Somatosensory evoked field similarity in monozygotic twins

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Introduction

Genetic studies of the electroencephalogram (EEG) in twins indicate a genetic contribution to individual differences in electrical brain activity. However, EEG is affected by electrical conductivity of tissue layers between the brain and recording sensors and heritability estimates may be inflated by greater similarity of intervening biological tissues in mono- than dizygotic twins. In this study we assess heritability of somatosensory brain activity with magnetoencephalogram (MEG) which is influenced much less by intervening tissue.

Methods

Averaged Somatosensory Evoked Fields (SEFs) were measured in 20 healthy right-handed MZ twin pairs, recruited from the Netherlands Twin Register (10M/10F; between 18 and 19 years), using a 151 sensor MEG scanner (VSM Medtech ltd). In two separate 2.5 minutes sessions the left and right hand was stimulated, at 2 Hz with pulse duration of 0.2 ms. Stimulus intensity was adjusted for each individual, just below the threshold of thumb twitch.

To correct for the influence of head position on MEG amplitudes, SEF data for each individual were extrapolated onto new data sets that all have the same sensor locations, corresponding to an average head position across all twins.

For each individual, characteristic SEF templates were obtained for two consecutive time windows. The templates were obtained by averaging in each time window the sensor that showed maximum magnetic outflux and the sensor that showed maximum influx (fig. 1).

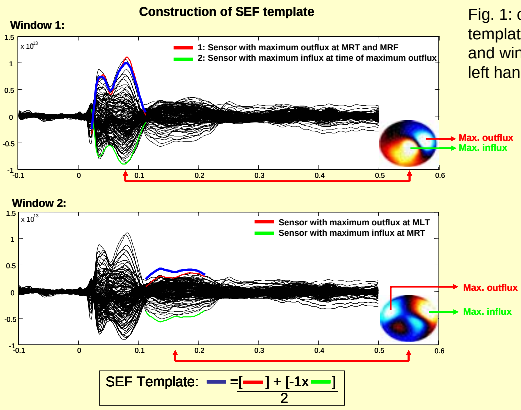

Fig. 1: construction of SEF template (in blue) for window 1 and window 2 illustrated for a left hand SEF.

Time window 1 covered the initial 90 ms phase of the SEF starting from the peak of the first SEF component; representing primary sensory cortex (SI) activation.

Time window 2 covered a subsequent, and final, 100 ms phase of the SEF; representing bilateral secondary somatosensory cortex (SII) activation.

Two between SEF template distance measures were used:

A: 1-temporal waveform correlation between SEF templates of two twins:

$$1-\frac{\sum_{i=1}^{N}(Xi-\overline{X})\bullet(Yi-\overline{Y})}{\sqrt{\sum_{i=1}^{N}(Xi-\overline{X})^2}\bullet\sqrt{\sum_{i=1}^{N}(Yi-\overline{Y})^2}}$$

B: euclidean amplitude difference between SEF templates of two twins:

$$\sqrt{\sum_{i=1}^{N}(Xi-Yi)^2}$$

with: X: template twin 1
Y: template twin 2
N: # samples

One way ANOVA, was applied to test whether distances between SEF templates of twins from MZ twin pairs (N=20) were lower compared to the distribution of SEF distances for all possible pairings of unrelated twins (N=760).

Results

SEF correlation and amplitude distances between SEF templates of twins, computed separately for left hand SEFs and right hand SEFs, are listed in Table 1.

stimulated hand	1-correlation window 1	1-correlation window 2	amplitude difference (pT) window 1	amplitude difference (pT) window 2
between twins of MZ twin pairs				
left	0.36 ± 0.40	0.58 ± 0.50	0.38 ± 0.17	0.29 ± 0.10
right	0.23 ± 0.18	0.39 ± 0.36	0.35 ± 0.14	0.27 ± 0.13
total	0.29 ± 0.27	0.48 ± 0.31	0.37 ± 0.10	0.28 ± 0.09
between unrelated twins				
left	0.70 ± 0.38	0.90 ± 0.55	0.61 ± 0.25	0.36 ± 0.14
right	0.70 ± 0.39	0.86 ± 0.55	0.68 ± 0.23	0.44 ± 0.18
total	0.70 ± 0.38	0.88 ± 0.55	0.65 ± 0.24	0.40 ± 0.17

Statistical analysis indeed confirmed that distances of SEF templates between twins of MZ twin pairs were significantly lower compared to template distances between randomly coupled, unrelated, twins (see also fig. 2):

one-way ANOVAs: distances between twins of MZ twin pairs (N=20) vs. distances between randomly coupled, unrelated, twins (N=760)

1-correlation:
left SEF , $F(778,1) = 15.64$, $p<0.001$ (window 1); $F(778,1) = 6.63$, $p=0.010$ (window 2)
right SEF , $F(778,1) = 30.06$, $p<0.001$ (window 1); $F(778,1) = 15.03$, $p<0.001$ (window 2)

Amplitude difference:
left SEF , $F(778,1) = 17.05$, $p<0.001$ (window 1); $F(778,1) = 5.63$, $p=0.018$ (window 2)
right SEF , $F(778,1) = 42.40$, $p<0.001$ (window 1); $F(778,1) = 17.86$, $p<0.001$ (window 2)

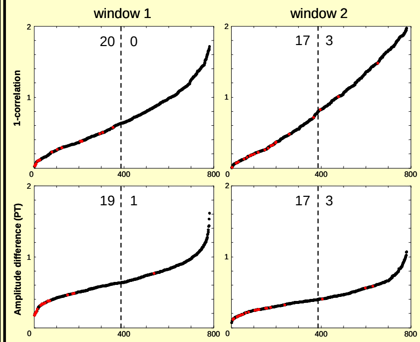

Fig. 2: Distances between templates of right hand SEFs for all possible twin couplings (N = 780); sorted in ascending order. For both distance measures and both time windows, the large majority of template distances between twins of MZ twin pairs (red dots: N = 20) are below the median (dashed vertical).

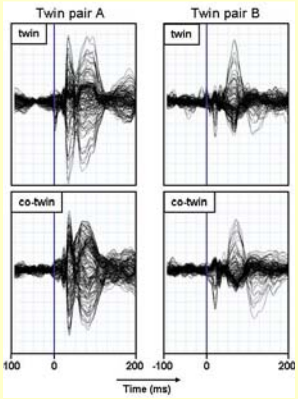

Fig. 3: SEFs of two selected twin pairs; the pairs exhibit high within twin pair (columns) but low between twin pair (rows) resemblance.

Conclusions

Our findings indicate that somatosensory evoked fields show a high degree of correspondence within MZ twin pairs (see also Fig. 3). This is compatible with a substantial influence of genetic factors on evoked brain activity, suggesting that MZ resemblance for brain activity is not a byproduct of greater MZ similarity in intervening biological tissue.
To exclude an effect of shared environment on SEF resemblance, we are currently extending the study with dizygotic (DZ) twin pairs.