



## Speed discrimination predicts word but not pseudo-word reading rate in adults and children



Keith L. Main<sup>a,b,c,1</sup>, Franco Pestilli<sup>a,\*,1</sup>, Aviv Mezer<sup>a</sup>, Jason Yeatman<sup>a</sup>, Ryan Martin<sup>d</sup>, Stephanie Phipps<sup>a</sup>, Brian Wandell<sup>a</sup>

<sup>a</sup> Department of Psychology, Stanford University, Stanford, CA, United States

<sup>b</sup> War Related Illness and Injury Study Center, Veterans Affairs, Palo Alto Health Care System (VAPAHCS), Palo Alto, CA, United States

<sup>c</sup> Psychiatry and Behavioral Sciences, Stanford University School of Medicine, Stanford, CA, United States

<sup>d</sup> Department of Psychology, Loyola Marymount University, Los Angeles, CA, United States

### ARTICLE INFO

#### Article history:

Accepted 2 September 2014

#### Keywords:

Reading  
Speed discrimination  
Contrast sensitivity  
Dorsal stream  
Magnocellular pathway

### ABSTRACT

Visual processing in the magnocellular pathway is a reputed influence on word recognition and reading performance. However, the mechanisms behind this relationship are still unclear. To explore this concept, we measured reading rate, speed-discrimination, and contrast detection thresholds in adults and children with a wide range of reading abilities. We found that speed discrimination thresholds are higher in children than in adults and are correlated with age. Speed discrimination thresholds are also correlated with reading rates but only for real words, not pseudo-words. Conversely, we found no correlations between contrast detection thresholds and the reading rates. We also found no correlations between speed discrimination or contrast detection and WASI subtest scores. These findings indicate that familiarity is a factor in magnocellular operations that may influence reading rate. We suggest this effect supports the idea that the magnocellular pathway contributes to word reading through an analysis of letter position.

Published by Elsevier Inc.

### 1. Introduction

Reading involves the coordination of brain areas that process visual and phonological information (Schlaggar & McCandliss, 2007). Reading begins with the visual recognition of orthography, the patterned symbols that constitute letters and words. This information is then translated into phonological representations by cortical areas specialized in language. Here we focus on the visual component of this process and submit evidence that word familiarity is a factor in magnocellular operations that may support reading rate.

Historically, cognitive theorists have studied visual word recognition as the first step of the reading process. Selfridge (1959) developed one of the earliest models of pattern recognition for letters. McClelland and Rumelhart later explored visual word recognition through their interactive activation model (McClelland & Rumelhart, 1981; Rumelhart & McClelland, 1982). Several other reading models followed, attempting to describe the cognitive interplay between word recognition, phonology, and semantics

(Coltheart, Curtis, Atkins, & Haller, 1993; Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001; Dehaene, Cohen, Sigman, & Vinckier, 2005; Grainger, Grainer, Farioli, Van Assche, & van Heuven, 2006; Grainger & Jacobs, 1996; Harm & Seidenberg, 2004; Hinton & Shallice, 1991; Morrison, 1984; Plaut, McClelland, Seidenberg, & Patterson, 1996; Seidenberg & McClelland, 1989; Whitney, 2001).

All of these models set visual information as the primary input and seek to explain the variety of behavioral data in word recognition. One consistent finding is that frequency and familiarity matter. Experience with specific words improves performance for those items on perceptual identification (Broadbent, 1967), lexical decision (Forster & Chambers, 1973), and naming tasks (Balota & Chumbley, 1984). Research also shows skilled readers have faster word naming times than less skilled readers (Mason, 1978). In reading, like any other cognitive process, more experience with an operation enhances performance of that operation. It is likely that fast recognition of words contributes significantly to efficient reading.

A growing literature suggests individual differences in word recognition and reading performance may stem, in part, from the functioning of the brain's visual system (for a review see Boden & Giaschi, 2007). The primate visual system consists of at least two parallel processing streams, the magnocellular (M) and parvo-

\* Corresponding author. Address: Department of Psychological and Brain Sciences, Indiana University, 1101 E. 10th St., Bloomington, IN 47405, United States.

E-mail address: [frk@stanford.edu](mailto:frk@stanford.edu) (F. Pestilli).

<sup>1</sup> These authors contributed equally to this research.

cellular (P) pathways (Shapley, 1990). The P pathway processes high-spatial, low-temporal chromatic information (Merigan, Katz, & Maunsell, 1991). The M pathway, in contrast, is more sensitive to luminance, low spatial-frequencies, and high temporal-frequencies (Merigan, Byrne, & Maunsell, 1991).

Approximately 10% of retinal ganglion cells are classified as magnocellular (Shapley & Perry, 1986). Their receptive fields cover relatively large portions of the visual field and they project strongly myelinated (fast conducting) axons downstream to the lateral geniculate nucleus (LGN). Lesion experiments in the LGN have shown M pathway deficits are identifiable through tests of contrast sensitivity, flicker resolution, and motion detection/discrimination (Merigan, Byrne, et al., 1991; Merigan, Katz, et al., 1991; Merigan & Maunsell, 1990; Schiller, Logothetis, & Charles, 1990). Psychophysical tasks incorporating these elements have become standard behavioral measures of magnocellular processing.

Reading achievement is correlated with performance on two agreed measures of the M pathway: coherent motion detection (Cornelissen, Bradley, Fowler, & Stein, 1994; Cornelissen, Hansen, Hutton, Evangelinou, & Stein, 1998b) and velocity discrimination (Demb, Boynton, & Heeger, 1997, 1998). This relationship suggests the M pathway may be a factor in reading ability. If this is the case, the mechanism remains unknown. One theory is the magnocellular pathway could impact reading by processing contrast sensitivity.

Deficits in contrast sensitivity could impair the visual analysis of features that compose letters and words, slowing word recognition and reading rate. Research indicates that individuals with impaired contrast sensitivity have slower peak reading rates (Akutsu, Legge, Ross, & Schuebel, 1991), slower overall reading rates (Legge, Pelli, Rubin, & Schleske, 1984), and longer fixations during reading (De Luca, Spinelli, & Zoccolotti, 1996). Some researchers have proposed that dyslexics have reduced contrast sensitivity and this may be the cause of their impairment (Borsting et al., 1996; Edwards et al., 2004; Evans, Drasdo, & Richards, 1994; Felmingham & Jakobson, 1995; Lovegrove et al., 1982; Martin & Lovegrove, 1984, 1987; Mason, Cornelissen, Fowler, & Stein, 1993), though others have disputed these claims (Ben-Yehudah, Sackett, Malchi-Ginzberg, & Ahissar, 2001; Cornelissen, Richardson, Mason, Fowler, & Stein, 1995; Gross-Glenn et al., 1995; Hayduk, Bruck, & Cavanagh, 1996; Williams, Stuart, Castles, & McAnally, 2003).

Another way the M pathway could influence reading is by directing attention to the positional relationships among letters, a process called position encoding. Models of orthographic processing describe a spatial accounting of the features that compose words (Dehaene et al., 2005; Grainger et al., 2006; Whitney, 2001). In models such as SERIOL (Whitney, 2001), a representation is built from the interaction of neural ensembles that code edges, letters, bigrams (letter pairs), then finally the whole word. The allocation of visual attention to familiar stimuli is likely a key factor in this process. Word representations are strengthened by repeated attention to specific letters and letter combinations (Whitney, 2001; Whitney & Cornelissen, 2005). In this way, stimulus familiarity may aid position encoding, speed word recognition, and ultimately enhance reading rate.

Experimental research demonstrates the effects of familiarity and position encoding on reading tasks. Mason (1978) reported familiarity effects in an analysis of word naming times. The general finding was that word naming is faster for skilled compared to less skilled readers. Additionally, naming time was increased in all participants by factors that reduce the familiarity of adjacent letters, such as using mixed-case words (i.e., MiXeD CaSe) and pronounceable pseudo-words (i.e., worthy vs. werply). Mason (1980) also showed the ability to code letter spatial position differentiates readers. She assessed letter and location identification in adults grouped as highly skilled or less skilled readers. Performance

between the groups was similar when identifying single letters in brief displays. However, skilled readers were significantly more accurate at identifying the serial position of a letter. This effect occurred in both word and non-word displays. Such findings suggest the visual perception of letter position and letter spatial relationships are important factors in word recognition and efficient reading.

Position encoding also seems to be tied to motion perception. Cornelissen and Hansen (1998) and Cornelissen et al. (1998a) measured coherent motion detection and accuracy on a single-word reading task in groups of school children. The reading task assessed “letter errors”, instances where participants confused letter positions in sounding out words. They found a positive correlation between motion detection thresholds and the number of letter errors. In a follow up with adults, Cornelissen et al. (1998a) classified participants as having either good or poor motion detection then tested them on a number of reading-based measures. They found the group with better motion detection was also more accurate on tasks dependent on position encoding, such as lexical decision for words or anagrams and primed reaction time for letters and non-alphabetic foils.

If the M pathway supports efficient reading through an analysis of letter position then word familiarity may be a factor. The letter combinations of familiar words may prompt fast recognition from a visual lexicon, whereas unfamiliar words require a longer, letter-by-letter analysis (Coltheart et al., 1993, 2001). If this is the case, the reading rates of familiar words may be more correlated with M pathway measures than the reading rates of unfamiliar words. In contrast, if magnocellular processing supports reading rate through other mechanisms, such as contrast sensitivity, word familiarity would not affect these correlations.

In the current study we sought to investigate the effect of word familiarity on correlations between reading rate, magnocellular thresholds, and general intelligence measures. We correlated psychophysical thresholds (speed discrimination and contrast detection) with reading rates in adults and children with a wide range of reading abilities. To manipulate familiarity, we assessed reading rates for real and pseudo-words using the Test of Word Reading Efficiency (TOWRE). Pseudo-words are pronounceable non-words and are consequently less familiar to participants than real words. To evaluate the M pathway, speed discrimination and contrast detection tasks were administered in a mesopic environment using parameters described in Demb, Boynton, Best, and Heeger (1998) and Demb, Boynton, and Heeger (1998). The Wechsler Abbreviated Scale of Intelligence (WASI) measured aspects of general intelligence such as reasoning and vocabulary skills.

Our approach to the data is as follows: 1. If familiarity is a factor in magnocellular processes that may influence reading rate, we expect a dissociation between correlations involving speed discrimination and the different reading rates (real and pseudo-word). There should be significant correlations between speed discrimination and real word reading rates. However, because pseudo-words are less familiar than real words, we anticipate diminished or no correlations for pseudo-word reading rates. 2. In contrast, if familiarity is not a factor in these magnocellular processes, we expect no differences between correlations of speed discrimination the above reading rates. 3. If contrast sensitivity is a factor in magnocellular processes, we expect significant correlations between contrast detection thresholds and the reading rates. 4. If contrast sensitivity is not a factor, correlations with contrast detection should be non-significant. This analysis could support speed discrimination or contrast detection as predictive of reading rates, real or pseudo-words, or combinations thereof.

While others have studied the relationship between motion perception and reading ability, our examination focused specifically on relationships between word familiarity, the M pathway,

Download English Version:

<https://daneshyari.com/en/article/7284602>

Download Persian Version:

<https://daneshyari.com/article/7284602>

[Daneshyari.com](https://daneshyari.com)