The role of context predictiveness in younger and older adults: EEG coherence in alpha and theta frequency bands

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Introduction. Although there is a lot of evidence for predictive processing during language comprehension, only recently electrophysiological signatures have been explored in young adults (Rommers, Dickson, Norton, Wlotko, & Federmeier, 2017). In older adults, these neural signatures have not been investigated yet, although there is evidence from N400 ERP studies for less efficient use of context in late adulthood (e.g. Federmeier, 2007). One of the difficulties of studying linguistic prediction is that researchers cannot easily differentiate between facilitated integration and pre-activation of the stimulus especially when measuring responses to a stimulus that matches or mismatches the context (e.g., through the N400) (Kutas, DeLong, & Smith, 2011). Here, we investigated the time sequence of neural events in the formation and verification/violation of predictions in older and younger adults by differentiating pre-activation and integration. We used coherence analysis (e.g., Shaw, 1984) to measure brain activity before the presentation of the target word and analysis of the N400 ERP component after the presentation of the target word. If older adults use prediction less efficiently than younger adults, as the N400 literature suggests, then they should also show weak pre-activation effects.

Methods. Younger (N=22; mean age= 24) and older (N=22, mean age = 67) individuals performed a picture-word matching task (materials and procedure from Dikker & Pylkkänen, 2011) in which sometimes the word could be predicted by the previous picture (e.g., the picture of an apple would predict the word "apple") (Predictive) and sometimes not (e.g., the picture of a grocery bag would not predict a specific word) (Non-Predictive). Before the presentation of the target word, we measured EEG coherence in theta and alpha bands, frequently associated with predictive processing, contrasting Predictive and Non-Predictive trials. Post word onset, we measured the N400 between match and mismatch trials.

Results. Linear mixed-effects models were adopted in the R environment (R Core Team, 2016). For the coherence analyses, we entered Predictiveness (Predictive/Non-Predictive), and Age (Younger/Older) with maximal random-effect structure. For the alpha band, we found a main effect of Predictiveness ($t = -2.14$; $p = .039$), in that Non-Predictive items showed greater alpha coherence than Predictive items, but no effect of age ($t = -0.94$; $p = .352$) nor interaction of Predictiveness x Age ($t = -0.38$; $p = .707$) (Fig. 1). Similar pattern of results was found for the theta band: Predictiveness was significant ($t = -2.17$; $p = .036$), but no effect of Age ($t = -0.94$; $p = .355$) nor interaction ($t = 0.39$; $p = .697$). For the N400 analysis, we entered Predictiveness, Congruency (Match/Mismatch), and Age as fixed effects and maximal random-effect structure. We found main effects of Predictiveness ($t = 3.87$, $p < .001$), Congruency ($t = 3.63$, $p < .001$), and Age ($t = 2.65$, $p < .001$). We also found a three-way interaction Predictiveness x Congruency x Age ($t = -2.33$, $p = .022$). Post-hoc analyses revealed that the effect was driven primarily by the younger adults (Fig. 2).

Discussion. We found decreases in alpha and theta band coherence in the Predictive condition, similarly to other studies (e.g., Rommers et al., 2017). This decrease has been connected with memory access (Pia, Roelefs, & Maris, 2004) or preparation for the upcoming input (Rommers et al., 2017). Younger and older adults did not differ in the pre-activation measures, suggesting that in both groups the underlying processes in preparation of upcoming input may be similar. Post word onset, older adults showed less negativity than younger adults independently of condition. Contrary to younger, older adults showed N400 effect in both Predictive and Non-predictive items. That may suggest that although older and younger adults use the same pre-activation processes, the integration process may be different. According to recent theories, the N400 may reflect prediction error (Rabovsky, Hansen, & McLeland, 2017). In this light, older adults may be more affected by context than younger adults, which may explain the presence of a prediction error even when the context is subtle.
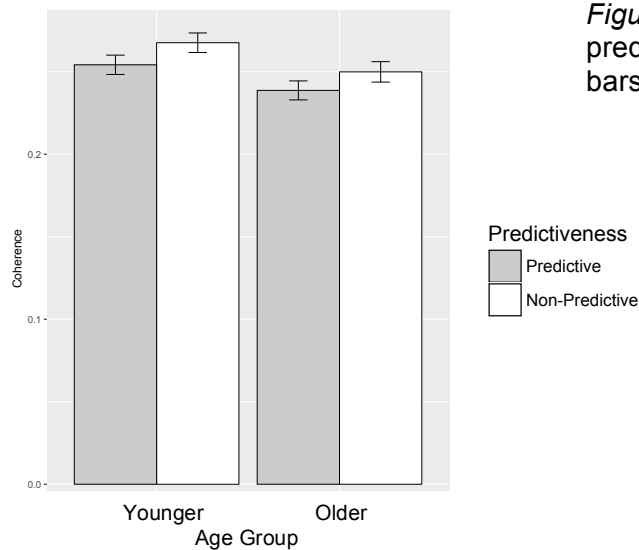
Figure 1. Coherence in alpha frequency band in predictive and non-predictive items. The error bars present standard error of the mean.

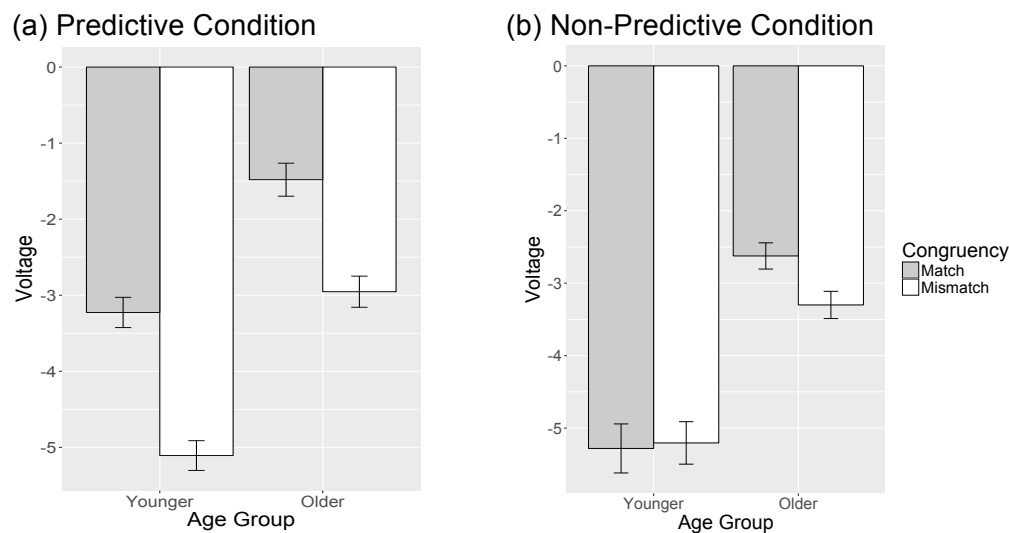(a) Predictive Condition

(b) Non-Predictive Condition

Figure 2. Predictive (a) and Non-Predictive (b) conditions contrasting the N400 component in younger and older individuals. The error bars present standard error of the mean.

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