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Vowelling and semantic priming effects in Arabic

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ABSTRACT

In the present experiment we used a semantic judgment task with Arabic words to determine whether semantic priming effects are found in the Arabic language. Moreover, we took advantage of the specificity of the Arabic orthographic system, which is characterized by a shallow (i.e., vowelled words) and a deep orthography (i.e., unvowelled words), to examine the relationship between orthographic and semantic processing. Results showed faster Reaction Times (RTs) for semantically related than unrelated words with no difference between vowelled and unvowelled words. By contrast, Event Related Potentials (ERPs) revealed larger N1 and N2 components to vowelled words than unvowelled words suggesting that visual-orthographic complexity taxes the early word processing stages. Moreover, semantically unrelated Arabic words elicited larger N400 components than related words thereby demonstrating N400 effects in Arabic. Finally, the Arabic N400 effect was not influenced by orthographic depth. The implications of these results for understanding the processing of orthographic, semantic, and morphological structures in Modern Standard Arabic are discussed.

1. Introduction

The process of written word identification is thought to bring into play at least three domains of knowledge: (a) orthographic knowledge which allows the computation of graphemes and their position in the word, (b) phonological knowledge which supports the computation of sounds from graphemes, and (c) semantic knowledge which provides information about the meaning of words (Coltheart, Rastle, Perry, Langdon and Ziegler, 2001; Harm, and Seidenberg, 2004). The activation of and interaction between these three domains of knowledge seem to significantly depend, among other factors, on the consistency of the mapping between orthography and phonology (Frost and Katz, 1992; Grainger and Ziegler, 2011; Ziegler and Goswami, 2005). Some languages (e.g., Greek, Italian, Spanish, etc…) have shallow orthographies with consistent relationships between graphemes and phonemes. As a consequence, orthographic input systematically activates phonological representations (Ellis and Hooper, 2001; Goswami et al., 1997, 1998). Other languages (e.g., English, French) have deep orthographies with inconsistent sound-spelling correspondences making the activation of phonological representations from script a less reliable option (Goswami et al., 1998; Landerl, Wimmer and Frith, 1997). Still other languages, in particular Semitic languages like Hebrew and Arabic, instantiate their orthographies in two versions: a shallow and a deep orthography (Abu-Rabia, 2001, 2007). In the shallow orthography, words are "vowelled" with the diacritics representing the short vowels (Azzam, 1984), thereby providing a one-to-one mapping between graphemes and phonemes. In the deep orthography system, consonants and three long vowels are represented by letters, but the three remaining short vowels are omitted (i.e., "unvowelled") thereby generating a high degree of inconsistency between graphemes and phonemes (Katz and Frost, 1992).

There are however some exceptions to the one-to-one mapping between graphemes and phonemes in vowelled words. For instance, the letter *alif* ' ', corresponding to the long vowel/aa/, can be mute in some words (e.g., كتبوا [katabuu]), "they wrote", or pronounced as a short vowel in other words (e.g., /i/ as [mi atun] in the word مائة, "a hundred"). Conversely, the demonstrative pronoun ذلك is pronounced with a long vowel/aa/as [ðaalika] although its orthography does not feature the *alif*. Thus, letters can be pronounced without being written and written without being pronounced. However, in spite of these counter-examples, the vowelled script of Arabic typically presents more regular graphemes to phonemes mapping than other languages (Azzam, 1984; Hansen, 2010). Interestingly, adult Arabic readers are mainly exposed to

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materials written using deep orthography, while shallow orthography is experienced by children in their early years of learning to read or in special reading materials like poetry and religious books.

Against this linguistic background, an interesting question that arises is how can Arabic, or for that matter Hebrew, function equally well with an unvowelled and a vowelled script? Boudelaa and Marslen-Wilson (2005, 2011) have argued that this is linked to the morphological structure of these languages. Arabic is characterized by a non-concatenative morphology whereby every surface form is analyzable into a consonantal root, that conveys semantic meaning, and a word pattern (made up of vowels and of a subset of consonants) conveying morphosyntactic and phonological information. For example, the form كتم [katama] conceal, hide (in the sense of hiding a secret), consists of the root {ktm} with the general meaning of hiding and the word pattern {fa ala} with the morphosyntactic meaning perfective, active. The word pattern vowels are essentially conveyed as diacritics in the vowelled script. There is evidence to suggest (a) that Arabic native speakers systematically parse the orthographic form into a root and word pattern and (b) that lexical access processes are initially oriented towards the root with information about the word pattern (i.e., the vowels) becoming available at a later stage (Boudelaa and Marslen-Wilson, 2005, 2011).

To date there is behavioral evidence suggesting that reading shallow orthographies relies upon phonological decoding of small orthographic units such as phonemes and phones, whereas reading deep orthographies depends upon the direct identification of larger orthographic units like syllables, or onsets and rimes (Cossu, Shankweiler, Liberman, Katz, and Tola, 1988; Frost, 1994, 1995; Grainger and Ziegler, 2011; Ziegler and Goswami, 2005; Seidenberg, 2011). In Arabic, reading accuracy has been found to be significantly higher for the shallow (vowelled) orthography than for the unvowelled (deep) orthography, both in normal children and in dyslexic children of various age groups (Abu-Rabia, 2007).

Results of experiments using neuro-imaging suggest that shallow and deep orthographies involve different neural substrates (Bourisly et al., 2013; Paulesu et al., 2000). Orthographic depth also has measurable effects on at least two components of the Event Related Potentials (ERPs): the N170 and the N320 component (Bentin et al., 1999; Proverbio and Zani, 2003) that are of most interest here. For instance, Simon et al. (2006) showed that the N170 amplitude is influenced by orthographic familiarity and word frequency. More recently, Taha et al. (2012) reported that the amplitude of the N170 recorded from Arabic adult readers was larger and its latency shorter to words written using the most familiar connected orthographic patterns than to words using less familiar unconnected letters patterns. Bar-Kochva and Breznitz (2012) showed that vowelled Hebrew words were associated with larger amplitude and longer latency of the N170 component at occipito-temporal sites than unvowelled Hebrew words. Where the N320 is concerned, Simon, Bernard, Lalonde and Rebaï (2006) report an N320 response to French, but not to unvowelled Arabic stimuli, suggesting that French requires the use of grapheme–phoneme conversion while Arabic does not (Ziegler et al., 2003).

Collectively these studies provide interesting insights into the temporal and topographic properties of orthographic processing in Semitic languages. However, they fall short of making any claims about the potential influence of vowelling on semantic processing. Specifically does the presence of vowel diacritics speed up semantic processing? The aim of the present study is to fill this gap by asking whether orthographic depth (vowelling) and semantic processing are independent or interactive. For this end, we used a semantic priming task, in which participants are asked to judge whether two sequentially presented words, a prime (e.g., drink) and a target (e.g., TEA) are semantically related or not. This task is particularly well suited to our purposes since subjects need to access their semantic knowledge in order to carry out the task, and this will allow us to determine if the time course and topography of access to semantic knowledge are modulated by vowelling.

Previous results using this paradigm have repeatedly shown that semantically related words are associated with faster RTs and lower error rates compared to unrelated words (e.g., Khateb et al., 2003, 2010). Moreover, previous results using the ERPs method have demonstrated that semantically unexpected words in sentence contexts (Kutas and Hillyard, 1980) or in word pairs (Bentin et al., 1985; Holcomb and Neville, 1990; Khateb et al., 2003, 2010) elicit larger negative ERP components with maximum amplitude 400 ms post-stimulus onset (i.e., N400 component) than semantically expected or related words (for reviews see Hagoort, 2008; Kutas et al., 2006; Kutas and Federmeier, 2011).

Interestingly, the N400 effect has been documented in many languages including Dutch (e.g., Brown and Hagoort, 1993; Gunter et al., 1997), English (e.g., Kutas and Hillyard, 1980; Boddy, 1981; Bentin et al., 1985), Finnish (e.g., Juottonen, Revonsuo and Lang, 1996), French (e.g., Besson and Macar, 1987; Khateb et al., 2003, and 2010), German (e.g., Heinze, Münte and Mangun, 1994; Günter et al., 1997), Italian (Cobianchi and Giaquinto, 1997), Japanese (Ueno and Kluender, 2009), Mandarin Chinese (e.g., Lee, Tsai, Huang, Hung and Tzeng, 2006; Ye, Luo, Friederici and Zhou, 2006), Norwegian (e.g, von Koss Torkildsen, Syversen, Gram Simonsen, Moen and Lindgren, 2007), Spanish (Wicha et al., 2003), Swedish (e.g., Ors, Lindgren, Berglund, Hägglund, Rosen and Blennow, 2001) but, to our knowledge, it has never been tested in Arabic (Bourisly et al., 2013) using the fMRI method and Taha et al. (2012) mainly examined the N170 component.

In summary, the specific aims of the present experiment were to determine (a) whether semantically priming effects can be demonstrated in Arabic both on RTs and on the N400 component and (b) whether the effects of orthographic (vowelled-unvowelled) and semantic factors (related-unrelated) on behavior and on the amplitude/latency of the N400 are independent or interactive. We hypothesized that unvowelled words can be more difficult to process (i.e., associated with slower RTs, higher error rate and larger N400 components) than vowelled words because different unvowelled words can share an identical consonantal structure but have different pronunciations and meanings. Alternatively however, it is conceivable that vowelled words prove to be more difficult to process (and consequently yield slower RTs, higher error rate and larger early perceptual and cognitive ERPs components, N1, P2, N2) than unvowelled words because they are visually more complex (due to the presence of diacritical marks) and less familiar to fluent adult Arabic readers who mainly read unvowelled words. Additionally, these two factors, visual complexity and familiarity, may interfere with semantic priming effects.

2. Methods

2.1. Participants

A total of 20 students (10 women), aged between 20 and 34 years old (mean: 27 years; sd: 9.89), from the University Mohammed V Agdal, in Rabat, Morocco, were tested in this experiment. They were all right-handed and without neurological disorders. Three participants were excluded from final data analysis because of a high number of trials contaminated by ocular and muscular artifacts. All participants use Arabic on a daily basis and were Master or PhD. students (mean number

Table 1
Examples of experimental items used in the experiment. For each example, the word in Arabic, a phonological transcription using IAP symbols and an English gloss are indicated.

	Prime		Target
	Related	Unrelated	
Vowelled	سَرِيرٌ [sariirun] *Bed*	عَسْكَرِيّ [askariʏʏun] *Military*	وِسَادَةٌ [wisaadatun] *Pillow*
Unvowelled	سرير [sariirun] *Bed*	عسكري [askariʏʏun] *Military*	وسادة [wisaadatun] *Pillow*