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Event-Related Potentials in the Study of Hungarian-English Bilingual Visual Word Recognition

Review of PhD Thesis

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The subject of this study is timely, addressing issues that are not only important for research but also have practical relevance for those working on the field of education and language teaching. In the dissertation, the Candidate examines the temporal characteristics of bilingual visual word recognition in three event-related potential (ERP) experiments. The first experiment included a language decision task with English words, Hungarian words, and interlexical homographs. The well-known homograph effect was replicated, and the study also found that that language typology does not influence word recognition; English and Hungarian words are processed similarly until semantic content is accessed, suggesting that word candidates from both languages are coactivated. In the second experiment, a lexical decision task was employed to measure the ERP correlates of real words (English and Hungarian) and non-words (nonsense letter strings). The results supported previous findings that reported divergent neural processing from the early phase of visual word recognition, suggesting differences in the orthographic and/or phonological processing of these items in addition to differences in semantic processing. The third experiment compared the processing of English pseudowords and Hungarian pseudowords. Once again, language typology did not influence word recognition, processing of English and Hungarian pseudowords were processed similarly in the early phases of visual word recognition. Overall, the results presented in the dissertation suggest that visual word recognition processing patterns are language-independent on lower cognitive levels (orthographic and phonological), but at higher cognitive levels (semantic), recognition is language-specific in alphabetic orthographies like English and Hungarian.

The introduction is easy to follow and provides a detailed overview of the most important and relevant theories of bilingualism and bilingual visual word recognition. Nevertheless, there are some redundant sections and coverage of the most important topics seems to be somewhat unbalanced. For instance, the introduction includes a long discussion about the brain structures underlying visual word recognition despite that the methodology of the dissertation is suitable for examining the temporal characteristics but not the structural characteristics of visual words recognition. On the other hand, the most relevant ERP components, their correspondence to the specific processes of visual word recognition (see for example Grainger and Holcomb, 2009) is only tangentially described. Description of the time course of monolingual visual word recognition to which the time

course of bilingual visual word recognition could be compared would have helped to interpret the results in a wider context. In addition, I have missed the discussion of some fundamental visual word recognition models (e.g. the dual-route cascade (DRC) model of Coltheart et al., 2001 or the widely cited and tested Bi-modal Interactive Activation Model, BIAM of Grainger and Holcomb, 2009). At the end of the chapter, a wide array of psycholinguistic phenomena is covered which helps to put the design of the studies and the experimental results into context.

The aim of the studies and the research questions and hypotheses are clearly stated and well-motivated. However, I have concerns about the framing of some hypotheses. First, research question Q2 asks: "What kind of awareness is essential in written word recognition?". In relation to this question H4 is proposed: "Orthographic and phonological awareness plays a crucial role in the ability of language selection in the case of pseudo-words.". However, neither phonological nor orthographic awareness was measured in the studies. It seems that the terms phonological awareness and phonological processing are used interchangeably, although they refer to only partially overlapping skills. Phonological awareness refers to the ability to recognize and manipulate the segments (especially the sounds) of language. It is a meta-cognitive skill. Phonological processing is a wider term, it encompasses phonological awareness, phonological working memory, and also grapheme-phoneme conversion. This, when the Candidate states that "What is certain is that pseudo-words require a higher-level phonological awareness.", the claim is unfounded as phonological awareness was not measured (no phoneme deletion test was used, no rhyme judgement task was employed). However, it is true that pseudowords require a higher-level phonological processing as the only way to read these items is through applying grapheme-phoneme correspondences. The decision in the experimental task whether the pseudoword would fit into the English or Hungarian language requires to apply phonotactic rules, but this can be achieved without phonological awareness (purely based on statistical learning). Second, H3 claims that "The recognition of non-words is faster due to the word superiority principle." This hypothesis is problematic in two ways. First, the word superiority effect (WSE) refers to the phenomenon that letters in words are recognized faster and more accurately than single letters or letters embedded in pseudoword or non-words (see e.g. Reicher, 1969; Wheeler, 1970). The Candidate inaccurately uses this term when she states that "Word superiority effect relates to a superior processing and better recognition of words in comparison to pseudo-words and non-words (Sand et al., 2016)." The finding that accuracy and reaction time to words tend to be better and faster than to non-words is called the lexicality effect (see e.g. Fiez et al., 1999). Second, the recognition of non-words should be slower based on this principle. Would the Candidate please clarify these issues?

The methodological details of the experiments are thoroughly described, the stimulus lists are well-prepared. The supplements are very useful to aid understanding of the design, and the methodological description is easy to follow. Nonetheless, it would have been helpful to repeat the full Hypotheses, not just their numbers under each relevant

experiment. Regarding the methods used, I have three questions. First, why was there no control group (a monolingual group) in the experiment? The results could have been stronger if the Candidate could verify that bilinguals process Hungarian and English words similarly in terms of orthographic and phonological processing and processing diverges only when semantic processing starts, but monolinguals process Hungarian and English words differently right from the early phases. Second, the third experiment used a modified version of the lexical decision task. Here the participants were instructed to decide whether the pseudowords presented on screen could fit into the Hungarian or into the English language. Would not this task structure qualify as a language decision task rather than a lexical decision task? Third, in the first experiment the grand average of the ERPs were calculated in the 380-420 ms time window on the C1 channel to represent the N400 component. What drove the time-window and channel selection? Was it based on previous literature or on the data-driven analysis results?

The results section provides clear and detailed description of the findings; the figures are informative and nicely formatted. The use of permutation-based cluster method for data analysis is impressive and represents cutting-edge methodological knowledge, raising the methods and results section to really high-standards.

The discussion integrates results with various segments of theories in bilingual visual word recognition. Although it would have been helpful to section the discussion according to hypotheses, the arguments were easy to read and follow. The interpretation of results is discussed in the context of the most relevant models; however, I have a suggestion for an alternative explanation (see the question below). I have three minor comments regarding the discussion. First, the Candidate states that “While Hungarian has a shallow writing system and is built on a consistent mapping of graphemes to phonemes, English has a deep one and there is no grapheme-phoneme correspondence rule in it.” This statement is only partially adequate, to make justice to the English language, it is grapheme-phoneme correspondence rules, although it is not as straightforward as it is in shallow orthographies since one letter maps onto more the one speech sound and one speech sound might map onto more than one letter. Second, the description and interpretation of the N170 component lacks precision. Although it is true that word and non-words differentially modulate its amplitude, this effect is not so clear cut for contrasting words and pseudowords. In addition, this component reflects not only the neural processing of words but also other visual stimuli, such as symbols or faces; thus, it is not regarded as a marker of word identification, rather it is a category-specific visual expertise marker, which can be measured as an index of print expertise with prelexical sensitivity to letter strings (for a review, see Amore et al., 2022). Third, the Candidate argues that “The results furthermore suggest that word recognition activates different parts of the brain from the moment of the stimulus onset until the identification of the word,…”. This argument is unfounded (probably due to imprecise wording) as EEG is not a method for measuring which brain areas are active (as the Candidate correctly discusses this issue previously in the methods section). This sort of wording can be observed

throughout the dissertation, and more efforts should be made to draw conclusions more carefully or word conclusions more precisely.

In sum, the work of the Candidate studies a vast and complicated topic, but based on the thorough and in-depth knowledge of the literature and by using cutting-edge methodology she has accomplished to provide both theoretically and practically relevant novel knowledge in the topic. In addition, the use of English including grammar and style leaves nothing to be desired throughout the dissertation giving a particularly pleasant reading experience. My questions are the following:

(1) What could be the practical application of the results, and what are the limitations of their application?

(2) Do the results provide support or refute any of the bilingual mental lexicon models?

(3) I propose an alternative explanation for the results. The result that only the word vs. non-word contrast yielded a statistically different result in the early time-window (150-300 ms), while the English and Hungarian words and pseudoword differed in the latter time window (mainly in the N400 component) could be explained based purely on orthographic processing without any reference to phonology. The word vs non-word contrast might evoke different N170 response based on their different bigram (especially positional bigram) frequency. Non-word contains letter clusters that are infrequent or nonexistent in a given orthography; thus, purely visual statistical sensitivity to these letter combinations can result in differential modulation of the N170 amplitude. In a similar vein, if the bigram frequencies do not give the reader any clue about what language is being presented (as would be the case if the bigram frequencies were equated between the Hungarian and the English stimuli which might have happened as a “side effect” of equating the word frequencies), no processing difference would emerge until semantic access. Then, if the word has two meanings as a homograph, higher N400 response is recorded than if it has only one meaning. If the words have no meaning but contain existing bigrams (that is they are pseudowords), they are processed similarly to word real words. If the bigram frequencies do not differ between the Hungarian and English pseudowords, there will be no difference in their processing early on that could help them in the decision. However, once semantic processing starts, the reader must realize that the stimulus has no meaning in either language, but have to decide to which language to fit the pseudoword. This decision result in the difference between Hungarian and English pseudowords in the late time window (after 500 ms). This could be based on some decision related revision process that recalculates the bigram frequencies and more precisely compares them in the two languages in order to make the decision about language. What is the Candidate opinion, is any

phonological or articulatory processing necessary in this task? How could the two accounts be tested empirically?

Overall, the dissertation meets the requirements of the doctoral school in terms of both content and form; therefore, I recommend it to be publicly discussed, and upon successful defense, I recommend that the doctoral degree be awarded to the Candidate.

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