dormant but ready to be expressed in the brain? Both patients discussed above had never had out-of-body illusions before, yet direct stimulation of their brain somehow generated experiences quite different from those of everyday life. Is this difference a matter of quality or degree? Many people have had dreams of intense, prolonged falling, even though they have never fallen from such heights before. Perhaps vestibular-somatosensory responses, at the extreme, can lead to the qualitatively novel impression of being outside of one's own body. Analogous studies in proprioception have shown that peripheral stimulation of muscle spindles can lead to illusions of impossible limb positions, such as experiencing one's own arm bent backwards against the joint [9,10].

Alternatively, these novel body illusions might reflect the fact that neurons representing vestibular impressions and body position are in direct conflict with veridical sensory information from vision. This latter explanation would imply that novel experiences instead reflect the novel combination of two or more familiar sensory experiences. Exactly how the brain gives rise to such extraordinary experiences will be an exciting topic for future investigations, perhaps for another sixty years.

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Letters

Show us the model

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Pinker and Ullman's [1] accounting of the facts about the past tense cannot be taken at face value and needs to be dissected more closely than possible here. Because of space limitations, we will focus on inaccuracies in their rendering of the Joanisse and Seidenberg model (J&S) [2].

(1) Pinker and Ullman claim that our model failed to produce the advantage for irregulars over regulars seen in some patients with left frontal damage. On the contrary, the model did produce this pattern; it occurred relatively rarely in multiple runs of the model (corresponding to multiple 'patients'), and it occurs infrequently in patients [3]. The advantage for irregulars is eliminated in the model and patients if the regular and irregular stimuli are closely controlled with respect to frequency, phonological complexity and concreteness [2,3].

(2) Pinker and Ullman's claim that the J&S model is a 'crude' instantiation of their theory rests on equating a highly structured, hierarchical lexical system containing all the apparatus illustrated in their Fig. 1 (p. 457, and elaborated in Pinker's books), with the semantic representations in our model, which consisted of exactly one bit per verb concept. Here Pinker and Ullman stretch to find a point of contact between our model and their theory, and ignore the differences. Their theory rests on a distinction between rule-governed forms and exceptions, which are said to be processed by independent modules governed by different principles [4]. This distinction plays no role in our model; the production of every past-tense form is determined by the conjunction of phonological and semantic constraints. These constraints (and others that apply under other circumstances, for example, in context) vary in how much they contribute to different forms, but all forms are generated using all weights. This is different from shunting some words to the lexicon and others to the rule. We also know (from submitted research) that the J&S results do not depend on using localist nodes. In sum, these are fundamentally different theories.

(3) Pinker and Ullman's claim that 'each model has been tailored to account for one phenomenon' and that 'few models account for more than one phenomenon or predict new ones' (p. 462), ignores the fact that our model's predictions about morphological deficits were *themselves* derived from work in a different domain – reading words. It was a further, correct prediction that patients with impaired morphology would exhibit corresponding forms of acquired dyslexia (phonological, surface). The same

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account extends to other phenomena, including some types of developmental dyslexia [5] and developmental language impairments. In two articles [6,7] we suggest how a phonological deficit could give rise to deficits in both inflectional morphology and aspects of grammar seen in cases of specific language impairment (SLI). Pinker and Ullman dismiss this account of SLI, citing studies that failed to find deficits in processing auditory (non-speech) signals in such individuals [8,9]. At best, however, such evidence indicates only that the language problem is not caused by a peripheral auditory-perceptual deficit. It has no bearing on the existence of processing deficits related to speech or phonology (as observed in [9,10] and many other studies). The principles that were implemented in the J&S model also produce the graded phenomena discussed by McClelland and Patterson, and explain facts about plurals and their occurrence in compounds [11]. Finally, one more prediction: German inflection will also turn out to be explained by the conjunction of phonological and semantic constraints [12].

Pinker and Ullman assert that connectionist models will ultimately need to incorporate structured symbolic representations. However, the opposite seems more likely. Pinker *et al.* have never implemented a computational version of their theory. Our models engage issues about the feasibility of proposed mechanisms at a level that they have not approached. Pinker's method, by contrast, involves describing the lexical system in words and ascribing to it whatever computational properties are desired. When Pinker and his colleagues begin to address how the complex system they propose could be learned and used, they will converge on the kind of mechanisms described in our models. Such models exhibit behaviors not deducible from symbolic theories and thus are not 'mere implementations' of them. This step would probably also increase their sensitivity to distinguishing between what is central to a model and what is an implementational detail of no theoretical consequence.

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The past-tense debate: exocentric form versus the evidence

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Homophone verbs that take different inflected forms (*shoe–shod, shoo–shooed*) are central to the past-tense debate [1–4]. Pinker and Ullman [1,2] claim that exocentric words (which lack a root in their head position, that is, verbs derived from nouns) are automatically regularized. Accordingly, inflection cannot be explained according to the distributional properties of language; it is also affected by grammatical concepts such as noun and verb.

What evidence is there that exocentric forms affect past-tense processing? To examine whether semantics or exocentricity governs homophone processing, Kim, Pinker, Prince and Prasada [5] elicited ratings of inflected forms of homophone verbs, and independent ratings of the semantic similarity of the verbs-in-context to standard irregular senses. Unfortunately, Kim *et al.* did not take any measure of whether verbs were exocentric (i.e. derived from a noun) or not. The data for the second of the two predictors supposedly being compared were plucked from thin air. In Kim *et al.*'s study, verbs that were already known to have a regular past tense were defined as 'denominal' and verbs that were known to have an irregular past tense were defined as 'deverbal'. Kim *et al.* then tested to see whether this 'classification' would better predict acceptability than their semantic measures, and finding that it did, concluded that exocentric forms, not semantics, determined homophone inflection patterns.

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