CORTEX XXX (2018) 1–14

Available online at www.sciencedirect.com

ScienceDirect

Journal homepage: www.elsevier.com/locate/cortex

Registered report

The consonant/vowel pattern determines the structure of orthographic representations in the left fusiform gyrus☆

Fabienne Chetail [a,b,*], *Mariagrazia Ranzini* [a,b], *Xavier De Tiège* [b,c,d], *Vincent Wens* [b,c,d,1] *and Alain Content* [a,b,1]

[a] *LCLD, CRCN, Université Libre de Bruxelles (ULB), Belgium*
[b] *UNI – ULB Neuroscience Institute, Université Libre de Bruxelles (ULB), Belgium*
[c] *Laboratoire de Cartographie Fonctionnelle du Cerveau (LCFC), Université Libre de Bruxelles (ULB), Belgium*
[d] *Magnetoencephalography Unit, Department of Functional Neuroimaging, Service of Nuclear Medicine, CUB Hôpital Erasme, Brussels, Belgium*

ARTICLE INFO

Article history:
Protocol received: Feb 05, 2015
Protocol accepted: May 06, 2016
Received 2 June 2017
Reviewed 29 August 2017
Revised 14 October 2017
Accepted 15 January 2018
Action editor Pia Rotshtein
Published online xxx

Keywords:
Visual word recognition
Letter processing
Consonant/vowel structure
Same/different matching task
MEG
VWFA

ABSTRACT

Recent findings demonstrated readers' sensitivity to the distinction between consonant and vowel letters. Especially, the way consonants and vowels are organised within written words determines their perceptual structure. The present work attempted to overcome two limitations of previous studies by examining the neurophysiological correlates of this perceptual structure through magnetoencephalography (MEG). One aim was to establish that the extraction of vowel-centred units takes place during early stages of processing. The second objective was to confirm that the vowel-centred structure pertains to the word recognition system and may constitute one level in a hierarchy of neural detectors coding orthographic strings. Participants performed a cross-case matching task in which they had to judge pairs of stimuli as identical or different. The critical manipulation concerned pairs obtained by transposing two letters, so that the vowel-centred structure was either preserved (FOUVERT-*fovuert*, two vowel letter clusters) or modified (BOUVRET-*bovuret*). Mismatches were detected faster when the structure was modified. This effect was associated with a significant difference in evoked neuromagnetic fields extending from 129 to 239 msec after the stimulation. Source localization indicated a significant effect in the visual word form area around 200 msec. The results confirm the hypothesis that the vowel-centred structure is extracted during the early phases of letter string processing and that it is encoded in left fusiform regions devoted to visual word recognition.

☆ Registered Reports Editor: Chris Chambers. Email address: ChambersC1@cardiff.ac.uk.

* *Corresponding author*. Laboratoire Cognition Langage Développement (LCLD), Research Centre in Cognition & Neuroscience (CRCN), ULB Neuroscience Institute (UNI), Université libre de Bruxelles (ULB), Av. F. Roosevelt, 50/CP 191, 1050, Brussels, Belgium.
E-mail address: fchetail@ulb.ac.be (F. Chetail).

[1] These authors contributed equally to the study.

https://doi.org/10.1016/j.cortex.2018.01.006

1. Introduction

Alphabets are made of symbols, which strongly vary in shape from one script to another (e.g., compare β and ε in Greek to ฐ and ๆ in Thai). Yet despite the disparity in visual shapes, current alphabets share basic features. The most straightforward one is the classification of symbols into two classes: consonants and vowels, although the signs for vowels appeared later in history than consonants and can be optional in Semitic alphabets such as Arabic or Hebrew (Shimron, 1993). Alphabetic scripts by no means constitute the sole solution that cultures invented to encode spoken languages in visual form, as attested from syllabaries and logographic/morphographic scripts, but in alphabetic scripts only characters are categorized as consonants and vowels. This formal categorization of letters is primarily driven by the relation between writing systems and spoken language. Speech is characterized by the quasi-regular alternation between relatively stable complex periodic waves –the vowels– and brief friction or explosion noises produced by constrictions or occlusions and release of articulators, the consonants (MacNeilage, 1998). This categorization of speech sounds has been extended to the symbols used to represent spoken forms, although the two sets of elements are not strictly isomorphic. In French for example, the N in *pente* (/pɑ̃t/) belongs to the class of consonant letters although it is included in a letter cluster (EN) that codes for a vowel phoneme. Despite some mismatches between letters and phonemes, the consonant/vowel (CV) categorization in the written modality is unambiguous, it is part of the basic knowledge of any child learning to read, and many recent findings have demonstrated readers' sensitivity to the CV distinction (e.g., Carreiras, Duñabeitia, & Molinaro, 2009; Chetail & Content, 2012, 2014; Duñabeitia & Carreiras, 2011).

The present magnetoencephalography (MEG) study aims at examining the spatiotemporal dynamics of the neural correlates of the sensitivity to the CV distinction and of its influence on the structure of the mental representation of orthographic strings. Contrary to Semitic writing systems where most vowels are specified by diacritics marks, there is no obvious visual distinction between consonant and vowel letters in languages transcribed with the Latin alphabet (e.g., French, English, Spanish). Any effect of CV structure in these languages therefore provides strong evidence that experience with print makes the visual word processing system tuned to letter category.

1.1. CV effects in written word processing

The role of consonants and vowels in written word processing has been discussed for decades, with a special focus on written word segmentation (e.g., Adams, 1981; Hansen & Rodgers, 1965) and on phonological assembly (e.g., Berent & Perfetti, 1995), but it has recently triggered a renewed interest. Several recent priming studies manipulated the preservation of consonant or vowel letters with isolated word recognition paradigms. For example, in a go/no-go semantic categorization task, Carreiras et al. (2009) presented participants with target words briefly preceded either by consonant-sharing primes (e.g., *frl* – *FAROL*) or by vowel-sharing primes (e.g., *aeo* – *ACERO*) while recording event-related potentials (ERPs). They found a dissociation of priming effects between the two conditions in time windows including the N250 and the N400 components. Consonant-sharing primes elicited a smaller negativity amplitude than control primes, whereas vowel-sharing primes elicited amplitudes as large as those elicited by control primes. The behavioural results produced a pattern consistent with neurophysiological observations, as word recognition was facilitated when targets were preceded by consonant-sharing primes (e.g., *frl*) compared to an unrelated control prime (e.g., *tsb*) whereas no such difference was found for vowel-sharing primes (e.g., Duñabeitia & Carreiras, 2011). These results were interpreted in terms of lexical selection constraints. Vowel letters constrain the identity of words to a lesser extent than consonant letters, presumably because the former are more frequent and less informative (e.g., more English words can be generated from _A_E than from F_C_). Word identification processes would therefore more strongly rely on consonants than on vowel letters to select a target among possible lexical candidates (see Duñabeitia & Carreiras, 2011; see also Nespor, Peña, & Mehler, 2003, for a similar argument in the spoken modality).

In addition, observations from dysgraphic patients' production errors suggest that the CV status of letters would not only play a role in lexical selection, but would also be used to structure spelling production. Cubelli (1991) described the spelling of two acquired dysgraphic patients who showed a striking selective deficit for vowels, and Caramazza and Miceli (1990) reported a patient whose spelling errors systematically preserved the letter category (i.e., consonants were substituted for consonants and vowels for vowels). They further observed that the CV structure was equally kept intact, that is the alternation of consonant and vowel letters (see also Buchwald & Rapp, 2006), leading to the conclusion that lexical orthographic representations specify the letter category separately from letter identity.

The notion of CV structure has been extended from production to word perception by Chetail and Content. They assembled several strands of behavioural evidence to support the idea that the organization of consonant and vowel letters determines the perceptual structure of letter strings in written word recognition (e.g., Chetail & Content, 2012, 2014; Chetail, Drabs, & Content, 2014; Chetail, Scaltritti, & Content, 2014). One study showed that readers rely on the CV structure to determine the number of syllables in written stimuli. The congruence between orthographic and phonological structure was manipulated by using words such as *client*, which have two syllables (/kli.jɑ̃/) but include only one orthographic vowel cluster (CCVVCC). Participants were slower and more error prone for such words compared to words with the same number of vowel clusters and syllables (e.g., *média*,/me.dja/, CVCVV). Further, when they failed to give the correct response, participants usually underestimated the number of syllables, meaning that they were more prone to count the number of vowel clusters than the number of syllables (Chetail & Content, 2012). Such results suggest that the way consonant and vowel letters are organized within strings determines the number of units perceived, with each vowel or vowel cluster being the core of an orthographic unit. Thus, a word like *réunion* would be structured as two orthographic

Please cite this article in press as: Chetail, F., et al., The consonant/vowel pattern determines the structure of orthographic representations in the left fusiform gyrus, Cortex (2018), https://doi.org/10.1016/j.cortex.2018.01.006