DISTANT PSYCHOPHYSIOLOGICAL INTERACTION EFFECTS BETWEEN RELATED AND UNRELATED PARTICIPANTS

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ABSTRACT

The aim of this study is to investigate possible remote psychophysiological interactions between sensorially isolated participants, using a protocol of photic stimulation and EEG measurements. It is an attempt to conceptually replicate past findings suggesting the presence of such interactions, and to clarify the role, (if any), of an existing emotional relationship and pre-session interaction between participant pairs.

Forty-one unpaid volunteers were assigned to one of three groups. One of these consisted of thirteen related pairs of participants who reported sharing an empathic relationship, another of five unrelated pairs (i.e. randomly matched strangers), and the last of five single participants. Related pairs spent some time alone together before testing, whereas unrelated pairs did not know each other and did not meet until after the session; single participants were told they would be paired with someone they didn't know, but were not matched with anyone. Pairs of participants simultaneously listened to a recording of a progressive relaxation procedure including suggestions aimed to induce a hypnagogic-like state, which was followed by 15 minutes of continuous drumming; this procedure was intended to induce a similar alteration of consciousness in both participants. During the drumming period the EEG of one person of the pair ("receiver") was recorded while the other ("sender") was occasionally stimulated with randomly timed single photic flashes. For the single participants group the same procedure was followed but there was no "sender" to observe the flashes.

EEG epochs that were time-locked on photic stimulation of the "senders" were taken from the continuous EEG record of the "receivers". Similar randomly sampled epochs were taken from periods of no stimulation to serve as controls. According to the null hypothesis no difference would be expected between these samples, as sensory stimulation of the "receivers" was homogenous throughout the experimental period. Event-related evoked alpha power measures revealed a tendency for samples from "remote" photic stimulation periods to show larger deviations from pre-stimulus baseline than control samples; these deviations were in the same direction as normal responses to direct photic stimulation. This difference between "remote" photic stimulation and control periods was found to be significant for the related pairs group at $p<0.023$ (Wilcoxon signed-ranks test, two-tailed; $N=13$). Deviations of similar direction and magnitude were found in unrelated pairs ($p<0.007$ when combined with related group, $N=18$), while recordings from single participants (when no other person was stimulated) showed no such effect. Further patterns identified in the results and possible interpretations are discussed.

INTRODUCTION

An increasing number of parapsychological experiments make use of physiological measures as dependent variables, rather than the more traditional psychological/behavioural measures. This choice relies on the fairly reasonable assumption that perception of any psi-mediated information will inevitably result in measurable changes in physiological parameters at some stage of the perceptual process, as is the case with ordinary perception. An additional motive for using such measures is the possibility that directly measuring physiological parameters may be advantageous in detecting subtle non-normal perceptual responses, which are perhaps not salient enough to rise above the threshold of conscious awareness. For psi experiments using psychophysiological recordings that directly measure parameters of brain activity, such as the EEG and fMRI, an extra potential advantage is that such measures could possibly help in identifying some of the underlying neural mechanisms that may be involved in psi processes. Of particular relevance to the present study is research using visual stimulation of one participant while measuring the EEG of another non-stimulated subject.

In one of the first studies to use such methodology, "senders" were stimulated with intermittent photic flashes at 6 and 16Hz. Seven pairs were tested, and while in only one of these the "receiver" showed alpha power blocking when the "sender" was stimulated, this pair was tested further and a repeatable effect was observed (Targ & Puthoff, 1974). In a subsequent study, pairs of subjects meditated together and were then taken to separate Faraday cages. One person of each pair was stimulated with trains of 100 flashes at random time intervals, while EEG was recorded from both. The stimulated subjects demonstrated visual evoked potentials as expected, which significantly correlated with the EEG activity of the non-stimulated subjects, which were said to demonstrate "transferred potentials" (Grinberg-Zylberbaum, Delaflor et al., 1994). Apparently this was not the case for the control condition, in which the subjects in each pair did not interact prior to the experiment. A subsequent attempt at a replication of this study by Sabell, Clarke et al., (2001) however, failed to find an effect. A more recent study using a similar experimental design but different stimuli and analysis methods, has reported significant deviations from baseline in non-stimulated participants when another was visually stimulated, but found no differences in effects between related and unrelated pairs and nothing resembling a "transferred potential" (Wackermann, Seiter et al., 2003). A conceptual replication by Radin, (2003) further suggested that "receivers" were indeed responding to the "senders" being stimulated and not to the distant stimuli themselves. Such interactions can perhaps more correctly be described as correlations rather than "remote responses", especially as it is not yet clear whether they exhibit the same physiological characteristics as responses to direct stimulation.

This project is intended to be a conceptual replication of these previous studies, an attempt to further explore the nature of these effects, and an attempt to clarify the issue of whether interpersonal relationship and prior interaction between participants is a variable affecting the observed effect.

METHOD

Design:

EEG was recorded from one participant while another spatially isolated subject was stimulated with photic flashes. Our participant pool consisted of three groups, involving empathically related pairs, unrelated pairs, and single subjects. Randomly timed stimuli (single photic flashes) were presented interspersed with randomly timed control events, and event-related band power measures were used to compare stimulation and control epochs. The null hypothesis predicts no differences between such epochs for the unstimulated person of the pair, and no differences between groups. Individual sessions, where each participant was directly stimulated while their own EEG was recorded, were also conducted in order to investigate the normal physiological responses to these stimuli.

Participants:

Forty-one unpaid volunteers took part in the study, divided into three groups; thirteen related pairs i.e. pairs of volunteers who reported sharing an empathic relationship (close friends, relatives or lovers), five unrelated pairs (i.e. ten individual volunteers who didn't know each other were randomly matched into pairs), and five single subjects (individual volunteers were not matched with another, although they were told they would be, i.e. there was no "sender"). There were 23 female and 18 male participants, with a mean age of 28.7, ranging between 20 to 58 years of age.

Audio materials:

We have attempted to alter the conscious state of our participants using an audio recording of a progressive relaxation procedure, which included suggestions for entering a hypnagogic-like state, followed by a recording of continuous drumming with an inter-beat frequency ranging between 4-5Hz (recording of live drumming). The aim of this procedure was to facilitate deep relaxation, to induce a non-ordinary

conscious state simultaneously in both participants, and to help participants maintain an awareness of each other, while also giving them suggestions for avoiding any effort to succeed in the task and for suspending any positive or negative expectations they may have.

System implementation:

A 40 channel NuAmps EEG system (Neuroscan, USA), was used for data acquisition and analysis. Thirty-two monopolar EEG channels were recorded (including references) from the following electrode sites: Fp1, Fp2, Fz, F3, F4, F7, F8, FCz, FC3, FC4, FT7, FT8, Cz, C3, C4, T7, T8, CPz, CP3, CP4, TP7, TP8, Pz, P3, P4, P7, P8, Oz, O1, O2 , A1 and A2. The reference was linked ears and we sampled at a frequency of 500Hz. A 50Hz bandstop filter was used, and the bandpass filter range was 1-100Hz. An electrode cap was used for electrode placement together with clip ear electrodes; all electrodes were sintered Ag/AgCl.

To present photic stimuli we used a pair of dark glasses fitted with eight white (clear) LEDs, (four over each eye). Photic flashes were triggered using TTL pulses from the parallel port of a PC running a script-driven program (Inquisit by Millisecond Software), which controlled the randomised presentation of two types of stimuli, one of which would trigger a flash and simultaneously register an event marker on the EEG trace, while the other (control event) would only set an event marker on the EEG trace with no associated flash presented. Inquisit used a pseudo-random algorithm to sample with replacement one of the two stimuli, and one of eight possible inter-stimulus delays of 1-8 seconds (i.e. mean IS interval was 4.5s). One hundred and eighty-six stimuli were presented during each joint session; on average half of these (93) would be single photic flashes and half would be control event markers on the EEG trace. Individual sessions (direct photic stimulation) consisted of 68 stimuli of each type, with the same range of randomly chosen inter-stimulus intervals.

The audio recording was played to both participants using a shared one-way audio link. The computer controlling stimulus randomisation was connected to the "sender's" LED glasses and to the EEG amplifier in the "receiver's" room and used synchronised TTL pulses to trigger flashes and set event markers on the EEG record, marking the timing of photic flashes and control periods. TTL inputs to the EEG amplifier are isolated from the participant and the amplifier, protecting against contamination of the EEG record from the electrical signals used to provide event markers, and of cueing the participants to the existence or timing of these signals. No auditory or visual cues were emitted from the amplifier that could indicate the presence of the triggers to the "receivers".

Procedure:

In individual sessions each participant was directly photically stimulated while his or her own EEG was recorded. In "remote" sessions, the EEG of one participant was recorded while the other (or no one in the case of the "no partner" group) was photically stimulated.

Related pairs of participants decided themselves who was to be the "sender" and who the "receiver", either by choice or randomly. They could spent 10-15 minutes alone together before the session, doing anything they thought might help them enhance their awareness of each other. Some possibilities were suggested, such as joint meditation, synchronised breathing, exchanging personal items (e.g. jewellery), but were encouraged to do whatever felt most appropriate for them both. They were discouraged from using verbal interaction during this period, and they were given the option to burn some incense while in the room together, of which they could each take some in their respective separate experimental rooms. This was thought to be likely to help them maintain any feeling of "connectedness" they may have achieved in the common room into the experimental period, as odours are especially effective as memory cues and are particularly effective in evoking the emotional elements of memories. Evidence from fMRI studies for example, indicates that the subjective experience of the emotional potency of odour-evoked memories is correlated with specific activation in the amygdala, which is greater in magnitude than that seen when the same memories are evoked using visual cues (Herz, Eliassen et al., 2004). A common odour in participants'

respective rooms would also make their sensory environments more similar. Participants were given a choice between different types of incense, and most pairs (but not all) opted to use some. After spending time alone together, participants went to their respective experimental rooms and did not interact with the experimenter again, (or anyone else), until the end of the session.

Unrelated pairs did not know each other prior to the experiment and only met after the session had finished. Therefore the experimenter chose randomly who was to be the "sender" and who the "receiver".

The five single participants who were not matched with a "sender" were told that they would be paired with someone they didn't know, and that they would meet them after the experiment (i.e. the same as what the unrelated pairs were told). They were all "receivers", and while the photic stimulation procedure was carried out as described above, there was no "sender" in the other room to observe the flashes. After the session the experimenter gave these participants a full debrief and explained the reasons for the deception.

At the beginning of each session the progressive relaxation instructions were played to the participants; this recording lasted for approximately 11 minutes and was followed by the drumming, which lasted for approximately 15 minutes. Two minutes after the drumming had started randomised photic stimulation was initiated, which lasted for an average of 11.7 minutes (the actual session length depending on the cumulative duration of the randomly chosen inter-stimulus intervals).

RESULTS

The raw EEG data from all $N = 41$ participants was treated with a 1-30Hz band-pass filter and visually inspected for artefacts. Channels that were consistently noisy or which lost electrode contact during recording were marked and excluded from further analysis. The entire EEG records of two participants had to be excluded from analysis due to faulty recording (loose reference electrode). One of these was a "sender" during direct photic stimulation, and the other a "receiver" (from the "alone" group), during remote photic stimulation.

Three-second long epochs were taken from the continuous EEG records, centred on stimulus presentations times (and random control markers) ranging from -1 to +2 seconds. According to the stimulus randomisation protocol we had used, the shortest possible interstimulus interval was 1s; therefore we could not use all of the 3s epochs, as some would contain more than one stimulus event and/or overlapping responses to stimuli. We therefore excluded from our analysis all events appearing after inter-stimulus intervals of <3s. Epochs were baseline corrected and those containing amplitudes >100μV were automatically rejected; epochs were also visually inspected and those found containing additional artefacts from eye movements or muscle activity were manually rejected. This manual artefact rejection was conducted blind as to whether epochs contained photic or control events. After such rejections, the number of epochs of each type available for analysis for each person and channel averaged at 55 for direct photic stimulation sessions and 70 for "remote" stimulation sessions. (The average number of stimulus events originally presented was 67 and 93 respectively).

The EEG data from direct photic stimulation sessions was analysed first in order to investigate the electrophysiological characteristics of normal responses to the photic stimuli we were using, and thus provide a template with which to guide the analysis of data from "remote" sessions.

Results of direct photic stimulation sessions:

Event-Related Band Power measures (ERBP) were used, where the raw EEG of all event-related epochs is band-pass filtered around a central frequency band of interest. We have chosen to focus on the alpha band (8-13Hz), as power in this band is well known to be affected by photic stimulation, e.g.(Kawaguchi, Jijiwa et al., 1993). We have used a measure of evoked (phase-locked) activity, as initial analysis demonstrated that evoked responses to photic stimulation are better defined and simpler to describe than induced (non phase-locked) responses. In evoked ERBP, the amplitude values within each epoch are squared in order to obtain power measures (μV^2), and a number of epochs that are time-locked to the stimulus are averaged point-by-

point (as in Event Related Potentials). Evoked alpha ERBP measures can therefore effectively be described as the specific alpha-band component of the general ERP.

The Global Field Power (GFP) was calculated for each participant from the 30 original electrode channels as a measure of global EEG activity. The GFP is defined as the standard deviation across multiple channels as a function of time, and is used to quantify the instantaneous global activity across the spatial potential field sampled over the scalp (Lehmann & Skrandies, 1980). An example of the GFP of the evoked alpha response to photic stimulation can be seen in Fig.1, showing a rapid increase in alpha power which starts almost immediately after stimulus presentation (*T*=0ms), peaks at 224ms and returns to baseline near 500ms after stimulus presentation.

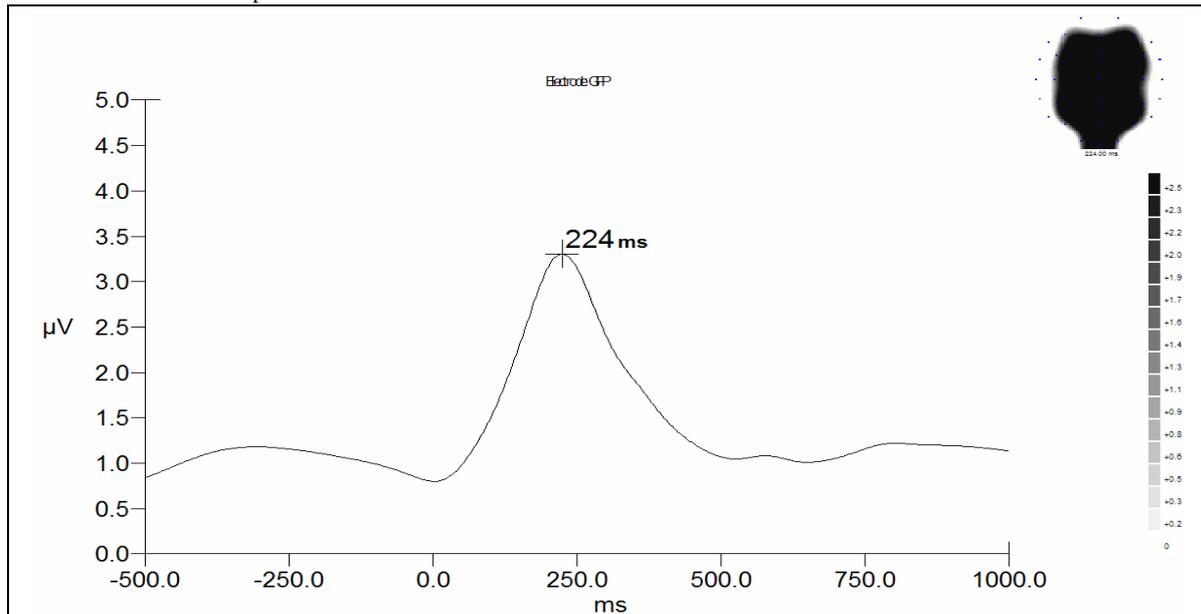
Figure 1: Evoked alpha response to direct photic stimulation; averaged Global Field Power for 30 channels and N=39 Ss.

We can define a period of interest within remote stimulation epochs based on the averaged responses of all participants to direct photic stimulation, on the assumption that if "receivers" are responding to photic stimulation of the "senders", their responses will have similar temporal characteristics. We therefore defined our test interval to be the range of 0 to 500ms after stimulus presentation, as responses to direct stimulation reach a maximum and return to baseline within this interval. As a comparison reference period we used the pre-stimulus interval of –500 to 0ms. We can calculate a ratio measure of post- to pre-stimulus power using

the formula: $10 * \log \dfrac{W_{post}}{W_{pre}}$

where W_{post} is the mean α-power in the 0 to 500ms post-stimulus interval and W_{pre} is the mean α-power in the –500 to 0ms pre-stimulus interval. Therefore if there is no difference between pre-stimulus and post-stimulus power the log-ratio value would be 0, whereas positive values would indicate a higher mean α-power in the post-stimulus interval, and negative values would indicate a higher mean α-power in the pre-stimulus interval. For example, the log-ratio of such a comparison for the response to direct photic stimulation seen in Fig.1 would be: $10 * \log (1.90 / 1.03) = 2.6$.

Results of "remote" photic stimulation sessions

As we would expect no systematic difference in α-power between pre- and post-stimulus intervals in the EEG of the "receivers", for the simple reason that they are not being stimulated themselves, we could in theory simply compare the above log-ratio of evoked α-power measures from epochs time-locked on photic stimulation of the "senders", against the expected value under the null hypothesis, i.e. 0. As we do not know

however the exact statistical properties of the EEG signal, such theoretical assumption may not be justified, and a safer route would be to compare the log-ratio from periods of photic stimulation of the "senders", against the same ratio from control periods of no stimulation. The null hypothesis would also predict no difference between such periods for the unstimulated "receivers". Figure 2 shows the mean estimated log-ratios of these intervals for the three groups and two conditions.
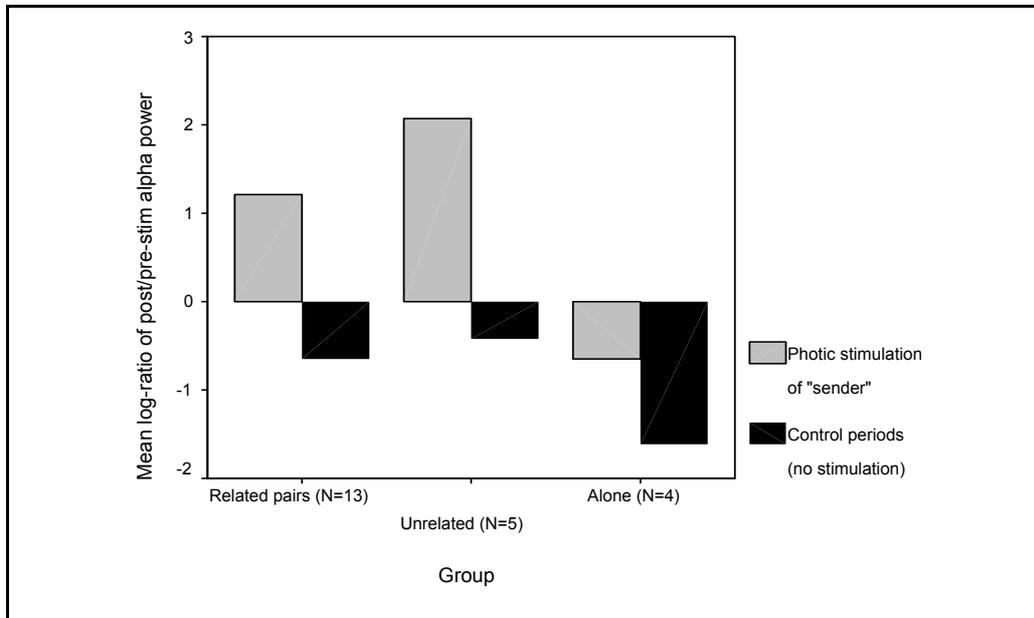

Figure 2: Mean log-ratios of post/pre-stimulus α-power (GFP) per group and condition.

A trend can easily be identified for positive ratios to be observed during epochs of photic stimulation of these participants' partners, for both related and unrelated pairs, indicating higher alpha power in post-stimulus intervals compared to the pre-stimulus baseline. No such difference can be seen in participants who were not matched with a partner (no one seeing the flashes); the log-ratios in this group are negative in both photic and control periods, indicating higher alpha power in the pre-stimulus interval. This is also the case for the control periods in the related and unrelated groups. Somewhat unexpectedly the deviation from baseline in photic periods appears larger for unrelated pairs, but the small number of participants in this and the "alone" group requires that we make such comparisons between groups only tentatively and with much caution.

These differences are highly comparable with recent findings in other studies, which have identified a similar pattern of effects between groups similar to these. Wackermann, Seiter et al., (2003) found deviations from baseline activity in the EEG of non-stimulated subjects, coinciding with periods when their partner was visually stimulated. Groups of related and unrelated pairs showed responses of similar magnitude, while a group of participants having no partner, and another with pairs where the "sender" could not see the stimuli, did not show any such responses. It is important to note that as in that study different visual stimuli (pattern reversal) and different EEG analysis methods were used to ours, the agreement between them is therefore only of a qualitative nature.

Table 1: Overall mean log-ratios of post/pre-stimulus α-power and standard deviations for each of the three groups and two conditions.

	Group	Mean	Std. Deviation	N
"Remote" photic stimulation periods	Related	1.22	1.9	13
	Unrelated	2.07	2.17	5
	Alone	-.65	1.33	4
	Total	1.07	2.01	22
Control periods (no stimulation)	Related	-.64	1.96	13
	Unrelated	-.41	1.76	5
	Alone	-1.62	3.07	4
	Total	-.77	2.08	22

To test the statistical significance of the observed difference we used a Wilcoxon matched-pairs signed-ranks test, which is distribution-free and does not rely on parametric assumptions. As can be seen in table 2 below, the difference in the related pairs group between photic and control epochs is significant at $p<0.023$ (N = 13; two-tailed). Conducting the test on groups as small as the unrelated pairs (N = 5) and unpaired participants (N = 4) is not likely to be reliable and will not be attempted. We could however combine the results from related and unrelated pairs, in which case we find a $p<0.007$ (N = 18; two-tailed). The overall difference between photic and control epochs for all three groups combined is also significant at $p<0.007$ (N = 22; two-tailed).

To estimate the effect sizes associated with these differences we calculated the values of the effect-size correlation r using the following formula:

$$ r = d / \sqrt{d^2 + 4} \qquad \text{where} \qquad d = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{(\sigma_1{}^2 + \sigma_2{}^2)/2}} $$

Table 2 shows the calculated effect sizes and p values for each group and combination of groups.

Effect sizes of $r > 0.3$ are considered to be large; for example the $r = 0.43$ seen in the related group indicates that the mean of the photic condition stands at the 84th percentile of the control condition. Such effect sizes are comparable to some of the largest found in DMILS studies, where for example, the average effect size for 19 such experiments was found to be $r = 0.25$ (Schlitz & Braud, 1997).

Table 2: Estimated effect sizes and p values for differences in evoked alpha power changes between control and photic conditions; calculated for all groups separately and in combinations.

	Related Pairs (N=13)	Unrelated Pairs (N=5)	"No sender" group (N=4)	Related & Unrelated Pairs (N=18)	All three groups combined (N=22)
Wilcoxon Signed - Ranks Test	$p < 0.023$ (2-tailed)	N/A	N/A	$p < 0.007$ (2-tailed)	$p < 0.007$ (2-tailed)
Effect size r	$r = .43$	$r = .55$	$r = -.1$	$r = .47$	$r = .41$

It will be useful at this point to look at the temporal and spatial characteristics of the averaged waveform of alpha-ERBP from the "remote" stimulation periods. Figure 3 shows the average Global Field Power for the two groups that appeared to show an effect, i.e. the related and unrelated pairs (*N*=18).
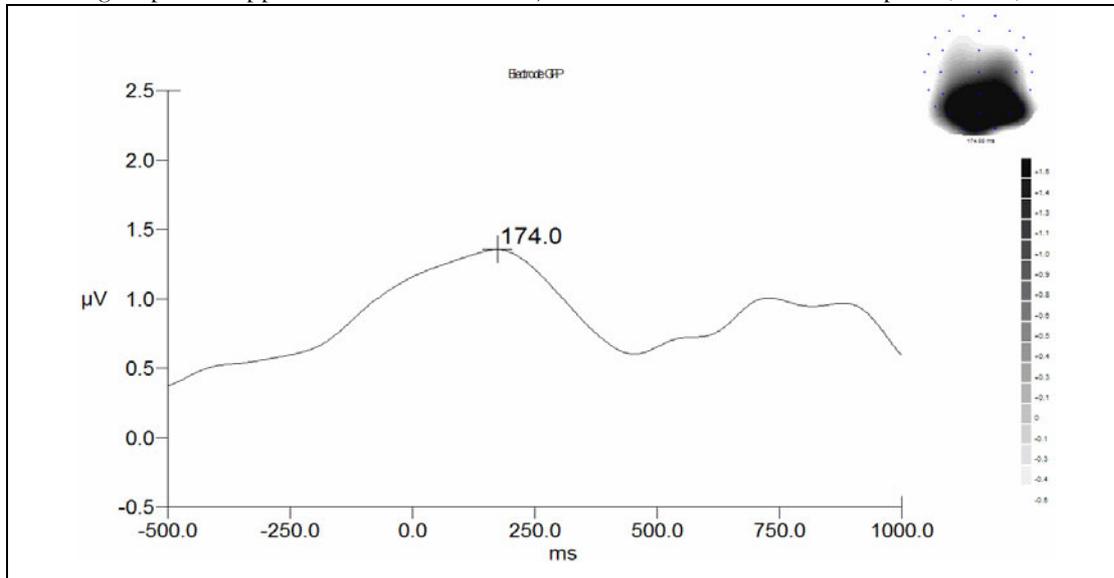

Figure 3: Mean Global Field Power of alpha-ERBP during "remote" photic stimulation for related and unrelated "receivers" combined (N=18).

This shows a relatively slow rise in phase-locked alpha power which peaks at 174ms post-stimulus; this "response" however also appears to begin to rise at least -150ms before stimulus presentation. Such a feature is obviously highly problematic if we attempt to interpret the effect as a physiological response to a remote stimulus, as it would violate the generally accepted assumption of linear causality, according to which responses follow stimuli and not vice versa. The spatial distribution of the effect however (see Fig.4) indicates a parietal/occipital locus for the observed deviation, which would be expected for the alpha component of a visual evoked response. Therefore unlike its problematic temporal characteristics, the posterior localisation of the effect is somewhat consistent with a physiological interpretation. The temporal evolution of the "remote response" can also be seen in Fig.4 and can be compared to that of the normal response to direct stimulation.
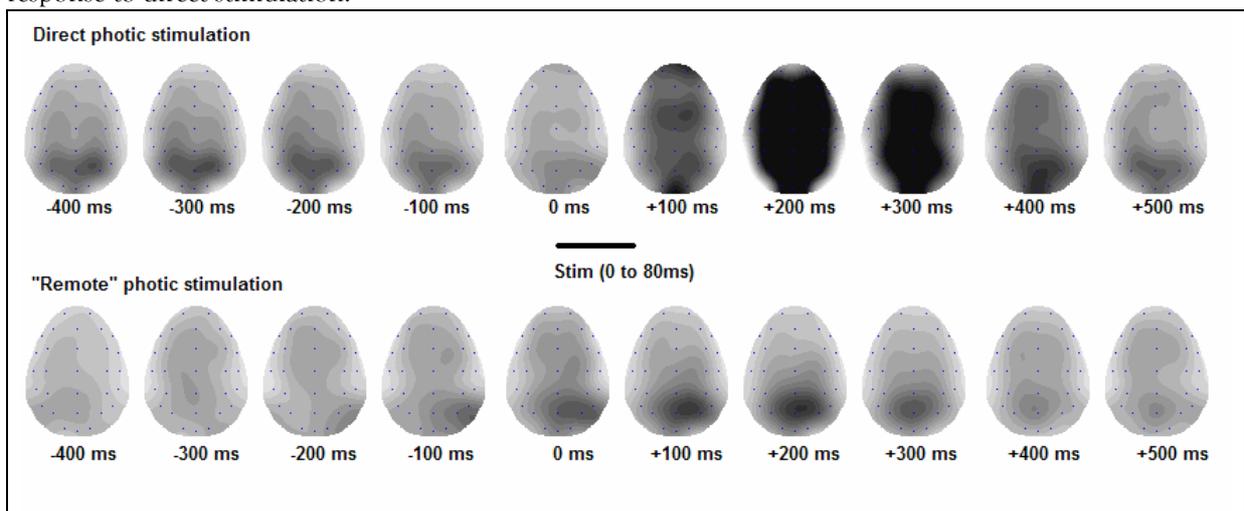

Figure 4: Spatial distribution of evoked alpha-power during direct photic stimulation (N=39) and during "remote" photic stimulation (related & unrelated pairs, N=18). Photic flashes were presented at T=0 for 80ms.

We are now in the process of analysing the results from the questionnaires administered to our participants, i.e. the *Modified Tellegen Absorption Scale* (Jamieson, 1986), the *Phenomenology of Consciousness Inventory* (Pekala, 1991), and a general participant information form, to further explore individual variables that may be related to performance in this experiment. Particular attention will be paid to the reported subjective consciousness alterations (in the PCI), and whether their intensity and quality, as well as correlations between the experiences of participants in each pair, relates in any way to task performance.

DISCUSSION

The results indicate that at times when the "senders" are stimulated with photic flashes the EEG of the "receivers" shows changes in α-power in the same direction as that seen when participants are themselves stimulated with photic flashes, i.e. phase-locked α-power increases during the post-stimulus period. As sensory stimulation for the "receivers" is homogenous throughout the experimental period, the significant difference between "remote" photic stimulation epochs and control epochs in log-ratios of post-/pre-stimulus α-power, suggests the presence of an anomalous effect during the "remote" photic stimulation periods. The lack of such a difference in the group of "receivers" who were not paired with a "sender", further suggests that this effect is dependent on sensory stimulation of another participant, and cannot be attributed to a general methodological flaw, or to direct extra-sensory perception of the remote stimuli. The parietal/occipital locus of the effect is consistent with what would be expected from the alpha component of a visual evoked response, and further suggests the presence of a "remote response".

The time-evolution of the observed effect however, is somewhat problematic and raises additional questions. The fact that "remote responses" appear to start at around -150ms pre-stimulus, and to peak 50ms before the "senders'" response to direct stimulation does, suggests one of two possibilities; perhaps the observed effect is not a genuine response to the remote events, as it is not accurately time-locked on these events, but is instead a fluctuation in α-power caused by unknown factors. If however the observed deviation from baseline represents a genuine anomalous response to the remote events, then this would seem to indicate the presence of a temporal as well as a spatial anomaly. As this was not a hypothesis we had considered before the analysis of the results, we can only present this possibility as a question to be explored further in future research. The lack of such a "pre-stimulus" element in responses to direct photic stimulation however, raises the question of why should such anomaly only be present in "remote responses". The temporal asynchrony between direct and "remote responses" (assuming the latter are genuine), would seem to suggest that what we are observing is not an ordinary stimulus-response effect. The physiologically counterintuitive features of the "remote responses" prompt us to suggest that perhaps it is better not to describe these anomalous effects as responses at all, but as "non-local biological interactions" (without implying the involvement of a quantum-mechanical process), or as "remote psychophysiological correlations".

The main limitation of this study was the small number of participants in the "unrelated" and "alone" groups, which made direct statistical comparisons between groups, as well as statistical tests within these two groups impossible to conduct. The related pairs group was the focus of the experiment, and the other two groups were added as exploratory elements within the study. As such they can only be useful for making qualitative comparisons between the groups. We are now planning a larger study with a similar design but with equal numbers of participants in each group, to enable formal statistical comparisons to be made. We are also considering using an "oddball" stimulation paradigm, which could further clarify the physiological characteristics of any anomalous effects found.

ACKNOWLEDGEMENT

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