

# DEVELOPMENTAL DIFFERENCES IN BRAIN SYSTEMS FOR READING

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Functional magnetic resonance imaging (fMRI) was used to examine the distribution of brain activation during four visual word-processing tasks performed by children (9-12 years) and adults (21-31 years). The four tasks were designed to separately emphasize orthographic, phonological, semantic, and syntactic processes. As expected, the adults performed these tasks more efficiently than the children, who were significantly less accurate in their performance. The patterns of brain activation in the two groups suggest that efficient processing of visual word forms in adults results in part from three trends. (1) A shift in activation from multimodal areas (namely, Wernicke's area in children) to activation of unimodal association areas (fusiform cortex in adults). (2) More restricted interactions between cortical areas in adults as the areas involved in linguistic processes become more specialized and efficient. (3) Overlap of areas associated with high accuracy and quick reaction times in adults as word representations become more directly accessible to areas involved in preparing a behavioral response. These trends reflect plasticity in neural processing during maturation, a process that effectively frees resources for processing unfamiliar stimuli as the ability to respond quickly and accurately to familiar stimuli improves.

**Key words:** reading, fMRI, developmental differences, visual word processing, neural plasticity

## Introduction

Learning to read is a process characterized by increasing efficiency in the ability to recognize written words, pronounce the words, understand the words' meaning, and understand the relationship between words in a sentence. These abilities result from orthographic, phonological, semantic, and syntactic processes. These processes are at least partially separable and likely to be subserved by different brain areas (Dapretto & Bookheimer, 1999; Rumsey et al., 1997a; Vigliocco, 2000). As these processes become more efficient, text can be read quicker and comprehension improves.

Most models of development assume that children initially rely on their semantic knowledge during reading, because graphe-

me (orthography) to phoneme (phonology) decoding processes are inefficient (Perfetti & Lesgold, 1977; Stanovich, 1980). As development proceeds, semantic processes play a lesser role in word identification, whereas phonological processes play a greater role (Booth, Perfetti & MacWhinney, 1999; Plaut & Booth, 2000). Orthographic processes also have an increasing role in word identification as spelling regularities and exception words become more familiar (Gernsbacher, 1984). These developmental changes in single-word processing undoubtedly increase the efficiency of reading. Syntactic processes represent higher-level processes that integrate the appropriate relationship between words. Some knowledge about