According to a classic theory of language comprehension, word-order and plausibility information each provide a cue to meaning within a language, combining for interpretation. For example, in the implausible English sentence *The pizza ate the boy*, *pizza* is usually interpreted as the agent of *ate*, because English relies more heavily on word-order than plausibility (see Kim & Osterhout, 2005; Kuperberg et al., 2003, for evidence that people consider plausibility in their initial interpretation; see MacWhinney et al., 1984; MacWhinney & Bates, 1989; Croft, 2002; Ferreira, 2003; Bornkessel & Schlesewsky, 2006, for evidence that final interpretation is driven by word-order). We present a challenge to such models in the form of structures where English syntax does not determine interpretation.

We investigated the comprehension of materials like (1)/(2), each crossing syntax (active/passive in (1); double-object (DO)/prepositional-phrase object (PO) in (2)) with plausibility (plausible/implausible). In Experiment 1, participants read sentences and indicated their interpretation (agent/patient for actives/passives; patient/goal for PO/DO). The results showed that people are sensitive to both syntax and plausibility in the active/passive constructions (see Fig 1a and statistics below), but the factors do not interact. Critically, in the DO/PO constructions syntax and plausibility interact (Fig 1b). Furthermore, in the implausible DO construction (2d), people are at chance in choosing an interpretation, demonstrating that syntax does not determine interpretation. (We replicated this effect in two additional experiments.)

These results cannot be explained by a model with a single cue for English syntax. Such a model predicts the same biases across constructions. Furthermore, the relative frequencies of DO/PO constructions cannot explain the results because DO and PO constructions are more closely matched in frequency than actives/passives. However, these results are straightforwardly explained by a noisy-channel model of comprehension (cf. Levy, 2008; Levy et al. 2009). In our model, the speaker’s intended utterance is sometimes corrupted, due to speech errors or external noise. An implausible sentence can thus be generated in two ways: intentionally or unintentionally (due to corruption/noise). When listeners interpret a sentence, they rationally account for the noise that may have been added to it. For example, the implausible DO sentence (2d) can be generated by noise from the plausible sentence (2b), by swapping adjacent NPs *the candle* and *the daughter*, or from (2a) by omitting the preposition *to*. In contrast, the implausible PO sentence (2c) cannot be generated as easily from a plausible sentence: generating it either requires multiple swaps of adjacent terms; a swap of non-adjacent terms; or the insertion of a particular word (*to*). The noisy-channel model thus predicts that an implausible PO sentence should be more often interpreted as intentionally implausible than an implausible DO sentence (which is easily explained by noise).

The noise assumptions of the model were evaluated in Experiment 2. 60 participants were asked how likely someone might accidentally produce implausible sentences (2c,d), given that they intended to produce either a plausible DO or PO. The results demonstrated that participants believed that implausible DO sentences were more likely to be produced accidentally than implausible PO sentences (p<0.001), consistent with the model’s noise assumptions.
In conclusion, noisy-channel models – originally developed for NLP applications – have much potential for explaining key phenomena in human sentence comprehension.

(1)a. Active/plaus: The boy ate the pizza.  b. Passive/plaus: The pizza was eaten by the boy.  
c. Active, implaus: The pizza ate the boy.  d. Passive, implaus: The boy was eaten by the pizza. 

(2) a. PO, pls: The mother gave the candle to the daughter.  b. DO, pls: The mother gave the daughter the candle.  
c. PO,imp: The mother gave the daughter to the candle.  d. DO,imp: The mother gave the candle the daughter.

Noisy channel model details: The noisy-channel model assumes that individuals have a prior probability distribution $P_M(\text{meaning } m)$ over the meaning that the speaker intends to communicate. Plausible meanings are assigned higher prior probability than implausible meanings. Given that speakers want to communicate a particular meaning, they have a distribution $P_S(\text{intended utterance } v \mid \text{meaning } m)$ over utterances that they will use in order to communicate their meaning. The noise distribution $P_N(\text{perceived utterance } u \mid \text{intended utterance } v)$ determines the probability that the listener will perceive an utterance $u$ given that the speaker intended to say $v$. By marginalizing over the possible intended utterances of the speaker, it follows that a rational listener will have the distribution

$$P(m|u) \propto P_M(m) \sum_v P_S(v|m)P_N(u|v)$$

over the intended meaning of the speaker given a perceived utterance.