The emergence of automaticity in reading: Effects of orthographic depth and word decoding ability on an adjusted Stroop measure

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Abstract
How long does it take for word reading to become automatic? Does the appearance and development of automaticity differ as a function of orthographic depth (e.g., French vs. English)? These questions were addressed in a longitudinal study of English and French beginning readers. The study focused on automaticity as obligatory processing as measured in the Stroop test. Measures of decoding ability and the Stroop effect were taken at three time points during first grade (and during second grade in the United Kingdom) in 84 children. The study is the first to adjust the classic Stroop effect for inhibition (of distracting colors). The adjusted Stroop effect was zero in the absence of reading ability, and it was found to develop in tandem with decoding ability. After a further control for decoding, no effects of age or orthography were found on the adjusted Stroop measure. The results are in line with theories of the development of whole word recognition that emphasize the importance of the acquisition of the basic orthographic code.

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Introduction

The development of reading ability takes several years. Children usually begin to learn to decode words in primary school between the 4 and 7 years of age, depending on the country of schooling. Learning the basic grapheme–phoneme conventions (“rules”) typically takes up to 2 years, depending on the number and complexity of the rules of the orthography (Frith, Wimmer, & Landerl, 1998; Goswami, Ziegler, & Richardson, 2005; Seymour, Aro, & Erskine, 2003; Ziegler & Goswami, 2006). Children’s word decoding skills, particularly decoding speed, continue to progress throughout primary and secondary school until adult levels are reached at 200 to 300 words per minute for continuous texts. Importantly, word decoding gradually becomes automatic (“encapsulated”) so that it does not interfere with comprehension processes in reading.

Facets of automaticity

Automaticity of cognitive processing is not an all-or-none feature of mental processes but rather a set of properties that do not necessarily co-occur (Moors & De Houwer 2006; Stanovich, 1990). There are at least four discernible properties of automaticity: speed, effortlessness, autonomy, and lack of conscious awareness (Kuhn, Schwanenflugel, Meisinger, Levy, & Rasinski, 2010; Logan, 1997). First, automatic word decoding is fast, resulting in word identification and initiation of naming well within 1 s. Indeed, it is so fast that written words are recognized “immediately” as “sight words” without overt signs of single letter–sound decoding (e.g., Ehri, 2005). Second, automatic word decoding is also effortless in the sense that it allows the reader to simultaneously think of the contents of the text or even to let thoughts drift. This facet of automaticity attracted much attention following the influential theory of the development of automaticity of word decoding by LaBerge and Samuels (1974). The dual-task paradigm has been the most commonly used in the study of this facet of automaticity. In this paradigm, the processing penalty of decoding on simultaneous processing of other tasks has been shown to diminish with reading ability (e.g., Horn & Manis, 1987). Third, automatic word recognition is executed obligatorily so that once the reader has set eyes on the printed word, the identity of the word—its spoken name and meaning—will be available to the reader. The reader cannot decide not to identify the word. This feature has been widely explored in the Stroop task (named after J. Ridley Stroop). In this task (Stroop, 1935), participants are asked to name the color in which words are printed while avoiding reading the words; for example, the word green is printed in blue, and the correct response is “blue” (MacLeod, 1991).

These three facets of automaticity all may be a consequence of a fourth property: modularity (“encapsulation”) of word decoding from conscious thought (Fodor, 1983; Kahneman, 2011; Stanovich, 1990). If automatic processing is shielded from conscious control, it allows for the development of great speed and effortlessness—at the expense of conscious control of processing. However, the three facets of automaticity do not appear to develop in synchrony. Stroop effects—indicating obligatory processing—have been shown to occur at the end of first grade in American school children (Ehri & Wilce, 1979; Stanovich, Cunningham, & West, 1981; West & Stanovich, 1978; West & Stanovich, 1979). This early occurrence does not entail that word recognition also occurs entirely immediate or without cognitive effort from first grade. For example, even second graders take longer to name number words than to name the corresponding digits (Ehri & Wilce, 1983). Automaticity in the sense of “immediate” and “effortless” continues to develop long after the emergence of the Stroop effect (e.g., Ehri & Wilce, 1979).

There may be several reasons for this asynchrony of the development of different facets of automaticity in reading. One is that some words may be recognized as wholes—so-called sight words—even though accuracy is far from perfect at the very beginning of reading development (Ehri, 2015). If words are recognized as wholes in the Stroop task, then such rapid and immediate recognition may interfere with naming of the colors in which they are presented. However, this does not mean that word recognition is effortless because as long as orthographic representations of words are linked to the lexicon only by partial grapheme–phoneme correspondences, they are unreliable and prone to lead to recognition mistakes. So, even though some words are recognized successfully as sight words,
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