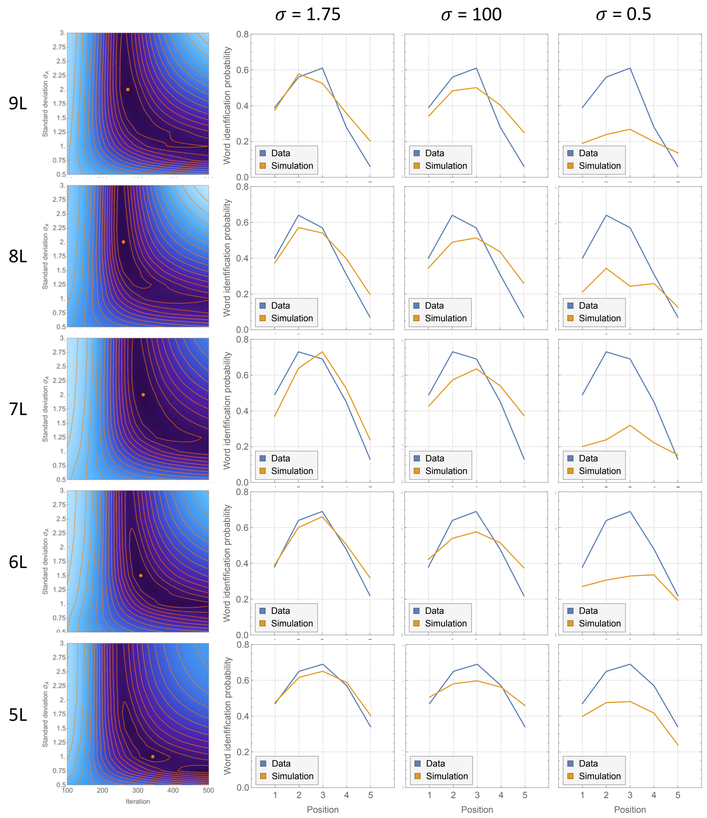
Simulation results:

- The best fit is obtained for σ_A values of 1, 1.5 and 2 for words of lengths 5, 6 and 7 or more, respectively
- The model is not sensitive to parameter values for σ_A and thus captures human data in a robust fashion
- With a σ_A value of 1.75, we simulate all the features of the empirical curves for all word lengths
- In contrast, uniform or narrow distributions fail to account for behavioral results

References

Aghababian, V. & Nazir, T. (2000). J. of Exp Child Psych, 76, 123-150. • **Dubois**, M., Lafaye de Micheaux, P., Noël, M.P. & Valdois, S. (2007). Cog Neuropsych, 6(1), 623-660 • **Ducrot**, S., Lété, B., Sprenger-Charolles, L. & Billard, C. (2003). Current Psych Letters, 10, 1 • **Ginestet**, E., Phenix, T., Diard, J., & Valdois, S. (submitted). Modelling length effect for words in lexical decision: the role of visual attention. • **Phénix**, T., Valdois, S., & Diard, J. (submitted). Bayesian word recognition with attention, interference and dynamics. • **Phénix**, T. (2018). *Modélisation bayésienne algorithmique de la reconnaissance visuelle de mots et de l'attention visuelle*. Université Grenoble Alpes.

Simulation Results



Left column: Contour plots of the MSEs between simulated and empirical data as a function of iterations and variance of attention distribution (the darker the color, the better the fit). Orange dots = best fit parameter values. *Three other columns* : Simulated word identification probability curves (in orange) as a function of fixation position and attention distribution: "standard" (σ = 1.75, 2nd column), uniform-like (σ = 100, 3rd column) and narrow (σ = .5, 4th column). In blue, the empirical curves.

Conclusion

- Varying the attention distribution affects the shape of the word recognition curves for all word lengths.
- **BRAID can successfully account for the optimal viewing position effect** reported in word recognition as a function of fixation position.
- The almost symmetrical curves obtained for a uniform attention distribution reinforce the idea that visual attention acts as an attentional filter, modeled in BRAID by a Gaussian distribution.
- The low recognition rate and atypical curve shapes that result from a narrow attention distribution mimic the behavioral data reported in some poor and / or dyslexic readers (Dubois et al., 2007; Aghababian & Nazir, 2000; Ducrot, Lété, Sprenger-Charolles, Pynte, & Billard, 2003).