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A new paper just came out in Cognition! It has been an incredibly amazing experience working with @raryskin and @LanguageMIT. We provide a noisy-channel explanation for the age-old linguistic illusion called “depth-charge” sentences. Check it out!
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sciencedirect.com
A noisy-channel approach to depth-charge illusions
The “depth-charge” sentence, No head injury is too trivial to be ignored, is often interpreted as “no matter how trivial...

12:55 PM · Dec 12, 2022

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It is common to see what people interpret from a sentence is not what the sentence literally means. Now, please read this sentence “no head injury is too trivial to be ignored”. What does this mean?

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Most people read this to mean “we should not ignore head injuries no matter how trivial they are”.

But the literal meaning is the opposite which is “ignore head injuries”! (Language Log: languagelog.ldc.upenn.edu/nll/?p=24582)

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These are called “depth-charge” sentences because processing them is like a depth-charge bomb that explodes in your mind after a while (Sanford & Emmott, 2012). It’s puzzling how a sentence like this can be completely misinterpreted and people don’t notice.

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Previous theories differ in what causes the misinterpretation, without consensus. For example, “no”, “trivial”, “too...to”, and “ignore” might contain too many negative meanings that overload processing (Wason & Reich, 1979).

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Or, the comprehension is underspecified and driven by world knowledge (e.g., Sanford & Sturt, 2002; Paape et al. 2020).

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Or even, the sentence itself is plausible and makes sense because “too trivial to be ignored” in this context means “so trivial to the extent that a head injury can be ignored” (Cook & Stevenson, 2010; Fortuin, 2014).

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We offer new insights into understanding this illusion. We hypothesize that depth-charge sentences result from "noisy-channel" comprehension processes (Gibson et al., 2013; Levy, 2008; Ryskin et al., 2018, following Shannon 1948), modeled within the Bayesian framework:

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$$\underbrace{m_i \rightarrow s_i}_{\textbf{intended}} \quad \underbrace{\dashrightarrow \ldots \dashrightarrow}_{\textbf{noisy channel}} \quad \underbrace{s_p \rightarrow m_p}_{\textbf{perceived}} \qquad P(s_i \mid s_p) \propto P(s_i)\ P(s_i \rightarrow s_p).$$

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Readers infer the most likely intended meaning of a perceived sentence (sp) by weighing the plausibility of possible alternative sentences (si) against the likelihood of possible sentences being produced with errors into the perceived sentence.

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In four experiments, we find that (a) the more plausible the intended meaning of the depth-charge sentence is, the more likely the sentence is to be misinterpreted; (b) the higher the likelihood of our hypothesized noise operations, the higher the misinterpretation rate is.
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In Exp.1, we replicated Paape et al. (2020) (n=58), showing that the depth-charge sentence in English was indeed rated as more plausible than other implausible controls (e.g., Some head injuries are too trivial to be ignored).

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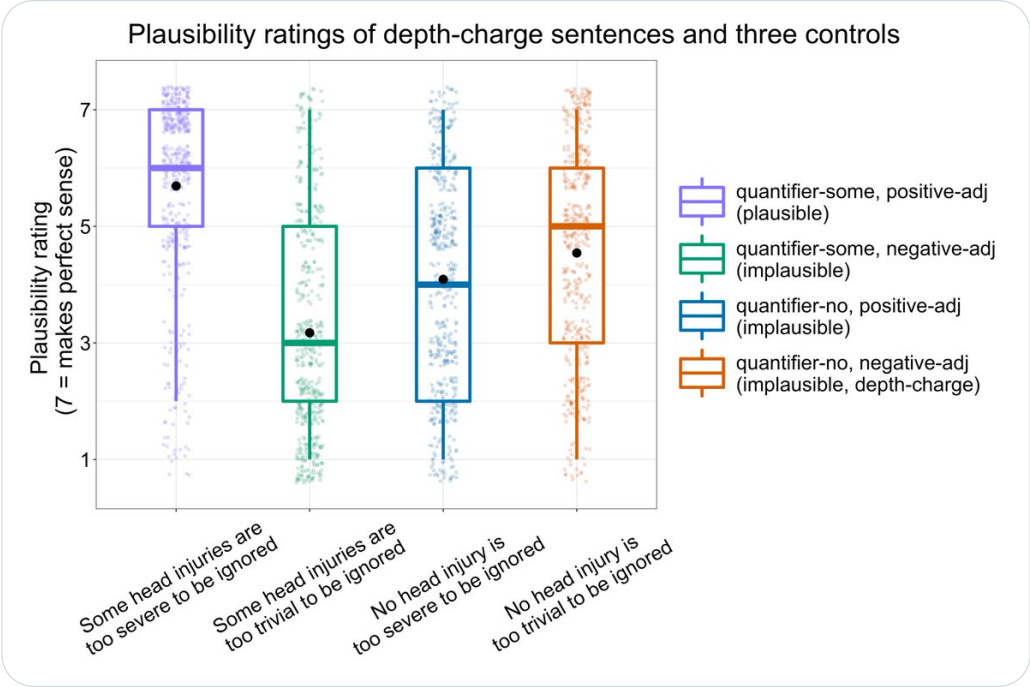

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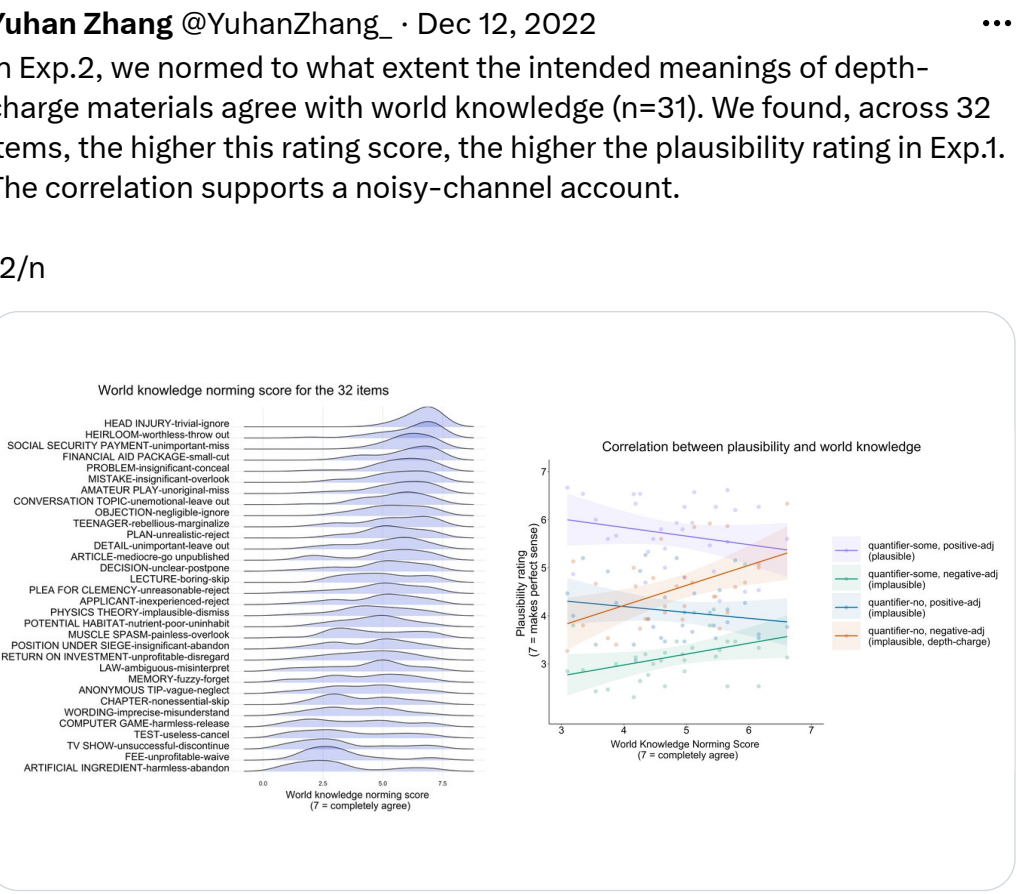

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In Exp.2, we normed to what extent the intended meanings of depth-charge materials agree with world knowledge (n=31). We found, across 32 items, the higher this rating score, the higher the plausibility rating in Exp.1. The correlation supports a noisy-channel account.

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We then proposed two noise operations for the intended sentence (si) to be produced as the depth-charge (sp). First, the intended sentence is “no head injury is so trivial as to be ignored” and the noise edit is a structural substitution (“so…as to” to “too…to”).

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Second, the intended sentence is “no head injury is too trivial to be treated” but is produced with an antonym substitution to be “...to be ignored”. We apply common production errors (e.g, Dell & Reich, 1981) to understand the depth-charge illusion.

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Conditions	Intended sentence (plausible)	Produced sentence (implausible)
Structural substitution *so…as to* → *too…to*	No head injury is so trivial as to be ignored.	No head injury is too trivial to be ignored. (depth-charge)
Structural substitution *too…to* → *so…as to*	No head injury is too trivial to be treated.	No head injury is so trivial as to be treated.
Antonym substitution with the intended *so…as to*	No head injury is so trivial as to be ignored.	No head injury is so trivial as to be treated.
Antonym substitution with the intended *too…to*	No head injury is too trivial to be treated.	No head injury is too trivial to be ignored. (depth-charge)

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In Exp.3, we constructed a 2x2 condition crossing noise type and the operation direction, using a noise-likelihood rating study. We found that structural substitution is more likely than antonym substitution.

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It is more likely for the intended “no head injury is so trivial as to be ignored” to be produced as the canonical depth-charge sentence “...is too trivial to be ignored” than from “too...to” to “so...as to”, consistent with how structural frequency interacts with production.

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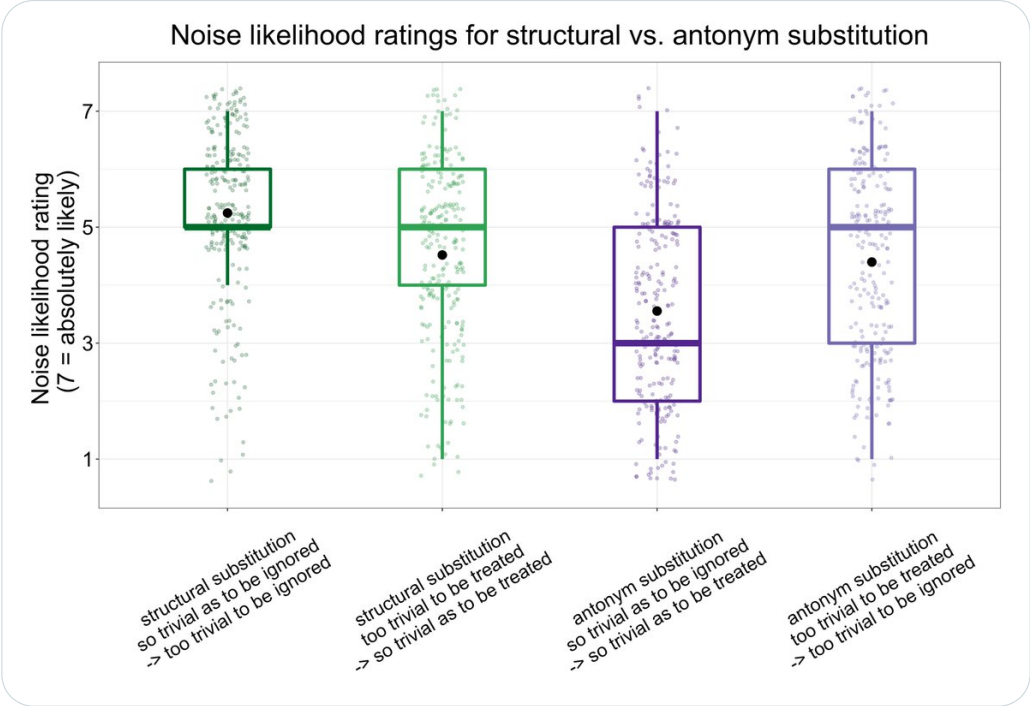

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In Exp.4, we found that the inference rates of the implausible sentences in the two structural substitution conditions positively correlated with their respective noise likelihood. This also supports the noisy-channel account.

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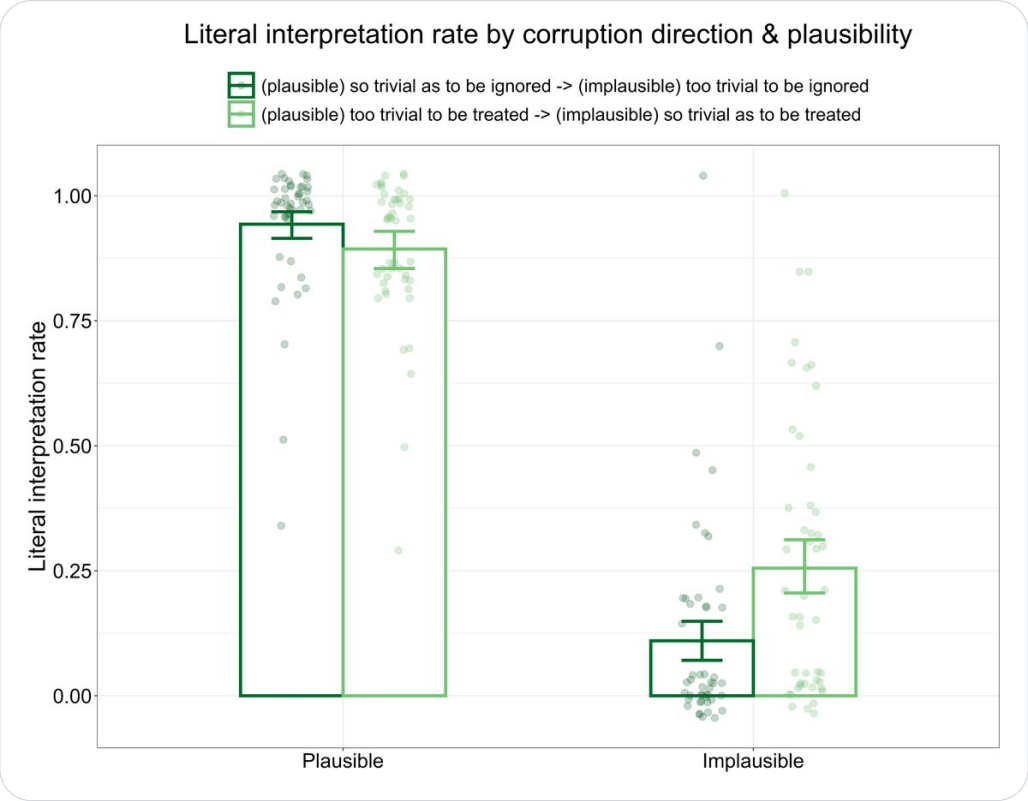

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In four experiments, the comprehension of depth-charge sentences is shown to correlate with (i) the plausibility of the intended meaning and (ii) the likelihood of hypothesized noise operations, which accord with predictions from the noisy-channel framework.

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Overall, we provide a promising noisy-channel account for the depth-charge illusion. In the future, we wish to explore more language illusions that could possibly be addressed by this framework.

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Open questions: How does negation work during the online processing of depth-charge sentences? There are so many of them and how do they affect each other?

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