EVENT-RELATED CORRELATIONS BETWEEN BRAIN ELECTRICAL ACTIVITIES OF SEPARATED HUMAN SUBJECTS:

PRELIMINARY RESULTS OF A REPLICATION STUDY

Jiří Wackermann, José Raúl Naranjo Muradás, & Peter Pütz

Dept. of Empirical and Analytical Psychophysics,
Institute for Frontier Areas of Psychology and Mental Health (IGPP)
Freiburg i.Br., Germany

Grinberg-Zylberbaum et al. (1994) reported an experiment with pairs of spatially separated, sensorily and electrically isolated subjects, in which one member of the pair was stimulated with light flashes eliciting brain electrical responses (visual evoked potential, VEP) while the other subject was resting; brain electrical activities (EEG) of both subjects were recorded simultaneously. The authors claimed that, if an emotional bond between the subjects was established, 'transferred potentials' (TP) occurred in the electrical activity of the non-stimulated subject synchronously with the VEPs in the stimulated subject. Later attempts to reproduce these findings were only partially successful (Fenwick et al., 1998; Sabel et al., 2001), but positive results from several conceptual replications have been recently reported (Standish et al., 2003; Radin, 2003; Radin, in press). — In our study based essentially on the same paradigm (Wackermann et al., 2003), we have not observed any 'transferred potentials', but we have found significant fluctuations of the average EEG power in the non-stimulated subjects at times of maximal VEPs in the stimulated subjects. The effect was independent from an emotional bond between the subjects. Here we are reporting results of a replication study.

Sixteen pairs of related subjects participated in the study (13M, 19F, age range 19–58 years). The relationship's duration and subjective rating of its intensity were recorded for each participating pair, but no special procedure was used to enhance the emotional connection between them. The subjects were seated in two electrically and acoustically shielded rooms, separated by ~50 cm empty space between the doubled walls of the rooms (average acoustic attenuation –64 dB). One member of the pair (A) was viewing a monitor on which the visual stimuli were intermittently displayed; the other member of the pair (B) was resting, with eyes open, in a dark room. In the stimulation periods of 1 sec duration an alternating black/white checkerboard pattern (three pattern reversals after each 250 msec) was displayed; during the inter-stimulus intervals (ISI) the monitor was blank. Each experimental session consisted of two halves: in one half of the session subject A was visually stimulated, while in the other half the monitor was covered by an opaque shield. The conditions, hereinafter referred to as 'uncovered' and 'covered', were applied in counter-balanced order. 168 stimuli were presented in each condition (duration ~12 minutes each), with ISI's randomly varied from 1.6 to 7.6 sec.

19-channel EEG was recorded simultaneously from both subjects during the sessions (sampling rate 256 data vectors/sec, band pass 0.15–70 Hz), using two EEG recording systems EADC220 (M&I Ltd, Prague, Czech Rep.) and stored on two different computers. Off-line, one-second segments of artefact-free EEG, aligned with the stimulus onset, were visually identified, re-computed against average reference, and de-trended. A pool of N_S post-stimulus and N_I inter-stimulus EEG segments was obtained for each subject and condition. Post-stimulus EEG data were averaged, and effective voltage of the averaged EEG was calculated in a sliding window,

$$V_{\text{eff}}(t) = \sqrt{\frac{1}{l}\sum_{s=-l/2}^{+l/2} u_{t+s}^2}\quad ,$$

where u_t denotes the averaged EEG voltage at time t (for a given channel and subject), and l is the window length. We used $l = 35$ data points (i.e. ~136 msec) consistently with Wackermann et al. (2003).

The variable of interest was $V^{\text{B}}_{\text{eff}}$ of the non-stimulated subject B at latencies t^*, at which $V^{\text{A}}_{\text{eff}}$ of the subject A in the condition ‘uncovered’ (i.e., physically stimulated) attained its maximum. To make these values inter-individually comparable, they were divided by $V^{\text{B}}_{\text{ref}}$ = median of 1000 effective voltages calculated for 1000 subsets of N_{S} segments which were drawn randomly from N_{I} inter-stimulus EEG segments and averaged. Thus we evaluated the ratios

$$Q = \frac{V^{\text{B}}_{\text{eff}}(t^*)}{V^{\text{B}}_{\text{ref}}}$$

individually for each condition, subjects pair and electrode site. [Note: Re-scaling by $V^{\text{B}}_{\text{ref}}$ could not affect the results because the statistics relied entirely on intra-individually constructed baselines.]

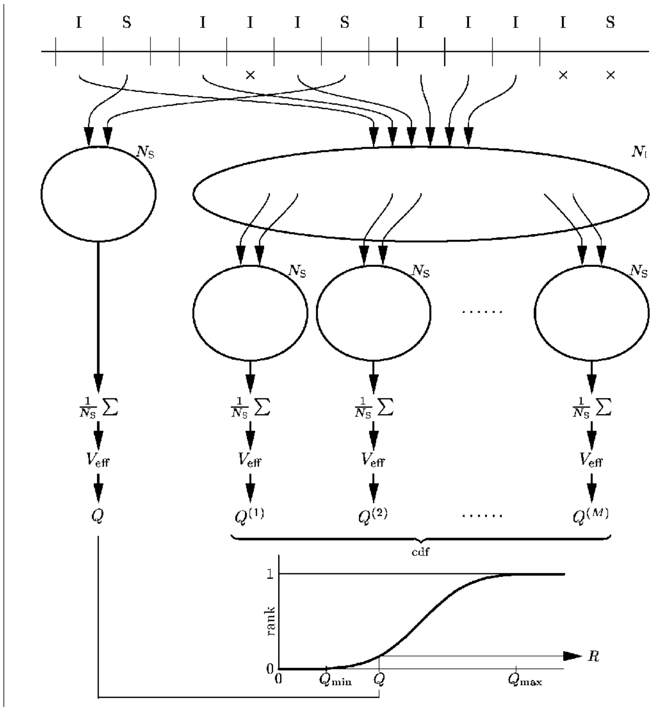

Fig.1. EEG data selection and processing flow chart. S = post-stimulus segment, I = inter-stimulus segment; × indicates data segments containing artefacts and excluded from the analysis. The ovals symbolise the two data pools, consisting of N_{S} post-stimulus and N_{I} inter-stimulus EEG segments ($N_{\text{S}} < N_{\text{I}}$).

In each randomisation run, N_{S} data segments were randomly chosen out of N_{I} available data segments and processed in the same way as post-stimulus data. The cumulative distribution function of the Q values obtained from M=1000 randomisation runs was constructed and used to transform the post-stimulus Q value to its respective rank R.

According to the null hypothesis there is no difference between the post-stimulus and inter-stimulus EEG in terms of the effective voltage. We used a randomisation statistics to test the hypothesis, as shown in Fig. 1: subsets of N_{S} segments were drawn randomly from N_{I} inter-stimulus EEG segments of the subject B, averaged, and their respective Q values calculated; then the rank R of the post-stimulus Q with respect to the cumulative distribution function (cdf) of the inter-stimulus Q’s was determined. Given the null hypothesis, the ranks R should be uniformly distributed on the interval [0;1]. To obtain an aggregated score for the whole experimental group, the ranks were transformed to Z-values, averaged across all n=16 subjects, and normalised

$$Z^{\text{rank}} = \frac{1}{\sqrt{n}}\sum_{j=1}^{n}\Phi^{-1}(R_j)\quad ,$$

where Φ^{-1} denotes the inverse Gaussian cdf; the Z^{rank} values thus should obey the normal Gaussian distribution. These statistics were calculated independently for both conditions ‘uncovered’ and ‘covered’ and each electrode location. For a direct comparison between conditions, normalised differences,

$$Z^{\text{diff}} = \frac{Z^{\text{rank}}_{\text{uncovered}} - Z^{\text{rank}}_{\text{covered}}}{\sqrt{2}},$$

were also calculated for each electrode location.

We found predominantly negative Z values in the ‘uncovered’ and positive Z values in the ‘covered’ condition. This is a confusing finding: even if we accept a possibility of a communication between the brain states of subjects A and B, it should manifest only in the ‘uncovered’ (physical stimulation) condition, but not in the ‘covered’ condition, as there is no electrical correlate of the stimulus in the A’s brain. The occurrence of positive Z’s in the ‘covered’ condition may thus indicate an imperfection of our randomisation statistics *or* a true deviation from the baseline distribution. However, if we use the ‘covered’ condition as the baseline, the distribution of Z^{diff}’s yields a clearer picture: most differences are negative (16 out of 19), five of them significantly deviating from zero ($P < .05$), while none of the positive differences is significant. Fig. 2 shows topographic distributions of Z^{rank}’s for both experimental conditions and Z^{diff}’s for the difference between conditions. Maximal effects are seen in the left parieto-occipital region and in the right frontal region.

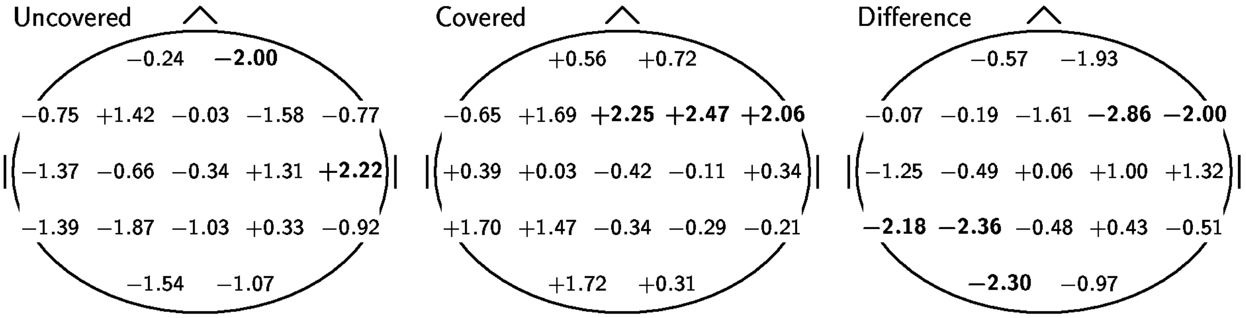

Fig 2. Topographic synopses of Z^{rank}’s and Z^{diff}’s for the nineteen EEG recording locations (system 10/20). Bold typeface indicates Z’s significant at the P(two-tailed) < .05 level.

Compared to the design of the previous study, the present study employed higher numbers of EEG recording channels, participants and stimuli per session; more broadly varied ISIs; and improved controls, since the ‘covered’ condition was now applied within each pair instead to another group of participants; [cf. the commentary by Kalitzin & Suffczynski (2003) and the reply by Wackermann (2003); see also Wackermann (2004)]. Our results suggest that, at times of the stimulated subject’s maximal response to the visual stimulus, the non-stimulated subject’s EEG power was *relatively reduced* (in terms of the ‘uncovered’ *minus* ‘covered’ difference). Since our earlier findings were inconclusive about the direction and topography of the effect (Wackermann et al., 2003, p. 63), we have undoubtedly made a progress in the *characterisation* of the effect; however, the *interpretation* of the effect remains unclear.

Our earlier results suggested that there may be subtle correlations between brain states of two separated subjects (a) caused by a yet unknown mechanism and (b) manifesting themselves when one of the brains responds to an environmental stimulus. However, in the present study we have deviations from mean chance expectation in *both* conditions; such a finding cannot be accounted for by any simple stimulus-response mechanism responsible for biophysical correlations of brain states. We are facing an enigmatic situation, unless we assume that the subject B’s brain responds to the physical presence of the stimulus rather than to the subject A’s brain response to the stimulus. Even with such an ‘ESP-like’ interpretation it remains unclear why should the subject B’s brain response go to two opposite directions, depending on whether the stimulus has or has not been perceived by subject A. Yet another interpretation might take into account an ‘experimenter effect’: the experimenters were not exposed directly to the visual stimuli but they were aware of their occurrence. These interpretations imply that our experiment was a kind of unintentional ESP-experiment: an assumption more disturbing than compelling. We hope to obtain more clarity from the next replication study, using a protocol with experimenters being unaware of stimulus presentations, and varying stimulus parameters to modulate the subject A’s brain response magnitude.

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References

Fenwick P.B.C., Vigus N., & Sanders S. (1998). The transferred potential. London: unpublished manuscript.

Grinberg-Zylberbaum J., Delaflor M., Attie L., & Goswami A. (1994). The Einstein-Podolsky-Rosen paradox in the brain: The transferred potential, *Physics Essays*, *7*, 422–427.

Kalitzin, S. & Suffczynski, P. (2003). Comments on “Correlations between brain electrical activities of two spatially separated human subjects”. *Neuroscience Letters*, *350*, 193–194.

Radin, D.I. (2003). Thinking outside the box: EEG correlations between isolated human subjects, *Proceedings of the 46th Annual Convention of the Parapsychological Association*, (ed. by S. Wilson), Vancouver, Canada, August 2–4, 2003), pp. 184–199.

Radin, D.I. (in press). Experimental investigation of event-related EEG correlations between isolated human subjects. *Journal of Alternative and Complementary Medicine*.

Sabell A., Clarke C., & Fenwick P. (2001). Inter-subject EEG correlations at a distance – The transferred potential, *Proceedings of the 44th Annual Convention of the Parapsychological Association*, (ed. by C.S. Alvarado, New York, NY, August 2–4, 2001, pp. 419–422.

Standish L.J., Johnson L.C., Richards T., & Kozak L. (2003). EEG evidence of correlated event related signals between distant human brains, *Quantum Mind 2003*, Tucson AZ: Center for Consciousness Studies, 18–19.

Wackermann, J., Seiter, C., Keibel, H., & Walach, H. (2003). Correlations between brain electrical activities of two spatially separated human subjects. *Neuroscience Letters*, *336*, 60–64.

Wackermann, J. (2003). Correlations between brain electrical activities of two spatially separated human subjects. Reply to the commentary by S. Kalitzin and P. Suffczynski. *Neuroscience Letters*, *350*, 194.

Wackermann, J. (2004). Dyadic correlations between brain functional states: present facts and future perspectives. *Mind and Matter*, in press.