A meta-analytical examination of the boundary paradigm

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Background

- Understanding vision and perception has been a human preoccupation since ancient times (Wade, 1998).

- Although the use of a meta-analysis is continuously becoming more common in Psychology, it is rarely a tool used in experimental reading literature. To our knowledge, only one meta-analysis has been conducted to date by Brysbaert, Drieghe, and Vitu (2005), which asked and answered theoretical questions about models of reading in relation to fixation probability (the likelihood to fixate or "skip" a word).

- The boundary technique, used to track eye movements while reading, has many different variations (see Rayner, 1998); the classic technique involves creating an invisible boundary at a fixed position within a sentence while masking the target word. Many different types of masks can be used to cover the target word including semantic, phonological, or orthographic.

- There is a critical difference between models explaining eye movement based around what event triggers the eyes to move. Various models rely on strict serial attention (e.g., E-Z Reader; Pollatsek, Reichle, & Rayner, 2006), requiring that lexical processing of a word be completed before attention and the eyes can move. Other models assume processing gradients (e.g., Glenmore, Reilly & Radach, 2006; and SWIFT, Engbert, Nuthmann, Richter, & Kliegl, 2005) where the range of visual processing extends over the entire perceptual span and can include several words without demanding as strict a relationship between lexical processing and eye movements.

- This study was unable to identify *any* work investigating differences between similar and dissimilar random letter masks. If word shape significantly impacts normal reading, it would require a dramatic revision of all current reading models.

Method

- In order to locate potential studies the following databases were accessed: PsychInfo, PsychArticles, Google Scholar, etc. Documents from 1979 (the date the boundary technique was created) to 2013 were examined for this study which included the following terms: eye movements, reading, and boundary. Searching for each item individually yielded results of over 200,000 articles. After combining the search items (i.e., eye movements AND reading AND boundary), only sixteen articles were returned. Eighty-eight articles were identified from a search of the primary articles' reference sections. This yielded 104 articles under consideration for this meta-analysis.

- Inclusionary and exclusionary criteria were developed and 6 published studies, including 11 experiments and 48 critical comparisons remained in the synthesis after all exclusionary criteria had been applied. Using these documents we conducted a small-scale meta-analysis to analyze the masking literature and to examine the extent to which the mask interferes with lexical processing.

Results

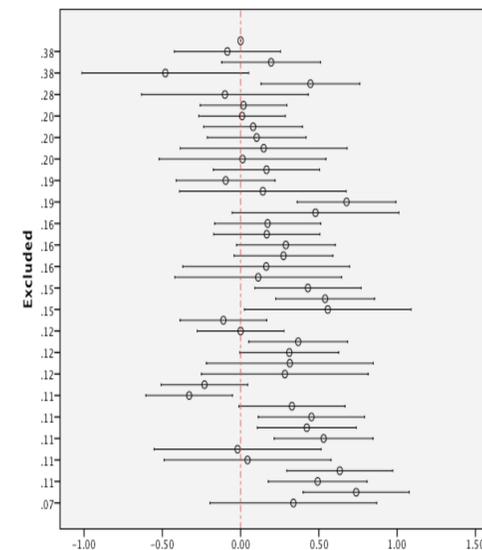### Theoretical Orientation & Effect Sizes
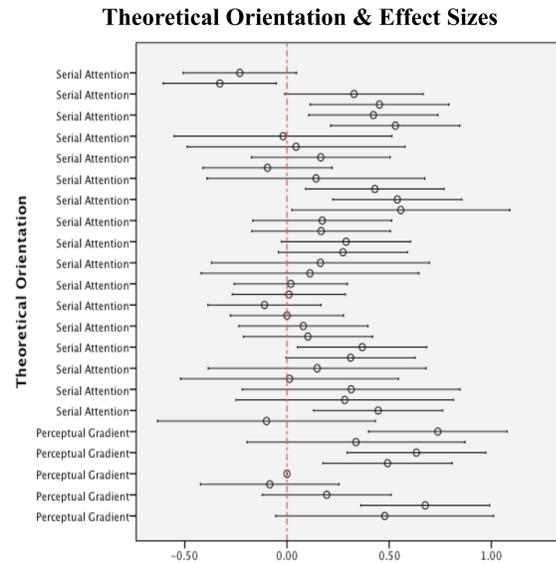
Studies with the highest amounts of excluded data were also those with the lowest effect sizes. As a result, the amount of data excluded from a study became a significant predictor. Likewise, the theoretical orientation behind each researcher's study was significantly different when that researcher was present in the experiment than when they were not. Consequently, further comparative research between different normal reading models will, through necessity, need to account for the theoretical orientation of the author, the amount of data excluded, and the eye tracking paradigm method provided for the research when considering reliability.

Eye Tracking System Chosen
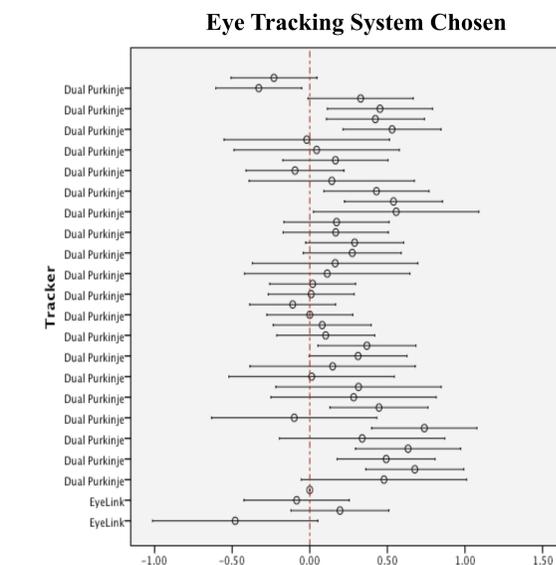
Search Terms and Number of Studies Identified

Search Term	Number
Eye Movements	16,802
Reading	> 100,000
Boundary	> 100,000
Eye Movements + Reading	5,796
Eye Movements + Boundary	69
Eye Movements + Boundary + Reading	16
Additional Articles from References	88
Total Articles Identified	104

Data Excluded

Mixed Model Coefficient Information

Predictor	β	SE	S β	Z	p-value
Amount of Data Excluded	-1.27	0.50	-0.35	-2.53	< 0.01
Theoretical Orientation	-0.24	0.10	-0.36	-2.48	< 0.01
Type of Tracker	0.28	0.15	0.21	1.88	ns
Year Published	-0.07	0.02	-0.44	-3.41	< 0.001

Year + Excluded Mixed Model Fitted Equation:
$$d_i = 148.185 - 0.74\text{Year}_i - 1.528\text{Excluded}_i + u_i + e_i$$

Discussion

- The mixed model provided the best fit for the data seen. Under the mixed model, four predictor variables were significant (Excluded, Rayner, Tracker, and Year), however, due to issues of multicolinearity, only Excluded and Year were included as significant predictors in the final mixed model.

- The amount of data excluded from a study was a significant predictor in the mixed model. Those studies with the highest amounts of excluded data (min = 7%, max = 38%, mean =17%, SD = 8%) were also those with the lowest effect sizes (mean effect size for 38% excluded= -0.09; mean effect size for 7% excluded = 0.54).

- The original question of mask type and word shape violations could not be addressed as expected. The studies never included a condition which compared a similar and a dissimilar random letter mask.

- As there were no similar and dissimilar random letter masks to compare, it remains a reasonable hypothesis that length and random letter masks interfere with lexical processing.

- There was a predictor of significance relating to theoretical viewpoint which provides evidence for the necessity of coding for theoretical viewpoint in any further meta-analysis of the reading literature, especially when parafoveal processing is being addressed.

Future Directions

- As it is impossible to conclude from existing data precisely in what way word shape violations are affecting continuous reading, empirical research on this question is clearly needed.

- Additionally, research into similar versus dissimilar letter masking needs be completed to better understand the orthographic influences on lexical preprocessing.

References

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