Irregular and regular verbs elicit identical morphological decomposition ERPs
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After almost two decades of studies examining the predictions of the Dual Route theory of verb inflection, the experimental record still contains contradictory conclusions. Newman et. al., (2007) presented written sentences, such as "Yesterday, I go to the store". Regular verbs with unexpected tense ("Yesterday, I kick the ball") elicited a left anterior negativity (LAN) event-related potential (ERP) (suggesting activation of rule computation) followed by P600 (perhaps indicative of repair processes). For irregulars, the authors observed *absence* of a LAN but presence of P600; they interpreted the absence of LAN as evidence that past tense irregulars are computed differently than regulars (look-up instead of rule). Note, however, that the Dual Route predicts that irregulars should generate an N400 effect, which was not observed. In contrast, Stockall & Marantz (2006) report an identical time course and priming pattern for regular and irregular verbs using magnetoencephalography; they argue that irregulars verb are fully decomposed into a root and an abstract tense suffix, in parallel to regular verbs because of the similar response pattern (see also Morris & Stockall (2012)). Here, we reassess the Newman et al. findings with two new experiments that extend the study design and complement subsequent literature. The Dual Route Model predicts that LAN will index morpho-syntactic rule violations and N400 will index lexical access violations, whereas Single Route predicts that regular and irregular violations will both be parsed as rule violations and elicit LAN responses.

ERP-methodology: ERPs were recorded time-locked to verb onsets and offsets using EGI systems and electrode nets while participants judged congruency. Data were re-referenced to the average; averaged ERPs were computed for incongruent and congruent tense for all relevant contrasts. Dimensionality reduction (from high-density scalp electrodes), component isolation and data-driven identification of brain responses were derived via temporo-spatial PCA/ICA one the subtraction (Incongruent-Congruent). Temporal-Spatial Factors were the dependent measures in ANOVAs.

Experiment 1: We replicated Newman et al., but used auditory stimuli, because written present tense form looks like a stem compared to the written past tense form, and thus, auditory stimuli minimize this factor; see Table 1 for the full design. Result: 25 participants' data (out of 30 tested) showed a LAN response to both regular and irregular verbs, but no N400 was observed. Contra Newman et al., no P600 was observed, but note that neither theory makes specific predictions about P600 that can serve to differentiate between Dual vs. Single Route.

Experiment 2: Another criticism of Newman et al. was that they measured the brain response only to *present* tense verbs, which have no overt inflection signal. In Experiment 2 we controlled for this by replacing "yesterday" with "now", making the overt inflected past tense form incongruent (see Table 2). Result: 31 (out of 33 tested) participants showed a LAN response to both regular and irregular verbs, similar to Experiment 1.

Conclusions: The results provide evidence that both irregular and regular verbs, when encountered with the "incorrect" tense, triggers LAN, which we interpret as reflecting morphosyntactic violation and re-computation. We also observed that the "LAN" was bilateral, and thus may be better termed "AN". In addition, the results show that the direction of the tense predicted by the adverb did not matter: Whether present tense or past tense is unexpected, the same brain response for correctness computation is elicited. This provides new support for the basic methodology in Newman et al.'s study. When a listeners encounters a present tense verb when past is expected, this activates the computations required for the correct form, and therefore provide insight into whether irregulars are processed by lexical look-up or rule. The findings support the proposal that irregular verbs have compositional structure (Halle & Marantz, 1994), e.g. [went] is psychologically decomposed and represented as /go/ + [PAST].

Table 1: design of Experiment 1 and 2; adverb tense is between-subject variable.

| ADVERB TENSE	VERB TENSE	VERB TYPE	congruency	example stimulus	# of trials
past (Exp 1)	past	irregular	congruent	I ate a sandwhich	56
past (Exp 1)	past	irregular	congruent	Yesterday, I ate a sandwhich	56
past (Exp 1)	past	regular	congruent	I walked to school	56
past (Exp 1)	past	regular	congruent	Yesterday, I walked to school	56
past (Exp 1)	present	irregular	congruent	I eat a sandwhich	56
past (Exp 1)	present	irregular	INCONGRUENT	Yesterday, I eat a sandwhich	56
past (Exp 1)	present	regular	congruent	I walk to school	56
past (Exp 1)	present	regular	INCONGRUENT	Yesterday, I walk to school	56
present (Exp 2)	past	irregular	congruent	I ate a sandwhich	40
present (Exp 2)	past	irregular	INCONGRUENT	Now, I ate a sandwhich	40
present (Exp 2)	past	regular	congruent	I walked to school	40
present (Exp 2)	past	regular	INCONGRUENT	Now, I walked to school	40
present (Exp 2)	present	irregular	congruent	I eat a sandwhich	40
present (Exp 2)	present	irregular	congruent	Now, I eat a sandwhich	40
present (Exp 2)	present	regular	congruent	I walk to school	40
present (Exp 2)	present	regular	congruent	Now, I walk to school	40
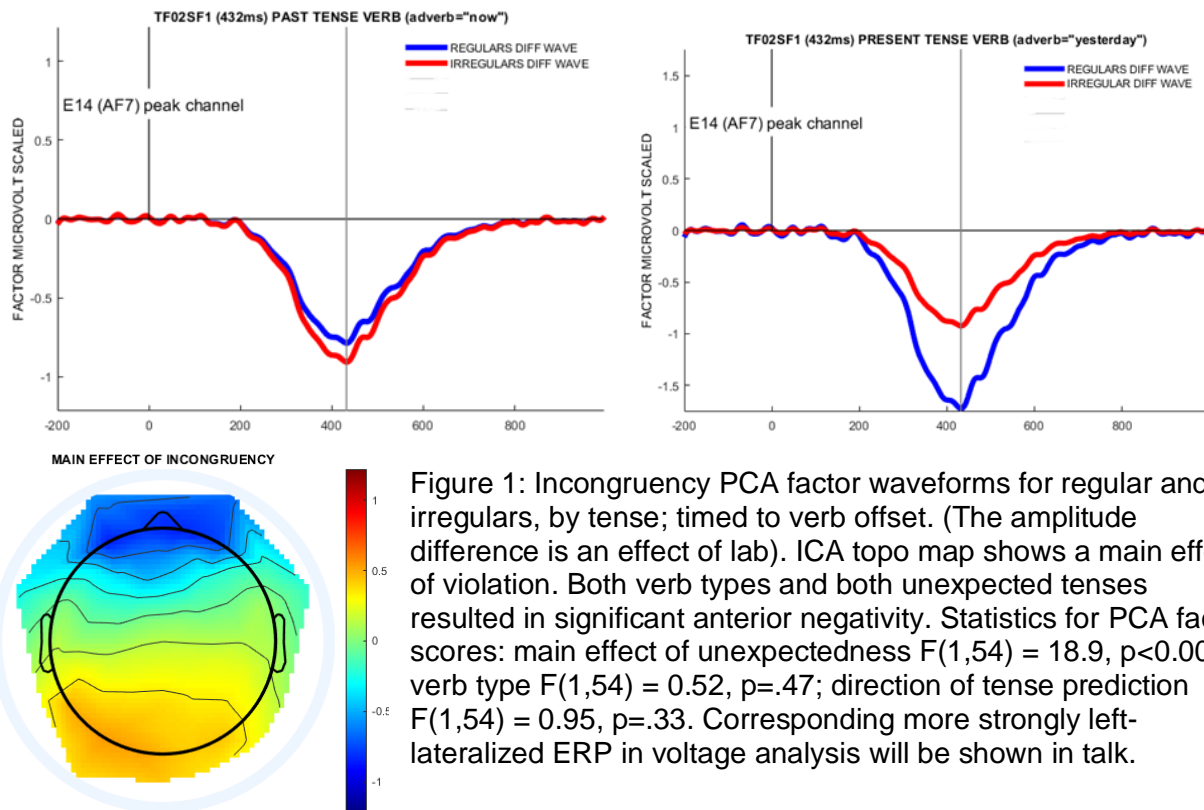
Figure 1: Incongruency PCA factor waveforms for regular and irregulars, by tense; timed to verb offset. (The amplitude difference is an effect of lab). ICA topo map shows a main effect of violation. Both verb types and both unexpected tenses resulted in significant anterior negativity. Statistics for PCA factor scores: main effect of unexpectedness $F_{(1,54)} = 18.9$, $p<0.0001$; verb type $F_{(1,54)} = 0.52$, $p=.47$; direction of tense prediction $F_{(1,54)} = 0.95$, $p=.33$. Corresponding more strongly left-lateralized ERP in voltage analysis will be shown in talk.

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