

Not only Letters (Aksharas) But Diacritics (Maatraas) Also Incur Processing Costs in Visual Word Recognition in Hindi: Evidence from Lexical Decision Tasks.

Mehrun Naaz¹, Prakhar Mishra², Anurag Khare (akhare@iitk.ac.in)³, Ark Verma⁴

¹National Forensic Sciences University, Gandhinagar, Gujarat, India, ^{2,3,4}Indian Institute of Technology Kanpur, Kanpur, India

Most studies have been done considering letters as the functional units. There are many orthographies whose functional units are not as simple as letters; e.g.: Chinese characters are made up of radicals and strokes, Arabic ones are made up of letters and diacritics. In Hindi, each segment is made up of aksharas and maatraas. It has been shown that all three, i.e. segments, aksharas, and maatraas (subsidiary units) are functional units for Hindi [1]. In this study, 2 experiments were carried out to investigate the processing cost of maatraas.

Experiment 1:

Participants: N=35 (Male=27, Female=8), Age range = 18 ~ 33 years (M=24.26, SD=4.22).

Stimuli: Words drawn from Shabd [2]. 1x5 design chosen with the factor “number of maatraas” with 5 levels (0, 1, 2, 3 and 4 maatraas). There were 395 4-segment (4 full aksharas) words.

Procedure: It was a lexical decision task. Detailed procedure is shown in figure 1.

Results: Model used: $\log(\text{response_time}) \sim \text{matracount} + (1|\text{subject_nr}) + (1|\text{target})$. Main effect of the number of maatraas was found ($F(4, 371.95) = 3.0703, p < 0.05$). Also, linear ($\text{Est} = 0.02693, t = 2.273, p < 0.05$) and quadratic ($\text{Est} = 0.02919, t = 2.470, p < 0.05$) trends were found to be significant. Graphic representation is in figure 2.

Experiment 2:

Participants: N=35 (Male=34, Female=1), Age range = 19 ~ 35 years (M=22.6, SD=3.88).

Stimuli: Words drawn from Shabd[2]. A 3x4 design was chosen with two factors i.e., prime type with three levels (identity, without maatraa and ALD_maatraas) and number of maatraas with 4 levels (1, 2, 3 and 4 maatraas). There were 316 4-segment (4 full aksharas) words.

Procedure: It was an LDT with 50 ms prime. Detailed procedure is shown in figure 3.

Results: Model: $\log(\text{response_time}) \sim \text{prime_type} * \text{n_maatraa} + (1|\text{subject_nr}) + (1|\text{target})$. Main effects of prime types ($F(2, 7929.4) = 63.14, p < 0.001$) and N_maatraas ($F(3, 296.3) = 7.41, p < 0.001$) were found. Differences between RTs of identity and w/o maatraas primes ($\text{Est} = 3.145e-02, t = 6.009, p < 0.001$) and w/o maatraas primes and all different maatraas primes ($\text{Est} = 2.804e-02, t = 5.347, p < 0.001$) were found to be significant. A significant linear trend of RT was found for the N_maatraas ($\text{Est} = 4.958e-02, t = 4.294, p < 0.001$). Graphics in figure 4.

Discussion: The results also suggest that processing of maatraas have their own costs (Exp 1) and that processing of maatraas starts during early stages of word recognition (Exp2). These findings offer hitherto unknown insights into the process of visual word recognition in Hindi and suggest that idiosyncratic script characteristics may differentially affect processing.

References

- [1] Rimzhim, A., Johri, A., Kelty-Stephen, D. G., & Fowler, C. A. (2021). Transposition Effects in an Aksharic Writing System: The Case of Hindi. *Language and Speech*, 64(4), 804–838.
- [2] Verma, A., Sikarwar, V., Yadav, H., Jaganathan, R., & Kumar, P. (2022). Shabd: A psycholinguistic database for Hindi. *Behavior research methods*, 54(2), 830–844.

Figures and Tables

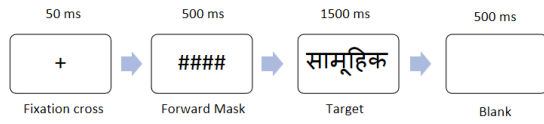


Figure 1: Procedure of Experiment 1.

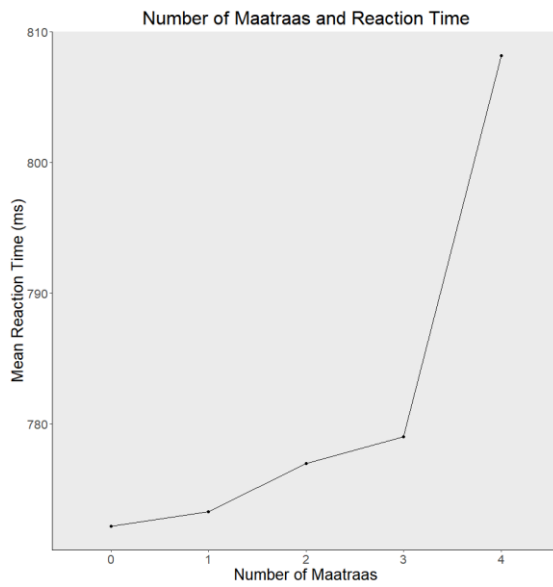


Figure 2: Mean reaction times of words for different number of maatraas for Exp1.



Figure 3: Procedure of Experiment 2.

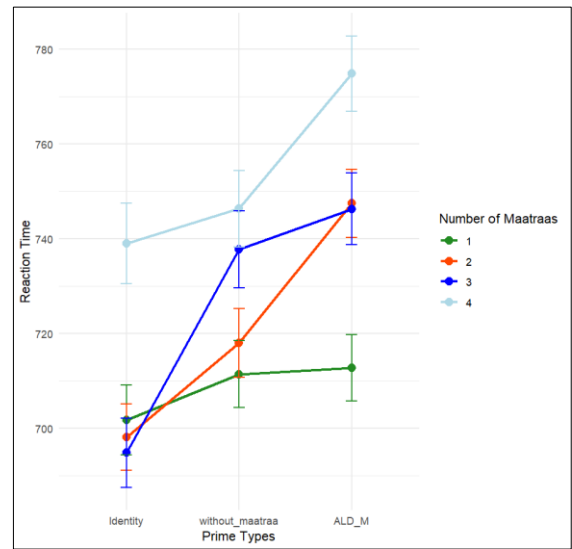


Figure 4: Interaction bet prime types and number of maatraas for reaction times for Exp 2.

Table 1: Description of properties of words selected for the experiments

Condition	Example (Word)	Zipf Frequency range	Exp
0-maatraa	अवसर (/əvəsər/ “opportunity”)	1.89~5.7 (M=3.15,SD=0.81)	Exp 1
1-maatraa	कबूतर (/kəbu:tər/) “pigeon”	1.89~5.71 (M=3.19,SD=0.83)	Exp 1&2
2-maatraa	विपरीत (/vɪpəri:t/) “opposite”	1.89~5.68 (M=3.21,SD=0.84)	Exp 1&2
3-maatraa	सामूहिक (/sa:mu:hɪk/) “collective”	1.9~5.95 (M=3.23,SD=0.85)	Exp 1&2
4-maatraa	कुमुदिनी (/ku.mu.dɪ.ni:/) “a water lily”	1.84~5.54 (M=3.16,SD=0.80)	Exp 1&2

Description of Hindi (Devanagari) orthography:

Hindi (Devanagari) is a segmental writing system. A word can be broken down into segments. Each segment is made up of aksharas and maatraas. For simplicity, aksharas can be treated as letter units and maatraas as subsidiary units of these aksharas. A segment can have more than one aksharas and maatraas. Example: the word “कुमुदिनी” has 4 segments i.e. “कु” (made up of akshara “क” and maatraa “ु”), “मु” (made up of akshara “म” and maatraa “ु”), “दि” (made up of akshara “द” and maatraa “ि”) and “नी” (made up of akshara “न” and maatraa “ी”).

Table 2: Examples to understand prime types used in this experiment.

Target Word	Prime Type	Prime
कुमुदिनी (/ku.mu.ɖi.ni:/) “a water lily”	Identity	कुमुदिनी (/ku.mu.ɖi.ni:/)
कुमुदिनी (/ku.mu.ɖi.ni:/) “a water lily”	Without Maatraa	कमदन (/kə.mə.ɖən/)
कुमुदिनी (/ku.mu.ɖi.ni:/) “a water lily”	All different maatraas (ALD_Maatraa)	केमादोना (/ke:.ma:.ɖo:.na:/)