LANGUAGE AND COGNITIVE PROCESSES
2012, 27 (3), 313–344

Psychology Press
Taylor & Francis Group

Syntactic and semantic predictors of tense in Hindi: An ERP investigation

Brian Dillon[1,2], Andrew Nevins[3], Alison C. Austin[4], and Colin Phillips[5]

[1]Department of Linguistics, University of Maryland, College Park, MD, USA
[2]Department of Linguistics, University of Massachusetts, Amherst, MA, USA
[3]Department of Linguistics, University College London, London, UK
[4]Department of Brain & Cognitive Sciences, University of Rochester, Rochester, NY, USA
[5]Department of Linguistics, Program in Neuroscience and Cognitive Science, University of Maryland, College Park, MD, USA

Although there is broad agreement that error signals generated during an unexpected linguistic event are reflected in event-related potential (ERP) components, there are at least two distinct aspects of the process that the ERP signals may reflect. The first is the *content* of an error, which is the local discrepancy between an observed form and any expectations about upcoming forms, without any reference to why those expectations were held. The second aspect is the *cause* of an error, which is a context-aware analysis of why the error arose. The current study examines the processes involved in prediction of morphological marking on verbal forms in Hindi, a split ergative language. This is a case where an error with the same local characteristics (illicit morphology) can arise from very different cues: one syntactic in origin (ergative

Correspondence should be addressed to Brian Dillon, Department of Linguistics, 226 South College, University of Massachusetts, 150 Hicks Way, Amherst MA, USA. E-mail: brian@linguist.umass.edu

Preparation of this paper was supported by grants to CP from the National Science Foundation (BCS-0196004, BCS-0848554, DGE-0801465) and the Human Frontier Science Program (RGY-0134), and by a semester research award from the University of Maryland. We are very grateful to Shradha Upadhyay for assistance in constructing materials and recruiting participants, and to Rajesh Bhatt, Dave Kush, and Shravan Vasishth for feedback on the study.

http://www.psypress.com/lcp http://dx.doi.org/10.1080/01690965.2010.544582

case marking), and the other semantic in origin (a past tense adverbial). Results suggest that the parser indeed tracks the cause in addition to the content of errors. Despite the fact that the critical manipulation of verb marking was identical across cue types, the nature of the cue led to distinct patterns of ERPs in response to anomalous verbal morphology. When verbal morphology was predicted based upon semantic cues, an incorrect future tense form elicited an early negativity in the 200–400 ms interval with a posterior distribution along with a marginally significant P600 effect. In contrast, when verbal morphology was predicted based upon morphosyntactic cues, an incorrect future tense form elicited a right-lateralised anterior negativity (RAN) during the 300–500 ms interval, as well as a P600 response with a broad distribution.

Keywords: Event-related potentials; Syntax; Prediction; Tense; Hindi.

Background

Neurolinguistic research has yielded much insight into the functional status of ERP components associated with sentence comprehension, with particular attention to the electrophysiological consequences of different types of linguistic anomaly. The fact that different types of linguistic errors elicit different responses suggests that the human parser is able to make at least moderately fine-grained distinctions among the problems that arise in sentence understanding. Previous research has established that morphosyntactic, semantic, and syntactic errors are characteristically associated with different ERP components. For instance, words that are anomalous with respect to morphological or syntactic features have long been recognised to generate the P600 response, a late posterior positivity that generally peaks around 600 ms post-stimulus (Friederici, Pfeifer, & Hahne, 1993; Hagoort, Brown, & Groothusen, 1993; Osterhout & Holcomb, 1992), as well as an earlier anterior negativity termed the (E)LAN (Coulson, King, & Kutas, 1998; Friederici et al., 1993; Hagoort, Wassenaar, & Brown, 2003; Lau, Stroud, Plesch, & Phillips, 2006; Neville, Nicol, Barss, Forster, & Garrett, 1991). Semantic anomalies in otherwise syntactically well-formed sentences typically elicit a central negativity around 400 ms known as the N400 (Kutas & Federmeier, 2000; Kutas & Hillyard, 1980; Lau, Phillips, & Poeppel, 2008). It is important to note that the exact functional significance of these ERP components remains a matter of debate. In particular, there appear to be instances of "semantic" error that engender P600 responses (Kim & Osterhout, 2005; Kolk, Chwilla, van Herten, & Oor, 2003; Kuperberg, 2007), as well as N400 effects associated with morphosyntactic factors such as case (Hopf, Bader, Meng, & Bayer, 2003).

Although ERP components such as the LAN, N400, and P600 are not uniquely elicited by anomalous stimuli, there is broad agreement that they do index processes that are triggered by the processing of an unexpected linguistic event, albeit with much debate over whether these effects are specific to linguistic stimuli (Coulson et al., 1998; Domahs, Wiese, Bornkessel-Schlesewsky, & Schlesewsky, 2008; Martín-Loeches, Casado, Gonzalo, de Heras, & Fernández-Frías, 2006; Münte, Heinze, Matzke, Wieringa, & Johannes, 1998; Núñez-Peña & Honrubia-Serrano, 2004; Patel, Gibson, Ratner, Besson, & Holcomb, 1998). It has often been suggested that the P600, in particular, reflects processes of error detection and repair (Friederici, Hahne, & Saddy, 2002; Gouvea, Phillips, Kazanina, & Poeppel, 2010; Hagoort, 2003b; Hahne & Friederici, 1999; Hopf et al., 2003; Kaan & Swaab, 2003a; but cf. Kaan, Harris, Gibson, & Holcomb, 2000). However, it remains unresolved what type of error-related processes these ERP components reflect. In particular, there are at least two distinct aspects of error processing that the ERP signal might reflect. The first is the *content* of an error, which is the local discrepancy between an observed form and an expected form, with no reference to why a particular form was expected. The second is the *cause* of an error, which is a context-aware analysis of the source of the expectation that the incorrect word violates.

The main difference between these two aspects of error processing involves the information contained in the error signal. A parser that tracks only error content is somewhat of a "black-box" system: it can recognise failure, but the reason for failure is not immediately recoverable. Successful diagnosis of an error, however, requires more than simply realising that something has gone wrong; it requires an analysis of the linguistic constraint that was violated. A parser that only tracks error content would not be able to effectively diagnose errors during comprehension. By contrast, a parser that tracks an error's cause can potentially target particular aspects of a parse for repair by recognising the source of an anomaly that it encounters. In many models of sentence processing, accurate diagnosis of errors is necessary as a critical step on the road to reanalysis and repair (e.g., Fodor & Inoue, 1994; Lewis, 1998). In contrast, there is less need for accurate diagnosis in parsing models that eschew explicit reanalysis and repair mechanisms in favour of parallel parsing and re-ranking of alternatives upon detection of unexpected input. Previous attempts to distinguish these types of parsing architectures have focused on patterns of easy vs. difficult reanalysis (Gibson, 1991; Meng & Bader, 2000; Sturt & Crocker, 1998), on evidence of the parser's sensitivity to transparent reanalysis cues (Fodor & Inoue, 1994), and on the parallels between ERP responses to garden paths and ungrammaticality (Hopf et al., 2003; Kaan & Swaab, 2003a, 2003b).

In the current study, we examine a verbal configuration in Hindi that is particularly well suited to investigating the nature of the parser's error signals, as it involves a case where the same local discrepancy can arise from two very different sources, one syntactic in origin, the other semantic in origin. This therefore provides a good test of whether ERP responses to linguistic anomalies reflect the cause or only the content of the errors that elicit them. The results have implications for the architecture of the parser and its ability to track information across time, as well as for the functional interpretation of the various error signals reflected in language-related ERP components.

Cause and content in previous ERP research

Previous ERP studies have routinely classified responses to linguistic errors as reflecting morphological, syntactic, or semantic anomalies, but it is more difficult to assess whether specific ERP responses reflect processing of the cause or the content of errors, because these properties are in general strongly correlated. Unsurprisingly, errors involving syntactic discrepancies are typically associated with syntactic constraints, and errors involving semantic discrepancies are typically associated with semantic constraints. In order to address this issue, it is necessary to find cases that dissociate the cause and content of an error, such as a semantic source for a morphological prediction. However, such cases have proven to be elusive.

For example, subject-verb agreement errors such as **the man mow the lawn* reliably elicit a P600 response (Gunter & Friederici, 1999; Hagoort et al., 1993; Lau et al., 2006; Osterhout & Nicol, 1999), often in combination with an earlier LAN component (Coulson et al., 1998; Friederici et al., 1993; Gunter, Stowe, & Mulder, 1997; Hagoort & Brown, 2000; Kaan, 2002; Kutas & Hillyard, 1983; Münte, Matzke, & Johannes, 1997; Osterhout & Mobley, 1995). Interpretations of this effect generally associate the LAN/P600 components with the morphological error, but it remains unclear whether the ERP response reflects processing of the cause of the error or its content. In the context of subject-verb agreement the content of the error is the feature mismatch between the observed bare verb form *mow* and the third-person singular forms required of verbs in that position, e.g., *mows, mowed*. Of course, the requirement for a third person singular verb form reflects a linguistic constraint on subject-verb relations, and this constraint is the cause of the error. Importantly, since both the content (the feature mismatch) and the cause (subject-verb licensing relations) are morphosyntactic in nature, the observed ERP responses are not informative about which aspects of error processing are reflected in the ERP response.

In ERP research on garden-path sentences it is similarly difficult to distinguish the contributions of processing the cause vs. processing the content of an error. Garden-path sentences are sentences that, when processed incrementally, lead the parser to commit to an incorrect parse from which it must subsequently recover (Bever, 1970; Frazier & Fodor, 1978; van Gompel & Pickering, 2007). Garden path sentences have been well studied in the ERP literature, and they are reliably associated with the P600 component (e.g., Hopf et al., 2003; Kaan & Swaab, 2003a; Osterhout, Holcomb, & Swinney, 1994). In these cases the contributions to the ERPs of the cause and content of the error are again hard to distinguish. For example, Osterhout and colleagues (Osterhout et al., 1994) compared ERP responses to sentences like those in (1).

(1a) The judge believed the patient was lying.
(1b) The judge charged the patient was lying.

The authors hypothesised that readers make a commitment to a particular syntactic analysis of the postverbal noun phrase, i.e., *the patient*, based upon the most common syntactic subcategorisation frame for the verb. For the verb *believe,* readers anticipate a clausal complement, whereas the verb *charge* biases readers to expect a nominal complement. Consequently, upon reaching the disambiguating verb *was*, no reanalysis is required in (1a), but the parser has to reanalyse its parse in (1b), leading to a P600 response. In the case of this garden path effect the content of the error is the fact that the current parse presents no possible integration site for the incoming word (the verb *was*). The cause of the error is the mismatch between the preferred subcategorisation of the main clause verb *charge* and the incoming verb's need for a subject. Hence, the cause of the error (the verb's subject requirement) and the content (the inability to find a syntactic integration site for the incoming verb) are both syntactic in nature, and so again the ERP response does not help to distinguish the contribution of cause and content to processing of these errors.

Thus, existing findings that associate specific ERP components with the diagnosis of errors leave open the question of whether the parser is sensitive to the cause or just the content of the errors that it detects. This is because it is difficult to determine, based on the response to a single error, which aspects of error processing the ERP response reflects.

A more promising approach in this direction is based on comparing the responses to pairs of closely related errors that are associated with different types of cues. This approach is pursued by Casado, Martín-Loeches, Muñoz, and Fernández-Frías (2005). These authors asked whether different cues to word order in Spanish would be reflected in different ERP components in the case of a word order violation. Casado and colleagues investigated cues that signal the less-common OVS word order (as opposed to the canonical SVO order in Spanish). A noncanonical word order can be signaled either by semantic or by syntactic cues. The semantic cue for OVS sentences consisted of an inanimate initial noun followed by a verb that requires an animate subject. For example, in the sentence *the opera sang the tenor*, a Spanish speaker can infer that he is processing an OVS sentence based upon the mismatch between the initial noun phrase and the semantic requirement that the verb imposes on its subject. The syntactic cue, in contrast, involved the case marking that is required of all animate object noun phrases in Spanish. In the Spanish counterpart of an English sentence like *the poet challenged the novelist,* the object noun phrase must be marked with a preposition, as in *el poeta desafió al* (*a*+*el*) *novelista*. Hence, if the second determiner bears the correct object case this confirms an SVO analysis, but if it does not bear correct object case, reanalysis to an OVS structure is required. Casado and colleagues found that both types of cues for the noncanonical word order elicited a P600 response, and found no qualitative differences between the two conditions. However, since the content of the two errors tested in that study was fundamentally different, contrasting incorrect verb-argument semantics with incorrect morphological marking, it is unclear whether the findings can distinguish ERP error signals stemming from the cause vs. the content of a given error. In order to answer this question, we look to a class of verbal morphology errors in Hindi where semantic and morphological information can be used to generate identical expectations about verbal morphology.

Processing of tense/aspect morphology

Two different types of anomaly have been classified as tense/aspect errors in previous ERP research. The first type of anomaly is true tense/aspect errors, typically involving a mismatch between a temporal adverbial and the form of a verb. For example, Newman and colleagues (Newman, Ullman, Pancheva, Waligura, & Neville, 2007) investigated responses to missing tense morphology on regular and irregular verbs in sentences such as **Yesterday I slip on ice*. They found that violations of this kind elicited a pronounced LAN effect for regular verbs, followed by P600 effects for both regular and irregular verbs. A similar study by Zhang and Zhang (2008) looked at erroneous aspect markers in Mandarin Chinese, examining the response to a perfective marker when it was preceded by an incompatible progressive adverbial. Zhang and Zhang found that aspect errors elicited a slightly left-lateralised, posterior negativity with a latency of 200–400 ms after the verb onset, in addition to a significant P600 response. Studies by a number of groups have found similar results for Italian, French, and Japanese, respectively (De Vincenzi et al., 2006; Fonteneau, Frauenfelder, & Rizzi, 1998; Hagiwara et al., 2000). These studies found that tense errors elicited an early negativity with a central or right-lateralised scalp distribution and a latency of 300–500 ms and a subsequent P600. Whereas the study by Newman and colleagues presented errors that were characterised by the lack of inflectional material in English, the studies on Mandarin, Italian, Japanese, and French presented errors that involved explicit morphological marking of an erroneous tense form, such as past tense verb morphology following a future tense adverbial.

A second class of morphosyntactic error that has been classified as a tense error involves the morphosyntax of auxiliary-verb sequences. Allen and colleagues examined sentences such as **He will stood,* which erroneously include tense morphology on the verb *stand*, in violation of the morphosyntactic requirements of English verb clusters (Allen, Badecker, & Osterhout, 2003). That study found that the erroneous past tense marking elicited a strong posterior P600 component, with no significant negativity in the response. A number of studies involving a similar type of morphosyntactic mismatch between an auxiliary and a verb have shown similar results: Osterhout and Nicol found similar results in response to sequences like **He can flying* (Osterhout & Nicol, 1999). Kutas and Hillyard (1984) looked at verb tense errors of a similar sort and found an early negativity, as well as a positive shift on the following word.

It is possible that these two types of tense errors probe different representations and processes. In particular, the studies in English that examined ill-formed auxiliary-verb sequences may not involve tense/aspect processing in the same way that true tense errors with mismatched adverbials do. For example, in the study by Allen and colleagues (Allen et al., 2003) the error may simply be a violation of the syntactic subcategorisation of the auxiliary *will*. In the current study we focus on tense/aspect errors that are specifically due to anomalous verbal morphology, rather than on violations of local morphological requirements of the type studied by Allen and colleagues and by Osterhout and Nicol. In Hindi, tense/aspect information can be cued by both semantic and syntactic contexts. By examining whether the context of the anomalous tense morphology is reflected in the ERP response to the error, we can better determine whether or not error processing reflects the parser's diagnosis of both the cause and content of errors.

The current study

Hindi provides an opportunity to explore the effects of the cause of errors by examining the licensing of verbal tense and aspect. There are two different ways to generate expectations about verbal morphology in Hindi. The first type of cue is semantic. When a sentence contains a past tense adverbial, Hindi requires a past tense verb (a dependency that is by no means unique to Hindi). The second of type of cue is morphosyntactic in nature: the ergative case marker -*ne* generates expectations for a perfective verb form. Hindi, like many other ergative languages, including Kurdish, Samoan, and Georgian (Payne, 1997), has an aspect-based split-ergative case system. The typical pattern is that these languages employ a nominative-accusative case marking system in imperfect or nonpast tenses, while other tense/aspect combinations employ an ergative-absolutive system (see DeLancey, 1981). Hindi obligatorily displays ergative-absolutive case marking in clauses with perfective aspect, and nominative-accusative case marking elsewhere.

In a nominative-accusative system, the subject of a transitive verb patterns with the sole argument of an intransitive predicate in case and agreement, to the exclusion of the object of a transitive verb. In contrast, in ergative-absolutive systems, the sole argument of an intransitive verb patterns with the object of a transitive verb in case and agreement, to the exclusion of the subject of a transitive verb (see Dixon, 1994). For example, In English—a nominative-accusative language—verb agreement and nominative case is controlled either by the subject of a transitive verb (*He sees the girls)* or by the sole argument of an intransitive verb (*He walks*). However, in Hindi ergative-absolutive clauses it is the object and intransitive subject that pattern together for purposes of case-marking and agreement. An example is given in (2). Note that the absolutive case in Hindi is not explicitly marked, and is homophonous with the nominative case. Thus, intransitive subjects without case marking are not informative with respect to tense or aspect, a feature that is relevant to our experimental design.

(2a)	*Larke-ne*	*roTii*	*khaayii*
	boy.SG.MASC-ERG	bread.SG.FEM-ABS	eat.PERF.SG.FEM
	"The boy ate the bread"		
(2b)	*Larkii*	*chalii*	
	girl.SG.FEM-ABS	walk.PERF.SG.FEM	
	"The girl walked"		

While all perfective clauses require ergative case marking, there is an alternative use of *-ne* that must be noted. In example (3), the case marker is used in an intransitive clause that does not have perfective aspect:

(3)	*Dev-ne*	*sonaa*	*hai*
	Dev-ERG/VOL	sleep	be.PRES.SG
	"Dev needs to sleep"		

(3) is an example of *volitional -ne* marking, where the postposition indicates obligation rather than ergative case or agentivity. This is a marked feature associated with certain dialects of Hindi, notably New Delhi Hindi (Montaut, 2004). This usage is rare in a Treebank corpus of Hindi/Urdu (Bhatt et al., 2009), and it was unattested in a sentence completion task that we administered, as we detail below. In addition, the volitional use of *-ne* is ungrammatical with future tense, a point that is relevant to the design of our study below. Thus, although the *-ne* marker is potentially ambiguous between

ergative and volitional forms, the available evidence suggests that ergative case is by far the preferred interpretation of this marker.

Setting aside cases of volitional -*ne*, only the subject of a transitive clause with perfective aspect bears the ergative case marker -*ne*. Crucially, ergative case marking can never co-occur with present or future tense verbs unless they are also marked for perfective aspect, and therefore this overt case marker is a reliable cue to verbal aspect. Because of the grammatical constraint on aspect, the ergative suffix imposes a constraint on the morphological shape of the verb, as does a temporal adverbial. Crucially, however, the morphological expectation derives in one instance from morphological features (i.e., the ergative case marker -*ne*), and in the other instance from the semantics of a past-tense adverbial.

The cause of an error in tense/aspect morphology can thus clearly be manipulated in Hindi, a fact that the current study takes advantage of. We examined the processing of an ungrammatical verb form—the future nonperfective—in the presence of either a semantic or syntactic cue to verbal morphology. In our study the future nonperfective form is ungrammatical either because it violates the tense requirements of a tense adverbial (a semantic requirement), or because it violates the aspect requirements of an ergative case marker (a morphosyntactic requirement). In both cases the content of the error is the same (i.e., the erroneous future nonperfective marking conveyed by the morpheme -*gaa*), as is the probability of occurrence of the verb form in question, which is zero due to the grammatical constraints. This allows us to separate the content of the error from its cause: a semantic/tense error vs. a morphosyntactic/aspect error.

The current study thus aims to address two related questions on the processing of cause and content in error diagnosis. First, is the parser able to identify the cause of an anomaly in error diagnosis? Second, to what degree are familiar ERP components sensitive to the content of an error versus its cause? Answers to these questions have important implications for both theories of sentence processing and for the functional interpretation of ERP components.

METHODS

Participants

Twenty-three members of the University of Maryland community participated in this study. Data from four participants were excluded due to high levels of artifacts in the EEG recordings. The remaining 19 participants (six females) had a mean age of 23.9, and all were healthy, native speakers of Hindi with no history of neurological disorder, and all were strongly right-handed based on the Edinburgh handedness inventory (Oldfield, 1971).

All participants were pre-screened prior to the study in order to ensure fluency in reading *Devanagari* characters. All participants gave informed consent and were paid US$15/hour for their participation, which lasted around 2½ hours, including set-up time.

Participants were Hindi native speakers primarily from Uttar Pradesh and Madhya Pradesh in north central India, regions where standard Hindi is the dominant language. All were native speakers of Hindi who had learned English as a second language, and who continue to use Hindi on a daily basis. In order to screen for mastery of standard Hindi agreement morphology and fluency in reading the Hindi *Devanagari* script, all participants took part in an off-line pre-test, consisting of 15 questions that addressed possible variation in grammatical forms. A number of speakers of nonstandard dialects were excluded based on errors in this pre-test, and a small number of additional participants were excluded because they lacked the reading fluency needed to comprehend Hindi sentences presented in an RSVP paradigm. All participants whose data are included in the analyses passed all screening tests.

Materials

The main ERP experiment had four conditions, with two parallel comparisons: for each type of cue to verbal morphology (semantic vs. syntactic cue), we manipulated the grammaticality of the verbal marking (grammatical vs. ungrammatical). The aim of the study was to determine whether ERP responses to the ungrammatical morphology differed as a function of the type of cue that predicted the marking. Experimental materials were carefully controlled in order to isolate the contribution of the different types of cues to the ERP responses. Example sentences from each condition, with the cue element and critical verb marked in bold, are shown in (4). AGR refers to an agreement morpheme, PERF refers to the perfective marker -(*y*)*aa*, and FUT refers to the future tense morpheme -*gaa* (see Table 1), and the *Devanagari* script form for sample verbs in each condition is shown in Table 1. Note that the future tense marker -*gaa* does not mark for aspect, and the perfective marker -(*y*)*aa* does not mark for tense. Other forms not shown here, such as future tense perfective forms, often mark perfective aspect on the verb stem, and mark tense on an auxiliary.

(4) a. *Haalaanki* ***us bunkar-ne*** *ek baRaa sveTar jaldi* ***bun-aa****, lekin grahaak-ne sabhii-kii*
although **that weaver-ERG** one big sweater quickly **weave-PERF**, but customer-**ERG** all-of
kimat ek-hii dii.
prices same give-**PERF** (Syntactic cue-grammatical)
"Although **that weaverwove** one big sweater quickly, the customer paid the same for all of them."

TABLE 1
Examples of third person masculine singular verb forms used in the ERP study, shown as presented to participants in Devanagari orthography, along with romanisation and translation

Devanagari form	*Romanised form*	*Morphemes*	*Translation*
बुना	*bun-aa*	weave-PERF	"he wove"
बुनेगा	*bun-e-gaa*	weave-3.SG-FUT	"he will weave"
गिरा	*gir-aa*	fall-PERF	"he fell"
गिरेगा	*gir-e-gaa*	fall-3.SG-FUT	"he will fall"

b. * *Haalaanki* ***us bunkar-ne*** *ek baRaa sveTar jaldi* ***bun-e-gaa****, lekin grahaak-ne sabhii-kii*
although **that weaver-ERG** one big sweater quickly **weave-AGR-FUT**, but customer-**ERG**
kimat ek-hii dii.
all-of prices same give-**PERF** (Syntactic cue-ungrammatical)
"Although **that weaver will weave** one big sweater quickly, the customer paid the same for all of them."

c. *Haalaanki* ***pichle shaam*** *vo raahgiir patthar ke-uupar* ***gir-aa****,*
although **last night** that traveler stone upon **fall-PERF**,
lekin use choT nahiin aa-yii
but to-him injures not happen-**PERF** (Semantic cue-grammatical)
"Although **last night** that traveler **fell** upon a stone, he was not injured."

d. * *Haalaanki* ***pichle shaam*** *vo raahgiir patthar ke-uupar* ***gir-e-gaa****,*
although **last night** that traveler stone upon **fall-AGR-FUT**,
lekin use choT nahiin aayii
but to-him injures not happen-**PERF** (Semantic cue-ungrammatical)
"Although **last night** that traveler **will fall** upon a stone, he was not injured."

Hindi is a verb-final language and tense/aspect markers appear as verb suffixes. Therefore, in order to minimise the risk of wrap-up effects associated with words in sentence-final position (Just & Carpenter, 1980), each critical region was embedded in a two-clause structure, such that the critical verb appeared at the end of a sentence-initial adverbial clause rather than in sentence-final position. The adverbial clauses were introduced in equal numbers by each of three subordinators: *haalaanki* (meaning "although"), *chunki* (meaning "since", "due to the fact that"), and *jab* (meaning "when", "at the time that"). Each of these subordinators created a clear expectation for a subsequent main clause.

The critical verbs were marked with either past tense perfective morphology (grammatical) or future tense nonperfective morphology (ungrammatical). Hindi past tense perfective forms are composed of a verb root and a single agreement suffix, whereas future tense nonperfective forms are comprised of a verb root with an agreement suffix and the future tense marker -*gaa*. Although the verb forms differed between the grammatical and ungrammatical conditions, this difference was identical within the syntactic and semantic cue conditions. Sample verb forms from each condition are shown in Table 1.

The syntactic and semantic cue conditions were configured such that a cue for verbal morphology always appeared as the third word in the sentence, and the critical verb always appeared as the eighth word, as shown in (3). The sentences were designed such that in the semantic cue conditions the only tense/aspect cue was a past tense adverbial, and in the syntactic conditions the only tense/aspect cue was an ergative case marker. Nevertheless, the semantic richness of each target clause was balanced by beginning every sentence with an adverbial. The semantic cue conditions started with a temporal adverb consisting of two words, such as *pichle shaam* ("last night"), *gujre hafte* ("past week"). The syntactic cue condition conditions contained a one-word manner adverb (e.g., *jaldi* "quickly") that provided no cue to the tense or aspect of the verb. Since the syntactic tense/aspect cue came from ergative case marking on the subject noun, and ergative case is restricted to the subjects of transitive verbs, all target clauses in the syntactic cue condition contained a transitive verb with two arguments. The ergative case-marker -*ne* appeared as a suffix on the subject noun, as the third word of the sentence. In contrast, intransitive verbs with a single argument were always used in the semantic cue condition, in order to eliminate the possibility of any tense/aspect cue arising from the case marking. Despite this difference, the discourse complexity of the syntactic and semantic cue conditions was balanced by presenting the same number of nouns before the critical verb. In the syntactic cue conditions the nouns were the two arguments of the transitive verb. In the semantic cue conditions the nouns were the subject and a noun in a postpositional phrase.

By placing the critical verbs in the eighth word position in all conditions it was possible to reduce the risk of ERP differences arising from the ordinal position of the verbs. Sentences were presented word-by-word, with post-positions displayed along with their associated nouns.

The experimental materials consisted of 120 sets of the 4 experimental conditions, which were distributed across four lists in a Latin Square design, such that participants saw 30 examples of each experimental condition. The 120 target sentences were combined with 330 filler items of similar length and complexity. The filler items included examples of correct and incorrect verb agreement, and examples of noun phrase internal agreement errors, such that the anomalies did not consistently appear in the same word position. Fillers that contained agreement errors were transitive sentences with nonperfective future tense verb forms, without ergative case marking or temporal adverbials. They were all biclausal structures similar to those used in the present study. Across the study as a whole, the ratio of correct sentences to incorrect sentences in each list was 1:1 (225 correct, 225 incorrect).

Offline tests of cue viability

In order to verify the effectiveness of our syntactic and semantic cues, and to ensure that both cues were equally unlikely to create an expectation for future tense nonperfective verb forms, we conducted a paper-and-pencil sentence completion task using materials adapted from our target items and fillers, as well as a corpus search for uses of the ergative marker *-ne*.

For the sentence completion task, nine native speakers of Hindi, none of whom participated in the ERP experiment, were given sentence fragments that stopped before the first verb, and were asked to complete the sentence in any way that seemed natural. The fragment completion study included three conditions. As in the ERP experiment, there was a syntactic condition that provided a tense/aspect cue in the form of ergative case marking, and a semantic condition that provided a tense/aspect cue in the form of a past tense adverbial. A third condition provided no cues to tense or aspect. The items in the no-cue condition were created by modifying sentences from the other two conditions to remove the tense/aspect cue. The syntactic cue conditions were modified by removing one noun phrase, and leaving just a single noun phrase with no ergative case marker. The semantic cue conditions were modified by replacing the temporal adverbial with a locative adverbial. 18 sets of three items were distributed across three lists in a Latin Square design, such that participants saw six items per condition. Target items were combined with 36 filler items to yield a 2:1 filler-to-target ratio.

The results of the fragment completion study are shown in Table 2. There was a bias for past tense verbs in the fragment completions across all conditions, but this bias was absolute only in the conditions that contained syntactic or semantic cues to tense/aspect morphology. 21% of completions in the no-cue condition contained present or future tense verbs, but no completions contained present or future tense verbs in either tense cue condition. Thus, we can conclude that the two types of tense/aspect cues (ergative case-marking and adverbials) are equally incompatible with the ungrammatical future tense forms used in the ERP study (0% completions). The only difference between the syntactic and semantic cue conditions was that the ergative case marker in the syntactic cue condition elicited 100% past perfective verb forms, whereas the semantic cue condition elicited a mix of past perfective and imperfective verb forms, consistent with the constraints of Hindi grammar. None of the completions in the condition with *-ne* marked nouns contained an instance of volitional *-ne*, which requires

TABLE 2
Results of the sentence fragment completion task

	Future	*Present*	*Past perfective*	*Past imperfective*
No cue	3/54 (6%)	8/54 (15%)	23/54 (43%)	20/54 (37%)
Semantic cue	0/54 (0%)	0/54 (0%)	39/54 (72%)	15/54 (28%)
Syntactic cue	0/54 (0%)	0/54 (0%)	54/54 (100%)	0/54 (0%)

an infinitive form with an appropriately inflected form of the auxiliary *ho* (to be).

In order to further assess the possibility of participants accessing the volitional interpretation of *-ne,* which does not contain any cues to aspect, we conducted a search of the Hindi/Urdu Treebank developed by Bhatt and colleagues (Bhatt et al., 2009). Of the 1123 instances of *-ne* marking that we analysed in this corpus, only 4—less than .01%—were consistent with a volitional interpretation. There were no instances of *-ne* marking co-occurring with future nonperfective forms. The corpus analysis and the sentence fragment study thus provide converging evidence that there is an overwhelming preference for ergative *-ne.*

Offline tests confirm that both the case marker *-ne* and the past tense adverbials that we used are appropriate and reliable tense/aspect cues. Thus in the ungrammatical conditions in our study, the probability of the future tense verb morphology was effectively zero for both semantic and syntactic cue conditions. Note that although the local content (i.e., the ungrammatical verb form) was the same, this ungrammaticality arose due to different causes in the semantic and syntactic cue conditions.

Procedure

Participants were comfortably seated in a dimly lit testing room approximately 100 cm in front of a computer monitor. Sentences were presented one word at a time in black letters on a white background in 30 pt *Devanagari* font. Each sentence was preceded by a fixation cross. Participants pressed a button to initiate presentation of the sentence, which began 1,000 ms later. Each word appeared on the screen for 400 ms, followed by 200 ms of blank screen. The 600 ms/word presentation rate is slightly slower than the presentation rate most commonly used for ERP studies in European languages, but pre-testing showed that this was the most comfortable rate for the Hindi speakers in the study. The last word of each sentence was marked with a period, and 1,000 ms later a question mark prompt appeared on the screen. Participants were instructed to read the sentences carefully without blinking and to indicate with a button press whether the sentence was an acceptable Hindi sentence. Feedback was provided for incorrect responses. Each experimental session was preceded by a 12-trial practice session that included both grammatical and ungrammatical sentences. Participants received feedback and were able to ask clarification questions about the task during the practice session. The experimental session was divided into six blocks of 75 sentences each. Breaks were permitted after each block as necessary.

EEG recording

EEG was recorded from 30 Ag/AgCl electrodes, mounted in an electrode cap (Electrocap International): midline: Fz, FCz, Cz, CPz, Pz, Oz; lateral: FP1/2, F3/4, F7/8, FC3/4, FT7/8, C3/4, T7/8, CP3/4, TP7/8, P4/5, P7/8, O1/2. Recordings were referenced online to the linked average of the left and right mastoids. An additional electrode was placed on the left outer canthus, and above and below the left eye to monitor eye movements. EEG and EOG recordings were amplified and sampled at 1 kHz using an analog bandpass filter of 0.1–70 Hz. Impedances were kept below 5 kΩ.

EEG analysis

All comparisons were made based upon single word epochs, consisting of the 100 ms preceding and the 1,000 ms following the critical words. Epochs with ocular and other large artifacts were rejected from analysis based on visual screening. Among the 23 participants who were tested, four were excluded due to recording difficulties that led to rejection rates exceeding 50%. The total rejection rate among the remaining 19 participants was 18% (range 16–22% across conditions). The waveforms of the individual trials were normalised using a 100 ms pre-stimulus baseline. Averaged waveforms were filtered offline using a 10 Hz low-pass filter for presentation purposes; however, all statistics were performed on unfiltered data. The latency intervals that were analysed statistically were chosen based upon visual inspection as well as previous conventions in the ERP sentence processing literature: 0–200 ms, 200–400 ms, 300–500 ms (LAN/N400), 400–600 ms, 600–800 ms (P600), 800–1000 ms.

In the ANOVA, topographically arranged groups of electrodes were defined as follows: left anterior (FT7, F3, FC3), midline anterior (FZ, FCZ, CZ), right anterior (F4, FC4, FT8), left posterior (TP7, CP3, P3), midline posterior (CPZ, PZ, OZ), and right posterior (CP4, P4, TP8). ANOVAs were performed hierarchically, using the within-subjects factors condition, anteriority (anterior/posterior), and laterality (left/midline/right). All p-values reported below reflect the application of the Greenhouse-Geisser correction where appropriate, to control for violations of the sphericity assumption (Greenhouse & Geisser, 1959), together with the original degrees of freedom.

Due to the large number of possible interactions in this design, we report as significant only those interactions for which follow-up analyses yielded significant contrasts within the levels of the interacting factors.

RESULTS

Acceptability question accuracy

Overall, the accuracy on the acceptability judgement task was 92%. The accuracy scores for individual conditions were as follows: semantic cue grammatical, 91%; syntactic cue grammatical, 94%; semantic cue ungrammatical, 91%, and syntactic cue ungrammatical, 92%. A repeated-measures ANOVA revealed no significant differences between conditions in accuracy scores.

Event-related potentials

Figure 1 shows topographic scalp maps that reflect the mean difference between the grammatical and ungrammatical tense/aspect conditions for 200 ms intervals following presentation of the critical verb in both the syntactic and semantic cue conditions. The grand average waveforms at the critical verb for the semantic and syntactic conditions can be seen in Figures 2 and 3, respectively. Visual inspection suggests an early negativity in both conditions, followed by later posterior positivities at around 600 ms. However, the timing, amplitude, and scalp topography of these effects differed across conditions. In the semantic cue conditions the negativity obtained during the 200–400 ms interval and showed a posterior scalp distribution. In contrast, in the syntactic cue conditions, the negativity showed a later and more anterior distribution, with a peak at around 400 ms. The late positivity in both the syntactic and semantic cue conditions showed the characteristic timing and posterior scalp distribution of a P600. However, visual inspection

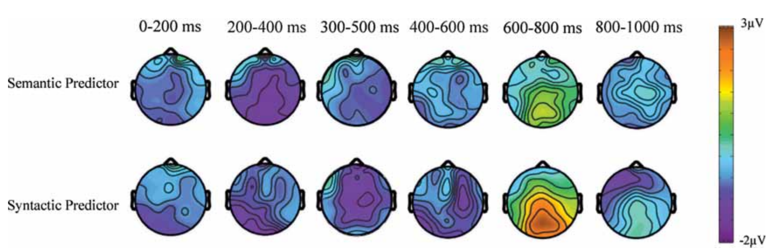

Figure 1. Topographic scalp voltage maps, showing the grand average difference between the ungrammatical conditions and the control conditions at successive intervals following the critical verb. 32 × 12 mm (600 × 600 DPI). [To view this figure in colour, please visit the online version of this Journal].

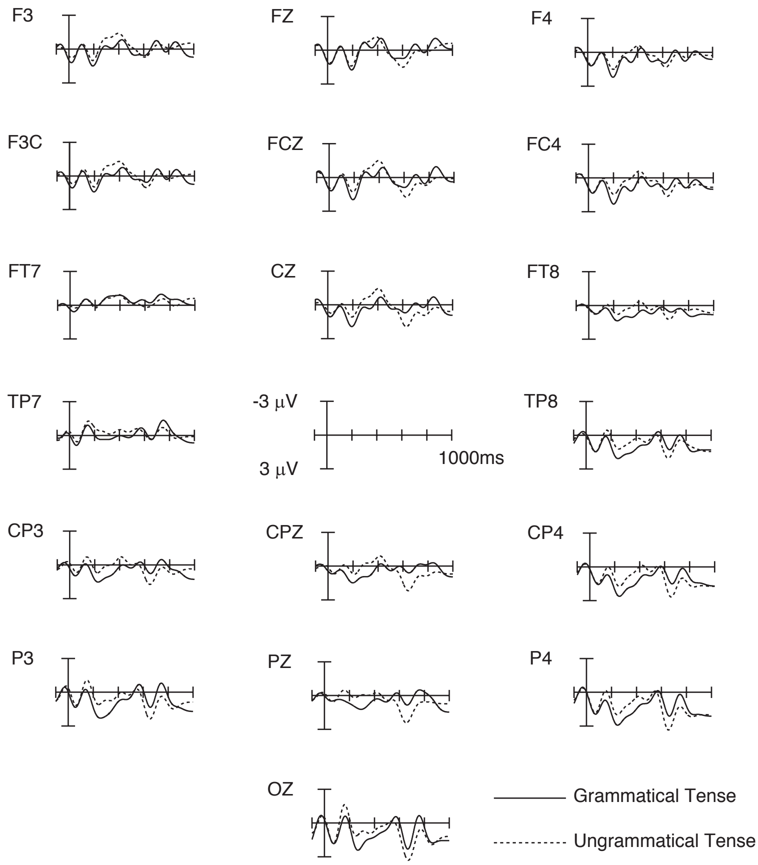

Figure 2. Grand average ERP responses elicited by the critical verb in sentences with a semantic cue to past tense (temporal adverb). 104 × 97 mm (600 × 600 DPI).

suggests that the positivity was long- lasting and had a greater amplitude in the syntactic cue conditions. These findings were tested statistically using repeated measures ANOVAs at a number of successive time intervals.

Visual inspection also suggests the possibility of differences in the ERPs elicited by the two grammatical conditions. However, the lexical differences between the syntactic-cue and semantic-cue groups of conditions were such that direct comparison is difficult: the conditions differed in the lexical material that preceded the critical verbs, and the critical verb differed in transitivity across levels of this factor, due to the need to isolate the contributions of syntactic and semantic cues. Consequently, the only comparisons from which conclusions can be confidently drawn are the comparisons of the ungrammatical conditions to their relative grammatical

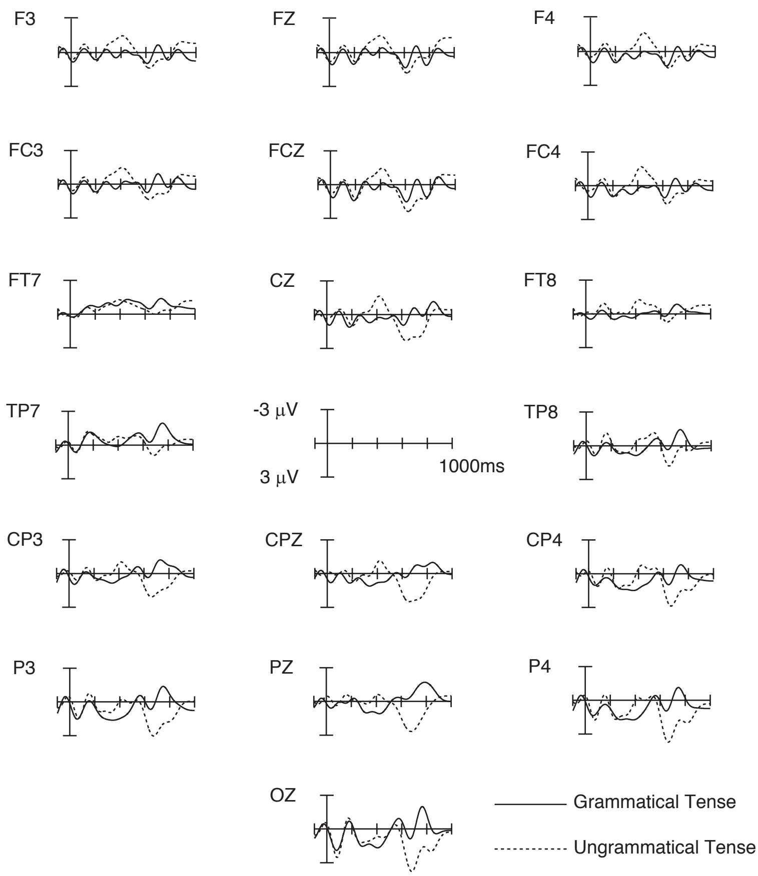

Figure 3. Grand average ERP responses elicited by the critical verb in sentences with a syntactic cue to past tense (ergative-marked subject). 103 × 98 mm (600 × 600 DPI).

control conditions. However, under most accounts, the differences in the pre-critical regions in the semantic and syntactic cue conditions would predict divergent processing profiles for the grammatical conditions, and direct comparison of the grammatical waveforms confirms this. Though it is the case that direct comparison cannot be made across the two ungrammatical conditions, we note that direct comparison of the two ungrammatical conditions reveals divergences between the early negativities seen in syntactic and semantic conditions, supporting the main conclusions drawn below (interested readers may inspect the supplemental figures and materials provided at http://www.people.umass.edu/bwdillon). However, because of the inconclusiveness of the comparisons across the factor of grammaticality, we report only those comparisons that were matched for structure and lexical items in the pre-critical region.

Separate ANOVAs were conducted within each level of the predictor factor, with the factors grammaticality, anteriority, and laterality as within-subjects factors. These analyses were followed with additional analyses of the effects of grammaticality at individual topographic regions of interest. The results for the syntactic cue conditions are shown in Table 3. These analyses revealed that the negativity reached significance only in the 300–500 ms interval in the right anterior region. In contrast, the late positivity was very reliable and broadly distributed across posterior regions, with marginal effects in the left and mid anterior regions.

Table 4 shows the results of statistical analyses of the effects of the grammaticality manipulation in the semantic cue conditions. In contrast to the syntactic cue conditions, the negativity elicited by a semantically cued error was significant in the 200–400 ms interval, and showed a posterior rather than an anterior distribution. Although the semantic cue conditions showed a posterior positivity in the 600–800 ms interval, as in the syntactic cue conditions, the effect was observed only at the posterior midline region. This suggests a smaller amplitude and much narrower topographic distribution than the positivity observed in the syntactic cue conditions.

Finally, in order to directly compare the amplitude of the P600 in the syntactic and semantic cue conditions we performed an additional analysis that followed a procedure used by Hagoort (2003a). ERP waveforms were

TABLE 3
ANOVA *F*-values at the critical verb for all time windows within the syntactic cue conditions, with the three factors *grammaticality, anteriority, and laterality*

Syntactic cue	*0–200 ms*	*200–400 ms*	*300–500 ms*	*400–600 ms*	*600–800 ms*	*800–1000 ms*
gram (1,18)	–	–	–	–	9.4**	–
gram × *ant* (1,18)	–	–	–	–	20.8***	–
gram × *lat* (2,36)	–	–	–	–	2.7†	–
gram × *lat* × *ant* (2,36)	–	–	–	–	2.7†	–
Anterior						
left gram (1,18)	–	–	–	–	3.7†	–
mid gram (1,18)	–	–	–	–	3.4†	–
right gram (1,18)	–	–	4.7*	–	–	–
Posterior						
left gram (1,18)	–	–	–	–	13.6**	–
mid gram (1,18)	–	–	–	–	16.5**	–
right gram (1,18)	–	–	–	–	12.9**	–

Note: † $.05 < p < .1$; * $.01 < p < .05$; ** $.001 < p < .01$; *** $p < .001$.

TABLE 4
ANOVA *F*-values at the critical verb for all time windows within the semantic cue condition, with the three factors *grammaticality, anteriority, and laterality*

Semantic cue	*0–200 ms*	*200–400 ms*	*300–500 ms*	*400–600 ms*	*600–800 ms*	*800–1000 ms*
gram (1,18)	–	–	–	–	–	–
gram × *ant* (1,18)	–	–	–	–	4.2†	–
gram × *lat* (2,36)	–	–	–	–	2.8†	–
gram × *lat* × *ant* (2,36)	–	–	–	–	–	–
Anterior						
left gram (1,18)	–	–	–	–	–	–
mid gram (1,18)	–	–	–	–	–	–
Right gram (1,18)	–	–	–	–	–	–
Posterior						
left gram (1,18)	–	4.0†	–	–	–	–
mid gram (1,18)	–	4.5*	–	–	3.3†	–
right gram (1,18)	–	5.1*	–	–	–	–

Note: † .05 $<p<$ .1; * .01 $<p<$ .05; ** .001 $<p<$ .01; *** $p<$ .001.

re-baselined relative to a 350–450 ms interval, in order to minimise potential confounds due to differences that existed prior to the P600 interval. Table 5 shows the mean voltage differences between the ungrammatical and grammatical conditions (along with their standard errors), for both the syntactic and semantic predictor conditions at each posterior region of interest in the 600–800 ms interval. Pairwise *t*-tests on the difference scores revealed that the P600 was larger in the syntactic cue conditions than in the semantic predictor condition at all posterior regions [left: $t(18) = 2.98$, $p < .01$, midline: $t(18) = 2.44$, $p < .05$, and right: $t(18) = 2.27$, $p < .05$].

TABLE 5
Mean and standard error of the re-baselined P600 effects in μV (obtained by subtracting grammatical from ungrammatical conditions), for all posterior regions between 600–800 ms

	Syntactic	*Semantic*
Left	3.73 (±0.59) μV	1.33 (±0.59) μV
Midline	4.41 (±0.71) μV	2.05 (±0.55) μV
Right	3.51 (±0.57) μV	1.92 (±0.44) μV

DISCUSSION

Summary of results

The current study took advantage of the morphosyntactic properties of Hindi to test whether comprehenders respond differently to errors that are identical in content, but that differ with regard to the source of the expectation that the error is in conflict with. As in English and other languages, past tense adverbials in Hindi (e.g., "last week") create an expectation for a verb with past tense morphology. The source of this expectation is the semantics of the adverbial. A more distinctive property of Hindi, which it shares with certain other split ergative languages, is that case marking on nouns can also be a reliable predictor of tense/aspect morphology. As a result, verbal morphology in Hindi can be cued by either semantic or morphosyntactic information. The ERP study showed that responses to an identical violation of morphological expectations differ as a function of the source of the expectation. Here we discuss the differences in more detail, with particular attention to the question of whether the observed differences are plausibly associated with the syntactic vs. semantic nature of the tense/aspect cue. We discuss the implications of these findings for models of parsing.

We focused on two distinct cues to tense/aspect morphology in Hindi: ergative-case marking (the syntactic cue) and temporal adverbials (the semantic cue). An offline sentence fragment completion task, as well as a corpus search, confirmed that neither cue may be followed by a future tense nonperfective verb form. From the sentence completion task, the only difference between the syntactic and semantic tense/aspect cues was that the completions in the syntactic condition contained exclusively past perfective verb forms, whereas the completions in the semantic condition included some past imperfective forms. This difference is consistent with Hindi grammar, which strictly links ergative case marking with perfective aspect. From this we can conclude that the future nonperfective tense/aspect forms used in the ungrammatical conditions of the ERP study were equally unexpected, irrespective of cue type, albeit for different reasons for each of the cue types.

We measured evoked potentials to grammatical and ungrammatical verb forms following both syntactic and semantic tense/aspect cues. In the conditions where semantic cues predicted verbal morphology, erroneous verbal forms elicited an early negativity in the 200–400 ms interval, with a broad posterior distribution. The relation of this negativity to other types of well-known ERP responses, such as the N400 or LAN, is discussed further below. Additionally, a small but reliable P600 effect was observed in the midline posterior region during the 600–800 ms interval. In contrast, in the conditions where morphosyntactic cues predicted verbal morphology, the same anomalous verbal morphology elicited a right-lateralised anterior negativity (RAN) during the 300–500 ms interval and a clear P600 effect with a broad posterior scalp distribution. In addition to the ANOVA analyses, a comparison of the amplitude of the P600 effect was conducted by measuring the amplitude of the error-related posterior positivity in each semantic cue condition, relative to a 350–450 ms baseline (following Hagoort 2003a). This analysis confirmed that the P600 effect was significantly larger and more broadly distributed in the syntactic cue conditions than in the semantic cue conditions. These results demonstrate both qualitative and quantitative differences in the response to the two cue types, despite the fact that the content of the anomalous verbal morphology—nonperfective future marking—was identical in both conditions.

These results suggest that the parser is more than a "black-box" system that is only sensitive to local deviations between expected and unexpected forms. Instead, the results suggest a language comprehension architecture that is able to rapidly recognise (and potentially act upon) different potential error causes. It could achieve this either by carrying forward information about the source of its expectations, or by recognising errors at separate levels of linguistic analysis (e.g., syntax, semantics, and discourse), such that the cause of an error can be inferred based upon the level of analysis that the content is detected.

Relation to previous ERP findings

The current findings extend and corroborate previous ERP findings on the processing of tense/aspect anomalies and errors in verbal morphology. The observed ERP response to a tense mismatch in the semantic cue conditions is similar to previous findings about tense and aspect errors that were cued by temporal adverbials (De Vincenzi et al., 2006; Fonteneau et al., 1998; Hagiwara et al., 2000; Newman et al., 2007; Zhang & Zhang, 2008). In each of these previous studies, an early negativity was observed, though with differing scalp distributions and temporal profiles across studies. In some of these studies the negativity was followed by a relatively modest P600 effect (De Vincenzi et al., 2006; Newman et al., 2007). Additionally, the negativity elicited by tense/aspect violations differed in both scalp distribution and time course from the N400 responses that were observed in the same participants in more canonical manipulations of semantic anomaly (Hagiwara et al., 2000; Newman et al., 2007; Zhang & Zhang, 2008). Newman and colleagues classified the left-lateralised negativity they observed as a LAN, due to its more frontal distribution. The negativity observed by De Vincenzi and colleagues showed a right-lateralised distribution that clearly contrasted with the distribution of the LAN elicited by an agreement violation condition in the same study. Zhang and Zhang (2008) observed a negativity with a similar time course (200–400 ms) and distribution similar to that seen in our study in response to a violation of aspect marking in Mandarin Chinese.

In our results the early negativity had a central and posterior distribution, and thus it was topographically more similar to the canonical N400 than the LAN. Nonetheless, in light of the consistent finding that standard N400 responses differ from tense- or aspect-related negativities in within-subjects comparisons, caution is warranted in linking the effect seen in the current study to standard N400 effects. Since the current study focused on the comparison of different cue types, it was not possible to compare the negativity that we observed to the response to more familiar semantic anomalies based upon the lexical content of open class words. If the negativity observed here is instead more related to the processes that elicit anterior negativities in other studies, then the question arises of what aspects of processing the negativity indexes. The LAN is most commonly associated with morphological or syntactic anomalies (Coulson et al., 1998; Friederici et al., 1993; Hagoort et al., 2003). An alternative view, espoused by a number of authors, is that the anterior negativies are an index of working memory load (Kluender & Kutas, 1993; Vos, Gunter, Kolk, & Mulder, 2001). If this is the case, then the negativity observed here might index (unsuccessful) working memory retrieval processes that attempt to link the future tense semantics of the verb with an appropriate reference point in the discourse model.

In the syntactic cue conditions we observed a RAN, followed by a robust P600 effect. Anterior negativities elicited by morphosyntactic anomalies are often left-lateralised (e.g., Friederici et al., 1993; Lau et al., 2006; Neville et al., 1991), but there are also many studies of morphosyntactic anomalies that have elicited bilateral anterior negativities (e.g., Hagoort et al., 2003; Hahne & Friederici, 1999). A RAN is not without precedent, however. Right anterior negativities have commonly been elicited by anomalies in music processing (Koelsch & Friederici, 2003; Koelsch, Gunter, Wittfoth, & Sammler, 2005), and by anomalous prosodic contours (Eckstein & Friederici, 2005). Of particular interest is a recent study by Ueno and Kluender (2009) that demonstrated a RAN in response to a morphological anomaly during the processing of Japanese *wh*-questions. In Japanese, *wh*-elements must be licensed by question particles that appear as verbal suffixes, just as ergative case in Hindi requires perfective morphology on the verb. Ueno and Kluender found that when the first verb form encountered after a *wh*-word did not bear a question particle suffix, a RAN was elicited. The presence of a RAN in our results extends this finding to Hindi, and may reflect similarities between the Japanese and Hindi dependencies. Both *wh*-words and ergative case-marked nouns are elements that must be licensed by specific verbal morphology (question particles or perfective marking, respectively). The ergative case marker -*ne* may generate expectations about verbal morphology in a manner similar to Japanese *wh*-words. If this is the case, then the RAN may index the processing demands involved in resolving a morphological dependency between a clause-final verb and its arguments. Clearly, however, more research is needed to determine which dependencies give rise to this effect, as a number of well-studied cases of morphological dependencies between verbs and their arguments (e.g., subject-verb agreement) have not yet been shown to elicit a RAN.

Both the syntactic and the semantic cue conditions elicited a P600 effect, but the magnitude of this effect was significantly larger in the syntactic cue condition. The P600 has been elicited by a diverse set of linguistic and nonlinguistic errors (Hagoort et al., 1993; Kuperberg, 2007; Núñez-Peña & Honrubia-Serrano, 2004; Patel et al., 1998), and it has been linked to processes of error recognition and reanalysis (Friederici et al., 2002; Hagoort, 2003b; Hopf et al., 2003; Kaan & Swaab, 2003a). A number of factors have been shown to influence P600 amplitude, including subcategorisation biases (Osterhout et al., 1994), experiment-internal error probabilities (Coulson, et al., 1998; Hahne & Friederici, 1999), the complexity of the processes initiated by the target word (Gouvea et al., 2010), and the saliency of the morphological violation (Coulson et al., 1998, Nevins, Dillon, Malhotra, & Phillips, 2007). It is unclear whether or not the difference in P600 effect magnitude is best regarded as a qualitative or quantitative difference. It is possible that it reflects an underlying qualitative difference in error response, but it may equally reflect a quantitative difference in response, possibly related to the degree of salience of the violation.

In the present study, there are at least two distinct ways in which a violation in the syntactic cue condition might be termed more "salient". One possibility involves the specificity of the expectations that the semantic and syntactic cues generate. Ergative case marking generates a narrow set of expectations about possible verbal morphology (i.e., the perfective marker—(*y*)*aa*), whereas a past tense adverbial is compatible with different past tense completions, as confirmed by the sentence-fragment completion task. Thus, although the probability of the observed nonperfective future tense form in both the syntactic and semantic cue conditions is ostensibly zero, due to grammatical constraints, comprehenders may have formed stronger commitments to specific verbal morphology in the syntactic cue condition. This in turn could lead to increased salience of the error in the event of a violation. Alternatively, representational differences between the error in the syntactic and semantic cue conditions may have made the same error more or less salient. In either case, however, the qualitatively different pattern observed in the other ERP responses involved suggests a representational difference between the two conditions. In what follows we discuss possible representational differences that may be responsible for the pattern of results that we observed.

Cause and content of the error

The first possible representational difference between the errors in our syntactic and semantic cue conditions involves the level of representation where the error obtains. We suggested above that the dependency between ergative case marking and perfective morphology is a specific morphosyntactic dependency, possibly analogous to other dependencies such as *wh*-scope marking in Japanese (Ueno & Kluender, 2009). This implies that the error in the syntactic cue condition is a failure to build a well-formed morphosyntactic dependency. Detection of this error does not necessarily depend on interpretive processes, and thus this account is compatible with a wide range of serial and parallel architectures. In contrast, there is no specific morphosyntactic problem in the semantic cue condition. The cause of the error is instead a conflict between the semantics of the future tense of the verb and the past tense adverbial. Detection of this error may only be possible once a full interpretation of the clause is constructed. As with the morphosyntactic error, this does not uniquely implicate a single architecture: parallel as well as serial orderings of syntactic and semantic composition could both easily capture this result. This account is compatible with any model that distinguishes constraints that apply to individual pairs of words or phrases and constraints that apply to compositional interpretations of sequences of words.

An alternative possibility is that the different ERP responses in the syntactic and semantic cue conditions might reflect differences in the processing of tense and aspect. As noted above, ergative case marking only grammatically requires perfective aspect, whereas the temporal adverbials that we employed are cues for past tense. The results of our sentence fragment completion study suggest that for practical purposes speakers treat both cues as effective predictors of past tense, but the grammatical difference must nevertheless be taken seriously. Based on behavioural evidence it has been proposed that tense and aspect are processed in qualitatively different fashions (Dickey, 2000). Tense has been described as a type of anaphoric relation between a specific time point highlighted by a clause and a "reference point" in the existing discourse model, and this anaphoric character is absent in many characterisations of aspect. However, it is important to distinguish grammatical aspect and lexical aspect (or *Aktionsart*), and the interpretation of grammatical aspect has been argued to always implicate a temporal "reference frame" (Comrie, 1976; Kazanina & Phillips, 2007; Reichenbach, 1947; Smith, 1991). It is difficult to say with certainty whether existing electrophysiological evidence distinguishes aspect and tense violations: early negativities have been noted by violations of aspect (Zhang & Zhang, 2008) and violations of tense alike (Fonteneau et al., 1998; Newman et al., 2007). However, there are considerable differences in scalp distribution and time course across these negativities, and differences among the languages and constructions used makes it difficult to conclude that the processing of tense and aspect is identical from an electrophysiological standpoint. Note that both our fragment completion study and our corpus search suggest that ergative case marking is a probabilistic predictor of both tense and aspect. It is associated with approximately 75% past tense perfective forms in the Hindi corpus that we examined, and with 100% past perfective forms in our completion study. Although this is not a strict requirement of Hindi grammar, it may have had an impact on the current results, making it difficult to conclude that the differences we observe are due to differences in the processing of tense vs. aspect. This remains a question for future research.

It is also important to note that while tense and aspect are marked with different morphological devices in Hindi, this would still not be reducible to a difference in error content in the current materials. Whether the relevant representational distinction is between morphosyntax and semantics, or between tense and aspect, the current results provide positive evidence that the cause of the error is available at the point of error detection. An error with identical content—an inappropriate future tense form—is processed differently, based on the constraints that it violates.

One alternative to this explanation is that the difference in error patterns observed in the two conditions is linked to an extra reanalysis step that might be involved in processing the sentences with *-ne* marking. If extra processing effort is required to suppress the incorrect volitional *-ne* interpretation, then this extra processing should only appear in the syntactic cue conditions, leading to a different error response than that observed in the semantic cue condition. This is an unlikely scenario, in light of the overwhelming preference for *-ne* to be treated as an ergative marker in both the sentence completion task and the corpus search. Additionally, there were no instances of volitional *-ne* within the experiment, and our participants were selected from a dialect region where the volitional use of *-ne* is more marked than in Delhi Hindi. For this reason, it is unlikely that volitional *-ne* would be adopted as the primary analysis for the *-ne* marker.

Implications for models of sentence processing

There has been long-standing interest in psycholinguistics in the question of how the parser is able to recover from incorrect structural analyses. A growing body of evidence implicating anticipatory structure-building processes in sentence understanding has made this question even more pressing, since anticipatory processes increase the risk of error. Accounts of successful recovery from error fall into a small number of classes. One common view is that the parser engages in reanalysis, i.e., a specific, error-driven repair mechanism that is triggered when anomalous input is presented (Bader, 1998; Ferreira & Henderson, 1991; Fodor & Inoue, 1994; Sturt, Pickering, & Crocker, 1999). An alternative is that the parser does not have specific reanalysis mechanisms, but instead simply reprocesses the input using otherwise normal parsing techniques (Grodner, Gibson, Argaman, & Babyonyshev, 2003). These first two approaches share the assumption that successful recovery from error involves the generation of a novel structure that is different from the one that was being pursued prior to the anomaly. A third approach posits that recovery from error does not really involve generation of novel parses, but instead involves the re-ranking of multiple alternative parses that are pursued in parallel, but with different activation levels (Gibson, 1991; Hale, 2003; Jurafsky, 1996; Levy, 2008; Spivey & Tanenhaus, 1998). Notwithstanding the differences between these accounts, they share a number of common properties. They assume that a dominant parse must be inhibited. They assume that alternative parses must be generated, or must receive heightened activation. These alternative parses presumably can only be generated if the parser is somehow able to inhibit the parsing steps that led the previously dominant parse to be dominant in the first place. Finally, the accounts share the assumption that information in the anomalous word plays a key role in the recovery process.

As already discussed above, if the parser has information about the cause of an error, this offers potentially useful information for correct diagnosis and repair of anomalous input. The parser can use information about the cause of an error to relate information about the content of the error to the space of alternative analyses. Indeed, many models of parsing implicitly or explicitly assume that this sort of information linking error content and alternative analyses is available. The model laid out in Fodor and Inoue (2000) is an example of a parsing model that explicitly adopts this assumption. Fodor and Inoue formalise this mechanism in terms of the *adjust* operation of their parser, which acts to repair one or both of a pair of features that have come into grammatical conflict as a result of an error. When defined in this way, the operation requires that information about the cause of the error be accessible to the parser.

The results of the current study suggest that information about the cause of an error could be made rapidly available to the parser. If the results reported here are representative of mechanisms that apply across a range of constructions and languages, then they would present a case for models that track error cause. The cause of an error is a powerful source of information that could support targeted diagnosis and repair of errors. We should note, however, that the current results do not necessarily suggest one specific model over another, and they are compatible with a variety of different sentence-processing models (e.g., Fodor & Inoue, 1994; Lewis & Vasishth, 2005; Spivey & Tanenhaus, 1998; Sturt & Crocker, 1998). The crucial component of these models for the current results is their ability to diagnose the cause of the error. This is naturally achieved in models that draw a clear distinction between morpho-syntactic and semantic processing, but models that instead encode this distinction implicitly may also be compatible with the current results.

If current results are indicative of a general feature of the parser, then they provide a case against models that do not allow the parser to easily recover information on the cause of errors. Most notably, this includes models that encode expectations only in terms of surface forms. A number of models of parsing adopt this strategy (Elman, 1993; Jurafsky, 1996; Levy, 2008; MacDonald, 1994). Under approaches of this type, identical conditional probabilities or expectations about observed forms are expected to engender identical processing difficulty, even in the situation where they are generated from distinct underlying (or "hidden") representations. The current results, however, suggest that forms with identical conditional probabilities induce divergent patterns of processing difficulty, because the probability of a future nonperfective verb form is (grammatically) zero in both contexts. In the case of the semantic cue, it is because future tense is incompatible with the past tense expectation, and in the case of the syntactic cue, it is because nonperfective aspect is incompatible with ergative marking. The strong view that conditional probabilities uniquely determine processing difficulty is incompatible with this finding. Instead, the current results suggest the need for processing models in which the cause of the error is encoded and/or recoverable in the course of parsing.

CONCLUSION

By looking at ERPs elicited by morphosyntactic and semantic cues to verbal morphology in Hindi, we asked whether information about the cause of errors is recoverable during online sentence comprehension. By showing that Hindi speakers react differently to the same morphological anomaly when the anomaly has different underlying causes, we showed that the parser does indeed have access to information about the cause and the content of errors. This finding lends support to a family of parsing models that directly exploit this type of information.

Manuscript received 11 June 2009
Revised manuscript received 15 November 2010
First published online 26 July 2011

REFERENCES

Allen, M., Badecker, W., & Osterhout, L. (2003). Morphological analysis in sentence processing: An ERP study. *Language and Cognitive Processes*, *18*, 405–430.

Bader, M. (1998). Prosodic influences on reading syntactically ambiguous sentences. In J. D. Fodor & F. Ferreira (Eds.), *Reanalysis in sentence processing* (pp. 1–46). Dordrecht, The Netherlands: Kluwer.

Bever, T. G. (1970). The cognitive basis for linguistic structures. In J. R. Hayes (Ed.), *Cognition and the development of language* (pp. 279–362). New York, NY: Wiley.

Bhatt, R., Narasimhan, B., Palmer, M., Rambow, O., Sharma, D., & Xia. F. (2009). A multi-representational and multi-layered treebank for Hindi/Urdu. In N. Ide & A. Meyers (Eds.), *Proceedings of the Third Linguistic Annotation Workshop*, *ACL-IJCNLP* (pp. 186–189). Singapore, August.

Casado, P., Martín-Loeches, M., Muñoz, F., & Fernández-Frías, C. (2005). Are semantic and syntactic cues inducing the same processes in the identification of word order? *Cognitive Brain Research*, *24*, 526–543.

Comrie, B. (1976). *Aspect*. Cambridge, UK: Cambridge University Press.

Coulson, S., King, J., & Kutas, M. (1998). Expect the unexpected: Event-related brain responses to morphosyntactic violations. *Language and Cognitive Processes*, *13*, 21–58.

DeLancey, S. (1981). An interpretation of split ergativity and related patterns. *Language*, *57*, 626–657.

De Vincenzi, M., Rizzi, L., Portolan, D., Di Matteo, R., Spitoni, G., & Di Russo, F. (2006). *Mapping the language: A reading time and topographic ERP study on tense, agreement, and Aux-V violations.* Paper presented at the AIPS Psycholinguistic Symposium, Rovereto, Italy, 13–15 September.

Dickey, M. W. (2000). *The processing of tense.* (Doctoral dissertation). University of Massachusetts, Amherst, MA.

Dixon, R. M. W. (1994). *Ergativity.* Cambridge, UK: Cambridge University Press.

Domahs, U., Wiese, R., Bornkessel-Schlesewsky, I., & Schlesewsky, M. (2008). The processing of German word stress: Evidence for the prosodic hierarchy. *Phonology*, *25*, 1–36.

Eckstein, K., & Friederici, A. D. (2005). Late interaction of syntactic and prosodic processes in sentence comprehension as revealed by ERPs. *Cognitive Brain Research*, *25*, 130–143.

Elman, J. L. (1993). Learning and development in neural networks: The importance of starting small. *Cognition*, *48*, 71–99.

Ferreira, F., & Henderson, J. M. (1991). Recovery from misanalysis of garden-path sentences. *Journal of Memory and Language*, *30*, 725–745.

Fodor, J. D., & Inoue, A. (1994). The diagnosis and cure of garden paths. *Journal of Psycholinguistic Research*, *23*, 407–434.

Fodor, J. D., & Inoue, A. (2000). Garden path re-analysis: Attach (anyway) and revision as a last resort? In M. de Vincenzi & V. Lombardo (Eds.), *Cross-linguistic perspectives on sentence processing* (pp. 21–61). Dordrecht, The Netherlands: Kluwer.

Fonteneau, E., Frauenfelder, U., & Rizzi, L. (1998). On the contribution of ERPs to the study of language comprehension. *Bulletin suisse de linguistique appliquée: Etudes en neurolinguistique*, *68*, 111–124.

Frazier, L., & Fodor, J. D. (1978). The sausage machine: A new two-stage parsing model. *Cognition*, *6*, 291–325.

Friederici, A. D., Hahne, A., & Saddy, D. (2002). Distinct neurophysiological patterns reflecting aspects of syntactic complexity and syntactic repair. *Journal of Psycholinguistic Research*, *31*, 45–63.

Friederici, A. D., Pfeifer, E., & Hahne, A. (1993). Event-related brain potentials during natural speech processing: Effects of semantic, morphological and syntactic violations. *Cognitive Brain Research*, *1*, 183–192.

Gibson, E. (1991). *A computational theory of human linguistic processing: Memory limitations and processing breakdown*. (Doctoral dissertation). Carnegie Mellon University, Pittsburgh, PA.

Gouvea, A., Phillips, C., Kazanina, N., & Poeppel, D. (2010). The linguistic processes underlying the P600. *Language and Cognitive Processes*, *25*, 149–188.

Greenhouse, S., & Geisser, S. (1959). On methods in the analysis of profile data. *Psychometrika*, *24*, 95–112.

Grodner, D., Gibson, D., Argaman, V., & Babyonyshev, M. (2003). Against repair-based reanalysis in sentence comprehension. *Journal of Psycholinguistic Research*, *32*, 141–166.

Gunter, T. C., & Friederici, A. D. (1999). Concerning the automaticity of syntactic processing. *Psychophysiology*, *36*, 126–137.

Gunter, T. C., Stowe, L. A., & Mulder, G. (1997). When syntax meets semantics. *Psychophysiology*, *34*, 660–676.

Hagiwara, H., Nakajima, H., Nakagome, K., Takazawa, S., Kanno, O., Ito, K., et al. (2000). ERP manifestations of processing syntactic dependencies in hierarchical structures of language: Time course and scalp distribution. In K. Inoue (Ed.) *Researching and verifying an advanced theory of human language* (pp. 519–545). COE Report #4, Chiba, Japan: Kanda University of International Studies.

Hagoort, P. (2003a). Interplay between syntax and semantics during sentence comprehension: ERP effects of combining syntactic and semantic violations. *Journal of Cognitive Neuroscience*, *15*, 883–899.

Hagoort, P. (2003b). How the brain solves the binding problem for language: A neurocomputational model of syntactic processing. *Neuroimage*, *20*, S18–S29.

Hagoort, P., & Brown, C. M. (2000). ERP effects of listening to speech compared to reading: The P600/SPS to syntactic violations in spoken sequences and rapid serial visual presentation. *Neuropsychologia*, *38*, 1531–1549.

Hagoort, P., Brown, C. M., & Groothusen, J. (1993). The syntactic positive shift (SPS) as an ERP measure of syntactic processing. *Language and Cognitive Processes*, *8*, 439–483.

Hagoort, P., Wassenaar, M. E. D., & Brown, C. M. (2003). Syntax-related ERP effects in Dutch. *Cognitive Brain Research*, *16*, 38–50.

Hahne, A., & Friederici, A. D. (1999). Electrophysiological evidence for two steps in syntactic analysis: Early automatic and late controlled processes. *Journal of Cognitive Neuroscience*, *11*, 194–205.

Hale, J. (2003). The information conveyed by words in sentences. *Journal of Psycholinguistic Research*, *32*, 101–123.

Hopf, J. M., Bader, M., Meng, M., & Bayer, J. (2003). Is human sentence parsing serial or parallel? Evidence from event-related brain potentials. *Brain Research*, *15*, 165–177.

Jurafsky, D. (1996). A probabilistic model of lexical and syntactic access and disambiguation. *Cognitive Science*, *20*, 137–194.

Just, M. A., & Carpenter, P. A. (1980). A theory of reading: From eye-fixations to comprehension. *Psychological Review*, *87*, 329–354.

Kaan, E. (2002). Investigating the effects of distance and number interference in processing subject–verb dependencies: An ERP study. *Journal of Psycholinguistic Research*, *31*, 165–193.

Kaan, E., Harris, A., Gibson, E., & Holcomb, P. (2000). The P600 as an index of syntactic integration difficulty. *Language and Cognitive Processes*, *15*, 159–201.

Kaan, E., & Swaab, T. (2003a). Repair, revision, and complexity in syntactic analysis: An electrophysiological differentiation. *Journal of Cognitive Neuroscience*, *15*, 98–110.

Kaan, E., & Swaab, T. Y. (2003b). Electrophysiological evidence for serial sentence processing: A comparison between non-preferred and ungrammatical continuations. *Cognitive Brain Research*, *17*, 621–635.

Kazanina, N., & Phillips, C. (2007). A developmental perspective on the Imperfective Paradox. *Cognition*, *105*, 65–102.

Kim, A., & Osterhout, L. (2005). The independence of combinatory semantic processing: Evidence from event-related potentials. *Journal of Memory and Language*, *52*(2), 205–225.

Kluender, R., & Kutas, M. (1993). Bridging the gap: Evidence from ERPs on the processing of unbounded dependencies. *Journal of Cognitive Neuroscience*, *5*, 196–214.

Koelsch, S., & Friederici, A. D. (2003). Towards the neural basis of processing structure in music: Comparative results of different neurophysiological investigation methods (EEG, MEG, fMRI). *Annals of the New York Academy of Sciences*, *999*, 15–27.

Koelsch, S., Gunter, T. C., Wittfoth, M., & Sammler, D. (2005). Interaction between syntax processing in language and in music: An ERP study. *Journal of Cognitive Neuroscience*, *17*, 1565–1577.

Kolk, H. H. J., Chwilla, D., van Herten, M., & Oor, P. (2003). Structure and capacity in verbal working memory: An ERP study. *Brain and Language*, *85*, 1–35.

Kuperberg, G. (2007). Neural mechanisms of language comprehension: Challenges to syntax. *Brain Research*, *1146*, 23–49.

Kutas, M., & Hillyard, S. A. (1980). Reading senseless sentences: Brain potentials reflect semantic incongruity. *Science*, *207*, 203–205.

Kutas, M., & Hillyard, S. A. (1983). Event-related brain potentials to grammatical errors and semantic anomalies. *Memory & Cognition*, *11*, 539–550.

Kutas, M., & Hillyard, S. A. (1984). Brain potentials during reading reflect word expectancy and semantic association. *Nature*, *307*, 161–163.

Kutas, M., & Federmeier, K. D. (2000). Electrophysiology reveals semantic memory use in language comprehension. *Trends in Cognitive Science*, *4*, 463–470.

Lau, E. F., Phillips, C., & Poeppel, D. (2008). A cortical network for semantics: (de)Constructing the N400. *Nature Reviews Neuroscience*, *9*, 920–933.

Lau, E. F., Stroud, C., Plesch, S., & Phillips, C. (2006). The role of structural prediction in rapid syntactic analysis. *Brain & Language*, *98*, 74–88.

Levy, R. (2008). Expectation-based syntactic comprehension. *Cognition*, *106*, 1126–1177.

Lewis, R. L. (1998). Leaping off the garden path: Reanalysis and limited repair parsing. In J. D. Fodor & F. Ferreira (Eds.), *Reanalysis in sentence processing* (pp. 247–284). Dordrecht, The Netherlands: Kluwer.

Lewis, R. L., & Vasishth, S. (2005). An activation-based model of sentence processing as skilled memory retrieval. *Cognitive Science*, *29*, 375–419.

MacDonald, M. C. (1994). Probabilistic constraints and syntactic ambiguity resolution. *Language and Cognitive Processes*, *9*, 157–201.

Martín-Loeches, M., Casado, P., Gonzalo, R., de Heras, L., & Fernández-Frías, C. (2006). Brain potentials to mathematical syntax problems. *Psychophysiology*, *43*, 579–591.

Meng, M., & Bader, M. (2000). Ungrammaticality detection and garden-path strength: Evidence for serial parsing. *Language and Cognitive Processes*, *15*, 615–666.

Montaut, A. (2004). Oblique main arguments in Hindi as localizing predications: Questioning the category of subject. In P. Bhaskararo & K. V. Subbarao (Eds.), *Non-nominative subjects* (pp. 33–56). Amsterdam: John Benjamins.

Münte, T., Matzke, M., & Johannes, S. (1997). Brain activity associated with syntactic incongruencies in words and pseudo-words. *Journal of Cognitive Neuroscience*, *9*, 318–329.

Münte, T. F., Heinze, H. J., Matzke, M., Wieringa, B. M., & Johannes, S. (1998). Brain potentials and syntactic violations revisited: No evidence for specificity of the syntactic positive shift. *Neuropsychologia*, *36*, 217–226.

Neville, H. J., Nicol, J., Barss, A., Forster, K. I., & Garrett, M. F. (1991). Syntactically based sentence processing classes: Evidence from event-related brain potentials. *Journal of Cognitive Neuroscience*, *3*, 151–165.

Nevins, A., Dillon, B., Malhotra, S., & Phillips, C. (2007). The role of feature-number and feature-type in processing Hindi verb agreement violations. *Brain Research*, *1164*, 81–94.

Newman, A. J., Pancheva, R., Waligura, D. L., Neville, H. J., & Ullman, M. T. (2007). An ERP study of regular and irregular English past tense inflection. *Neuroimage*, *34*, 435–445.

Núñez-Peña, M. I., & Honrubia-Serrano, M. L. (2004). P600 related to rule violation in an arithmetic task. *Cognitive Brain Research*, *18*, 130–141.

Oldfield, R. C. (1971). The assessment and analysis of handedness: The Edinburgh inventory. *Neuropsychologia*, *9*, 97–113.

Osterhout, L., & Holcomb, P. J. (1992). Event-related potentials elicited by syntactic anomaly. *Journal of Memory and Language*, *31*, 785–806.

Osterhout, L., Holcomb, P. J., & Swinney, D. A. (1994). Brain potentials elicited by garden path sentences: Evidence of the application of verb information during parsing. *Journal of Experimental Psychology: Learning*, *Memory and Cognition*, *20*, 786–803.

Osterhout, L., & Mobley, L. A. (1995). Event-related brain potentials elicited by failure to agree. *Journal of Memory and Language*, *34*, 739–773.

Osterhout, L., & Nicol, J. (1999). On the distinctiveness, independence, and time course of the brain responses to syntactic and semantic anomalies. *Language and Cognitive Processes*, *14*, 283–317.

Patel, A. D., Gibson, E., Ratner, J., Besson, M., & Holcomb, P. J. (1998). Processing syntactic relations in language and music: An event-related potentials study. *Journal of Cognitive Neuroscience*, *10*, 717–733.

Payne, T. E. (1997). *Describing morphosyntax: A guide for field linguists*. Cambridge, UK: Cambridge University Press.

Reichenbach, H. (1947). *Elements of symbolic logic*. New York: The Free Press.

Smith, C. (1991). *The aspect parameter*. Dordrecht, The Netherlands: Kluwer.

Spivey, M. J., & Tanenhaus, M. K. (1998). Syntactic ambiguity resolution in discourse: Modeling the effects of referential context and lexical frequency. *Journal of Experimental Psychology: Learning, Memory and Cognition*, *24*, 1521–1543.

Sturt, P., & Crocker, M. (1998). Generalized monotonicity for reanalysis models. In J. D. Fodor & F. Ferreira (Eds.), *Reanalysis in sentence processing* (pp. 365–400). Dordrecht, The Netherlands: Kluwer.

Sturt, P., Pickering, M., & Crocker, M. (1999). Structural change and reanalysis difficulty in language comprehension. *Journal of Memory and Language*, *40*, 136–150.

Ueno, M., & Kluender, R. (2009). On the processing of Japanese Wh-Questions: An ERP study. *Brain Research*, *1290*, 63–90.

van Gompel, R. P. G., & Pickering, M. J. (2007). Syntactic parsing. In G. Gaskell (Ed.), *The Oxford handbook of Psycholinguistics* (pp. 289–307). Oxford, UK: Oxford University Press.

Vos, S., Gunter, T. C., Kolk, H., & Mulder, G. (2001). Working memory constraints on syntactic processing: An electrophysiological investigation. *Psychophysiology*, *38*, 41–63.

Zhang, Y., & Zhang, J. (2008). Brain responses to agreement violations of Chinese grammatical aspect. *NeuroReport*, *19*, 1039–1043.