

# PROSODIC AND STRUCTURAL CORRELATES OF PERCEIVED PROMINENCE IN RUSSIAN AND HINDI<sup>1</sup>

Tatiana Luchkina<sup>a</sup>, Vandana Puri<sup>b</sup>, Preethi Jyothi<sup>a</sup>, Jennifer S. Cole<sup>a</sup>

<sup>a</sup>University of Illinois

<sup>b</sup>not affiliated

[luchkin1@illinois.edu](mailto:luchkin1@illinois.edu), [vanu.p.sharma@gmail.com](mailto:vanu.p.sharma@gmail.com), [pjyothi@illinois.edu](mailto:pjyothi@illinois.edu), [jscole@illinois.edu](mailto:jscole@illinois.edu)

## ABSTRACT

Perceived prominence in Russian and Hindi, free word order languages, can be communicated prosodically and structurally, via word order. Paired production and perception experiments with native speakers show that discourse-prominent constituents are marked acoustically, via a perceptible increase in vowel intensity and  $f_0$ , and structurally, via a change in word order and placing a word into a designated position in a sentence or clause.

**Keywords:** *perceived prominence, Russian, Hindi*

## 1. INTRODUCTION

Information accessibility, and the related notion of perceived (information) prominence, have been offered a variety of interpretations in the linguistic and psychological literature [1,2]. In cognitive accounts [3,4], the accessibility or givenness of discourse entities is described in terms of the activation costs associated with bringing these entities into the focus of the speaker's/hearer's attention. Information accessibility may therefore be viewed as gradual or continuous, but categorically discretized in production through lexical choices and prominence marking devices, such as prosody, word order, or morphological markers [5].

This work investigates the simultaneously available structural and prosodic means of encoding information status and perceived prominence in two free word order languages, Russian and Hindi. Our goal is to understand which factors guide naïve readers' or listeners' perception of a word as prominent in a discourse or narrative. To this end, we offer an empirical test of whether the position of a word in a sentence or phrase, along with its acoustic-prosodic properties and information status, mediate its perceived prominence.

## 2. PERCEIVED PROMINENCE AND INFORMATION STRUCTURE

One way to operationalize accessibility and relative prominence of discourse entities is to categorically distinguish between information that belongs to the shared knowledge of the speaker and the hearer [6], and may be perceived as less prominent in a dialogue or narrative, and information that critically

requires updating the mental state of the hearer, such that it reflects the new knowledge communicated by the speaker. Across languages, the salience of such critical or prominent information may be signaled in more than one way.

There is strong evidence that acoustic-prosodic parameters, e.g., intensity, duration, and fundamental frequency, can reflect the information status and perceived prominence of discourse entities [7,8,9,10]. Discourse-prominent information can be also signaled by structural means, i.e., strategic syntactic positioning of prominent information. Structural cues to perceived prominence are especially important in so-called 'free word order' languages, where the surface order of sentence constituents can be varied for pragmatic or information structural purposes. To illustrate, in a study by Vainio and Jarvikivi [11], Finnish listeners rated ex-situ focused words, i.e., words pre-posed or post-posed relative to their canonical position, as more discourse-prominent *and* prosodically-prominent, regardless of the availability of prosodic cues in the study materials. Vainio and Jarvikivi conclude that structural prominence has a top-down influence on the interpretation of a word as prosodically- and pragmatically-prominent.

### 2.1. Prosodic and Structural Encoding of Prominence in Russian and Hindi

Russian is a free word order language with SVO as the pragmatically neutral, default constituent order. Hindi is a head-final SOV language with an established subject-first preference [12,13]. As in other free word order languages, words in Russian and Hindi can appear in-situ, fronted, or post-posed relative to their canonical syntactic position. Russian is known to exhibit focus fronting and right-edge dislocation for information structure (henceforth, IS) purposes [14,15]. The nuclear pitch accent in Russian is realized inside the most prominent, focused constituent [16], which, unless contrastive, contains discourse-novel information. The position of the nuclear accent is thus variable, and is critical to signaling the location and the size of the focused constituent.

In Hindi, the use of nuclear pitch accenting for IS purposes has been questioned [17,18], although an

increase in intensity and segment duration, a rise in f0 maxima, and a distinctive ‘hammock’ f0 contour with expanded pitch range followed with post-focal compression have been found to mark the (contrastively) focused constituent [18,19,20]. Word order variability in Hindi has been characterized as discourse-motivated and used to achieve topicalization or to encode focus and emphasis [18]. Hindi is also known to utilize the pre-verbal position in a clause or sentence for focused constituents [21]. In a recent eye-tracking study, Vasishth et al. [13] found that sentences with given-new ordering of information in Hindi were read faster than sentences in which new information occurred before given information. Vasishth et al. suggest that structural encoding of prominence in Hindi may bear on discourse processing and the comprehension or retention of discourse material.

## 2.2. Study Goals

This study contributes to the understanding of perceived prominence in Russian and Hindi. Specifically, we explore how prosody and syntactic position can be used to mark discourse-prominent information. In Experiment 1, we analyze word order and the IS status of a word in relation to its perceived prominence during the silent reading of discourse in Russian and Hindi. In Experiment 2, we report results of an unguided prominence rating task which involved auditory comprehension of the study materials by linguistically naïve Russian and Hindi speaking participants. We lay out evidence that both prosodic and structural encoding of prominence are actively attended to during discourse comprehension.

## 2.3. Method

### 2.3.1. Materials

Two published narratives originally used in [22], were read orally by a female speaker of Russian (age 28). With an average sentence length of 5.2 content words, approximately 30% of the sentences in the chosen narratives deviate from the canonical SVO order. Hindi materials, originally used in [23] include oral narratives drawn from sixteen audio recordings with hand-labeled phonetic transcripts available through OGI Multi-language Telephone Speech Corpus [24]. Each excerpt was produced by a different Hindi speaker and averaged 24.10s in length (~592 content words). Overall, approx. 2% of the utterances in the Hindi corpus deviate from the canonical SOV order.

### 2.3.2. Structural and acoustic feature pre-processing

All ex-situ occurrences in the corpora were treated as possible cases of structural prominence. Words occupying the pre-verbal position in the Hindi narratives, as well as words marked with emphatic morphemes *bhii* and *hii* were treated as separate categories of potentially prominent information in the Hindi corpus.

Acoustic-prosodic measures of f0 (Hz) max and range, mean intensity (dB), and vowel duration (ms) were extracted as correlates of prosodic prominence. Acoustic measures were taken from each syllable of each IS-coded content word.<sup>ii</sup>

The information status of each content word in the corpora was evaluated based on a simplified version of Bauman and Riester’s [25] RefLex framework. Two rounds of annotation, referentially- and lexically-oriented (see Table 1), were completed. Referents in the corpus were classified as *r-given*, *r-bridging*, *r-new*, and *r-unused*. At the lexical level of annotation, words were classified as *l-given*, *l-accessible*, or *l-new*.

**Table 1:** Definitions of the information categories used for inferential analyses based on [25]

| Referential level                                | Lexical level                                     |
|--|---|
| <i>r-given</i> : coreferring anaphor             | <i>l-given</i> : recurrence of same expression    |
| <i>r-bridging</i> : non-coreferring anaphor      | <i>l-accessible</i> : two lexically-related words |
| <i>r-new</i> : a new referent/concept            | <i>l-new</i> : word unrelated to another word     |
| <i>r-unused</i> : discourse-new, generally known |   |

RefLex annotation of the Russian corpus was independently done by two native speakers. Inter-rater agreement (linearly weighted Kappa) between the annotators, across texts was satisfactory:  $\kappa=0.89$ ,  $SE=0.03$ ,  $\alpha=0.05$ . A native Hindi speaker and an advanced L2 speaker of Hindi annotated half of the Hindi narratives each.

### 2.3.3. Unguided Prominence Rating Task (PRT)

For each word in the study materials, the relationship between its normalized acoustic measures, IS status, sentence position, and perceived prominence was tested in the unguided prominence rating task (henceforth, PRT). Following the methodology reported by [26], a perception task was conducted which included 39 clause-size excerpts from the Russian corpus and the entire content of the Hindi corpus, presented in written modality (Experiment 1) and auditorily (Experiment 2). Materials were presented online. The interface of the experiment and the instructions for the prosody

transcription were provided in Hindi and Russian, using the corresponding scripts. Russian respondents read the entire portion of the text preceding the target segment, read or listened to the target segment and identified discourse-prominent word(s) in the target segment by associating them with one level of the binary variable “+/- prominent”. Hindi respondents identified prominent words in the scripted narratives presented in entirety. Following [26], no formal definition of prominence was given. Participants were instructed to mark only those words that ‘were the focus of their attention’ in the utterance. Any number of content words could be marked as prominent.

#### 2.3.4. Participants

Twenty Hindi speakers provided prominence ratings for the Hindi corpus; each speaker rated 6 or 10 different productions. All participants were native Hindi speakers (also fluent in English), living in the United States at the time of participation. The same group of participants participated in Experiments 1 and 2. Forty-nine Russian speaking respondents completed Experiment 1 and 28 different respondents completed Experiment 2. All participants were monolingual Russian speakers residing in Russia at the time of participation. Despite the differences in the experimental materials and methodology, overall consistent sets of correlates of perceived prominence were obtained for both languages under study.

#### 2.3.5. Analyses of the PRT responses

Responses to the prominence rating task (PRT) were assessed for inter-rater agreement. In the Russian version of the task, the agreement coefficients obtained translate into fair but highly significant agreement levels: Fleiss’ kappa  $\kappa=0.26$  ( $p<.001$ ) for the silent reading PRT (Exp. 1) and  $\kappa=0.36$  ( $p<.001$ ) for the auditory PRT (Exp. 2) In the Hindi version of the task, a slightly higher level of inter-rater agreement was obtained in the silent reading PRT  $\kappa=0.29$ , ( $p<.001$ ) than in the auditory PRT ( $\kappa=0.26$ ,  $p<.001$ ). Following Cole, Mo, and Hasegawa-Johnson [26], each word in the narratives was assigned two prominence scores (one per test modality), which were computed by dividing the total number of times a word was marked as prominent by the total number of participants who responded to the relevant test question. Obtained prominence scores were used as a quasi-continuous measure of perceived prominence. Separate generalized linear models were fit to the p-scores from Experiments 1 and 2.

## 2.4. Results Using Prominence Ratings

**Silent reading PRT:** *In the Russian corpus* (Model 1,  $F(8, 537)=53.29$ ,  $p<.001$ ), words positioned ex-situ, specifically, post-posed ( $t=2.94$ ,  $p<.005$ ) and fronted ( $t=3.02$ ,  $p<.005$ ) relative to the canonical position received consistently higher prominence scores. At the lexical IS level, higher prominence ratings were obtained for *l-accessible* ( $t=2.26$ ,  $p<.05$ ) and *l-new* ( $t=3.20$ ,  $p=0.001$ ) than for *l-given* words. At the referential level, relative to *r-given*, words carrying *r-unused* and *r-bridging* information received significantly lower prominence scores ( $t=-9.54$ ,  $p<.001$  for *r-unused* and  $t=-3.54$ ,  $p<.001$  for *r-bridging*), whereas *r-novel* words were rated higher ( $t=3.15$ ,  $p<.005$ ).

*In the Hindi corpus* (Model 2,  $F(15, 1522)=13.98$ ,  $p<.001$ ), fronted words received consistently lower prominence scores (ex-situ fronted:  $t=-2.16$ ,  $p<.05$ ), whereas post-posed words received consistently higher prominence scores ( $t=2.11$ ,  $p<.05$ ), as well as words in the pre-verbal position ( $t=7.13$ ,  $p<.001$ ). For IS effects at the lexical level, higher prominence ratings were obtained for *l-given* words than for any other lexical IS category ( $t=-2.39$  for *l-accessible*, and  $t=-2.72$  for *l-new*). At the referential level, relative to *r-given* category, all other IS-ref categories received significantly higher prominence ratings ( $t=3.98$  for *r-bridging*,  $t=2.33$  for *r-unused*, and  $t=6.58$  for *r-novel* words).

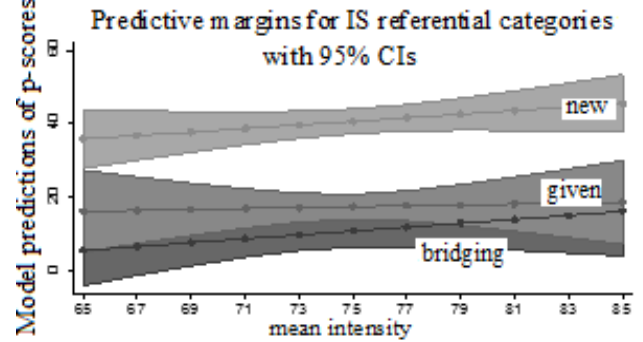
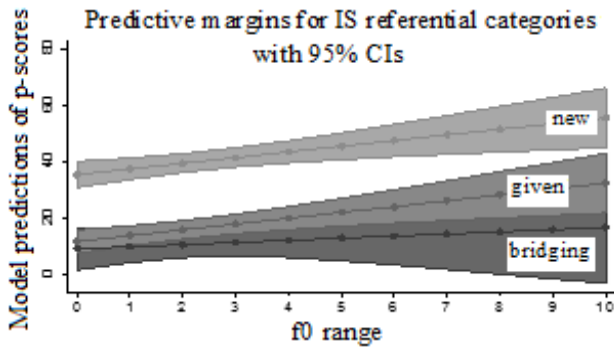
**Auditory PRT:** *In the Russian corpus* (Model 3, linear regression,  $F(12, 502)=16.46$ ,  $p<.001$ ), only words post-posed, relative to the canonical position received higher prominence scores ( $t=2.77$ ,  $p<.01$ ). At the lexical IS level, higher prominence ratings were obtained for *l-accessible* ( $t=1.98$ ,  $p=0.05$ ) words, relative to *l-given* words. At the referential IS level, relative to *r-given* information, words carrying *r-unused* and *r-bridging* information received significantly lower prominence scores ( $t=-4.99$ ,  $p<.001$  for *r-unused* and  $t=-2.52$ ,  $p<.01$  for *r-bridging*), whereas *r-novel* words were associated with higher prominence scores ( $t=4.59$ ,  $p<.001$ ). The acoustic-prosodic measures of syllable mean intensity ( $t=2.35$ ,  $p<.05$ ) and  $f_0$  range ( $t=3.57$ ,  $p<.001$ ) were positively associated with perceived prominence.

*In the Hindi corpus* (Model 4, mixed effects generalized linear model<sup>iii</sup>, log likelihood = -372.2), words marked with emphatic morpheme *hii* were rated higher on prominence ( $z=2.92$ ,  $p<.005$ ), as well as words in the pre-verbal position ( $z=4.89$ ,  $p<.001$ ) and ex-situ post-posed words ( $z=2.41$ ,  $p<.05$ ). At the lexical IS level, *l-new* words obtained

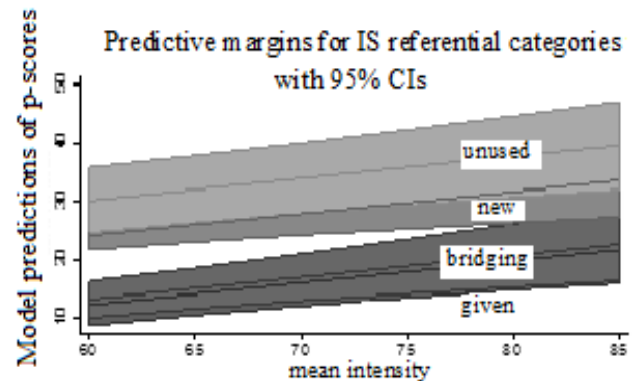
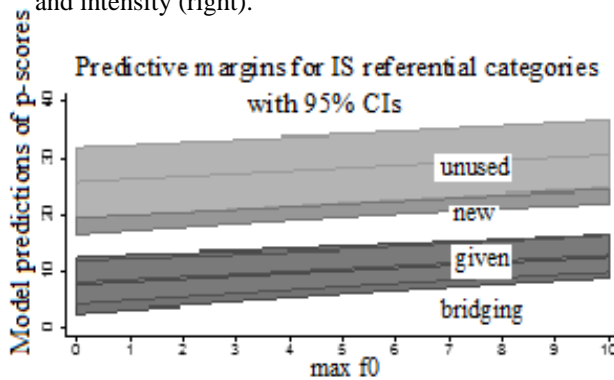
lower prominence ratings than *l-given* words ( $z=-2.54, p<.005$ ). At the referential level, *r-new* and *r-unused* information received higher prominence ratings ( $z=5.02, p<.001$  for *r-unused*, and  $z=4.18, p<.001$  for *r-new* words) than *r-given* words. The acoustic-prosodic measures of segment intensity ( $z=3.56, p<0.001$ ) and  $f_0$  maxima ( $z=2.87, p=0.001$ ) were positively associated with perceived prominence.

### 3. DISCUSSION

In this work we found that independently of the modality of presentation, in Russian and Hindi, words identifying discourse-new and, in Hindi, previously unmentioned referents are perceived as highly prominent. In the auditory modality, listeners treat the acoustic-prosodic realization of a word as a cue to its discourse status.



**Figure 1:** Predictive margins with 95% confidence intervals for referential IS categories in Russian. The y-axis represents linear prediction for p-scores (scale 0-100) in relation to the covariate on the x-axis:  $f_0$  (left) and intensity (right).



**Figure 2:** Predictive margins with 95% confidence intervals for referential IS categories in Hindi. The y-axis represents linear prediction for p-scores (scale 0-100) in relation to the covariate on the x-axis:  $f_0$  (left) and intensity (right).

Figures 1-2 show linear predictions for the relationship between acoustic-prosodic measures  $f_0$  and mean intensity (x-axes) and p-scores (y-axis) for the IS referential categories in Russian and Hindi data. Predicted values were obtained from post-hoc analysis with the mixed-effect regression model, Model 3 above.

Figure 1 shows that in Russian, expanding the  $f_0$  range by about half an octave (6st), and, similarly, increasing the mean intensity by 20 dB is associated with a 7-10% increase in the auditory p-score. In Hindi, the acoustic-prosodic correlates  $f_0$  maxima and intensity are positively correlated with perceived prominence and the magnitude of these effects is comparable to that observed in the Russian data (see Figure 2).

This is evident from the finding that greater vowel intensity in both languages and  $f_0$  range in Russian and  $f_0$  maxima in Hindi, reliably influence the perception of a word as prominent.

We have presented evidence that in Russian and Hindi, structural encoding of perceived prominence, via positioning of a word in a sentence or clause, is attended to during discourse comprehension. Hindi speakers perceive words located in structurally prominent pre-verbal position as highly prominent. Additionally, ex-situ positioning of a word reliably contributes to its perception as prominent. The ex-situ position effect is especially apparent in Russian, a language known for focus-fronting and IS-triggered right-edge dislocation. In Hindi, the ex-situ position effect was only detected in the silent reading PRT, when no acoustic-prosodic information was available to prominence raters. The

practical significance of structural prominence in Hindi requires further investigation.

#### 4. CONCLUSION

This study contributes to the understanding of discourse-prominence in two free word order languages, Russian and Hindi. Results of the unguided prominence rating experiments show that acoustic-prosodic cues and a structurally 'strong' sentence position are attended to during reading or auditory comprehension of discourse. Further studies are necessary to reveal patterns of co-variation among the cues to prominence in Russian and Hindi, to see whether cues are complementary or additive, or whether each cue type is associated with a specific prominence function.

#### 5. REFERENCES

- [1] Watson, D. G. (2010). The many roads to prominence: Understanding emphasis in conversation. In B. Ross (Ed.), *The Psychology of Learning and Motivation*, 52, 163-183. Elsevier.
- [2] Arnold, J.E., Losongco, A., Wasow, T., & Ginstrom, R. (2000). Heaviness vs. newness: The effects of structural complexity and discourse status on constituent ordering. *Language*, 76, 28-55.
- [3] Chafe, W.L. (1976). Givenness, contrastiveness, definiteness, subjects, topics, and point of view. In Li, C. (ed.), *Subject and Topic*. New York: Ac. Press.
- [4] Lambrecht, K. (1994). *Information Structure and Sentence Form*, Cambridge University Press.
- [5] Morgan, J. L., Meier, R. P., & E. L. Newport (1987). Structural packaging in the input to language learning: Contributions of prosodic and morphological marking of phrases to the acquisition of language. *Cognitive Psychology*, 19, 498-550.
- [6] Krifka, M. (2007). Basic notions of information structure. In C. Fery & M. Krifka (eds.), *Interdiscip. Studies of Information Structure 6*, Potsdam
- [7] Ladd, R. D. (2008). *Intonational Phonology*. Cambridge University Press.
- [8] Bolinger, D. (1986). *Intonation and its parts: Melody in spoken English*. London: Edward Arnold.
- [9] Pierrehumbert, J., Hirschberg, J. (1990). The Meaning of Intonational Contours in the Interpretation of Discourse, in P. Cohen, J. Morgan, & M. Pollack, (eds). *Intentions in Communication*, MIT Press, Cambridge MA. 271-311.
- [10] Breen, M., Fedorenko, E., Wagner, M. & Gibson, E. (2010). Acoustic correlates of information structure. *Language and Cognitive Processes*, 25, 1044-98.
- [11] Vainio, M., Järvikivi, J. (2006). Tonal features, intensity, and word order in the perception of prominence. *Journal of Phonetics*, 34, 319-342.
- [12] Kidwai, A. (2000). *XP-Adjunction in Universal Grammar: Scrambling and Binding in Hindi-Urdu*. Oxford: Oxford University Press.
- [13] S. Vasishth, R. Shafer, & Srinivasan, N. (2012). The role of clefting, word order and given-new ordering in sentence comprehension: Evidence from Hindi. *Journal of South Asian Linguistics*.
- [14] Slioussar, N. (2011a). Processing of a free word order language: The Role of Syntax and Context. *Journal of Psycholinguistic Research*, 40:291-306.
- [15] Neeleman, A., Titov, E. (2009). Focus, contrast, and stress in Russian. *Linguistic Inquiry* 40, 514-524.
- [16] Jackendoff, R. (1972). *Semantic Interpretation in Generative Grammar*. Cambridge: MIT Press.
- [17] Féry, C., Pndey, & Kentner, G. (2014). The prosody of Focus and Givenness in Hindi and Indian English. Accessed from researchgate.net.
- [18] Patil, U., Kentner, G., Gollrad, A., Kügler, F., Féry, C., & Vasishth, S. (2008). Focus, word order, and intonation in Hindi. *Journal of South Asian Linguistics*
- [19] Genzel, S., Kügler, F. (2010) The prosodic expression of contrast in Hindi, in Proc. of Speech Prosody 2010.
- [20] Gambhir, V. (1981). *Syntactic restrictions and discourse functions of word order in standard Hindi*. Doc. Dissertation, Univ. of Pennsylvania.
- [21] Kidwai, A. (1999). *Word Order and Focus Positions in Universal Grammar*. In: Rebuschi, G. & L. Tuller (eds.), *The Grammar of Focus*.
- [22] Luchkina, T., Cole, J. (2014). Structural and prosodic correlates of prominence in free word order language discourse. In proc. of Speech Prosody 7, Dublin.
- [23] Jyothi, P., Cole, J., Hasegawa-Johnson, M., & Puri, V. (2014). An investigation of prosody in Hindi narrative speech. In proc. of Speech Prosody 7, Dublin.
- [24] Muthusamy, Y. K., Cole, R. A. & Oshika, B. T. (1992). "The OGI multi-language telephone speech corpus" in proc. of ICSLP.
- [25] Baumann, S., Riester, A., (2012). Referential and Lexical Givenness: Semantic, Prosodic and Cognitive Aspects. In: Elordieta, G., Prieto, P. (Eds.), *Prosody and Meaning*, Mouton De Gruyter, Berlin, New York.
- [26] Cole, J., Mo, Y., & Hasegawa-Johnson, M. (2011). Signal-based and expectation-based factors in the perception of prosodic prominence. *Laboratory Phonology*, 425-452.

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<sup>ii</sup> Acoustic data were extracted from each syllable of each IS-coded word in Russian and Hindi corpora. f0 and intensity were automatically measured in Praat from the center region of the vowel, excluding 10 ms. from the left and right edges of the vowel as identified by acoustic criteria, and normalized within-speaker.

<sup>iii</sup> Vowel height in all data and vowel length in Hindi data were introduced as control factors. Speaker was included as a random effect in the Hindi model (Russian materials were produced by a single speaker).