Foreword to the Special Issue "Learning to Read: Early Latency Language ERPs"

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While cognitive models of language comprehension vary widely, they all agree on depicting it as being a very complex process, although some attribute its chief complexities to the serial interactions of a large set of discrete modules and others to parallel interactions within one of a few widely distributed modules. Hemodynamic studies (such as functional magnetic resonance imaging or positron emission tomography) of language comprehension have confirmed the complexity of the language areas but are largely blind to their temporal ordering. As such, the hemodynamic literature has had a tendency to emphasize the parallel view of the reading process.

Leading examples of both the serial and parallel views, the Dual-Route Cascaded Model (Coltheart, Rastle, Perry, Langdon, & Ziegler, 2001) and the Triangle Model (Seidenberg & McClelland, 1989), agree that aside from semantics one can distinguish between an orthographic level of processing (based on visual word form) and a phonological level of processing (based on conversion to an auditory code). However, the ordering of interactions even at this simplified level remains contentious, with some views envisioning largely parallel resonance feedback patterns (Van Orden & Goldinger, 1994) rather than a serial information pathway.

The importance of examining earlier ERP components is especially clear when studying the language process in the developmental context. In a serial view of language processing, it would be almost mandatory for the lower levels to develop before they could begin to pass on useable information to the higher levels of language. Conversely, in a parallel view of language processing, especially one involving resonant interactions between different domains of representation, one might expect development to progress in parallel within the different levels.

A methodology that has the potential to clarify to what extent language processing can be understood as being a serial information processing flow is event-related potentials (ERPs), which, unlike hemodynamic measures, have millisecond time resolution. Thus far, the current language ERP literature is dominated by studies of the N400, a response peaking at 400 ms that has proven to be a robust and illuminating index of semantic processing and to also be responsive to manipulations of at least some pre-semantic parameters. While the N400 has yielded many insights and advances, it seems likely that deeper insights into the serial aspects of language comprehension would require greater attention to earlier ERP components to determine if any evidence for sequential stages of processing can be obtained. The contributors to this special issue have done just so (see also Barber & Kutas, 2007; Dien, 2009b; Friederici, 2002) and their findings provide two general insights into this issue of serial versus parallel processing.

First of all, as discussed in a recent review (Dien, 2009b), an array of different ERP components have been reported that appear to reflect different aspects of reading comprehension. Two in particular, that are highlighted in this special issue, appear to have promise for reflecting the orthographic and phonological levels. An early left posterior negativity termed the N170 by two of the papers (Maurer, Blau, Yoncheva, & McCandliss, in press; Yoncheva, Blau, Maurer, & McCandliss, in press) and the N150 by another (Spironelli, Penolazzi, & Angrilli, in press) appears to reflect an important aspect of orthographic processing (Schlaggar & McCandliss, 2007). Conversely, a later left lateral negativity termed the N320 by one of the papers (Frishkoff, Perfetti, & Westbury, in press) appears to reflect some aspect of phonological processing. Both ERP components have been given multiple names and so it has been suggested (Dien, 2009b) that, to reduce confusion, it may be helpful to include the peak channel as part of the label, as in "N170po7" and "N300t3" respectively. While more study is required, the clear latency differences between these ERP components already suffices to bolster the view that some aspects of visual word recognition, at least, are clearly serial in nature.

The second general observation has to do with the role of the right hemisphere (RH). While the two leading models of reading comprehension cited earlier (Coltheart et al., 2001; Seidenberg & McClelland, 1989) are silent on the matter of the right hemisphere, some views of reading comprehension (Bakker, 1990, Dien, submitted) postulate an important role for the RH during the development of reading.

In one of the studies (Frishkoff et al., in press), adults learned from context a set of previously unknown words. Among other observations, a right-lateralized P100o2 (denoting a positivity peaking at about 100 ms with the strongest amplitude at electrode O2, see Dien, 2009b) effect was seen to become stronger with training. It seems likely that this P100o2 effect reflects the increasingly right-lateralized occipital activity that has been reported in developmental studies of reading (Szaflarski et al., 2006).

A second study (Spironelli et al., in press) in this special issue reports apparently right-lateralized activity at a further point in the comprehension process, marked by the ERP component that they term an N150. They report a gender effect in that their sample of ten-year old Italian boys produced bilateral effects whereas the girls produced right-lateralized effects. This ERP component is normally left-lateralized in adults, as they showed in a prior paper comparing two adult samples with this set of children (Spironelli & Angrilli, 2009). This observation thus suggests that the beginning readers in this study were relying on their RH for word recognition.

The other two studies (Maurer et al., in press; Yoncheva et al., in press) in this special issue further strengthened this account. They found that when an adult sample learned an artificial script with a logographic appearance (a single symbol) but where its parts corresponded to different phonemes, they displayed a strengthening of a right-lateralized N170 in a perceptual task (Maurer et al., in press) and a left-lateralized N170 in a phonology task (Yoncheva et al., in press). The authors suggested that the apparently obligatory left-lateralization of the N170 to real words in adults could be due to automatization of the reading process. In an earlier study (Brem et al., 2005) involving learning a clearly alphabetic artificial language resulted in an amplification of a LH N170 even when the task was perceptual in nature. They suggest (Maurer et al., in press) that the reason for this observation is that the artificial script was sufficiently similar to the participant's native tongue that their left-lateralized reading system automatically engaged. An alternative interpretation is that an artificial script where the constituents are physically separated is more conducive to LH associative analysis (see Dien, 2009a), in contrast to the present studies (Maurer et al., in press; Yoncheva et al., in press) where the parts are physically connected into a unitary whole, yielding a bias towards a RH configural analysis. Indeed, faces, which are generally thought to elicit configural analysis (Maurer, Grand, & Mondloch, 2002), generally elicit a right-lateralized N170 (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Rossion & Gauthier, 2002). Clearly these intriguing results open up some important lines of enquiry.

Finally, these results underscore the case for the active role of RH in the development of language. For example, the task-dependent effects in this pair of studies (Maurer et al., in press; Yoncheva et al., in press) strongly suggest that the same could account for findings in children as well. In other words, some of the differences between children and adults could be due to strategic choices by the children as to how to process the word stimuli rather than neural maturation, given that the right-lateralized effects were in this case observed in adults with fully mature brains. These studies show clearly that in the future it will be important to try to match not just performance levels (see Brown et al., 2005; Schlaggar et al., 2002) but also cognitive strategies. Furthermore, they also help highlight the potential confound of comparing the response to newly learned words in children with the response to long-known words in adults. Conversely, studying only well-learned words in children can potentially underestimate the role of the RH.

In summary, even as these early latency language ERP studies strengthen the position of serial word recognition processes, they introduce a new RH element into the picture. It would seem that even as the word recognition processes are proceeding, to a large extent, in serial within a given hemisphere, they are at least sometimes proceeding in parallel between the two hemispheres. Such findings are already beginning to inform new generations of both serial (Dien, submitted) and parallel (Monaghan & Shillcock, 2008) processing models. The findings presented in this special issue therefore epitomize how ERP methodology has the potential to illuminate the broader questions of reading comprehension and its developmental acquisition.

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