

Attentional Processing in Visual Word Recognition: Evidence from Hindi

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How does spatial attention influence visual word recognition? Over the past several decades, numerous models have been proposed to specify the architecture of visual word recognition (henceforth VWR) such as the Dual-Route Cascaded (DRC) model [1] and the Triangle model [2]. However, these traditional models treat VWR as an isolated linguistic process, failing to provide a detailed account of how domain-general cognitive processes—specifically spatial attention—interact with VWR [3, 4]. Moreover, early literature on spatial attention and VWR often treated the two as independent processes [5] and offered mixed opinions regarding their interaction. However, more recent empirical results suggest a tight coupling between spatial attention and VWR [6, 7]. These studies however, were done on English language which is written in Roman script, and failed to provide clarity about whether this interaction is generalizable to other orthographies as well. To address this issue, recently we had conducted spatial cueing experiments [8] similar to McCann et al. (1992), using Hindi language which is written in *Devanagari* script. The stimuli in these experiments were kept linear (like English language) with limited visual complexity in orthography. Our findings had shown that unlike English language, attention influences reaction time and accuracy of depending on target-lexicality i.e., faster reaction time and higher accuracy for only ‘word targets’ compared to ‘pronounceable nonwords targets’ when attention was engaged at a spatial location (i.e., for valid cue condition).

One issue which still remains unclear is: how attention influences VWR when visual characteristics and complexity is increased in Hindi word/nonword targets? To address this issue, in the current study we manipulated number of *matras* (2, 3, and 4) in the Hindi word/nonword targets as well as spatial attention (valid, invalid cues). Thirty-six participants performed a Lexical decision task in which attention was manipulated with exogenous spatial cues with cue-to-target validity 50/50 i.e., 50% of the times cue and target can appear at the same location. The presentation of all the stimuli was fully randomized. Linear mixed effects model was fit to the reaction time and error data and the results for RT showed no main effect of attention, $\beta = -0.013$, $SE = 0.024$, $t(1180.94) = -0.53$, $p = .598$, nor a significant main effect of Number of matras. Only a significant main effect of Lexical-status was found, $\beta = 0.077$, $SE = 0.024$, $t(1150.49) = 3.20$, $p = .001$, indicating that responses to nonwords were significantly slower than responses to words. Similar results were found for the error data. Taken together, these findings show that attention does not interact with VWR in Hindi when visual complexity is increased. These findings pose challenges for the current theories of VWR and highlight that languages which are written in different orthography than English might adopt relatively

different mechanisms of VWR depending on sparse or dense orthographic properties of the language.

References

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Additional information about the language of the current study

The *Devanagari* writing system is a major script of the Brahmic family, used to write languages such as Hindi, Marathi, Nepali, Sanskrit etc. Hindi is one of the most widely used language of this writing system with approximately of 600–610 million people worldwide. It falls into the category of segmental writing system also called as alphasyllabary or abugidas (see: (Rao et al., 2012)). In this writing system, consonant-vowel (CV) sequences are combined within character units. Like alphabets, alpha-syllabaries distinguishes vowel and consonant, but as in a syllabary, each alpha-syllabic character (known as ‘Akshar’ in Hindi) maps onto a CV syllable. Akshars comprise of either letter [L] or the combination of letters and matras [L+M]. some words are made just of akshars, whereas other words are made of combinations of akshars and matras.

Hindi language is particularly interesting case because words in this language words can be made both linearly and non-linearly (Kumar et al., 2024; Vaid & Gupta, 2002; Verma et al., 2021). For example, in Hindi, a word can be made either by only consonant units (e.g., the word ‘कलम’ (/k/+l/+m/; meaning, *pen*)), or via the help of diacritics (e.g., the word कोमल; (/k/ + o (marked as a diacritic above /k/) + /m/ + /l/) meaning, *soft*)). Words with only consonant units are similar to words in English, written linearly only with letters whereas words with one or more matra (diacritic) differ from English words in terms of visual characteristics and complexity. This presents a unique opportunity to examine how spatial attention influences word recognition both when words are visual simple made of only letters as well as when words are visually complex when made of multiple matras.

Indeed, previous research suggests that the difficulty of word recognition may be directly influenced by these visual and structural intricacies and complexity (Chang et al., 2016; Ellis et al., 2004; Frost, 2012; Pae, 2022). Also, it has been suggested that orthographies with high visual density and non-linear structures may necessitate greater involvement of spatial attention for successful character-to-vowel binding (Di Bono & Zorzi, 2013; Pae, 2022; Rao & Singh, 2015). Similarly, recent findings by Kalra et al. (2025), and (Singh & Rao, 2014) suggest that the alphasyllabic nature of Devanagari imposes unique constraints on the visual-attentional system. Due to these unique constraints, selection via spatial attention may be expected to differ from the way it manifests in English language.