# Appendix S2

*Reversed polarity analysis*

## 1. The analysis

In order to distinguish the MMN effect from the N100 effect, we conducted an additional analysis focused on the comparison of MMN/MMP responses recorded at frontal-central sites (F1, F2, F3, F4, Fz, FC1, FC2, FC3, FC4, FCz, C1, C2, C3, C4 and Cz) and those recorded at the mastoid sites (TP9 and TP10). The pre-processing steps for this analysis were performed in the same way as reported in the main paper; however, the signal was in this case re-referenced offline to the average of all EEG electrodes, rather than to the approximated right and left mastoid bones. The inspection of 'collapsed' waveforms revealed increased negativity in the 100–200 ms time window at the frontal-central electrodes, with an accompanying positivity at the mastoid electrodes (see Figure S1).

In order to check whether the conditions are significantly different, we performed a linear mixed effects analysis with the aid of the lme4 package (Bates et al., 2012) in the R software (R Core Team, 2012) in the MMN/MMP time window (i.e., 100–200 ms). Sound (i.e., standard and deviant) and site (i.e., frontal-central and mastoids) were included in the model as fixed effects, and the intercepts for participants and for electrodes were included as random effects. In addition, in order to compare the size of the effect (expressed in terms of the deviant minus standard difference) in the three languages under investigation, we conducted another linear mixed effects analysis, with language (i.e., Polish, English, and Norwegian) and site (i.e., frontal-central and mastoids) as fixed effects, and the intercepts for participants and for electrodes as random effects. The descriptive statistics for these analyses are presented in Table S3 and Table S4 below.

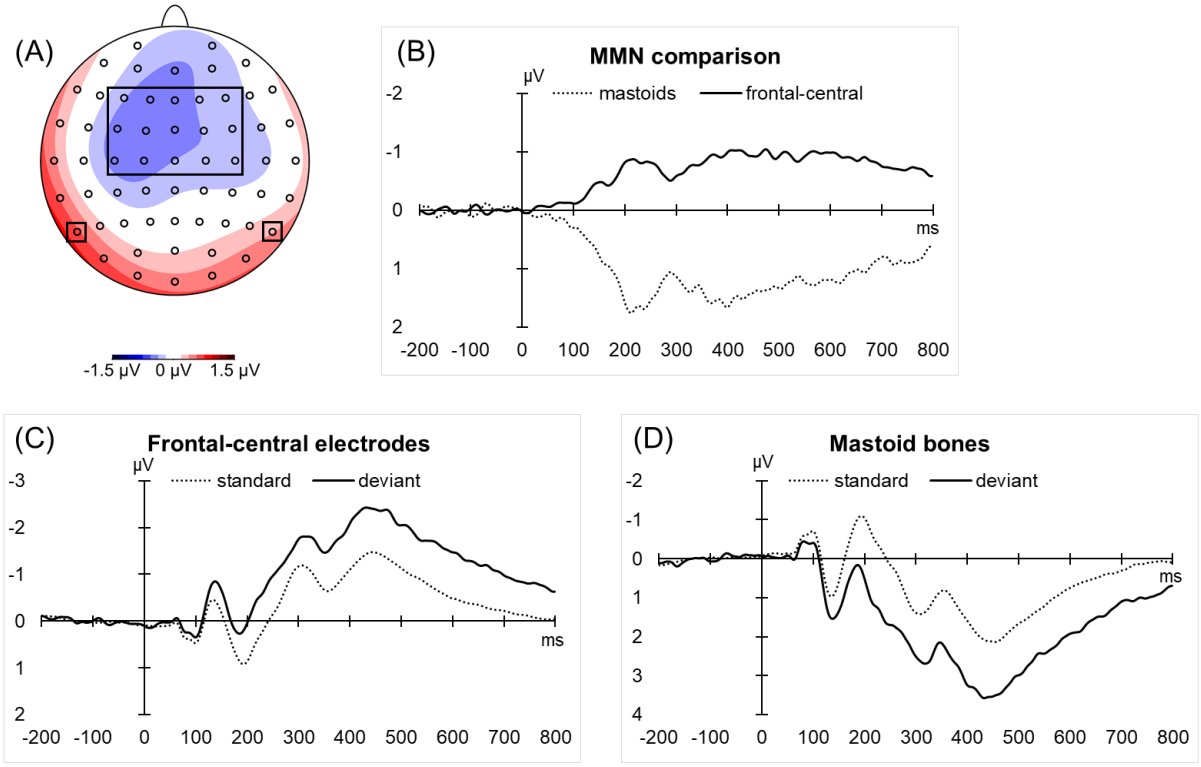


**Figure S1:** The comparison of MMN/MMP responses recorded at mastoid electrodes (TP9 and TP10) versus those obtained from frontal-central electrodes (F1, F2, F3, F4, Fz, FC1, FC2, FC3, FC4, FCz, C1, C2, C3, C4 and Cz). Panel A presents mean voltage difference maps (deviant minus standard), with the electrodes of interest marked in rectangles. Panels A–C present the comparison of the MMN/MMP recorded at both sites (panel B) as well as grand average ERPs time-locked to the onset of the standard (dashed line) and deviant (solid line) at frontal-central electrodes (panel C) and mastoid electrodes (panel D).

| | **emmean** | **SE** | **df** | **lower.CL** | **upper.CL** |
|---|---|---|---|---|---|
| ***Frontal-central*** | | | | | |
| standard | 0.263 | 0.114 | 26.1 | 0.0282 | 0.4980 |
| deviant | –0.205 | 0.114 | 26.1 | –0.4399 | 0.0298 |
| ***Mastoids*** | | | | | |
| standard | –0.131 | 0.143 | 52.1 | –0.4193 | 0.1564 |
| deviant | 0.680 | 0.143 | 52.1 | 0.3918 | 0.9675 |

**Table S3:** Descriptive statistics for standard and deviant sounds obtained at two sites: frontal-central and mastoids.

| | **emmean** | **SE** | **df** | **lower.CL** | **upper.CL** |
|---|---|---|---|---|---|
| ***Frontal-central*** | | | | | |
| L1 Polish | –0.666 | 0.0799 | 49.5 | –0.826 | –0.505 |
| L2 English | –0.469 | 0.0800 | 49.6 | –0.630 | 0.308 |
| L3/L*n* Norwegian | –0.281 | 0.0799 | 49.5 | –0.441 | 0.120 |
| ***Mastoids*** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| L1 Polish | 1.240 | 0.1707 | 100.8 | 0.901 | 1.579 |
| L2 English | 0.744 | 0.1707 | 100.8 | 0.406 | 1.083 |
| L3/L*n* Norwegian | 0.449 | 0.1707 | 100.8 | 0.110 | 0.788 |

**Table S4:** Descriptive statistics for the MMN/MMP (expressed in terms of deviant minus standard difference) in the language conditions (Polish, English, and Norwegian) at two sites: frontal-central and mastoids.

## 2. ERP results

Model comparison revealed a statistically significant interaction effect between sound and site ($\chi^2$ (1) = 107.77; $p < 0.001$). We then performed Tukey based pairwise comparisons, the results of which revealed that deviant sounds elicited significantly more negative amplitudes than standard sounds at the frontal-central electrodes ($p < 0.001$), but significantly more positive amplitudes at the mastoid electrodes ($p < 0.001$) (see Table S5). Further, we observed a statistically significant interaction effect between language and site (see Figure S2) ($\chi^2$ (2) = 26.04; $p < 0.001$). At the frontal-central electrodes, we observed statistically significant differences between all language pairs: Polish-English ($p < 0.05$), English-Norwegian ($p < 0.05$), and Polish-Norwegian ($p < 0.001$). At the mastoids, we observed statistically significant differences only between Polish and Norwegian ($p < 0.001$) (see Table S6).

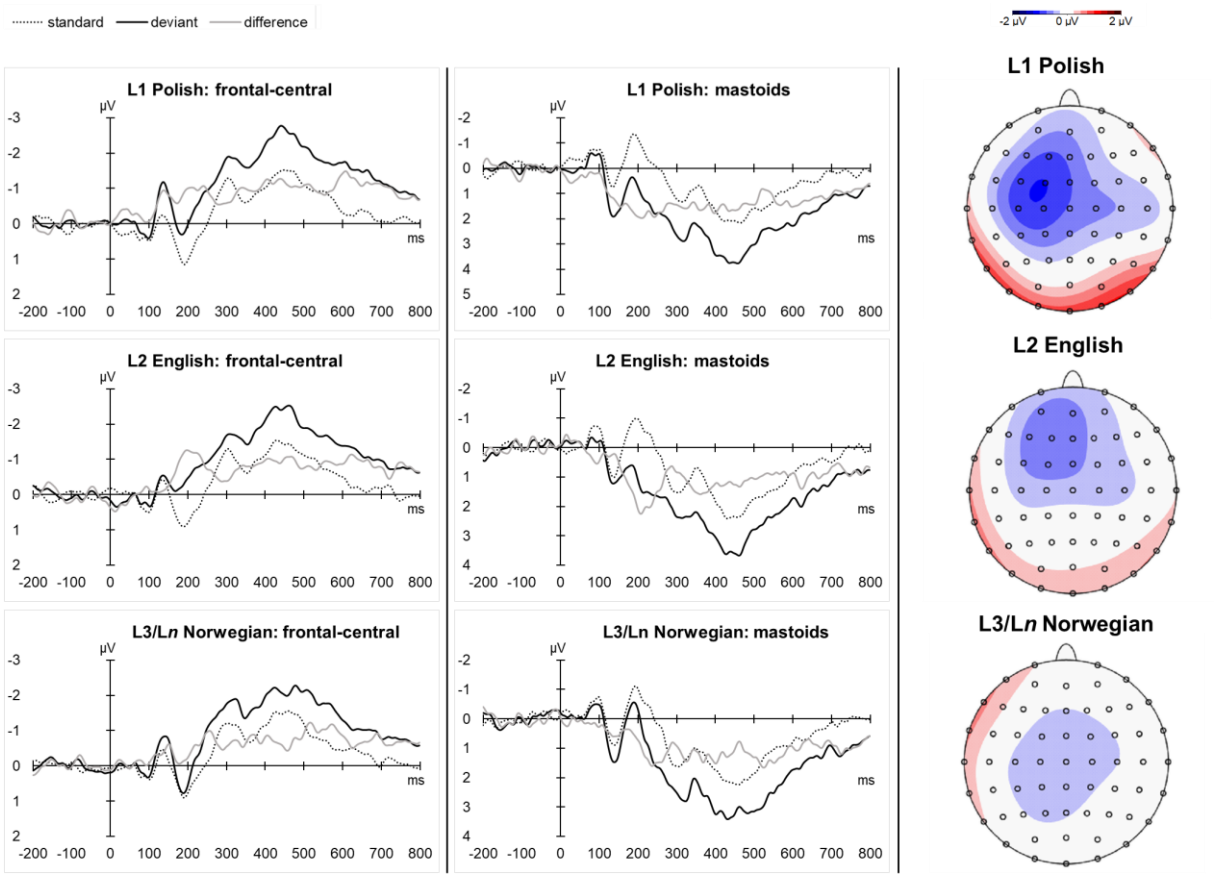


**Figure S2:** The comparison of MMN/MMP responses recorded at mastoid electrodes (the left panel) and frontal-central electrodes (the middle panel) in L1 Polish, L2 English, and L3/L*n* Norwegian. The right panel presents mean voltage difference maps (deviant minus standard) in the three conditions in question.

| Compared Conditions | Estimate | SE | df | t.ratio | *p*-value |
|---|---|---|---|---|---|
| ***Frontal-central sites*** | | | | | |
| deviant–standard | –0.468 | 0.0418 | 2206 | –11.203 | <0.001 |
| ***Mastoids*** | | | | | |
| deviant–standard | 0.811 | 0.1144 | 2206 | 7.091 | <0.001 |

**Table S5**: Pairwise comparisons between experimental conditions: standard/deviant and frontal-central/mastoids. Degrees-of-freedom method: Kenward-Roger. P-value adjustment: Tukey method for comparing a family of 3 estimates.

| Compared Conditions | Estimate | SE | df | t.ratio | *p*-value |
|---|---|---|---|---|---|
| ***Frontal-central sites*** | | | | | |
| English–Polish | 0.197 | 0.0792 | 1079 | 2.485 | 0.0349 |
| Norwegian–Polish | 0.385 | 0.0791 | 1079 | 4.866 | <0.001 |
| English–Norwegian | –0.188 | 0.0792 | 1079 | –2.377 | 0.0463 |
| ***Mastoids*** | | | | | |
| English–Polish | –0.495 | 0.2166 | 1079 | –2.287 | 0.0580 |
| Norwegian–Polish | –0.791 | 0.2166 | 1079 | –3.651 | <0.001 |

| | | | | | |
|---|---|---|---|---|---|
| English–Norwegian | 0.295 | 0.2166 | 1079 | 1.364 | 0.3605 |

**Table S6**: Pairwise comparisons for the MMN/MMP effect expressed in terms of the deviant minus standard difference in the three language conditions: Polish, English and Norwegian. Degrees-of-freedom method: Kenward-Roger; p-value adjustment: Tukey method for comparing a family of 3 estimates.