Prediction and its limits in the processing of negative polarity items

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Predictive processing is a key topic in the neurolinguistic literature, although most work has focused on lexical-semantic pre-activation and the role of *contextual constraints* [2;8;13]. Divergently, psycholinguistic literature on this topic has focused on expectations in the processing of (syntactic, semantic, pragmatic) *dependency relations* [6;11]. We combine insights from both fields to investigate ERPs and oscillatory dynamics in the maintenance and resolution of the dependency relation between a negative polarity item (NPI) and its licenser. NPIs require a "negative" environment, which is governed by syntactic, semantic, or pragmatic licensing mechanisms [1;3;7;10]. Crucially, German allows some NPIs to precede their licenser (see (1)), instantiating a forward-looking dependency with an upcoming licenser.

Experiment: In a 2x2 design, we manipulated the presence of an NPI and position of the licensing negation. The remaining context stayed constant, allowing us to target both pre- and post-negation windows to reveal (i) processing mechanisms while maintaining an expectation for a grammatically necessary negation, and (ii) integratory processes once negation occurs. EEG was recorded while 32 younger adults read 160 items and 160 grammatical fillers presented at 400ms per word. Target items contained *nicht* 'not' before (1a/b) or after (1c/d) a prepositional phrase (PP). Negation is obligatory for NPI conditions (1a/c) but optional without NPI (nonPI) (1b/d). Fillers used similar structures (also starting with *so* in one half and *sehr* 'very' in the other), but no negation. Stimuli were normed for naturalness, with no significant differences (all t<2). Data was collected over two sessions to reduce adaptation to the material.

Analyses: ERPs were analysed via cluster-based permutation tests (CBPTs) on the 100-800ms window time-locked to the negations. Time-frequency (TF) data in the beta and gamma band (linked to prediction+integration [12;14;15]) were analysed using wavelet analysis. Using CBPTs, oscillatory power in the NPI and nonPI conditions was compared in an 0.8s time window time-locked to the negations and in two preceding time windows, the 2s window before early ('<u>is he in the company</u>') and the 1.6s window before late negation ('<u>with the monthly revenue</u>'). In all comparisons, licenser expectations arguably exist only for the NPI conditions.

ERP results. CBPTs indicated a significant difference (p<.05) between conditions (1a) and (1b) due to a frontal negativity in the NPI condition, with the cluster extending from roughly 512-600ms. No significant differences were found at the late negation (1c vs. 1d).

TF results. CBPTs indicated increased beta power for the NPI compared to the nonPI conditions in the region preceding early negation (p<.05), as well a combination of reduced beta (p<.05) and increased gamma power (p<.05) at early negation itself. In the region preceding late negation, we find no differences between the NPI and nonPI conditions. At late negation itself, beta power was increased for the NPI compared to the nonPI condition (p<.05).

Discussion: The anterior negativity in the ERP data mirrors results for filler-gap dependencies [4;5;9]. In line with that work, it may reflect memory costs of storing and integrating the NPI with its licenser. The time-frequency activity preceding and including early negation is further in line with active prediction of the licenser, as increased beta activity preceding a target has previously been linked to prediction maintenance, whereas gamma activity at the target word is argued to reflect a match between bottom-up and top-down input [12;14;15]. Still, the absence of ERP effects at late negation and the lack of beta-gamma effects at this region suggest that active prediction of the licenser may wane with increased distance, instead re-emphasising bottom-up processing mechanisms. Our study contributes to understanding the engagement and the limits to predictive mechanisms in language processing.

(1) *Holger hat letztes Jahr einen eigenen Betrieb gegründet.*
Holger has last year a own company founded
a./b. *{So recht$_{NPI}$/Sehr häufig$_{nonPI}$} <u>ist er in der Firma</u>* ***nicht*** *<u>mit dem monatlichen Umsatz</u> zufrieden.*
{Really$_{NPI}$/ Very often$_{nonPI}$} <u>is he in the company</u> **not** <u>with the monthly revenue</u> satisfied
c./d. *{So recht$_{NPI}$/Sehr häufig$_{nonPI}$} <u>ist er in der Firma</u> <u>mit dem monatlichen Umsatz</u>* ***nicht*** *zufrieden.*
{Really$_{NPI}$/ Very often$_{nonPI}$} <u>is he in the company</u> <u>with the monthly revenue</u> **not** satisfied
Holger has founded his own company last year. {He is not really satisfied with the monthly revenue./He is not very often satisfied with the monthly revenue.}

Table 1: Example of the stimulus material used in the experiment. Colours indicate whether the second sentence started with an NPI (red) or a nonPI (blue). Negations (ERP analysis regions) are marked in bold. Additional regions of interest for the time-frequency analysis are underlined.

condition	expression	negation	mean	sd
1a	NPI	early	5.34	0.90
1b	nonPI	early	5.02	1.09
1c	NPI	late	5.32	0.93
1d	nonPI	late	5.19	0.96

Table 2: Norming study results–Naturalness ratings (1-7) for the 160 items included in the EEG study.

Fig. 1: Representative electrode for the comparison of NPI and nonPI at the early negation

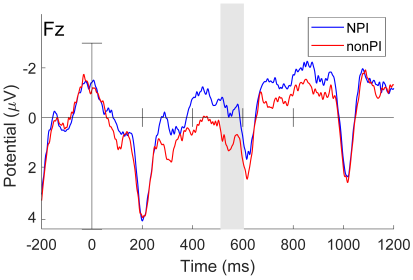


Fig. 2: Representative topography of the cluster revealed from comparing NPI and nonPI at the early negation (1a vs.1b)

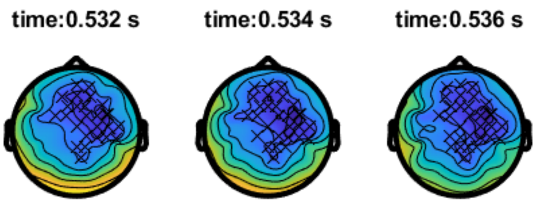
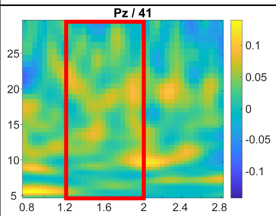
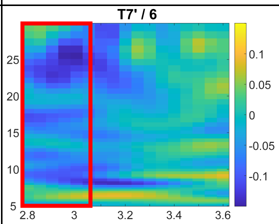
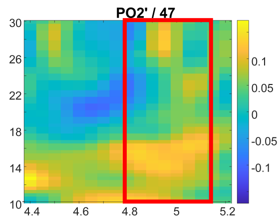
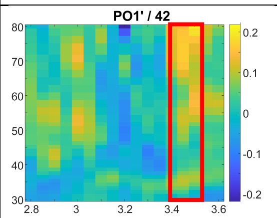


Fig. 3: Time-frequency effects for the comparison of NPI and nonPI indicated by time from sentence onset. Duration of cluster significance is indicated by red highlights.

	0.8s-2.8s	2.8s-3.6s	2.8s-4.4s	4.4s-5.2s
	is he in the company	*not$_{Early}$*	*with the monthly revenue*	*not$_{Late}$*
BETA			n.s.	
GAMMA	n.s.		n.s.	n.s.

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