

Individual differences in 1/f slope impact metonymy processing and meaning adaptation: An EEG investigation of naturalistic discourse

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Little is known about how listeners integrate expressions beyond their literal denotation such as referential metonymies (e.g., *The hoody is smiling*, where *the hoody* refers to the person wearing it) during the continuous construction of a discourse. Electrophysiologically, metonymies elicit a Late Positivity (LP) peak around 600 ms post onset, which has been interpreted as reflecting a referential shift / discourse update. LP amplitude is further modulated by the degree of conventionalisation, as evidenced by place-for-event metonymy: the more conventionalised a metonymy (e.g., *Woodstock*), the smaller the LP (Schumacher et al., 2023). Metonymy also elicits a larger N400, likely indicating prediction error, when the context does not facilitate the metonymic use (Schumacher, 2014). Previous research in this area has examined metonymies with little or no context in highly controlled experiments. Furthermore, individual differences have not been considered. In two EEG studies, we used naturalistic discourses to test repeated metonymic use to determine whether an ad hoc metonymic extension is instantiated in the discourse model immediately (LP at first mention only), or whether a gradual meaning adaptation occurs (gradual decrease of LP with increasing mentions). In a post hoc analysis, we tested whether differences in the aperiodic (1/f) slope of the EEG modulate this adaptation. The steepness of the 1/f slope is related to the extent of synchrony in neuronal firing, which has been linked to the degree of neural noise (Voytek & Knight, 2015). Steeper slopes reflect higher synchrony, accordingly, a higher degree of neural noise. Previous research in the language domain suggests that steeper 1/f slopes are associated with stronger predictive processing (Dave et al., 2018) and that individuals with steeper 1/f slope are more flexible in updating their internal predictive models in response to novel language input in comparison to those with shallower 1/f slopes (Bornkessel-Schlesewsky et al., 2022). Participants (N = 84, two EEG studies combined) listened to ten reports in German in which speakers described their interaction with four different people in the context of dating apps. After introducing each person with a salient property (see (1)), the property was used to refer to this person four times over the subsequent discourse. For both studies, only the first three mentions were analysed, because the manipulation did not differ up to that point. Event-related potentials were time-locked to the onset of each noun, all of which followed predicates licensing an animate agent to enforce the metonymic reading (German verb-before-subject structure). Data were analysed with linear mixed models with mean amplitude as dependent variable and condition (metonymy vs. control – 20 each x 3 mentions = 120), region of interest (ROI), mention (position of each mention within report) and 1/f slope for each participant as fixed factors. The random effect structure included random intercepts and slopes by items for mention and random intercepts and slopes by subjects for mention and condition. The results indicate a biphasic N400-LP effect for metonymy vs. controls (see fig. 1). In line with previous findings from controlled experiments, we interpret the N400 (300-800 ms) as reflecting a context-induced prediction error and the LP (800-1200 ms) as reflecting inference-based updating costs. The data further provide evidence of a gradual process of conventionalisation as discourse unfolds (decreasing LP with increasing mention – see fig. 2) and a decrease in prediction error (decreasing N400). Regarding the influence of individuals' 1/f slope on conventionalisation: while there was no effect of 1/f on the N400, the analysis revealed a 4-way interaction of 1/f slope*condition*mention*ROI. Participants with steeper 1/f slopes showed larger LP effects for metonymies early on in the text and a more substantial reduction of the LP effect over subsequent mentions. This suggests that participants with a steeper 1/f slope adapt quicker to metonymic shifts, likely due to higher suppression of the literal meaning. These results indicate that neurophysiological differences shape the process of pragmatic inferencing and meaning adaptation.

References

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(1) Stimulus (sentence snippets) example from Report 1 translated from German

I vividly remember the moment when I decided to use a dating app to get to know someone. [...] I met the first guy after writing back and forth for a while. He was a businessman who worked on sustainable projects in his spare time. It all seemed quite nice, but the **businessman₁** only talked about himself. [...] Another guy I met was a bit more reserved in his writing, but the pictures he had of himself on his profile were very appealing. When we met, I recognized him straight away, since he was wearing the fedora that I recognized from his photos. After we got ourselves a coffee, the **fedora₁** was already chatting to me very actively, which was really pleasant. In comparison, the **businessman₂** hardly spoke at all. [...] But I have to say that the **fedora₂** was much more interested. By contrast, the **businessman₃** student didn't behave particularly pleasantly. I found it odd that I knew more about his studies than about him as a person [...] The **fedora₃** frequently to me. He even asked me for another date.

FIGURE 1

Mean amplitude (μV , y-axis) as a function of time (ms, x-axis) for metonymy (yellow) and control condition (blue). Categorical division of mentions (1-3) for visual purpose only (subscript 1 in example).

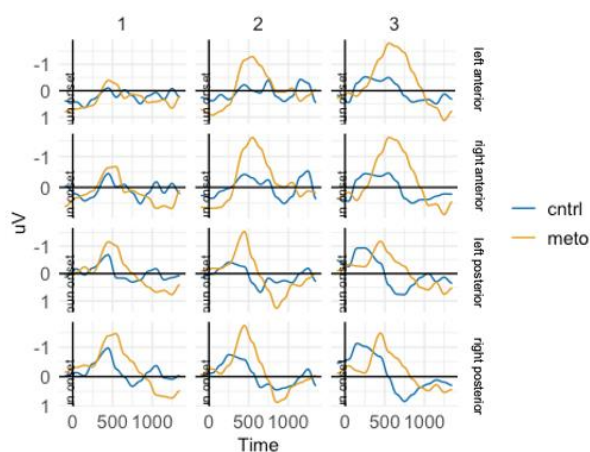


FIGURE 2

4-way interaction of ROI & condition & mention & 1/f slope for mention 1-3. Mention divided from the 5th to the 95th quantile (visualisation purpose only). Trichotomisation of 1/f slope into low, medium, and high for visual purposes only.

