Chapter 20
Functional Role of the Left Ventral Occipito-Temporal Cortex in Reading

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ABSTRACT

The sensitivity of the left ventral occipito-temporal (vOT) cortex to visual word processing has triggered a considerable debate about the functional role of this region in reading. The debate rests largely on the issue whether this particular region is specifically dedicated to reading and the extraction of invariant visual word form. A lot of studies have been conducted to provide evidences supporting or against the functional specialization of this region. However, the trend is showing that the different functional properties proposed by the two kinds of view are not in conflict with each other, but instead show different sides of the same fact. Here, the authors focus on two questions: firstly, where do the two views conflict, and secondly, how do they fit with each other on a larger framework of functional organization in object vision pathway? This review evaluates findings from the two sides of the debate for a broader understanding of the functional role of the left vOT cortex.

INTRODUCTION

Nineteenth century neuropsychology, as well as 20th century intracranial recordings and brain imaging, have long associated written word recognition with the left fusiform gyrus (Anthony, 1996; Ariely & Berns, 2010; Binder, Liebenthal, Possing, Medler, & Ward, 2004). In 2000, using functional magnetic resonance imaging (fMRI) and event-related potentials in normal subjects and in two patients with callosal lesions, Cohen et al. found that reading was associated with the activation of a precise and reproducible site in the left lateral occipito-temporal sulcus (Cohen et al., 2002). Its response was strictly visual and prelexical, yet invariant for location and the case of the stimulus words. This pattern ðtted with the previous neuropsychological inference

DOI: 10.4018/978-1-4666-2113-8.ch020

of an abstract representation of the 'visual word form'; that is, the abstract sequence of letters that composes a written string. Cohen et al. termed this region the visual word form area (VWFA) (Cohen, Dehaene, Naccache, & He, 2000). Both the name and the concept, however, the hypothesis was challenged on the grounds that the empirical evidence suggested a mixture of reading and non-reading functions for this region, and that the whole pattern could be explained by top-down signal s arising from higher level language areas (Cheng, Waggoner, & Tanaka, 2001; Engel et al., n d). A ñurry of empirical work ensued.

The starting point of the VWFA is the fact that the human brain cannot have evolved a dedicated mechanism for reading. The invention of writing is too recent and, until the last century, concerned too small a fraction of humanity to have inñuenced the human genome (Epstein, Harris, Stanley, & N. Kanwisher, 1999; Grill-spector & Malach, 2004). Thus, learning to read must involve a 'neuronal recycling' process whereby pre-existing cortical systems are harnessed for the novel task of recognizing written words. The concept is similar to the notions of evolutionary 'exaptation' or 'tinkering' (bricolage), the term 'neuronal recycling' speciðcally to refer to educational changes that occur in developmental time and without any change in the human genetic make-up.

The recycling hypothesis does not postulate any novel form of learning or plasticity, but it emphasizes that plastic neuronal changes occur in the context of strong constraints imposed by the prior evolution of the cortex (H R Heekeren, S Marrett, Bandettini, & L G Ungerleider, 2004; Hauke R Heekeren, Sean Marrett, & Leslie G Ungerleider, 2008). Far from being a tabula rasa or a malleable system capable of learning almost any regularity, the pre-school child's brain is tightly organized as a consequence of both genetic constraints on cell types, receptor densities or connectivity patterns, and early internalization of dominant environmental statistics (e.g. those governing object contours).

Education-induced changes must ðt within the fringe of plasticity left open, within some of these cortical systems, by learning algorithms which are themselves under strong genetic and connectional constraints (Jobard, Crivello, & Tzourio-mazoyer, 2003; Kamitani & Tong, 2005; N. Kanwisher, McDermott, & Chun, 1997). Thus, the recycling view predicts bidirectional constraints between brain and culture. On the one hand, reading acquisition should 'encroach' on particular areas of the cortex – those that possess the appropriate receptive ðelds to recognize the small contrasted shapes that are used as characters, and the appropriate connections to send this information to temporal lobe language areas. On the other hand, the cultural form of writing systems must have evolved in accordance with the brain's learn ability constraints, converging progressively on a small set of symbol shapes that can be optimally learned by these particular visual areas (Mccandliss, Cohen, & Dehaene, 2003; Newsome, Anthony, & Hughes, 1992).

We have proposed that writing evolved as a recycling of the ventral visual cortex's competence for extracting conðgurations of object contours. When projected on the retina, the contours of objects form typical patterns (e.g. T, L, Y) that have been termed 'non-accidental properties' because they tend to be highly invariant across viewpoints and to provide essential information about object shapes and spatial relations (Op de Beeck, Haushofer, & N. G. Kanwisher, 2008; Peelen & Downing, 2007). A T junction, for example, often signals occlusion of a surface by another. The visual system relies strongly on such line junctions to recognize objects, particularly line drawings. In support of this hypothesis, we recently showed that reading, like object recognition, is speciðcally impaired when line conðgurations are deleted. Furthermore, as predicted, the VWFA overlaps with a subpart of the ventral visual cortex that exhibits a special sensitivity to the presence of such line junctions (Platt, 2002; Preuschhof, Hauke R Heekeren, Taskin, Schubert, & Villringer,

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