Comprehending Novel And Conventional Metaphors In Marathi: An EEG Study

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Abstract

This study investigates processing of conventional and novel metaphors in Marathi, an SOV language, with behavioural and electrophysiological measures, to extend graded models of metaphor comprehension established with SVO languages. Participants performed literal truth value judgment tasks with reaction time (RT), accuracy, and event-related potentials (ERPs) recorded. Behavioural results showed that literal sentences elicited the fastest RTs and the highest accuracy, contrasted by conventional metaphors' longer RTs and lower accuracy, reflecting decision-level conflict. Novel metaphors showed intermediate performance, indicating increased semantic processing demands with reduced conflict. ERP analyses of the N400 revealed greater centro-parietal negativity for novel metaphors relative to literal and conventional sentences, consistent with increased semantic integration difficulty, although ROI-level effects were not statistically significant. Overall, the findings support cross-linguistic robustness of graded model of metaphor comprehension, and how semantic processing varies as a function of familiarity by extending N400-based accounts of metaphor processing to Marathi.

Keywords: Metaphor comprehension; Event-related potential (ERP); N400; Semantic integration; Marathi language; Figurative language

INTRODUCTION

Metaphor is a fundamental mechanism of human cognition, enabling the understanding of abstract concepts through mappings to more concrete domains (Lakoff & Johnson, 1980). Rather than serving merely as a stylistic device, metaphor reflects systematic cross-domain correspondences grounded in embodied experience. For example, expressions such as *a high income* and *a warm welcome* instantiate conceptual mappings like MORE IS UP and AFFECTION IS WARMTH. Grady's Primary Metaphor Theory further proposes that such conceptual mappings arise from recurring phenomenological experiences and, consequently, are bound in the emerging "primary scene" (Grady, 1997).

A central question in metaphor research concerns how figurative meanings are accessed during comprehension (Coulson, 2008; Weiland et al., 2014; Columbus et al., 2015). Early philosophers proposed a literal-first processing route, whereby literal meanings are computed prior to figurative reinterpretation (Grice, 1975; Searle, 1979). In contrast, direct access models argue that metaphorical meanings can be accessed immediately when context supports them (Gibbs, 1994; Glucksberg, 2003). Empirical evidence suggests that metaphor comprehension is neither strictly sequential nor categorical, but graded, with processing costs modulated by familiarity, salience, and conventionality (Giora, 1997).

Several theoretical frameworks converge on this graded view. Structure-mapping approaches posit that novel metaphors require effortful alignment of relational structures between domains, whereas conventional metaphors rely on more readily available mappings (Gentner, 1983; Gentner & Wolff, 1997). Similarly, class-inclusion models propose that metaphors involve the construction of ad hoc categories that become more efficient with repeated use (Glucksberg et al., 1997). The Graded Salience Hypothesis further predicts that familiar meanings—whether literal or metaphorical—are accessed more readily than less salient ones (Giora, 1997). Together, these accounts suggest that metaphor processing varies continuously as a function of familiarity.

Event-related potentials (ERPs) provide a means of examining the temporal dynamics of this process. The N400 component, peaking around 400 ms, is widely interpreted as an index of semantic integration difficulty (Kutas & Hillyard, 1980). Previous studies have shown that novel metaphors elicit larger N400 amplitudes than literal or conventional expressions, reflecting increased integration demands (Coulson & Van Petten, 2002; Pynte et al., 1996; Tartter et al., 2002). Lai et al. (2009) further demonstrated that novel metaphors engage prolonged processing, as evidenced by both enhanced N400 and later positive components. These findings support a view of metaphor comprehension as a dynamic process involving graded recruitment of semantic networks, modulated by familiarity and task demands.

Most neurocognitive research on metaphor thus far has focused on English and other Indo-European languages, raising questions about the cross-linguistic generalizability of the models currently being tested. Marathi, an Indo-Aryan language with a canonical Subject–Object–Verb (SOV) structure and frequent use of metaphors, provides a valuable test case. For example, a Marathi phrase मनावर

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दगड ठेवणे *maraavar dagaḍ ṭhevne* (literally 'place a stone on one's heart' and metaphorically 'suppress one's emotions') illustrates a metaphorical mapping between physical weight and emotional burden. Despite Marathi's status as the second-largest domestic language in India and its strong literary culture, which contribute to productive metaphor generation, figurative language processing in Marathi has remained largely unexplored in psycholinguistics.

The present study investigates whether graded effects of metaphor comprehension generalize to Marathi by examining behavioural and electrophysiological responses to four sentence types: literal sentences, conventional metaphors, novel metaphors, and anomalous sentences. Participants performed a literal truth-value judgment task while reaction times, error rates, and ERPs were recorded.

METHODOLOGY

Participants

A priori power analysis conducted in G*Power for a repeated-measures ANOVA design (effect size f = 0.25, power = 0.95), yielding a minimum required sample of 36 participants, and 35 subjects participated for data collection (17 females), with normal or corrected-to-normal vision and no history of neurological disorders or traumatic brain injury. All participants were right-handed and reported Marathi as their first language with full spoken and written proficiency. Additional exclusion criteria included the presence of implanted electronic devices incompatible with EEG recording. Participants were recruited through purposive sampling via institutional mailing lists and received monetary compensation of 200 Indian Rupees for their participation. All selection and experimental procedures were approved by the institute ethics committee, and the participants' language backgrounds were collected via an LHQ3 questionnaire (Zhang et al., 2020).

Stimuli

A total of 152 Marathi sentences were constructed across four experimental conditions: Literal Sentences (LS), Conventional Metaphors (CM), Novel Metaphors (NM), and Anomalous Sentences (AN). Sentences were organized into 38 matched sets, each derived from a shared verbal predicate. For each set, four sentence variants were created—one per condition—resulting in 38 × 4 sentences. All sentences have the canonical Marathi Subject–Object–Verb (SOV) structure and were matched for length (5–6 words) and lexical frequency to minimize confounding factors. All conditions within each item shared an identical syntactic structure and predicate, differing only in the object noun phrase, as in Table 1. The main verb served as the critical target for ERP analysis, given Marathi's SOV word order. In SOV languages, the verb provides crucial information for integrating preceding arguments and resolving the overall event structure. While preliminary semantic expectations may arise earlier in the sentence, full propositional meaning is typically finalized at the verb. Time-locked ERPs to the sentence-final verb, therefore, allow examination of sentence-level semantic integration processes, capturing the point at which meaning is fully composed across conditions while avoiding variability associated with earlier incremental interpretations. In addition, the use of a literal truth-value judgment task was adapted to emphasize literal evaluation, thereby increasing sensitivity to conflict between automatic figurative meaning and task demands.

CMs were constructed based on well-established conceptual mappings described in Primary Metaphor Theory (e.g., WARMTH IS AFFECTION, ARGUMENT IS WAR), and were expected to be familiar and readily interpretable to native speakers. NMs were generated by pairing source and target domains not conventionally associated in primary metaphor or Marathi discourse, resulting in semantically plausible interpretations from an unfamiliar sequence of expressions. ASs were syntactically well-formed but semantically implausible, serving as a control condition for semantic violation. LSs expressed concrete, non-metaphorical meanings using the same lexical material.

Table 1: Example sentences and their source and target

Sentence Type	Sentence	Word-by-Word Gloss	Source	Target
Literal Sentence (LS)	सीमावरील प्रत्येक सैनिकावर हल्ला झाला. तिने महत्त्वाची वस्तू त्याच्याकडे पाठवली. तीव्र उन्हाने पर्वतावरील बर्फ वितळला.	on the border every soldier attacked was she important object him-towards sent intense sun-by mountain-on ice melted	War Object Transfer Melting	War Object Physical Substance
Conventional Metaphor (CM)	माझ्या प्रत्येक मुद्द्यावर हल्ला झाला. तिने महत्वाची सूचना त्याच्याकडे पाठवली. त्याच्या मिठीने माझे हृदय वितळले.	my every point-on attack happened she important instruction him-towards sent his hug-by my heart melted	War Object Transfer Melting	Argument Information Emotion/Affect
Novel Metaphor (NM)	आमच्या प्रत्येक आशेवर हल्ला झाला. तिने तिची निराशा त्याच्याकडे पाठवली. त्याच्या शब्दांनी कामगारांचा संप वितळला.	our every hope-on attack happened she her disappointment him-towards sent his words-by workers' strike melted	War Object Transfer Melting	Hope Emotion Social Conflict
Anomalous Sentence (AS)	पावसाच्या प्रत्येक थेंबावर हल्ला झाला. घड्याळाने वेळेचा आकार बागेकडे पाठवला. त्याच्या पत्राने पुस्तकाचं पान वितळलं.	rain-of every drop-on attack happened clock-by time-of shape garden-towards sent his letter-by book-of page melted	War Object Transfer Melting	Weather Time Inanimate object

Stimulus Validation

Stimuli were validated through a pretest with 20 independent native Marathi speakers (aged 18–30). NMs were rated on two 5-point Likert scales assessing familiarity (1 = extremely unfamiliar, 5 = extremely familiar) and interpretability (1 = not meaningful, 5 = completely meaningful). Only NMs with mean familiarity ratings below 3 and interpretability ratings above 3 were retained, ensuring that NMs were unfamiliar yet meaningful. This validation step ensured a clear distinction between conventional and novel metaphor conditions prior to EEG recording.

Procedure

The experiment employed a 4 (Condition: LS, CM, NM, AN) × 38 (Items) within-subject design. Sentences were presented across four blocks of 38 trials each, with each block containing an equal number of sentences from each condition. A Latin square design ensured that participants did not encounter multiple versions of the same item within a block. The trial order was randomized for each participant.

Each trial began with a fixation cross presented centrally for 350 ms, followed by serial visual presentation of sentence words. The words were displayed sequentially with increasing durations (500-900 ms, Figure 1) to approximate natural reading rhythms while maintaining temporal control for ERP analysis. Following sentence presentation, participants performed a literal truth-value judgment task (LTVJ), on whether the sentence was literally true or false via button press—"true" expected for LS and "false" expected for CM-NM-AS. The LTVJ, measuring reaction times (RTs) and accuracy, was chosen to encourage literal semantic evaluation, thereby increasing processing demands for metaphorical sentences. In addition, the use of LTVJ was expected to emphasize literal evaluation, thereby increasing sensitivity to conflict between automatic figurative meaning and task demands.

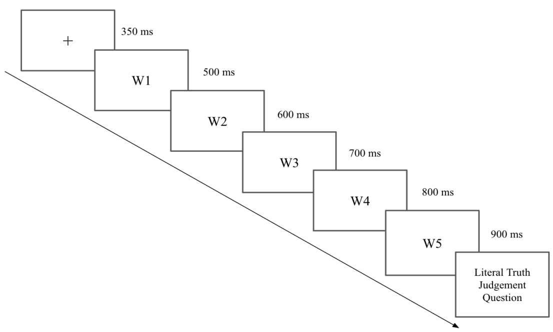

Figure 1: Trial structure and sequence of events in a single experimental trial

Behavioural Data Analysis

Behavioural data were analysed to assess performance differences across conditions. Accuracy was computed based on the correct identification of literal sentences as true and metaphorical and anomalous sentences as false. RTs were measured from the onset of the response prompt to the participant's button press. Only trials with correct responses were included in RT analyses. Mean accuracy and RTs were entered into repeated-measures analyses of variance (ANOVAs) with Condition (LS, CM, NM, AN) as a within-subject factor.

Electrophysiological Recording

Time-locked EEG data were recorded using a Neuroelectrics 8-channel wireless EEG system with wet gel electrodes. Electrode placement followed the international 10-20 system and included Fp1, Fp2, F3, F4, T7, Cz, Pz, and Fz. Signals were transmitted wirelessly via the Necbox device and recorded using NIC2 software. EEG was sampled at the native acquisition rate and stored in .edf and .easy formats along with event markers corresponding to stimulus presentation.

EEG preprocessing was conducted using Python-based pipelines and EEGLAB. Continuous data were band-pass filtered between 0.1 and 40 Hz, and line noise was attenuated using a notch filter. Data was downsampled to 250 Hz and re-referenced to the CMS electrode. Independent Component Analysis (ICA) was applied to identify and remove components associated with ocular and movement artifacts. Cleaned data were segmented into stimulus-locked epochs time-locked to the onset of the target word and baseline-corrected using a 200 ms pre-stimulus interval. Mean ERP amplitudes were extracted from predefined time windows of interest and entered into ANOVAs with Condition (LS, CM, NM, AN) as a within-subject factor. Greenhouse–Geisser corrections were applied where assumptions of sphericity were violated.

RESULTS

Data from 34 participants (17 females; average age = 21.38, right-handed, normal or corrected-to normal vision) were included in the final analyses. Although data were collected from 35 participants, one data set was excluded because its accuracy was below 80%. All reported results are based on the remaining dataset.

Behavioural Analysis

RTs were analysed using a repeated-measures ANOVA with Condition (LS, CM, LM, AS) as a within-subjects factor. Mauchly's test indicated that the assumption of sphericity was violated, $\chi^2(5) = 16.65$, $p = .005$; therefore, Greenhouse–Geisser correction was applied ($\varepsilon = 0.813$). The analysis revealed a significant main effect of Condition, $F(2.44, 82.93) = 7.64$, $p < .001$. Bonferroni-corrected pairwise comparisons showed that reaction times for LS were significantly faster than those for CM ($p < .001$), NM ($p = .002$), and AS ($p = .011$) while no significant differences were observed between CM and NM ($p = .224$), CM and AS ($p = 1.00$), or NM and AS ($p = 1.00$), as illustrated in Figure 2.

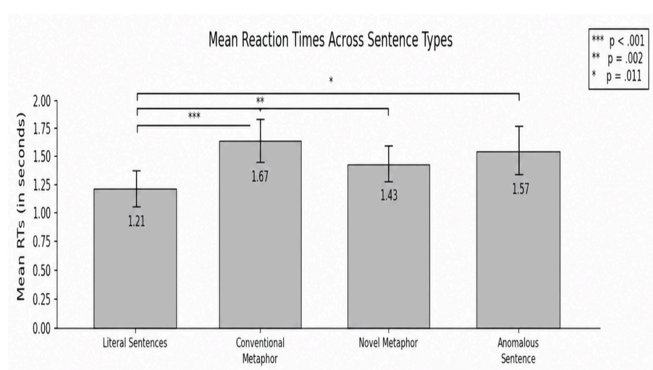

Figure 2: Mean RTs across sentence types in the LTVJ (error bars represent ±1 standard error).

A similar repeated-measures ANOVA was conducted for accuracy. Mauchly's test again indicated a violation of sphericity, $\chi^2(5) = 21.63$, $p < .001$, and Greenhouse–Geisser correction was applied ($\varepsilon = 0.705$). The results revealed a significant main effect of Condition, $F(2.11, 69.78) = 22.67$, $p < .001$, $\eta^2 = 0.407$. Post hoc comparisons indicated that the accuracy for LS was significantly higher than that for CM ($p < .001$), NM ($p = .031$), and AS ($p < .001$). Additionally, the accuracy for CM was significantly lower than that for NM ($p < .001$) and AS ($p = .009$) sentences. No significant difference was found between NM and AS ($p \geq 1.00$).

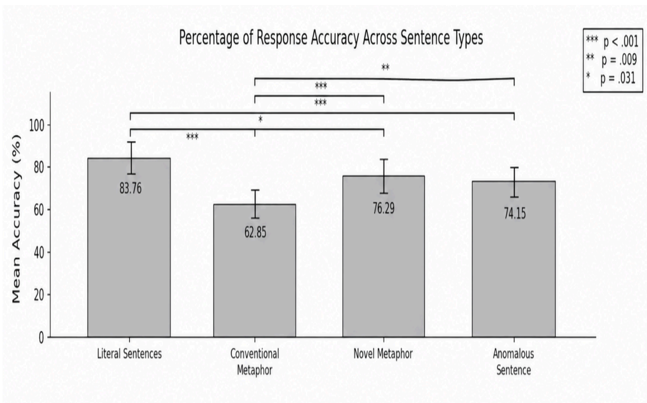

Figure 3: Response accuracy across sentence types in the LTVJ (error bars represent ±1 standard error).

These results indicate that literal sentences were processed significantly faster than all other conditions, and no reliable differences were observed among metaphorical and anomalous sentences.

EEG Data Analysis

Given the canonical centro-parietal distribution of the N400 component, analyses focused on midline electrodes (Cz and Fz), where N400 effects are typically maximal. A lateral temporal electrode T7 was included to capture activity from language-relevant temporal regions.

At the midline electrodes, a graded pattern is observed within the N400 time window. Novel metaphors (NM) exhibit relatively greater negative-going amplitudes compared to literal (LS) and conventional metaphor (CM) conditions, while anomalous sentences (AS) show a similar but more variable pattern. Conventional metaphors closely resemble literal sentences in both amplitude and waveform morphology.

Figure 4 shows grand-average ERPs at electrode Cz. The N400 pattern is most clearly observed at this centro-parietal site, with NM eliciting relatively greater negativity compared to LS and CM, and AS showing increased variability.

Figure 5 shows grand-average ERPs at electrode Fz. Compared to Cz, condition-related differences are less pronounced at this frontal site. Nevertheless, NM exhibits relatively greater negative-going amplitudes within the N400 window compared to LS and CM, while AS shows moderate variability. This pattern suggests that condition-related effects extend to frontal regions, though with reduced magnitude.

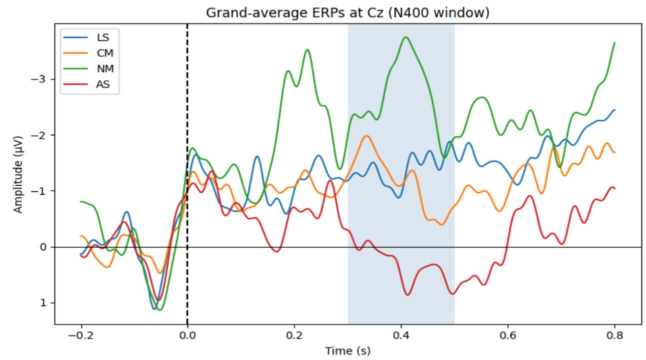

Figure 4: Grand-average ERPs for N400 component at Cz.

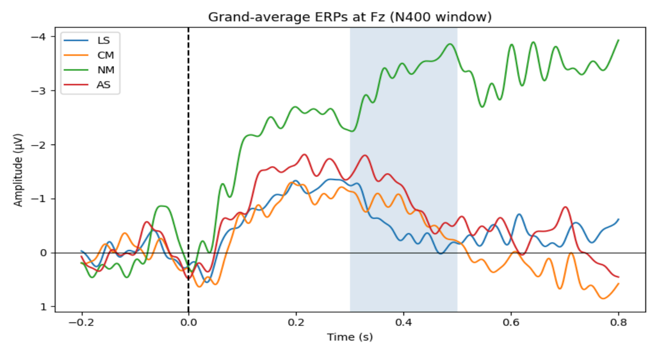

Figure 5: Grand-average ERPs for N400 component at Fz

Figure 6 shows grand-average ERPs at electrode T7. Compared to centro-parietal sites, condition-related differences are less clearly differentiated, with greater variability observed across waveforms. Within the N400 time window, NM exhibits relatively more negative-going amplitudes compared to LS and CM, while AS shows a similar but less consistent pattern. This temporal distribution suggests that condition-related effects extend to lateral temporal regions, although with reduced clarity and magnitude compared to centro-parietal sites.

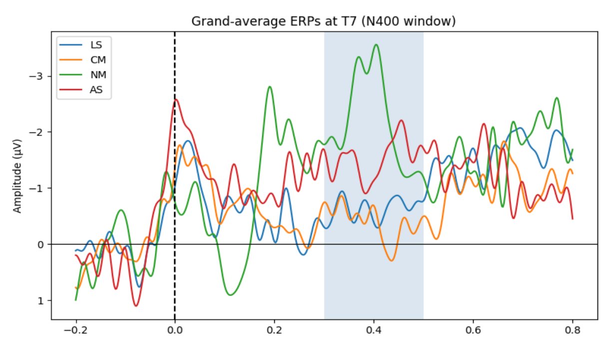

Figure 6: Grand-average ERPs for N400 component at T7

Figure 7 shows scalp topographies of N400 difference waves (300–500 ms) for the NM–LS, AS–LS, and CM–LS contrasts. Across contrasts, the strongest effects are observed over centro-parietal regions. The NM–LS contrast exhibits the most focal centro-parietal negativity, whereas the CM–LS contrast is more attenuated. The AS–LS contrast shows a broader and more variable distribution.

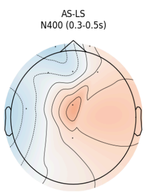

Figure 7: Scalp distributions of N400 difference waves (300–500 ms)

No canonical N400 activity was observed at prefrontal (Fp1, Fp2) and frontal (F3, F4) electrodes, consistent with their limited role in semantic integration processes. While frontal electrodes (F3, F4) exhibited negative-going deflections within the N400 time window, these effects were attenuated relative to centro-parietal sites, with a slightly stronger negativity observed at F4 compared to F3.

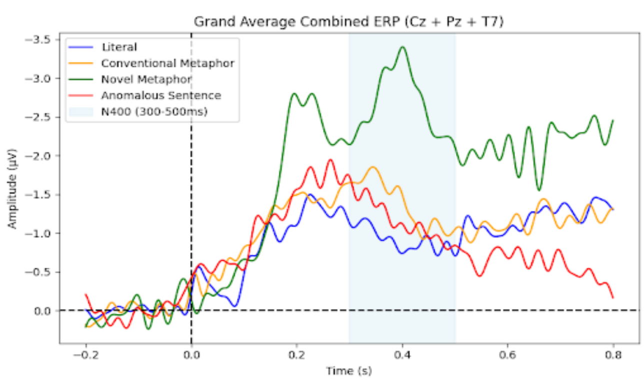

Figure 8: Grand-average ERP waveform averaged across 3 electrodes (Cz, Pz, T7)

Figure 8 shows the grand-average combined ERP waveform averaged across Cz, Pz, and T7 electrodes, time-locked to the onset of the sentence-final verb (0 ms). The shaded region represents the N400 time window (300–500 ms). A graded pattern is observed, with novel metaphors eliciting the largest negative-going amplitudes, followed by anomalous sentences, while literal and conventional metaphor conditions show relatively reduced negativity. This combined waveform highlights the overall distribution of semantic integration effects across central and temporal regions, reinforcing the pattern observed at individual electrodes.

To quantify these effects, mean N400 amplitudes (300-500 ms) were analysed using a two-way repeated-measures ANOVA with Condition (LS, CM, NM, AS) and Channel (F3, F4, Fp1, Fp2, T7, Cz, Pz, Fz) as within-subject factors. The analysis revealed a significant main effect of Condition, $F(3, 99) = 3.52$, $p = .018$ (Greenhouse–Geisser corrected $p = .024$), indicating differences in N400 amplitude across conditions. The main effect of Channel and the Condition × Channel interaction were not significant ($p > .05$).

Follow-up analyses at individual electrodes did not reveal significant effects of Condition (all $p > .05$). Specifically, one-way repeated-measures ANOVAs at Cz and Pz showed no significant main effect of Condition (Cz: $p = .366$; Pz: $p = .388$). Descriptively, however, both electrodes showed a consistent pattern in which novel metaphors and anomalous sentences elicited relatively more negative amplitudes compared to literal and conventional sentences.

Overall, the electrophysiological findings suggest that while condition-related differences in N400 amplitude are observable at a global level, the effects are spatially distributed and do not reach statistical significance at individual electrode sites. Nevertheless, the observed patterns are consistent with increased semantic integration demands for less familiar or semantically incongruent expressions.

DISCUSSION

The present study examined how metaphoricity and familiarity modulate behavioural and neural indices of semantic processing in Marathi. Behavioural results revealed clear differences across conditions, with literal sentences eliciting the fastest responses and highest accuracy, while metaphorical sentences—particularly conventional metaphors—produced slower responses and reduced accuracy. At the neural level, ERP waveforms showed graded differences across conditions, with novel metaphors eliciting relatively larger N400 amplitudes over centro-parietal regions compared to literal and conventional sentences. However, these effects did not reach statistical significance at individual electrode sites or at the ROI level (Cz, Pz, T7), indicating that the observed patterns are subtle and spatially distributed. Together, these findings support a graded account of metaphor comprehension, broadly aligning with established psycholinguistic models.

The behavioural results can be understood in relation to both semantic processing and task demands. Literal sentences showed the fastest response times, consistent with direct and contextually congruent mappings that require minimal integration effort. In contrast, conventional metaphors elicited slower responses despite their familiarity, a pattern that can be explained by the nature of the Literal Truth Value Judgment (LTVJ) task, which aims to induce literal interpretation of the sentence stimuli.

According to Glucksberg (2003), metaphors are processed as categorical assertions, leading to rapid activation of figurative meaning. In the LTVJ task, this automatic activation creates interference, as participants must suppress the figurative interpretation to respond “false.” This conflict resembles a metaphorical Stroop-like effect, where dominant figurative meanings compete with task-relevant literal judgments, resulting in delayed responses. Swinney’s (1979) findings further support this interpretation, showing that multiple meanings are activated in parallel and subsequently selected based on context. In this case, the task demands bias selection toward literal meaning, increasing response time.

Novel metaphors, in contrast, showed intermediate performance. Their unfamiliarity reduces automatic figurative activation, thereby decreasing decision-level conflict, while still requiring effortful semantic integration. Overall, the behavioural pattern reflects an interaction between automatic semantic activation and task-driven selection processes, highlighting the context-sensitive nature of metaphor comprehension.

ERP results provide converging evidence for graded semantic processing. Novel metaphors elicited relatively larger N400 amplitudes over centro-parietal regions compared to literal and conventional sentences. The N400 is widely interpreted as an index of semantic integration difficulty, reflecting the ease with which incoming information is incorporated into an evolving context (Kutas & Federmeier, 2010). The increased negativity for novel metaphors, therefore, may reflect the greater effort required to integrate non-salient, cross-domain mappings.

This interpretation is consistent with previous ERP studies showing enhanced N400 responses for novel metaphors compared to conventional metaphors (Coulson & Van Petten, 2002; Lai et al., 2009; Tartter et al., 2002), which has suggested that, within the 300–500 ms window, multiple semantic interpretations are simultaneously activated (Swinney, 1979), and novel metaphors require additional processing to resolve competing meanings and construct appropriate mappings. Moreover, anomalous sentences did not consistently elicit larger N400 amplitudes than novel metaphors, which confirms the view that the N400 reflects semantic integration rather than anomaly detection (Kutas & Federmeier, 2010). While anomalous sentences violate expectations, they may not support meaningful integration, leading to more variable or attenuated responses. In contrast, novel metaphors, though initially unexpected, would ultimately permit coherent interpretation and therefore engage stronger integrative processing.

Topographical analyses further revealed that these effects were strongest over centro-parietal regions, consistent with the canonical distribution of the N400 (Kutas & Hillyard, 1980). Although statistical significance was not observed at the ROI level, the spatial pattern aligns with established findings, suggesting that the underlying mechanisms of semantic integration are engaged in a similar manner. This pattern is further reflected in the combined centro-parietal waveform, which shows a graded increase in negativity for novel metaphors relative to literal and conventional conditions, despite the absence of statistical significance at the ROI level.

Frontal electrodes (F3, F4) showed weaker and more variable condition effects compared to centro-parietal sites, suggesting involvement in semantic selection processes rather than core integration. Notably, a slightly stronger effect at F4 relative to F3 may indicate sensitivity to broader semantic associations, consistent with accounts of right-hemisphere involvement in processing less conventional meanings (Jung-Beeman, 2005).

Activity at the temporal electrode (T7) further suggests engagement of lexical-semantic processing within a broader language network. Given its proximity to left perisylvian regions, including areas associated with semantic retrieval and control (Hagoort, 2005; Friederici, 2011; Jefferies, 2013), this activity likely reflects the interaction between lexical access and higher-order selection processes during metaphor comprehension.

Together, the results suggest a progression from semantic integration (centro-parietal N400) to controlled selection (frontal regions) and task-related evaluation (prefrontal regions), highlighting the distributed nature of metaphor processing. The observed graded pattern supports theoretical accounts that emphasize continuous variation in metaphor processing as a function of familiarity and salience. In particular, the results align with the graded salience hypothesis (Giora, 1997), which proposes that more familiar meanings are accessed more efficiently, while less salient meanings require additional processing. Our findings could enable such models to be extended to Marathi, a typologically distinct SOV language. Despite differences in word order and cultural context, the observed behavioural and neural patterns align with findings from English and other languages, suggesting that the underlying mechanisms of metaphor comprehension are broadly cross-linguistically robust.

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