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## **Remote psychophysiological interaction effects in response to photic stimulation; a study utilising consciousness alterations.**

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### ***Abstract***

This project combines research on the relationship of altered states of consciousness to psi phenomena, with the methodology of EEG and photic stimulation procedures. Several past studies have highlighted the relationship between alterations in conscious states and psi experiences, based both on self-reports of such experiences as well as on the results of laboratory experiments. Other studies have made use of photic stimulation techniques and EEG recordings in order to look at possible remote anomalous interactions between physically separated participants. The rationale behind this project is that a combination of this methodology with a procedure designed to alter the participants' state of consciousness is likely to be helpful in demonstrating possible psi effects, and may also help to elucidate theory and advance practical applications in these areas.

An experiment was conducted with three groups of participants; 13 related pairs (who knew each other well), 5 unrelated pairs (randomly matched strangers) and 5 single participants. Related pairs spent some time alone together before testing, while unrelated pairs did not meet each other until after the session; single participants were told they would be paired with someone (as unrelated pairs) but were not. Both participants in each pair simultaneously listened to a relaxation procedure with instructions aimed to induce a hypnagogic-like trance state, followed by drumming. This procedure was expected to induce a similar change in conscious state in both participants. EEG was recorded from one person of the pair, while the other was stimulated with randomly timed photic flashes.

EEG epochs were taken from the "receiver" during periods of photic stimulation of the "sender" and from periods of no stimulation. According to the null hypothesis, no difference would be expected between these samples. Event-related alpha power measures showed a tendency for EEG samples from photic stimulation periods to show larger deviations from baseline than control samples; this difference was found to be significant at  $p < 0.042$  for all three groups combined. Related and unrelated pairs demonstrated responses of similar magnitude ( $p < 0.025$  combined), while recordings from single participants (when no other person was stimulated) showed no such effects. Further patterns identified in these results and possible implications are discussed in more detail.

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## *Introduction*

*“I consider these efforts to elucidate the personality structures and states of consciousness which enhance the psi faculty, and the experimental conditions best suited to trigger it off, as perhaps the most significant among the new directions in parapsychology.”*

Arthur Koestler

An increasingly clear finding in parapsychological research is that effect sizes in psi tasks seem to vary in relation to certain individual and environmental variables. Among such variables are personality and other cognitive traits of the participants, as well as their state of consciousness during the psi task. This is comparable to findings in other areas in psychology, where performance in various cognitive tasks is affected by such variables.

Spontaneous parapsychological phenomena are often associated with alterations in conscious experience, and some techniques for altering consciousness such as the *Ganzfeld* (homogenous sensory stimulation, which effectively constitutes perceptual deprivation), have been assimilated into psi research and have provided some of the strongest evidence to date for the existence of psi phenomena (Bem & Honorton, 1994).

Other techniques for altering consciousness, such as meditation and yoga, have a long history of association with psi phenomena, as is often reported in various traditional texts and in the reports of practitioners of these mental disciplines. This association is also supported by contemporary psi research, where meditators have consistently been shown to score better in psi tasks than non-meditators, (e.g. in PK tasks, (Matas and Pantas 1971). Other studies have found pre-meditation to post-meditation differences in ESP tests, with improved performance in tests carried out in the post-meditation period (Schmeidler 1970);(Dukhan and Rao 1972); (Rao et al. 1978).

Hypnosis is another state that was shown to be often effective in improving psi performance, as can be seen in a meta-analysis comparing ordinary-state ESP with hypnosis-facilitated ESP (Stanford & Stein, 1994) Results from individual studies however are often contradictory, and this is probably due to the large variety of often loosely defined procedures used for inducing hypnotic states in different studies. A

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very wide spectrum of experiential states can be induced through hypnosis, and factors such as subject and hypnotist personality variables, as well as interpersonal variables, are often as important as induction procedures themselves in shaping the magnitude and quality of responses.

The dream state has also been successfully utilised in psi research, most notably in the series of experiments carried out at the Maimonides Medical Centre (Child 1985). Overall, if one examines the collective results from ordinary-state ESP experiments, and the results from studies utilising dreams and the Ganzfeld technique, it becomes clear that the hit rates in studies using no manipulation of consciousness are considerably lower (Radin, 1997).

Various personality traits have also been associated in past research with scores in psi tests. Low scores in *Neuroticism* scales were often found to correlate with higher scores in ESP experiments, and the positive correlation of *Extraversion* to ESP scores has been particularly consistent (Palmer, 1978). A possible interpretation of these findings is that both of these traits relate to one's ability to cope with anxiety, especially in a social context such as a parapsychological experiment. As relaxation (reduced anxiety) has been repeatedly associated with better performance in psi tasks (e.g. Ganzfeld studies), this could be a mediating factor for the correlation (Palmer, 1977). Another personality variable often found to correlate with better psi performance is Openness to Experience; this has sometimes proved to be a better predictor of psi performance than Extraversion (van Kampen et al. 1994). Other studies have found that participants' attitudes towards and beliefs regarding the existence of psi correlate with their scores in psi tasks, what has been called the "sheep-goat effect"; participants who are open to the possibility of psi generally score better than those who are highly sceptical. This effect has been replicated in several studies and is considered to be a consistent finding in psi research (Palmer, 1977), although it has been argued that the underlying factor in this effect may again be the Openness dimension (van Kampen et al. 1994).

Hypnotic susceptibility is one other individual variable which has been found to correlate positively with better ESP scores in most studies where this trait has been measured (Palmer, 1977). This is obviously related to the findings mentioned above which suggest some effectiveness of hypnosis as a psi-conducive altered state, and is a good example of how individual personality traits are closely interrelated with the

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effects of altered states of consciousness in modulating psi performance. Other variables related to hypnotic susceptibility, such as suggestibility and dissociation, have also been associated with higher scores in psi tests and increased reporting of spontaneous psi experiences (Irwin 1985); Zingrone & Alvarado, 1994).

One of the aims of this study is to investigate the potential relationship of certain individual personality variables to scores in a test measuring possible direct mental interaction between pairs of participants. The individual variables to be taken into account will be hypnotic susceptibility, absorption, and the existence or not of an established emotional relationship between the pairs of participants. Prior to experimental sessions we will administer the *Modified Tellegen Absorption Scale* (Jamieson 1986), essentially a measure of the ease by which people can become absorbed in one aspect of their experience to the exclusion of all else. This measure is correlated with hypnotic susceptibility, ability to enter altered states as well as reported psi experiences (Irwin 1985). Dissociative experiences are also correlated to this measure, and it is worth paying attention to the complex interactions among such cognitive variables as hypnotic susceptibility, absorption, openness to experience, boundary thinness, fantasy proneness and constructs such as perceptual defensiveness.

We will attempt to induce altered states of consciousness in our participants using a relaxation procedure which includes hypnotic suggestions for entering a hypnagogic-like state. This will be followed by drumming at a frequency of 4-5Hz, which is expected to further deepen and prolong the state alteration. The aim of this procedure will be to induce deep relaxation, to help participants maintain a conscious and unconscious awareness of each other, to allow them to dissociate from the immediate temporal/spatial environment, and to induce a pleasant, calm, meditative state, all of which are expected to help in achieving a psi-conducive state. We will also give suggestions for the suspension of effort, disbelief, and both positive and negative expectations, attitudes which are believed to be detrimental in generating psi effects.

As the experimental methodology we will be using EEG and photic stimulation procedures. Past studies making use of this methodology to look at possible remote interaction between participants met with some success; for example, in a study by Targ, R. & Puthoff, H. (1974), 'senders' were stimulated with intermittent photic

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flashes of 6 and 16Hz. After the testing of seven 'receivers', one of these, who was the only one to have shown alpha power blocking when the sender was stimulated, was extensively tested further and a consistent effect was demonstrated. In a more recent study by Grinberg-Zylberbaum et al. (1994), 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, and EEG was recorded from both. The stimulated subjects showed evoked potentials as expected, which significantly correlated with the EEG activity of the non-stimulated subjects, which were said to demonstrate 'transferred potentials'. This was not the case for the control condition, in which the subjects in each pair did not interact prior to the experiment. A more recent experiment using similar methodology has also found positive results, but found no differences in effects between related and unrelated pairs (Wackermann, Seiter et al. 2003). This project is intended as a conceptual replication of these previous studies, and as an attempt to clarify the issue of whether the interpersonal relationship between participants is a variable affecting the observed effect, as well as exploring the role of the individual variables mentioned above.

## *Method*

### **Design:**

An experiment was designed where EEG measurements were taken from participants while their partner was being remotely stimulated with photic flashes. Three conditions were used, involving related pairs, unrelated pairs, and single subjects. Randomised stimuli were presented interspersed with randomised control epochs, and event-related band power measures were used to compare possible differences between stimulation and control epochs. The null hypothesis predicts no such differences for the unstimulated person of the pair. Direct photic stimulation with synchronous EEG recording of each person individually was also conducted to investigate the normal physiological responses to such stimuli.

### **Participants:**

Forty-one participants were recruited, all unpaid volunteers who found out about the study through flyers posted on notice boards in Edinburgh, or through word

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of mouth. This flyer (shown in *Appendix A.1*) gave a brief introduction to the topic of the study and requested volunteers to take part. Pairs of people who share a close empathic bond and had experienced synchronicities or ESP-like incidents involving each other were specifically encouraged to participate. Some indications as to the type of participant we expected to be suitable were included, for example by mentioning that previous experience with meditation or other mental disciplines is considered to be an advantage, as are creative/artistic abilities. Therefore although we encouraged people with specific characteristics to take part, participants were entirely self-selected and we only screened out people with a history of epilepsy for safety reasons. We recruited 13 related pairs, i.e. pairs of volunteers who already shared an empathic relationship, five unrelated pairs (i.e. ten individual volunteers who didn't know each other were randomly matched into pairs), and five people who were not matched with anyone, but were told that they were (i.e. unbeknownst to them there was no "sender"). Although we encouraged pairs in different kinds of relationships to take part (lovers, friends, relatives), nine of our bonded pairs consisted of couples of opposite gender in sexual relationships, three pairs were close friends and one was a mother-daughter pair. Of the three pairs who were friends, one consisted of same-sex friends and the other two of friends of opposite gender. Overall there were 23 female and 18 male participants, with a mean age of 28.7, ranging between 20 to 58 years old.

## **System implementation:**

- EEG system: Hardware and Software

A dedicated EEG system was purchased by the Koestler Parapsychology Unit from *Neuroscan Laboratories, Palo Alto, Texas* with the help of a grant from Inova. This system consists of a 40 channel '*NuAmps*' electrophysiological signal amplifier and a *Dell 'Inspiron'* laptop PC running *Scan 4.3*, the software used for data acquisition and analysis. The *NuAmps* amplifier provides inputs for up to 40 monopolar channels (including the reference leads), all of which are referenced against the ground lead. The selected references are applied in the software and bipolar derivations can also be computed. *NuAmps* is capable of sampling rates

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between 125-1000Hz and has an A/D resolution of 22 bits. The full input scale is  $\pm 130\text{mV}$  and bandwidth is from DC to 300Hz, depending upon sampling frequency selected. NuAmps uses optical signal isolation, and can receive 14 digital TTL inputs (for event marking). NuAmps is connected to the host PC running Scan 4.3 via the USB port; this PC (laptop) is powered by a medical grade isolated power supply to ensure full electrical isolation of the subjects. Electrode leads can be connected individually to NuAmps via the headbox, or if an electrode cap is used, through a 37-pin connector.

The Scan 4.3 software package has two modules; '*Acquire*', which is used to control signal acquisition (i.e. channel selection, impedance testing, online filtering, recording etc) and '*Edit*', which is used for subsequent offline signal analysis of the recorded EEG record. All parameters of the NuAmps amplifier are exclusively software-controlled through *Acquire*. *Edit* can be used to filter and epoch the recorded EEG trace and to perform various types of analysis such as FFT, Event-Related Potentials, Even-Related Band Power, coherence measures etc.

To control stimulus presentation and to provide EEG event markers we used another PC, which was also fitted with a medical grade isolated power supply in order to maintain electrical isolation of the subjects. This PC was connected to the NuAmps amplifier using a custom-made cable.

- Software used for stimulus presentation and randomisation

To provide stimulus presentation we used '*Inquisit*', a software package for running psychological experiments made by *Millisecond Software*. This package was specifically chosen for its ability to provide time accurate stimulus presentation in a Windows OS environment. Providing reliable, accurate timing data is often a problem in Windows as it is not a real time operating system. As a result it may introduce anomalies into stimulus presentation times and response latency measurements, which can be problematic when millisecond-scale accuracy is important, as is the case when EEG recordings are involved. It is an unfortunate feature of Windows that no software package can guarantee accurate timing every time, but specially designed applications such as *Inquisit* can take steps that make timing anomalies very rare. This system has been independently tested by researchers at the University of Ghent, Belgium, using

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FASTLOG, a program they developed for testing the timing accuracy of PC experimentation software (De Clercq, Crombez et al. 2003). The relative difference between the data given by Inquisit and their system never exceeded 1.84msec in these tests, and in most cases was <1msec.

A command script was written giving instructions to Inquisit for controlling the experimental sequence; this included the following parameters:

Three types of stimuli were used, the first one, (named 'SingPhot'), instructed Inquisit to send two simultaneous TTL pulses through the parallel port, one to the (white) LED glasses to produce a single flash of 80msec duration, and the other to NuAmps to set an event marker on the EEG trace at the beginning of the stimulus presentation.

The second one, ('DudPhot'), involved sending only one TTL pulse to NuAmps in order to set an event marker on the EEG trace. As no photic stimuli were presented during these events, these markers were used to sample control periods from the EEG trace.

The third type of stimulus, ('TrainPhot'), first involved sending two simultaneous TTL pulses, one to the 'Orion' audio-visual stimulation device to trigger a train of 23Hz photic pulses which were presented through the LED glasses, and the other to NuAmps to mark the beginning of this event. This continuous photic stimulation lasted for 11 seconds, at the end of which another pair of TTL pulses were send, one to switch off 'Orion' and the other to mark the end of stimulation on the EEG record.

## Stimulus presentation and randomisation:

Each of the 'SingPhot' and 'DudPhot' stimuli had a prestimulus latency between 1 and 8 seconds, in one-second steps, and the 'TrainPhot' stimuli always had a fixed prestimulus latency of 4.5sec. Therefore for EEG sampling purposes the mean inter-stimulus latency was 4.5sec.

For the individual sessions all three type of stimuli were used, whereas for the joint (remote) sessions only single flashes ('SingPhot') and control markers ('DudPhot') were used.

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Therefore for the joint (remote) sessions, 'SingPhot' and 'DudPhot' stimuli were pseudorandomly sampled with replacement, from a "basket" containing eight of each such stimuli, with a prestimulus delay of 1-8 seconds each. For the participants however, who were only aware of the 'SingPhot' stimuli (photic flashes), as the control 'DudPhot' stimuli were not perceptible, the mean inter-stimulus latency was 8sec and varied between 1-16sec. Sampling with replacement ensured that each type of stimulus and latency had an equal probability of being selected each time, thus eliminating any possible expectation effects and anticipatory responses. One hundred and eighty-six such stimuli were presented during each remote session; therefore we would expect on average half to be single flashes (and associated event markers on the EEG), and half to be control event markers on the EEG trace (with no associated photic stimuli) with a mean interstimulus latency of 4.5s.

The individual sessions consisted of 156 stimuli, including series of continuous flashes at 23Hz of 11s duration. Again, stimuli were selected with replacement, and the relative probability of selection each time was 0.43 for the photic stimuli, 0.43 for the control stimuli and 0.13 for the continuous flashes (therefore average numbers of stimuli of each type were approximately 67, 67, and 20 respectively). Inter-stimulus latencies were as described above. A transcript of the *Inquisit* commands for stimulus presentation is given in Appendix E.

- Hardware used for photic stimulus presentation:

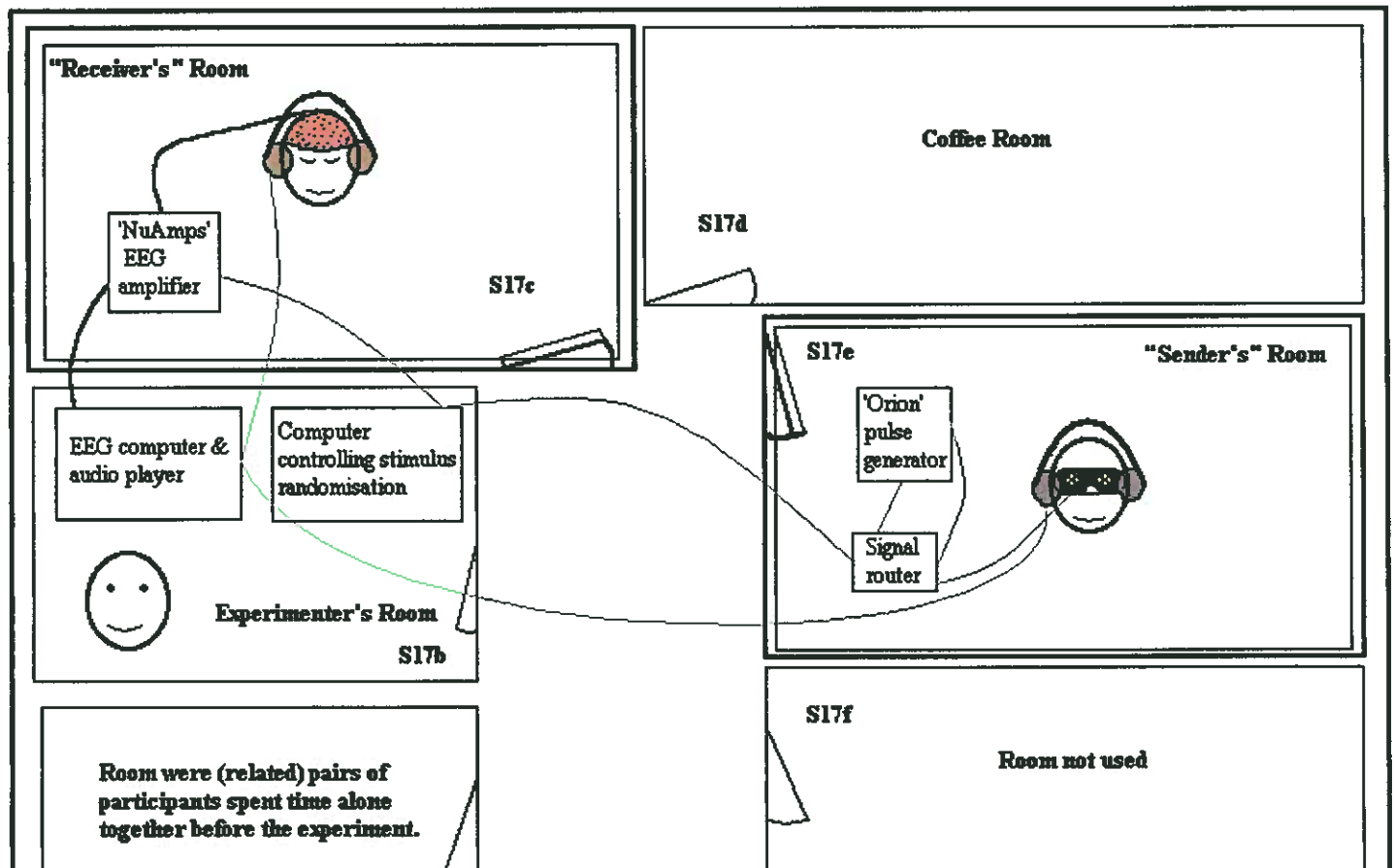
To present photic stimuli we used a pair of standard plastic sunglasses fitted with eight white (clear) LEDs, four over each eye. These could be used to photically stimulate both eyes simultaneously or independently. We also used an 'Orion' "light and sound" device made by *Synetic Systems*, which can provide repetitive audio-visual stimulation at various frequencies and patterns, when used in combination with headphones and the LED glasses described above. We used the 'Orion' unit (controlled via the PC) to provide the repetitive photic stimulation signal to the glasses (TrainPhot), while single photic flashes were triggered directly from the PC which controlled stimulus presentation. The glasses were connected via a stereo lead to a box containing a purpose-built circuit, which was used to enable the remote controlling of the Orion unit from the PC. This circuit also acted as a switchboard

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directing the TTL trigger pulses coming from the PC either to the LED glasses (to trigger single flashes) or to the Orion unit (to turn it on and off). A full diagram of this circuit can be seen in Appendix B.

- Overall description of stimulus presentation and EEG recording system as a whole; networking and automatisisation.

Figure 1 demonstrates the layout of the laboratory, the positions of the participants and experimenter and the connections between the experimental apparatus. The audio recording was played using the EEG computer, and was conveyed to both participants using a shared one-way audio link. The computer responsible for stimulus randomisation was connected to an electronic circuit (Appendix B) in the sender's room which in turn was connected to the LED glasses and the 'Orion' signal generator. This computer was also connected to the EEG amplifier in the receiver's room, in order to be able to use TTL pulses to set event markers on the EEG record designating the timing of photic flashes and control periods. These TTL inputs have galvanic isolation from the participant and the amplifier, there is therefore no danger of contaminating the EEG record with interference from the electrical signals used to



- Relaxation recording and audio stimulation

A progressive relaxation procedure was prepared and recorded in audio format, its primary aim being to help participants relax physically and mentally prior to the experimental period. As well as instructions for relaxation, the recording also included some general suggestions for entering a pleasant altered state, quite similar to both a mild hypnotic trance and a hypnagogic state, as well as gentle suggestions for the participants to remain aware of each other during the session. No direct suggestions were given to expect or attempt success in the psi task; it was preferred to try and direct the participants into a state likely to be conducive to success, but discourage, or at least not to encourage conscious effort to succeed.

This recording which lasted for approximately eleven minutes was followed by a drumming recording, which was taken from a CD made by Leo Rutherford and Howard Charing (*Drumming for the shamanic journey*). This drumming is normally intended to be used for practising 'shamanic journeying' i.e. entering an altered visionary state with the help of drumming and other stimuli and practises such as guided visualisation, regulated breathing, psychoactive substances and/or other methods. In the recording used in the experiment, two people were drumming using single headed frame drums, with the drums held facing each other to optimise reverberation. It has inter-beat intervals of around 0.2 - 0.25msec (frequency of 4-5Hz), and although the beat rhythm is relatively constant, subtle changes in pitch are of considerable complexity and give the impression that the drumming pattern is constantly changing, thus keeping one's attention continuously engaged. The recording also gradually increases in volume over the 15-20 or so minutes that the session lasts, but this is generally too subtle to be consciously perceived. After the drumming (and the photic stimulation period) ends, participants listen to another brief recording of verbal instructions, intended to help them to gently return to their ordinary state of consciousness. This part lasts for approximately 1.5min, and includes

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suggestions for gradually directing attention outwards, increasing somatic self-awareness and for returning to ordinary consciousness feeling alert and refreshed.

Two different recordings of the relaxation procedure were used, one for participants during their individual session, and one for participants in pairs during their joint (remote) session. The procedure itself was virtually identical, but in the case of the recording for the joint session instructions referred to both participants (using the plural tense), and also included a few additional suggestions encouraging them to remain aware of each other during the session. As the relaxation procedure was expected to induce some loss of self-awareness, the combined effect of diminished self-consciousness and suggestions for remaining aware of each other is expected to facilitate to some extent a loosening of perceived boundaries between people in each pair. This is expected to be a desirable state for the aims of this experiment and was therefore encouraged. The full transcript of both versions of the relaxation procedure can be found in Appendix C.

- Scales and questionnaires administered

We used of a modified version of the Koestler Parapsychology Unit's Participant Information Form to collect general information about our participants (Appendix A.2). In addition, we administered the Tellegen Modified Absorption Scale (Jamieson 1986) prior to the joint session, and the Phenomenology of Consciousness Inventory (Pekala 1991) after the participants had completed their joint session together. These can be found in Appendix D.

## **EEG settings:**

Thirty-two monopolar channels of EEG were recorded (including references) from the following sites according to the standard 10/20 system: 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. Reference used was linked ears (A1+A2/2), and we were sampling at a frequency of 500Hz. A notch (bandstop) filter was used set at 50Hz to eliminate main power frequency interference, and the bandpass filter was

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set at 1-100Hz. A *'Quick-Cap'* electrode cap was used along with clip ear electrodes. All electrodes were sintered Ag/AgCl, and the electrode gel used was *'Quick-Gel'* sold by *'Advanced Medical Equipment Ltd.'*

## **Procedure:**

For their individual session, (when their EEG was recorded while they were photically stimulated themselves), participants could come to the laboratory either with their partner or on their own, and either before, on the same day, or after their joint (remote) session together. This was left to the participants to decide and was primarily dependent on when it was convenient for them to come. Looking at the subsequent overall order of testing sessions, it appears that this essentially randomised the order of sessions for each pair of participants (i.e. sender's individual session, receiver's individual session, joint session). Prior to their first session participants were asked to complete the Participant Information Form (Appendix A.2), and before their second session they were asked to complete the Modified Tellegen Absorption Scale (Appendix D), regardless of which of these was their individual or the joint session.

Individual sessions followed the same procedure as the joint session, except that participants spent no time with their partner prior to testing. They were welcomed and given a brief tour of the lab and research facilities, while the experimenter explained the procedure, rationale and aims of the experiment. Nothing was withheld from the participants (with the exception of the five participants who were not matched with a sender but were not told this until after the testing). The electrode cap was then fitted and electrode gel applied, and participants were led to room S17c where they were comfortably seated in a reclining position. Measurements were taken to test electrode contact and adjustments were made where needed to improve conductivity and lower impedance to less than 5k $\Omega$ . Once clean EEG records were obtained, participants wore the headphones and LED glasses and adjusted the volume and brightness to their preferred level. The experimenter asked participants to keep their eyes closed throughout the session, and pointed out that they could stop the

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session at any time if they wished to, simply by taking the glasses and headphones off.

The ambient light was dimmed and the door closed before the experimenter initiated EEG recording. After two minutes of baseline recording during silence, the relaxation procedure was played to the participant through the headphones. This lasted for approximately 11 minutes and was followed by drumming, lasting for approximately 15 minutes. Two minutes after the drumming had started, the experimenter initiated the program which controlled photic stimulation. This lasted for an average of 11.7 minutes, the actual duration depending on the proportion of the randomly chosen pre-stimulus intervals associated with each stimulus. After the conclusion of photic stimulation, the experimenter manually faded-out the volume of the drumming recording, and played the final post-session instructions for gradually returning to ordinary consciousness.

At this point the EEG recording was terminated and the experimenter entered the participant's room, removed the electrode cap and showed them to the bathroom if they wished to wash the electrode gel from their hair.

For the joint session, the same experimental procedure was followed, with the following variations. If the two participants had not already decided who was to be the "sender" and who the "receiver", they were asked to do so now, and if they preferred not to decide they were given the option to choose randomly by tossing a coin. The person who was to be the "receiver" then wore the electrode cap and test measurements were taken to ensure proper electrode contact, before both participants were shown to the room where they would spend time alone together (S17a in Fig. 1). They were told they could spend 10-15 minutes there doing anything they thought would help them enhance their awareness of each other. Some possibilities were suggested, such as meditation, synchronised breathing, exchanging personal items (e.g. jewellery), but they were encouraged to do whatever felt most appropriate for them both and to feel free to improvise. They were also gently 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 isolated experimental rooms. This was thought to be a possible way of helping them maintain the feeling of "connectedness" achieved in the common room into the experimental period, as odours are often effective as potent memory triggers

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and are particularly effective in evoking emotional elements of memories. Evidence from fMRI studies indicate 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 the participants' separate rooms would also help make their sensory environments more similar. Participants were given a choice between different types of incense, and most pairs (but not all) made use of some.

Finally the experimenter wished them good luck with the session, closed the door and went to the control room (S17b Fig.1) where he remained until the end of the session. From this point onwards the participants did not interact with the experimenter again, (or anyone else), until the end of the session.

After their time alone together, the participants went to their respective experimental rooms; these were S17c for the "receiver" and S17e for the "sender". The "receiver" connected the electrode cap he/she was wearing to the amplifier, at which point the experimenter could see the EEG trace appear on the screen of the EEG computer in the control room. Both participants closed the double doors of their respective rooms, sat comfortably in the reclining chairs and put on the headphones, while the "sender" also wore the LED-fitted glasses. The experimenter started recording the EEG, and soon after started playing the audio sequence of relaxation instructions, followed by drumming and then the final instructions. This was the same as in the individual sessions, with the only exceptions mentioned above (i.e. suggestions to participants during the relaxation period to remain aware of each other). During the drumming period the "sender" was exposed to randomly timed photic flashes, using the randomisation protocol described above. At the end of the session, after the final instructions for returning to the ordinary conscious state, the experimenter stopped the EEG recording, opened the doors to the experimental rooms, and helped the "receiver" remove the electrode cap. Participants were then asked to complete the Phenomenology of Consciousness Inventory in relation to their subjective experiences during the experimental period, particularly during the drumming period.

For the unrelated pairs who didn't know each other prior to the experiment the procedure was exactly the same as with the related pairs, except that they spent no time together before their joint session. Individual participants were randomly

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allocated into pairs by the experimenter, and the "receiver" had the electrode cap fitted and was already in his/her experimental room by the time the "sender" arrived at the laboratory, thus making sure they had no direct contact before the session.

Participants in this group were introduced to each other for the first time after the end of the session.

The five participants who were not matched with a "sender" were told that they were 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). After the session the experimenter gave them a full debrief, apologised and explained the reasons for the deception.

## Results

The raw EEG data from all N=41 participants was treated with a band-pass filter set at 1-30Hz and visually inspected for artefacts. Channels that were consistently noisy, or which were accidentally disconnected during recording, were marked and excluded from further analysis (an average of one-two channels per person). The total number of channels per participant therefore varied, and as two of the channels recorded corresponded to the reference electrodes which were also not included in the final analysis, the maximum number of channels per participant was 30. Reference electrodes from two participants were accidentally disconnected during their sessions effectively interrupting the recording, therefore all data from these two subjects was excluded from subsequent analysis. One such sample was from a "sender" in an unrelated pair (during direct stimulation) and the other from a "receiver" in the 'no partner' group (during "remote" stimulation).

We divided the data into two main groups; one consisted of EEG recordings during each individual subject's direct photic stimulation (both "senders" and "receivers"). The other consisted of EEG recordings from unstimulated "receivers" when their (related or unrelated) partner was photically stimulated, or in the case of

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the 'no partner' group, when photic flashes were presented in the absence of a perceiving "sender".

The numbers of participants in each group therefore were as follows:

**Table c.1:** Numbers of participants divided by the role they had taken in joint sessions. All participants were individually stimulated with photic flashes while their own EEG was recorded. Results from one "sender" were excluded due to faulty recording.

<b>Direct Photic Stimulation</b> (N=39)	
"Senders"	N=17
"Receivers"	N=22

The twenty-two "receivers" also had their EEG recorded during the joint session when their partner, a randomly matched stranger, or no one was being stimulated. These participants can be further divided into three groups according to the pairing condition they were in (Table c.2).

**Table c.2:** Numbers of participants according to condition. The 'no sender' condition originally had 5 participants, but data from one were rejected due to faulty recording (see above).

<b>"Remote" Photic Stimulation</b> (N=22)	
"Receivers" in related pairs	N=13
"Receivers" in unrelated pairs	N=5
"Receivers" with no partner	N=4

Three-second long epochs were sampled from the continuous EEG records, centred around stimulus presentations times (and random control markers) and ranging from -1sec pre-stimulus to +2sec post-stimulus. All epochs were baseline corrected and those containing amplitudes  $>100\mu\text{V}$  were automatically rejected, as these most likely involved artefacts. Other artefacts however often appear at lower amplitudes, within the same voltage range as normal EEG activity. For this reason all epochs were also visually inspected and those found containing additional artefacts such as eye movements and face muscle activity were manually rejected. We preferred to manually reject epochs containing eye movements rather than use correction algorithms to remove them, as our participants kept their eyes closed throughout the session and there were relatively few eye movement artefacts.

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We had originally planned to sample epochs of shorter duration, and only later decided to take 3second long epochs to enable us to see the full evolution of responses (some of which continued beyond +1sec post-stimulus), and to avoid sampling epochs containing overlapping responses to more than one stimulus. According to the stimulus randomisation protocol we used, the shortest possible interstimulus interval was 1sec; therefore we could not use all of the 3sec 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 <3sec. After such rejections the number of epochs left 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). An equal number of random control markers was used to sample epochs from periods of no stimulation.

## **Results of direct photic stimulation sessions**

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 used, and thus provide pilot measurements with which to plan the analysis of data from "remote" sessions.

Two main methods of summarising the raw EEG data were used:

1. **Event-Related Potentials**: simple averaging of epochs across time to reveal voltage changes that are time-locked to the stimulus event.
2. **Event-Related Band Power (synchronisation and desynchronisation) measures**: estimates of power changes (within a certain frequency band) in a post-stimulus interval, relative to a reference pre-stimulus interval.

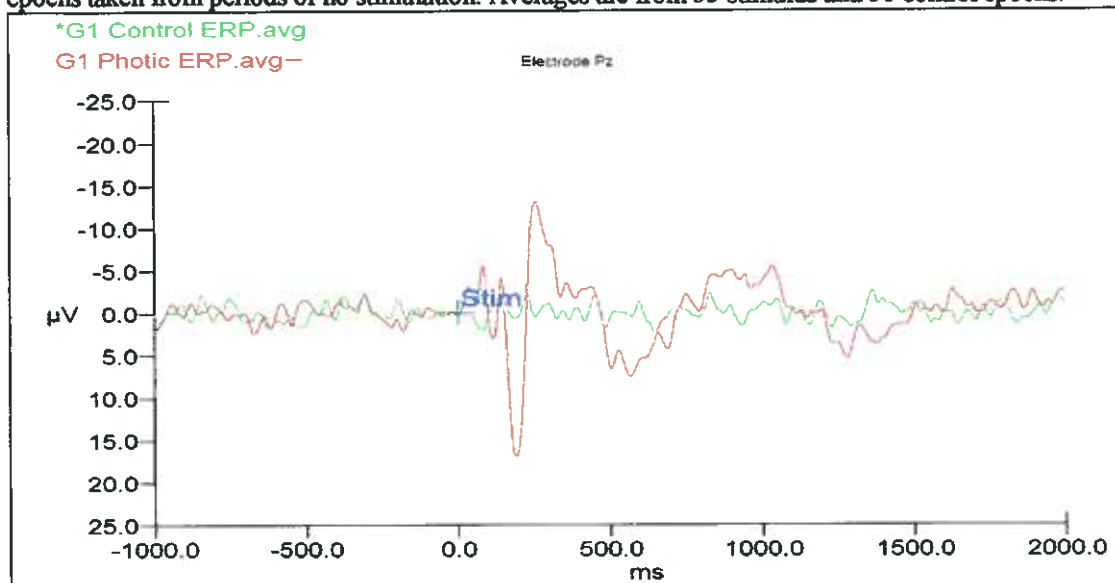
## 1. Event-Related Potential (ERP) measures

*Event-Related Potentials* can be defined as voltage changes in EEG activity that are directly related to the perception of some externally presented stimulus, or the occurrence of an internal mental event (such as the decision to initiate a finger movement). These are normally in the range of microvolts, and as total EEG activity is usually in the order of tens of microvolts, the ERP signal can be said to be hidden within the background "noise" of general EEG activity. By repeatedly presenting the stimulus however, and then taking a number of EEG epochs all time-locked to the stimulus event, it is possible to extract the ERP component by averaging voltage values at each time-point across epochs. Because epochs are time-locked to a stimulus event, (in this case a photic flash), such averaging will reduce all EEG activity that is not time-locked to this event, as such random voltage variations will tend to cancel each other out. On the contrary, ERP activity that has a fixed temporal relationship to the event will not be attenuated in this way, and with the additive averaging of several epochs will eventually stand out from the diminishing background noise, given a sufficiently large number of epochs.

Figure c.1 shows the averaged ERPs of one of our participants in response to photic flashes (red line). Such visual ERPs, (also called *Visual Evoked Potentials, VEPs*), have a relatively consistent latency and amplitude across subjects, provided that the visual stimulus is the same. In comparison, the green line shows time-averaged EEG epochs from the same subject and electrode taken from periods of no stimulation. Amplitude for the control averages generally remains within the  $\pm 2.5\mu\text{V}$  range, while for the VEPs it exceeds  $\pm 15\mu\text{V}$  at its peaks. The largest deflection can be observed at P200, that is 200ms after stimulus onset in the positive direction (downwards on the scale). This is a typical component of visual and other evoked potentials, and although its latency varies somewhat across electrode sites and subjects, the average from multiple electrodes and several participants tends to peak almost precisely at 200ms post-stimulus. Other large components can be seen at roughly N250 and P550.

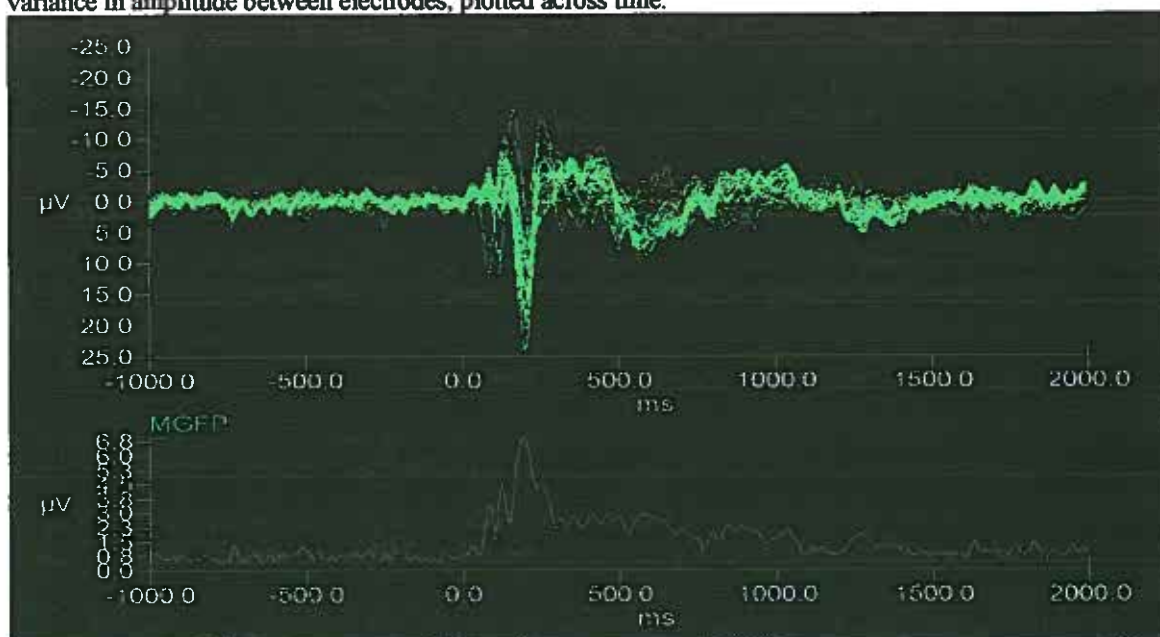
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**Figure c.1:** Visual evoked potentials from subject G1, electrode Pz. Line in red represents averaged epochs taken during direct photic stimulation (-1s to +2s); the green line represents averaged control epochs taken from periods of no stimulation. Averages are from 55 stimulus and 56 control epochs.



In Figure c.2 we can see the average ERPs from all electrodes (same participant) superimposed, demonstrating the relatively small variations in latencies and amplitudes between electrode recording sites.

**Figure c.2:** Superimposed ERPs from all (32) electrodes from subject G1. Bottom graph shows variance in amplitude between electrodes, plotted across time.



In most cases, early ERP components occurring at <100ms post-stimulus are considered to be directly related to external stimulation, e.g. transmission of signals

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from peripheral sense organs via sensory pathways to the cortex, whereas later components are thought to be primarily of endogenous origin and related to cortical processing of the received information (Rugg and Coles 1993). As slower potentials of lower amplitude can still be clearly seen as late as 1000ms and 1300ms post-stimulus (Fig. c.1), and the waveform only returns to pre-stimulus levels after about 1500ms, our choice of relatively long 3s epochs appears justified. The 1s pre-stimulus interval is not really useful for ERP analysis, but becomes essential when we look at event-related band power measures.

## 2. Event-Related Band Power analysis (Evoked and Induced ERD/ERS)

*Event-Related band power* measures (ERBP) make use of the same basic principles as ERPs, but also involve performing some additional calculations on the raw data. The first difference is that while ERPs include activity in all available frequencies, in ERBP the EEG of all event-related trials is band-pass filtered around a central frequency band of interest, and all electrical activity outside this band is therefore filtered out. This is obviously removing information from our signal; the reason for wanting to do this at all, is that there are event-related responses that consist of frequency-specific changes in EEG activity, which can be too small to be detected when activity in other frequencies is also present in the signal. In these cases, such filtering amounts to reducing extraneous noise from the signal, i.e. EEG activity that is perhaps not relevant to the research questions addressed. As the next step, a number of epochs that are time-locked to the stimulus are again averaged point-by-point, but the amplitude values are first squared in order to obtain power measures ( $\mu V^2$ ); these contain no negative values, and are essentially an absolute measure of electrical activity (an alternative is to use absolute amplitude values).

In the type of ERBP measures that we will be using, a pre-stimulus interval is also used as reference, against which activity in the post-stimulus period is compared. Therefore, if there is a decrease in electrical brain activity after stimulus presentation relative to before, the response is called *Event-Related Desynchronisation (ERD)*, as it indicates loss of power within the specified frequency band (and perhaps a shift of activity to different frequencies). If on the other hand, power in the post-stimulus

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interval increases relative to pre-stimulus, the effect is called *Event-Related Synchronisation (ERS)*, as it implies an amplification of activity in the given frequency band, as a response to a perceptual (or other) event (Pfurtscheller and Aranibar 1977).

ERD and ERS estimates are calculated as percentages using the following formula:

$$f_1: \quad ERD(ERS)\% = \{(RefPower - TestPower) / RefPower\} * 100$$

Therefore power in the post-stimulus (Test) interval is defined as a percentage of power in the pre-stimulus (Ref) interval; whether the estimated value is negative or positive indicates the direction of the difference. Somewhat counter-intuitively perhaps, *positive* percentages indicate *desynchronisation*, whereas *negative* percentages indicate *synchronisation*<sup>1</sup>.

Perhaps the most well studied example of ERD is “alpha-blocking”, i.e. a decrease in power within the alpha band (8-12Hz) as a response to an external stimulus. This effect is extremely robust and easy to demonstrate; as simply sitting with eyes closed soon produces an EEG dominated by alpha activity in most people, the presentation of almost any type of sensory stimulus (visual, auditory, tactile etc) in such a condition triggers a sudden and dramatic reduction of alpha power, and an associated increase of power in higher frequencies (which is however, harder to detect) e.g. (Nogawa, Katayama et al. 1976).

Recently, several researchers have drawn attention to the fact that such ERD/ERS calculations as described above, can contain information about two quite distinct dimensions of the underlying electrocortical activity; namely, *phase-locked* activity, which involves amplitude changes that are directly triggered by the stimulus event (i.e. as in ERPs), and activity which involves amplitude changes which are time-locked, but not phase-locked to the stimulus event e.g. (Kalcher and Pfurtscheller 1995), (Klimesch, Döppelmayr et al. 2000). Phase-locked responses (also called *evoked*) typically have short latencies and evolve within a small time frame, while the non-phase-locked responses (also called *induced*), evolve over a much larger time window, and in the case of alpha ERD often appear as a slow

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negative drift. In terms of the underlying neural dynamics involved in these processes, this difference has been interpreted as indicating that while evoked responses represent a transient phase-locking of post-synaptic activity in pyramidal neurons which is triggered by a specific stimulus (as in the early components of ERPs), in contrast, induced responses can be seen to relate to changes in parameters associated with, and affecting, frequency oscillations in neuronal networks. One such variable is the strength and pattern of dynamical interconnections between network elements; therefore induced components are highly frequency-specific, as neural networks can display different states of functional organisation at different oscillation frequencies (Pfurtscheller and Lopes da Silva 1999). Evoked potentials on the other hand, have been described as the result of the stimulus resetting the phases of the ongoing EEG activity, a process that is largely frequency-independent.

These two components in ERBP measures are relatively independent but complimentary aspects of EEG activity, and several studies have found seemingly 'paradoxical' responses, where for example, induced alpha power decreases in response to a stimulus, while evoked alpha power increases during the same time interval (Klimesch, Döppelmayr et al. 2000). For these reason we decided to initially investigate responses to direct photic stimulation in our study using both measures, and use our findings to guide subsequent analysis of data from the "remote" stimulation sessions.

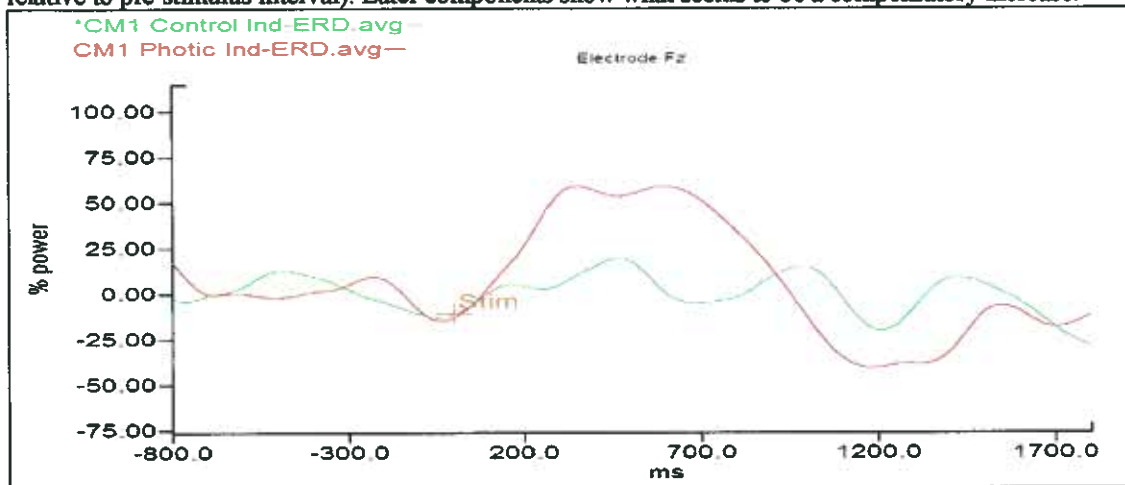
To calculate induced responses, EEG epochs were bandpass filtered at 8-12Hz, the standard alpha frequency range. Then the point-to-point intertrial variance was calculated and averaged over time, and formula  $f_i$  used to calculate post-stimulus activity as a percentage of activity in the pre-stimulus reference interval (-1s to 0). This is repeated for epochs from both photic stimulation and control conditions. Figure c.3 shows an example of the responses we found using this method. (Please note that 200ms have been trimmed from either side of the waveform to remove filter warm-up artefacts.)

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<sup>1</sup> In a more recent paper, Pfurtscheller (1999) suggests using an amended version of the original formula so that negative percentages indicate desynchronisation and positive values indicate synchronisation. Although we consider this to be a more intuitively correct approach, we will use the original formula

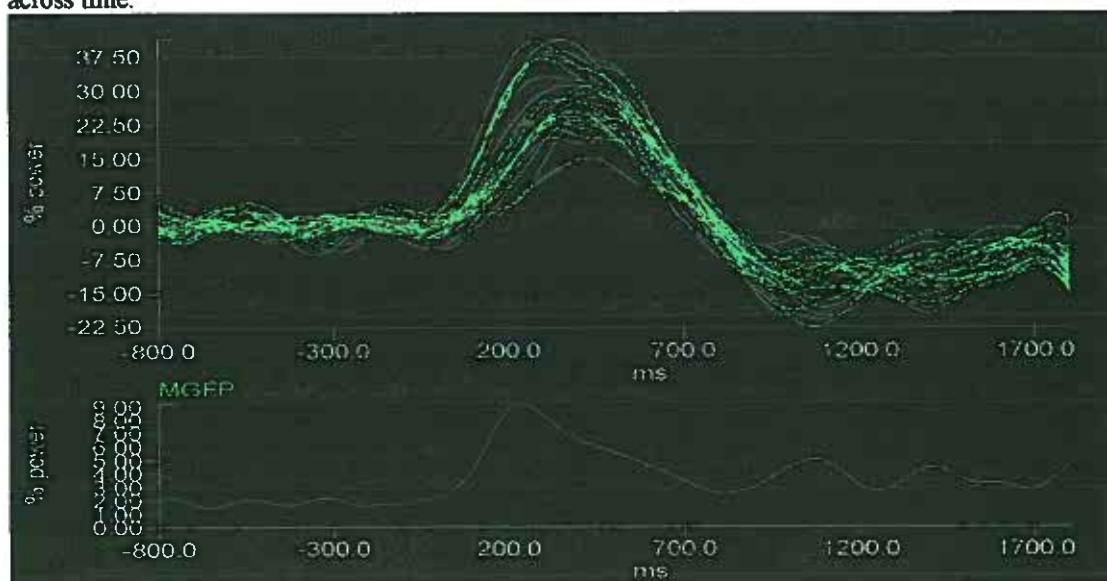
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**Figure c.3:** An example of induced responses to photic stimuli (alpha band), from subject CM1. Early components show the expected alpha desynchronisation (positive percentages indicate power decrease relative to pre-stimulus interval). Later components show what seems to be a compensatory increase.



The expected alpha desynchronisation effect can be seen for photic stimulation epochs (red line), while no such effect is apparent for controls (green). This seems to reach a peak at 200ms and remain at considerably low levels for more than 500ms before returning to baseline. A later negative component can be seen around 1200ms showing alpha synchronisation, i.e. increase in alpha power relative to pre-stimulus baseline. This seems to represent a compensatory response to the earlier power decrease, what has sometimes been called an 'alpha rebound' effect. Figure c.4 shows the averaged induced responses for all 39 subjects, with all 30 electrodes superimposed.

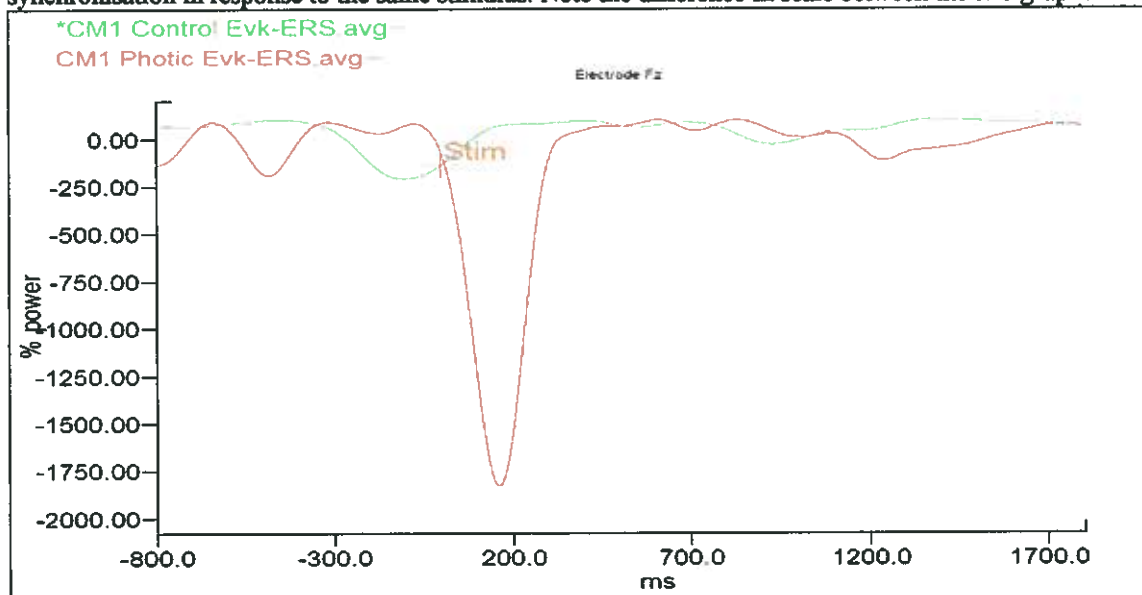
**Figure c.4:** Induced ERD responses to direct photic stimulation, averaged for all subjects (N=39). Separate lines are single electrodes (30). Lower graph shows variance between electrodes plotted across time.



throughout this paper as the software we used for the analysis constraints us to this option.

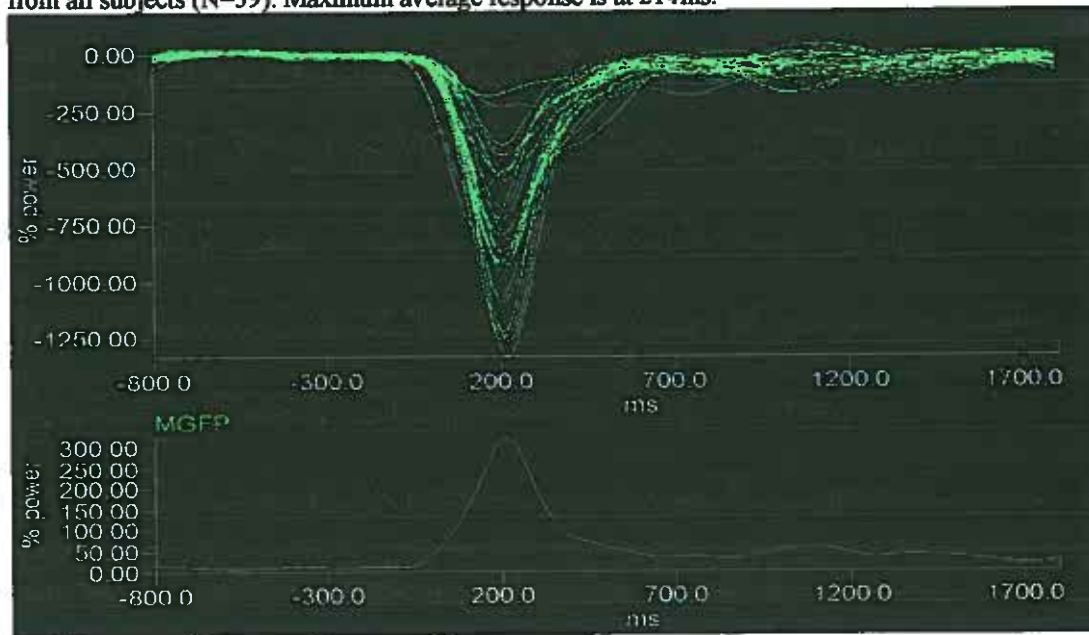
To calculate evoked event-related responses to photic stimulation, EEG epochs were filtered as above (bandpass 8-12Hz), and amplitude was squared and time averaged across epochs, so that the value at any given time point is the average of all squared voltages at that point. The ERD/ERS percentage was then estimated by comparing the pre-stimulus baseline to the post-stimulus period using formula  $f_1$ . An example of evoked alpha response to photic stimulation can be seen in Fig. c.5. Although this refers to the same subject and electrode, and therefore the same EEG data, as the induced alpha desynchronisation response seen in Fig. c.4, evoked event-related alpha measures show a short-lasting alpha synchronisation component which peaks just before 200ms. Unlike the induced response which has a much longer time evolution, evoked alpha activity returns to baseline about 400ms after stimulus presentation.

**Figure c.5:** Evoked alpha response to photic stimulation, subject CM1. Contrary to the induced ERD response from the same subject and electrode seen in Fig. c.4, evoked ERBP measures show alpha synchronisation in response to the same stimulus. Note the difference in scale between the two graphs.



The combined (averaged) evoked alpha responses of all 39 participants are shown in Fig. c.6, with all electrodes superimposed.

**Figure c.6:** Evoked alpha power synchronisation responses to direct photic stimulation, averaged from all subjects (N=39). Maximum average response is at 214ms.



These differences between evoked and induced responses were expected for the reasons discussed above; evoked responses are the result of a stimulus effectively resetting the phase relationships between waveform components, while induced responses can be said to relate to frequency-specific changes in dynamical neural connectivity. In this sense, evoked activity is more directly stimulus-bound, whereas induced activity, while also related to the stimulus, reflects more widespread changes in the activity of neural interactions that control the frequency components of the EEG signal. In the specific case of our results above, induced components clearly relate to a temporary disruption of the previously dominant alpha rhythm as an effect of photic stimulation, whereas evoked components seem to be a direct result of sensory processes responding to the stimulus. We had no reasons, theoretical or otherwise, to expect one of these neural processes and associated measures to be more responsive to a “remote” stimulus than the other. Therefore our subsequent decision to use evoked, rather than induced event-related band power measures for the main analysis of data from the “remote” stimulation sessions, was primarily based on the observed differences between the properties of the waveforms produced by each method. These differences are discussed below.

Evoked ERBP responses are in most cases more clearly defined, having a short onset latency and a steep rise and fall, and the latency of their peak is fairly consistent between subjects and electrodes. The onset latency and shape of induced

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responses on the other hand, is more variable both between subjects and between electrodes. Also, the longer time evolution of induced responses and the fact that they often involve both early power increase components and later decrease components (see Fig. c.3&4), adds a further level of complication to their analysis. More importantly perhaps, evoked responses show much larger changes from pre-stimulus baseline activity than induced responses do (even though the actual voltage values involved are smaller), and are therefore likely to be easier to discriminate from random noise. Also, in our pilot tests we could identify small deflections in evoked alpha activity during “remote” photic stimulation somewhat suggestive of a response, while no such changes could be seen in induced alpha activity. Therefore we decided to focus on evoked alpha power changes as our main measure in the analysis for the “remote” sessions, at least as a first step.

## **Results of “remote” photic stimulation sessions**

The alpha power changes following direct photic stimulation seen above, are strong enough not to warrant statistical significance testing in order to demonstrate that a stimulus-related response is present in the signal; the difference when compared to control periods of no stimulation is clear enough. We did not expect any “remote” responses, if present, to be as easily identifiable however, and formal statistical testing would in any case be required to ascertain that any such signal can be confidently discriminated from random fluctuations in EEG activity. Although ERD/ERS measures are by definition already comparing post-stimulus activity against a pre-stimulus baseline, such measures would still need to be compared against control samples taken from intervals where no stimuli were presented.

The same algorithm used for randomising the inter-stimulus presentation latencies of photic flashes was also used to set random event markers on the EEG record in real time, i.e. during the session itself. These control events had the same temporal properties as photic stimuli (e.g. average pre- and post-stimulus latencies), and were equally likely to be presented at any given point in time. These therefore can be used to define random samples of EEG activity from inter-stimulus intervals, but

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have the added advantage of having exactly the same statistical properties as test samples<sup>2</sup> (see *Method* section for more on the properties of photic and control stimuli). We will be using these control periods as baseline reference against which to compare a test interval of interest from the “photic” stimulation epochs. The next question that needs to be addressed is how to choose this interval.

## Choosing analysis parameters:

One of the reasons we decided to use evoked ERBP measures, was because evoked responses have an easier to define time evolution than induced responses, (as can be seen in Fig. c.5&6), as well as a generally lower between-subject and between-electrode variability in latency and magnitude of responses. These features would perhaps be less important had we intended to define the test interval of interest separately for each subject and electrode site; instead however we defined the test period of interest based on the averaged responses of all participants. This was done both for simplicity, due to the relatively large number of electrode sites we were recording from, as well as for the fact that we had no theoretical or other expectations about whether any responses, if found, would resemble more the “receivers” own responses to photic stimulation, or those of the “senders”. The maximum peak of averaged evoked alpha power responses to direct photic stimulation for all subjects was just over 200ms, (Figure c.7), and we chose this to define the latency of our expected peak of response from non-stimulated “receivers” (the maximum was in fact at 214ms, but we used 200ms as our central latency for simplicity, as the difference in %power between them was minimal). Since the curve is largely symmetric, and the response starts almost immediately after stimulus presentation<sup>3</sup>, we defined our test

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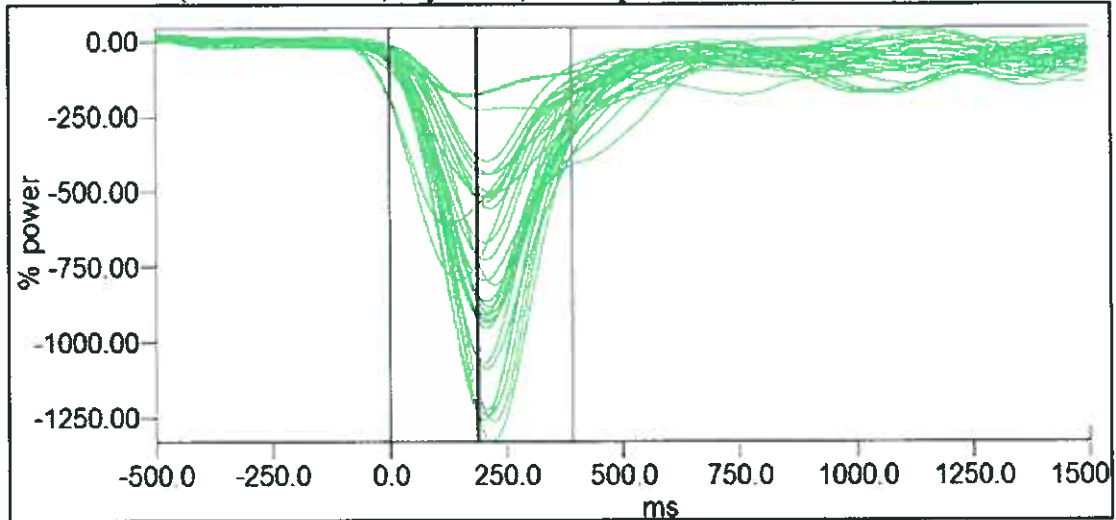
<sup>2</sup> This would not be very important perhaps in most psychophysiological experiments. In experiments such as this one however, where we are trying to ascertain whether or not our stimuli are perceived by our subjects at all, according to the null hypothesis our “test” epochs are effectively nothing more than random samples from the running EEG record, and are no different to our control epochs. It is important therefore to ensure that test and control epochs are chosen equally randomly, so as to be statistically comparable.

<sup>3</sup> It is impossible to specify precisely when the response starts with this measure, as a running window is used in ERD/ERS analysis in order to calculate post-stimulus activity relative to power in the pre-stimulus reference interval as a function of time. This has a smoothing effect on the resulting waveform, which is why responses appear to start before stimulus presentation; this is an artefact of the analysis technique. It is equally impossible to specify precisely when the response ends.

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interval to be the range of 200ms before and after the peak response, i.e. 0-400ms, and this range seemed to contain most of the magnitude of the responses.<sup>4</sup>

**Figure c.7:** Chosen interval of maximum average evoked responses to direct photic stimulation for all participants (0-400ms). This was used as the test interval in the “remote” photic stimulation periods for the “receivers”. (If lines seem bend, they are not; it’s an optical illusion...)



For every “receiver”, evoked alpha power was calculated as a percentage of pre-stimulus power for epochs time-locked upon photic stimulation of his or her partner (at time 0ms); as before, the pre-stimulus reference interval was set at -800ms to 0ms. The average percentage of evoked alpha power change (increase/decrease) for the test interval 0-400ms was calculated per participant and electrode. The evoked alpha power in random control periods was similarly calculated as a percentage of ‘pre-event marker’ activity. In contrast with test periods however, for control samples we averaged values for the entire length of the epoch following such markers, i.e. the following 1.8 seconds. As these samples were to be used as references, and we had no reason to expect any specific time-locked components to appear in these epochs, it was preferable to average over as long a period as we could in order to minimise potential effects of brief random power fluctuations, and therefore provide a more accurate baseline measure of ongoing EEG activity.

In our experimental hypothesis we predicted a difference in relative alpha power measures between the two periods, but we had no theoretical reasons to predict a direction to the difference; on the contrary, previous research into similar

<sup>4</sup> On afterthought, we should have both chosen a slightly wider margin, and have set the peak latency at 214ms in order to maximise accuracy; it is highly unlikely however that this would have had any significant impact on the results.

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apparently “remote” physiological responses strongly suggests that this effect lacks directional and topographical consistency, and is, in the words of one of the authors, “physiologically counterintuitive” (Wackermann, Seiter et al. 2003). A brief visual exploration of comparisons between control and test waveforms in our data seemed to suggest the same. There were differences between the reference control periods and the “remote” stimulation periods, but these seemed quite erratic and inconsistent, in direction, location, latency and magnitude, although a general tendency for a deviation at the same latency and in the same direction as the normal response was noticeable. Therefore after calculating the mean evoked alpha ERBP for photic and control periods for each subject and electrode, we had both negative percentage values (indicating alpha power increase relative to pre-stimulus), and positive values (indicating alpha power decrease), in both periods, although negative values seemed to be the norm, especially so for photic periods. As we were not interested in the direction of differences however, we used the absolute values of mean alpha power change in these periods, thereby comparing photic and control periods only in respect to the magnitude of power changes and not to their direction. These absolute values were averaged per subject and period (i.e. values for separate electrodes was collapsed into a mean), which condensed our data to only two values per subject; an estimate of absolute evoked alpha power changes during the test period of interest (photic stimulation for “sender”, 0-400ms), and one such estimate for the randomly sampled control periods (0-1800ms). Although such averaging meant that we lost all spatial information about the localisation of responses, comparisons between electrodes across subjects would have been difficult, as rejecting data from problematic electrodes meant that not everyone had the same number or combination of electrodes in their final results. In fact only five participants out of the 22 had all thirty channels present in the final analysis, and one had five missing (most had only one or two channels removed). The estimated means per subject, condition and period can be seen in *Appendix D*. Table c.4 shows the estimated group means and standard deviations.

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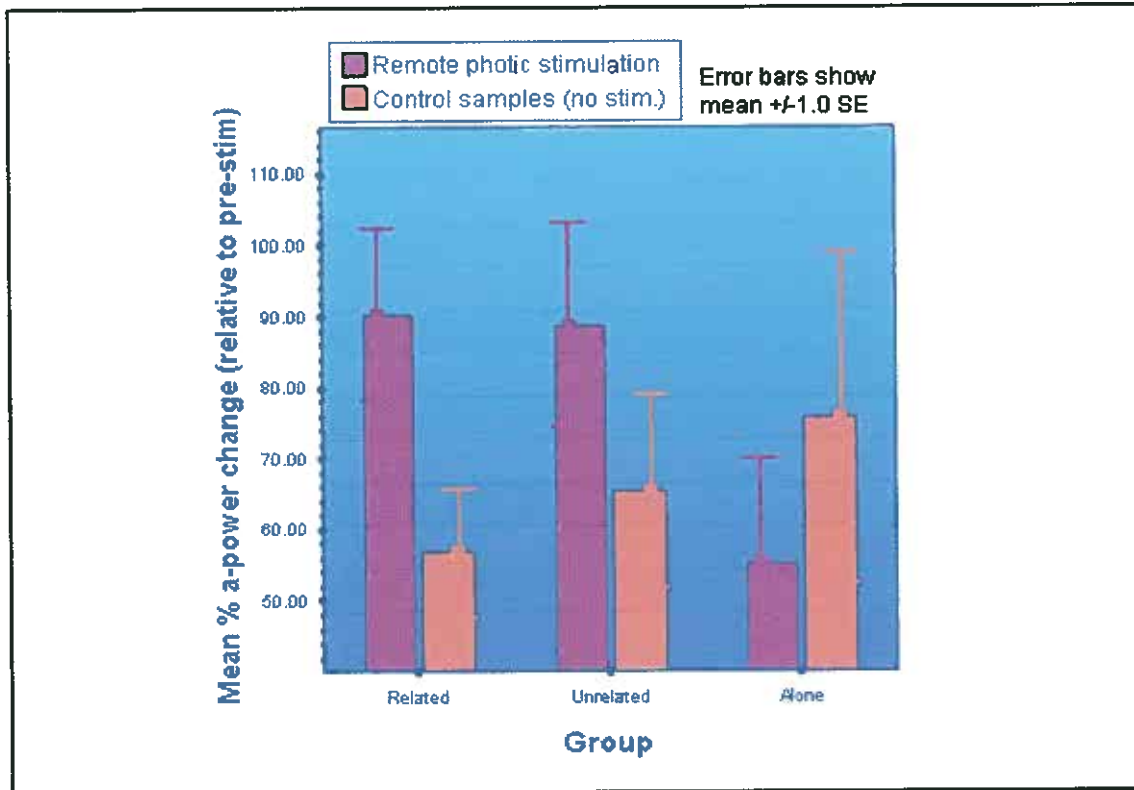
**Table c.4:** Overall mean estimated alpha power changes (as absolute percentages of prestimulus power) and standard deviations for each of the three groups and two conditions.

	Group	Mean	Std. Deviation	N
Photic stim. periods (for "sender")	Related	90.0322	43.59944	13
	Unrelated	88.6574	32.00610	5
	Alone	55.0541	29.33921	4
	Total	83.3601	39.88962	22
Control Periods	Related	56.5473	32.47676	13
	Unrelated	65.1939	30.40467	5
	Alone	75.4858	46.57493	4
	Total	61.9558	33.82537	22

A trend can easily be identified in these tables, for higher values of alpha power changes to be more often observed during photic stimulation of these participants' partners, compared to their control periods of no stimulation, both for unrelated as well as related pairs. No such trend appears in the results from participants who were not matched with a partner (no one seeing the flashes), although the small number of participants in this and the unrelated group means that these estimates are less reliable than those of the group of related pairs, which had more than twice the number of participants. Still, a trend can clearly be seen, and this is more obvious when the grouped results are presented in graphical format.

**Figure c.9:** Bar graph of average evoked alpha power changes for each group and stimulation period. Means are from absolute percentages of alpha power change relative to a pre-stimulus control period, averaged across electrodes and subjects.

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This again shows a clear difference between samples taken during “remote” photic stimulation and control periods, and better demonstrates the pattern of distribution of this difference between the three groups. There is hardly any difference between related and unrelated pairs as to their estimated alpha power changes during the “senders” photic stimulation periods, whereas the “no sender” group has a much lower mean score, which is actually lower than its own mean score for the control periods.

These differences are highly comparable with recent findings in other studies, which have identified an almost identical pattern of effects between groups similar to these. In a study looking at possible electrophysiological responses of participants during periods when their physically isolated partner was stimulated with visual pattern-reversal stimuli (a checkerboard pattern), (Wackermann, Seiter et al. 2003), found deviations from baseline activity in the EEG of the 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

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participants having no partner, and another with pairs where the “sender” could not see the stimuli, did not show any such responses.

An additional difference between groups appearing in our results is the somewhat paradoxical distribution of scores during the control periods (Fig. c.9). This seems to follow the exact reverse pattern to the one seen in “photic” periods, with the “no sender” group having the highest baseline score, followed by the unrelated and the related groups. Whether this is a meaningful effect or an artefact due to the small sizes of the unrelated and “no sender” groups is an open question. Under the null hypothesis we would expect no difference between any of these scores, for either the control or photic periods. According to our experimental hypothesis, we would expect a difference between photic and control periods, and based on past research one could perhaps predict the observed difference between the three groups in photic scores. But the difference seen between groups in data used as control references, which were effectively random samples from periods of no stimulation for either participant, if found to be genuine, would be even more puzzling, not to mention difficult to interpret.

## Significance testing:

To test the statistical significance of the observed difference between estimated alpha power changes in photic and control samples we decided to use a non-parametric statistic, as we cannot be sure whether our data meet the minimum requirements for performing parametric tests. Even though parametric tests are generally considered to be quite robust to small-to-moderate violations of their assumptions, we preferred to use Wilcoxon’s matched-pairs signed-ranks test, which is distribution-free and does not rely on parametric assumptions.

As we had made no predictions regarding expected differences between groups, but only for differences in EEG activity between control periods and “remote” photic stimulation periods, we will initially perform a test on the overall data from all three groups combined. As we can see in table c.4 above, even with the results of the “no sender” group included, which show the opposite trend to the other two groups, the overall mean alpha-power change estimate for the photic condition was 83.36, while for the control condition it was 61.95. The Wilcoxon test found this difference to be significant, at  $p < 0.042$  (two-tailed). As the overall difference between the two

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conditions is now known to be significant, we are more justified in separating the three groups according to the trends they have shown. This may not have much formal value in respect to adding to the validity of our findings, but it can be very useful nevertheless for further exploring the data. If therefore we exclude the “no sender” group from the analysis, and perform the Wilcoxon test again using only the results from related and unrelated pairs, we find a much stronger effect at  $p < 0.012$  (two-tailed). If we perform the test only with the results from the 13 related pairs we still obtain a significant value at  $p < 0.023$  (two-tailed), despite the relatively small N. Performing the test on groups with sizes as small as the unrelated pairs (N=5) and unpaired participants (N=4) is not likely to be reliable, and would only be significant if an extremely large effect was present.

### Effect size estimates:

At this stage it would be useful to estimate the effect sizes associated with these differences. We calculated the values of Cohen’s  $d$  and the effect-size correlation  $r$  using the following formulas:

$$f_2: \quad d = \frac{(M_1 - M_2)}{\sqrt{[(\sigma_1^2 + \sigma_2^2)/2]}}$$

$$f_3: \quad r_{y\lambda} = d / \sqrt{(d^2 + 4)}$$

For the three groups combined, the effect-size estimates were  $r = 0.27$ , and  $d = 0.58$ , both of which indicate a moderate effect size. Table c.5 shows the calculated effect sizes and p values for each group and combination of groups.

**Table c.5:** 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.

	All three groups (N=22)	Related & Unrelated Pairs (N=18)	Related Pairs (N=13)	Unrelated Pairs (N=5)	“No sender” group (N=4)
Effect size	$d = .58$	$d = .86$	$d = .87$	$d = .75$	$d = -.53$
	$r = .27$	$r = .39$	$r = .4$	$r = .35$	$r = -.25$
Wilcoxon Signed - Ranks Test	$p < 0.042$ (2-tailed)	$p < 0.012$ (2-tailed)	$p < 0.023$ (2-tailed)	N/A	N/A

## Bial

When the two groups in which participants were paired with a “sender” (related & unrelated), are considered together, the effect size rises to the considerably large value of  $d=0.86$ . This can be said to indicate that the two groups of scores, (photic and control epochs), for these participants have a 47.4% non-overlap. As effect size, unlike significance estimates is independent of N, the 13 related pairs alone show a slightly higher effect size with  $d=0.87$ . Unrelated pairs alone show a relatively smaller effect size ( $d=0.75$ ), and the group of participants who were not matched with a partner show a moderate effect size in the opposite direction  $d= -0.53$ . This could potentially indicate an interesting and highly paradoxical effect, but due to the very small N for this group we cannot conclude with any certainty that this is not an artefact. Also, as effect size estimates work with the assumption that the data come from a normally distributed population, we used the Kolmogorov-Smirnov goodness-of-fit statistic to test whether our data meet normality assumptions; this returned a non-significant value, indicating that we can safely assume they do. While this applied to the data overall however (photic and control scores separately), we cannot assume that this is also the case for the smaller groups we used above, due to the few data points they consist of. We can still use the effect size estimates however as a useful measure for comparing the relative differences between conditions, while remaining aware of its possible limited reliability where the smaller groups are concerned. The effect sizes seen above are comparable to those found in studies looking at ‘*Direct Mental Interactions with Living Systems*’ (DMILS), where for example, the average effect size for 19 such experiments was found to be  $r=0.25$  (Schlitz and Braud 1997). While these experiments all involved “distant intentionality” as the experimental variable, (i.e. one participant was consciously trying to affect the physiological activity of another from a distance) and most used Electrodermal Activity (EDA) measures, while in our study no conscious intention was involved and we measured EEG, their protocol is generally similar to ours, more so than any other experimental paradigm we are aware of. It is reassuring then to find such similar, if not higher, effect sizes in our study, and naturally adds to our confidence in the validity of both our findings as well as theirs.

## **Additional confirmatory analysis:**

One possible objection to the statistical analysis conducted above, would be that for test periods (remote photic stimulation) we used intervals of 400ms, whereas for reference periods we used 1800ms intervals (see Fig. c.7). Longer intervals were chosen for reference periods in order to provide baseline measures more representative of general EEG activity, but as the overall statistical properties of the recorded EEG are unknown, we cannot be certain that this would not introduce some form of bias in our comparisons. Therefore to further verify the validity of our measures it was deemed necessary to randomly sample from the EEG records sets of data of similar length, (taken from periods when no stimuli were presented), and conduct the same type of analysis as we did for our original data.

To do this, we used the original sequences of events (i.e. same interstimulus intervals between photic and control events), but randomised the starting time of these sequences to generate ten pseudo-sequences for each participant (each participant was exposed to a unique sequence of events generated by the real-time stimulus randomisation used during their sessions; these sequences were recorded). The random number function in *Excel* was used to choose a starting time within a window of 15-45sec after the start of EEG recording. As photic stimulation only begun 15min after the start of EEG recording, this window ensured that the pseudo-event sequences generated this way would fall within the relaxation period and would not overlap with actual events used in the original analysis. Random samples generated in this way, using the original event sequences, also ensured that the temporal relationship between these pseudo-events (“photic” and control) was the same as the one between remote photic and control events in the original samples. Also, the exact same number of events of each type was sampled this way, and therefore the only difference between these pseudo-events and the ones we used for our original analysis, is that the former are not time-locked to any external event that was occurring during the session, unlike the original samples which were time-locked the photic stimulation of the “senders”.

For each participant, ten complete sets of data were generated in this way, each of equal size to the original experimental data set (these data sets were sampled from overlapping periods and are therefore not independent; independence would of

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course be preferable, but is unfeasible in this case as it would require approximately two hours of continuous EEG recordings to be available per subject). The same analysis conducted on the original data set as described above, was conducted for each of the ten pseudo-sets; i.e. a measure of absolute evoked alpha power changes within the test interval of interest (pseudo-“photic” samples, 0-400ms post-“stimulus”) was compared with a similar measure from pseudo-“control” samples (0-1800ms post-“stimulus”). None of these ten comparisons revealed differences between these random samples of a similar magnitude to the one observed in our experimental data set; the average effect size for these ten random comparisons was  $d=0.117$ , with a range between  $-0.28 < d < 0.38$ , whereas for the experimental data set the effect size was  $d=0.58$ . This is generally reassuring, but it is important to note that these pseudo-comparisons tend to gravitate towards positive effects, i.e. there is a small tendency for pseudo-“photic” samples to show larger  $\alpha$ -power changes than “control” samples in general. The overall mean for  $\alpha$ -power changes in “photic” periods (always relative to a pre-stimulus interval) was 77.28%, whereas for “control” periods it was 76.38%. This is difficult to explain, but is likely to be related to the difference in size between test and control samples (i.e. 400ms and 1800ms respectively), or alternatively, it could be an artefact created by the temporal relationship between “photic” and “control” epochs.

Whatever the cause of this difference, it implies that our previous direct statistical comparison of photic and control periods is unjustified; these random comparisons indicate that there is a general trend for similar samples from any period of the EEG to differ in the same direction as that seen in our experimental samples. This need not invalidate our results however; the difference seen in these random samples is much smaller to the one observed in our experimental data. Although small, it still needs to be taken into account and it strongly indicates that for our statistical tests to be valid, we need to compare the differences seen in our experimental samples against the actual average differences estimated with these random control samples, and not against a hypothetical expectation of no difference between photic and control epochs.

To enable such comparisons, we have calculated a relative effect score for the difference between photic and control samples using the following formula:

$$f_4: \quad E = (\alpha\text{-powerTest}) / (\alpha\text{-powerTest} + \alpha\text{-powerReference})$$

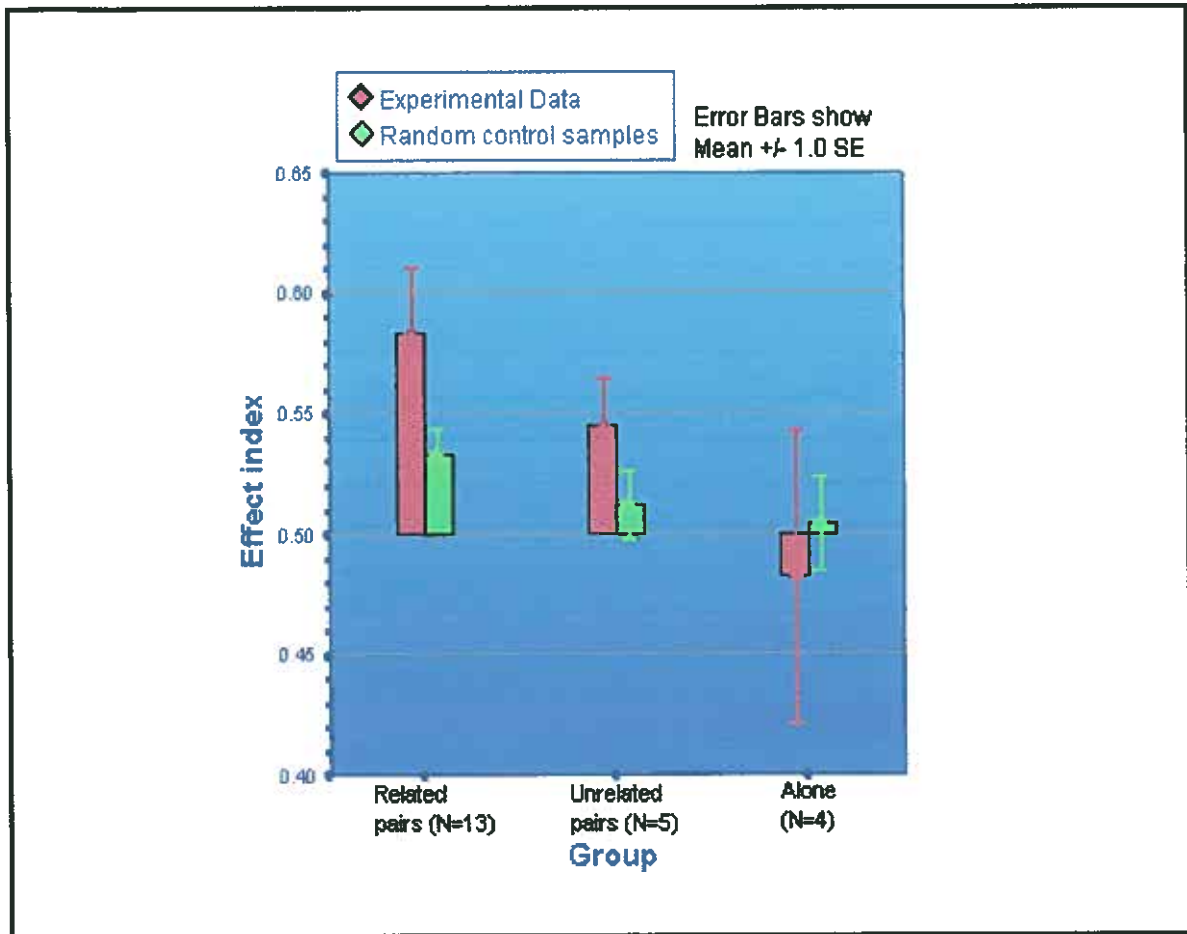
## Bial

where the relative difference in mean estimated  $\alpha$ -power changes between Test (photic) and Reference (control) periods is calculated as a score  $0 < E < 1$ , where the expected mean (given no difference) would be  $E = 0.5$ . Higher scores than 0.5 would indicate larger  $\alpha$ -power changes in test (photic) periods relative to control periods, whereas scores tending towards 0 would indicate the reverse. The advantage in calculating such a normalised effect score is that it can enable us to compare the observed difference in our experimental data set with a baseline estimated from the ten randomly sampled data sets. As we have now seen that these random data show deviations in the same direction as our experimental data, this baseline would be far more accurate than the theoretical mean of 0.5 (which was in a sense, the assumption behind our original analysis). This would therefore constitute a more conservative and more accurate statistical test of the null hypothesis, i.e. that any differences seen between remote photic and control periods are due to chance.

The relative effect index  $E$  was calculated separately for each person and electrode, for the original data set and for each of the ten additional random control data sets. Values were averaged for each person, and the ten random data sets were averaged into one set of scores (individual values can be seen in *Appendix E*). Comparisons between the  $E$  values of our original data and the mean of random controls can be seen in fig. c.10.

**Figure c.10:** Mean effect index  $E$  values for experimental data and random controls.

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Average values per group can be seen below in table c.6.

**Table c.6:** Estimated relative effect score  $E$  and standard deviations for experimental data and random control data for all groups. Below are calculated effect sizes and p values for differences between experimental data and random control samples.

		All three groups (N=22)	Related & Unrelated Pairs (N=18)	Related Pairs (N=13)	Unrelated Pairs (N=5)	“No sender” group (N=4)
Experimental data	Mean effect index $E$	0.556	0.572	0.583	0.544	0.482
	Standard deviation	0.098	0.087	0.098	0.045	0.122
Random control data	Mean effect index $E$	0.523	0.527	0.533	0.512	0.504
	Standard deviation	0.038	0.037	0.039	0.032	0.039
Effect size	Cohen’s $d$	$d = .44$	$d = .67$	$d = .67$	$d = .82$	$d = -.24$
	effect-size $r$	$r = .22$	$r = .32$	$r = .32$	$r = .38$	$r = -.12$

# Bial

<b>Wilcoxon Signed -Ranks Test</b>	$p < 0.042$ (2-tailed)	$p < 0.025$ (2-tailed)	N.S.	N/A	N/A
------------------------------------	---------------------------	---------------------------	------	-----	-----

As can be seen above, the overall difference for all three groups is still significant at the same level as our original analysis, and so it is also for the related and unrelated groups combined. It is not however independently significant for the related pairs; as before, Ns for Unrelated and “Alone” groups are too small for conducting tests of significance. The effect size for all three groups is still at a similar moderate value ( $d=0.44$ ), while related and unrelated pairs again show moderate to large effect sizes at  $d=0.67$  and  $d=0.82$  respectively (the apparently larger effect size for unrelated pairs is due to smaller variances, rather than larger difference in scores; please keep in mind the differences in N when making comparisons between groups).

It is clear from this analysis that the pattern and significance of the effect remains unchanged, even when compared to a more stringent baseline. This secondary analysis has further demonstrated that the probability of the differences observed between remote photic and control periods to be due to random fluctuations in EEG activity is exceedingly unlikely, and we must therefore seek an alternative interpretation for this effect.

To summarise, we have observed significant differences in a measure of alpha power changes in the EEG activity of our participants between periods of photic stimulation of their partner and periods of no such stimulation. As we have taken all possible precautions to exclude the possibility of anticipatory responses through randomisation of stimulus presentation times, of spurious deviations by comparing these measures with randomly sampled control periods, and of sensory cueing by complete physical isolation of participants, we can conclude that photic stimulation of their (related or randomly matched) partner has a measurable effect on their physiology. This conclusion is also supported by the lack of similar effects in participants undergoing the same procedure, when (without their knowledge), no other participant was photically stimulated. We can reach no conclusions at the present as to the physical and physiological mechanism underlying this effect, although the lack of a consistent physiological signature is perhaps indicative of a response that can manifest via several possible neural pathways. Indicators as to what

mediating psychological and physiological factors might be involved can however be pointed out and will be now discussed.

## Discussion

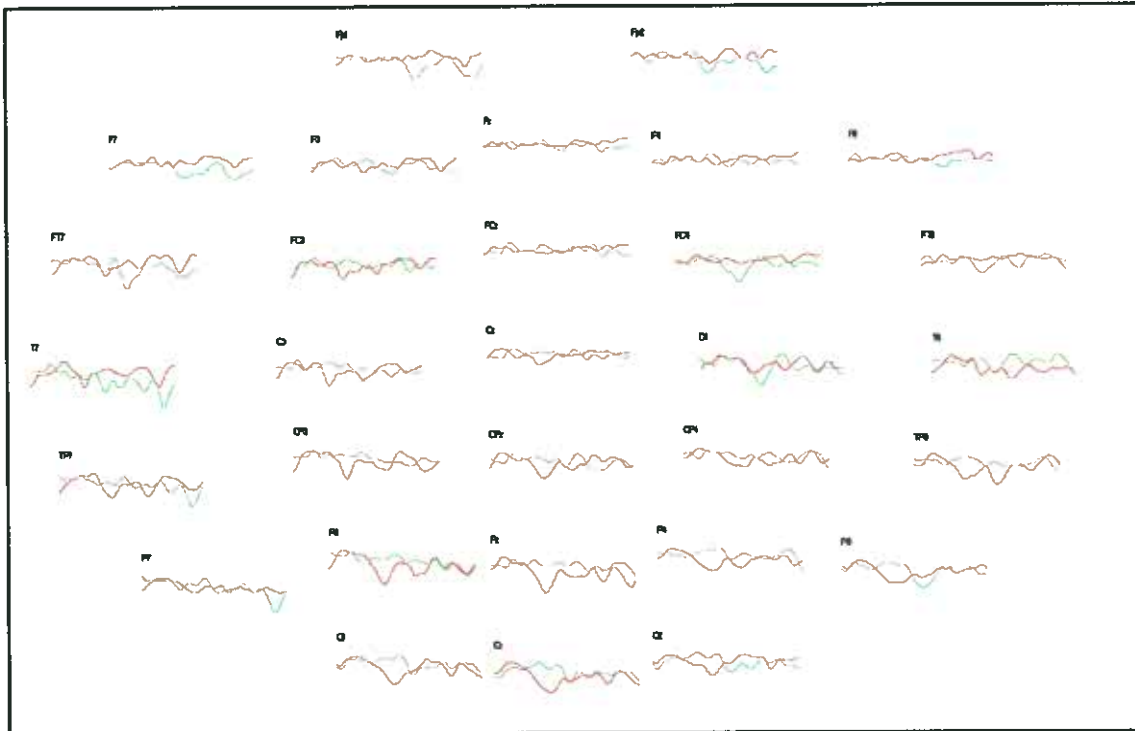
The results of this experiment support the findings of previous studies investigating this effect, and are particularly in agreement with the results of a study by (Wackermann, Seiter et al. 2003) showing that photic stimulation of one participant can have a measurable effect on the physiology of another, and that emotional relationship and prior interaction between participants is not a necessary factor for such an effect to manifest. This is somewhat surprising from a psychological perspective, in that there is no apparent reason, apart from experimental demands, for such an interaction to manifest between strangers.

On the other hand, the lack of an effect when no other person was stimulated, strongly suggests an effect that involves remote physiological interactions between living systems, and not paranormal access to remote information (i.e. the timing of the flashes).

Looking at the topographical distribution of responses, we can see a pattern indicating that the effect is largely localised in left-posterior cortical areas. (see Fig. d.1).

***Table d.1:*** Topographical distribution of the effect across the scalp. Green lines indicate reference epochs and red lines indicate remote stimulation epochs. As can be seen, the effect is more visible in the occipital and parietal regions and is maximal in the left hemisphere.

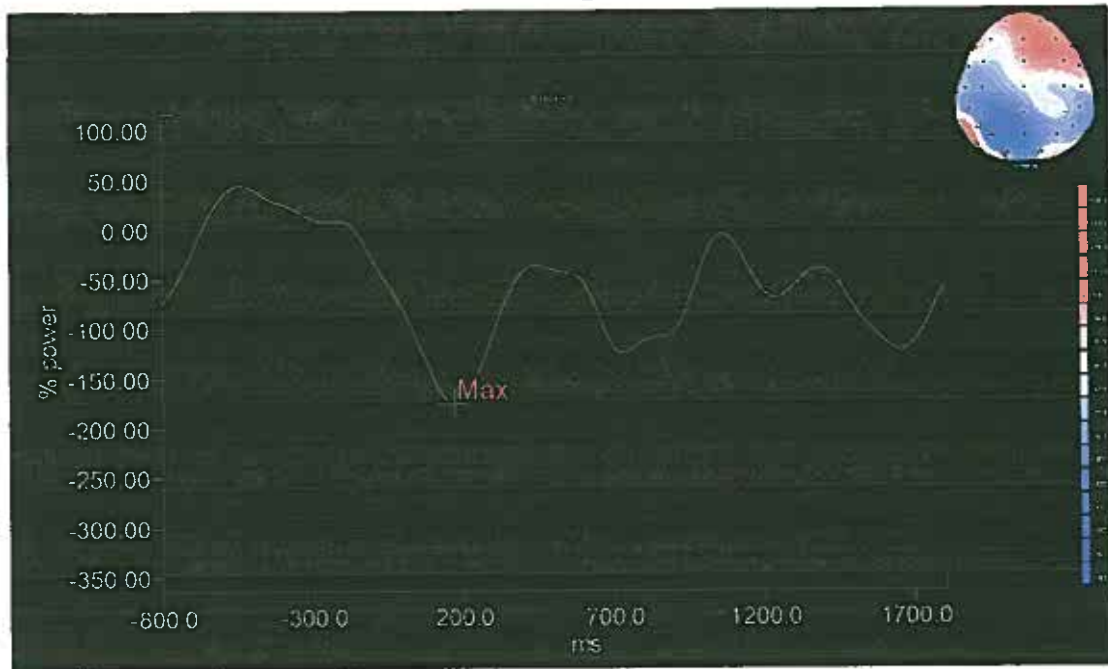
# Bial



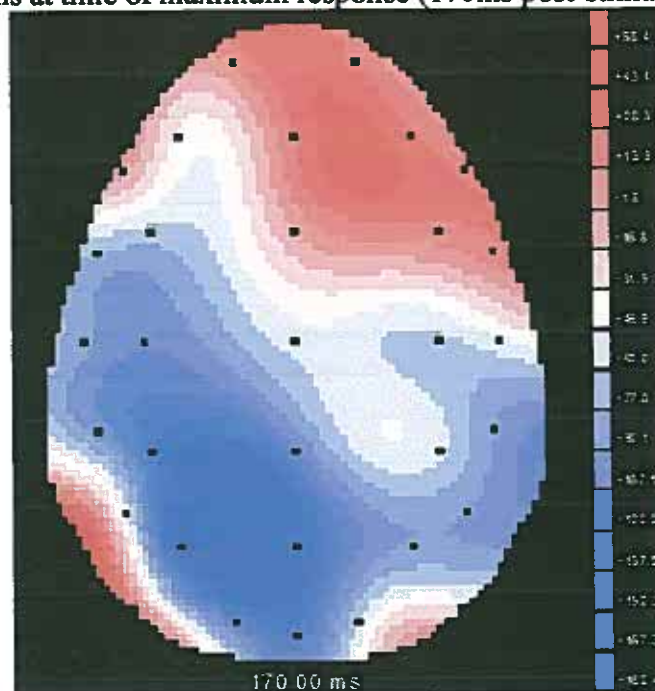
The fact that this localisation appears strongly indicates that the effect is indeed a physiological response and not an erratic artefact, which would be expected to show no such topographical signature. Also, as the occipital region, where the visual cortex is located, is well known to show the largest responses to direct photic stimulation, the posterior location of the effect is not surprising. The lateralisation of the effect to the left hemisphere is more puzzling, and we have no suggestions at the present as to the possible reasons for this. The pattern of the spatial distribution of the effect can be seen more clearly in figure d.2 and d.3.

**Figure d.2:** Timing of maximum effect for electrode P3 (which shows the largest response) is at 170ms post-stimulus. Top right inset shows spatial distribution of effect across the scalp at this time (see fig. d.3)

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**Figure d.3:** Spatial distribution of alpha-power increases (blue) across scalp electrode locations at time of maximum response (170ms post-stimulus).



One curious observation from these graphs is that time of maximum effect for these “remote” responses is at 170ms post-stimulus, whereas responses to direct photic stimulation where maximal near 210ms. Also, it is worth noting that an alpha-

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power decrease can be seen in right anterior areas (red in fig. d.3). Whether this is related in any way with the observed “remote” responses remains to be seen. We are now analysing the results according to single electrodes to see which ones reveal individually significant effects.

We are also now analysing the results from the questionnaires administered to our subjects, i.e. the *Modified Tellegen Absorption Scale*, the *Phenomenology of Consciousness Inventory* and the general participant information form, to further explore variables that could be related to individual performance in our experiment. Particular attention will be paid to the reported subjective consciousness alterations (in the PCI), and how the intensity and quality of these, as well as correlations between the experiences of participants in each pair, may relate to task performance.

Another strongly unusual aspect of the results that needs to be mentioned can be seen by examining figures c.9 and c.10. As the overall mean of alpha power changes for the random samples is approximately 70%, we can see that the observed effect in our experimental data, for the related pairs at least, is partly due to unusually large alpha-power changes during test epochs (remote photic stimulation), as well as unusually low alpha-power changes in control epochs. This is a highly paradoxical finding, and if genuine, may suggest that the effect cannot be entirely explained as a remote physiological interaction between living systems, but would imply a teleologically driven process, where experimental demands and expectations also play a role in defining the results. This perhaps could also explain the apparently reverse effect seen in participants with no partner, although the small N in this group requires that this possibility be only considered with caution. These unusual fluctuations seen in our reference data require further study and will be addressed in our follow-up study.

This study will be conducted during the coming summer, and as well as using a larger number of participants, with equal numbers of related/unrelated pairs and alone participants to make direct comparisons between groups more possible, we intent to add the following elements to our methodology:

- Use intentional influence periods as well, where one participant intentionally attempts to influence the physiology of their partner (as in DMILS paradigm)
- Use an ‘oddball’ paradigm where unusual stimuli are occasionally presented in order to enhance responses

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- Stimulate both participants with flashes, sometimes synchronously and sometimes not; look for differences between individual responses when only one is stimulated, to responses when both are stimulated
- Compare pairs undergoing the consciousness alteration procedure (relaxation and drumming) to pairs experiencing no such procedure, to test whether consciousness alterations play a role in facilitating the observed effects.
- Attempt to address the question whether the effect follows a physiological stimulus-response pattern, or appears to have intrinsically acausal characteristics suggesting perhaps a teleologically driven process.

We will be sending a research update with the results of the topographical analysis and the results of the analysis of the administered questionnaires as soon as these are ready, and we will also be sending updates as to the progress of the next phase of this research described above. We are grateful to the Bial Foundation for the generous support of this project, without which this exploration into what we believe to be frontier areas in our understanding would not have been possible.

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## Appendix A

### A.1: Sample of the flyer used for participant recruitment.

#### **Would you like to take part in research into empathy and ESP?**

We are now doing research exploring the possibility that people who share an emotional connection are sometimes able to communicate and interact with each other from a distance without using any of the commonly recognised senses, an ability that has sometimes been called 'telepathy' or 'ESP'.

Such communication is often experienced in the form of hunches and gut feelings about the other person that turn out to be accurate, or in the form of synchronicities and seemingly odd coincidences, such as calling each other on the phone at the same time, or mentioning something that they have been thinking about.

Recent experiments seem to suggest that this kind of remote interaction might not be so rare after all, and could possibly be happening regularly on an unconscious level but that we only become consciously aware of it occasionally. In this study we are using EEG (brainwave) recordings to see if such communication is registered on a physiological level.

We are now looking for volunteers to take part in this study, so if you find the topic interesting and would like to participate, or if you simply want to know more about it please get in touch.

We are primarily looking for pairs of people who share a close empathic connection, regardless of the type of the relationship; what is important is that you share a sense of mutual understanding and empathic awareness of each other. Ideally you might have had the kind of experiences mentioned above, or feel that you sometimes communicate or interact in ways you cannot explain. People with experience in yoga, meditation, martial arts or any other mental discipline (including any activity that requires concentration, like juggling or playing a musical instrument), and people with creative/artistic abilities are especially welcome, but anyone can take part as long as you are not suffering from any type of epilepsy. We are also looking for individual volunteers (you will be paired with someone you don't know). If you are considering taking part please get in touch and we'll let you know more about it. This research is based in the Koestler Parapsychology Unit at Edinburgh University.

You can call me at: (0131) 65 11 684 or 0781 77 33 196 (please leave a message and I'll call you back), or email me at: [marios@moebius.psy.ed.ac.uk](mailto:marios@moebius.psy.ed.ac.uk)

Many Thanks!

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**A.2:** Sample of form given to participants requesting information likely to be relevant for the study. All personally identifiable information has been kept confidential.

## *Participant Information Form*

Thank you for volunteering to take part in our research.

As a first step, we would like to gather some general information about you which will help us evaluate the results of our research.

All the information you give us will be kept strictly confidential. The completed questionnaire will only be seen by myself, and only averaged group results will be included in the research report. Please feel free to skip any question that you prefer not to answer.

Thank you for your help with our work!

Name: \_\_\_\_\_

Age: \_\_\_\_\_ Date of birth: \_\_\_\_\_

Gender: M / F (circle as appropriate)

Email: \_\_\_\_\_

Phone: \_\_\_\_\_

Would you like to be sent your own and the general group results? Yes / No



# Bial

If yes, did you practice consistently of sporadically?

Consistently

Sporadically

If yes, do you still practice?

1      2      3      4      5      6      7  
Never                      Weekly                      Daily

10. Do you spent time doing any other practice that requires considerable mental concentration and physical coordination, such as juggling, acrobatics, playing a musical instrument, rock climbing etc?                      Yes / No

If yes, please describe \_\_\_\_\_

11. Are you experienced with other methods used to intentionally alter your state of consciousness, such as psychedelic/entheogenic substances, holotropic breathwork, ritual, or drumming, chanting and dancing (if used specifically with the intention of altering consciousness)?                      Yes / No

If yes, please describe \_\_\_\_\_

12. Do you have any other experience you feel might be relevant but is not covered in the above sections (e.g. any other training or personal practices)?                      Yes / No

If yes, please describe \_\_\_\_\_

13. Do you have regular sleep patterns?                      Yes / No / Uncertain

14. Do you usually feel you get enough sleep?                      Yes / No

Please use the following definitions for answering the next few questions:

**Psi** is a general term for abilities like **Extra Sensory Perception**, or **ESP** (i.e. reception of information without the use of the known senses or logical inference) and **Psychokinesis** (i.e. mental influence on the physical world).

ESP can be further subdivided into **Telepathy** (ESP of thoughts, feelings or behaviour of another person), **Clairvoyance** (ESP of distant events of concealed objects), and **Precognition** (ESP of the future).

15. Do you feel that psi is possible?

1      2      3      4      5      6      7  
Yes                      Uncertain                      No

16. Do you feel you have genuine psi experiences?

1      2      3      4      5      6      7  
Never                      Occasionally                      Frequently

# Bial

17. Have you ever had an experience which is best explained by telepathy?

1      2      3      4      5      6      7  
Yes                      Uncertain                      No

18. Have you ever had an experience which is best explained by precognition?

1      2      3      4      5      6      7  
Yes                      Uncertain                      No

19. Have you ever had an experience which is best explained by psychokinesis?

1      2      3      4      5      6      7  
Yes                      Uncertain                      No

20. Have you ever had an experience in which you felt as if your consciousness was separated from your physical body?

1      2      3      4      5      6      7  
Yes                      Uncertain                      No

If yes, please describe any notable related circumstances \_\_\_\_\_

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21. Were you raised in an environment where there is a tradition of paranormal ability which is still believed in to some degree? Yes / No

If yes, please describe \_\_\_\_\_

22. How confident do you feel that your psi ability will affect the outcome of this experiment?

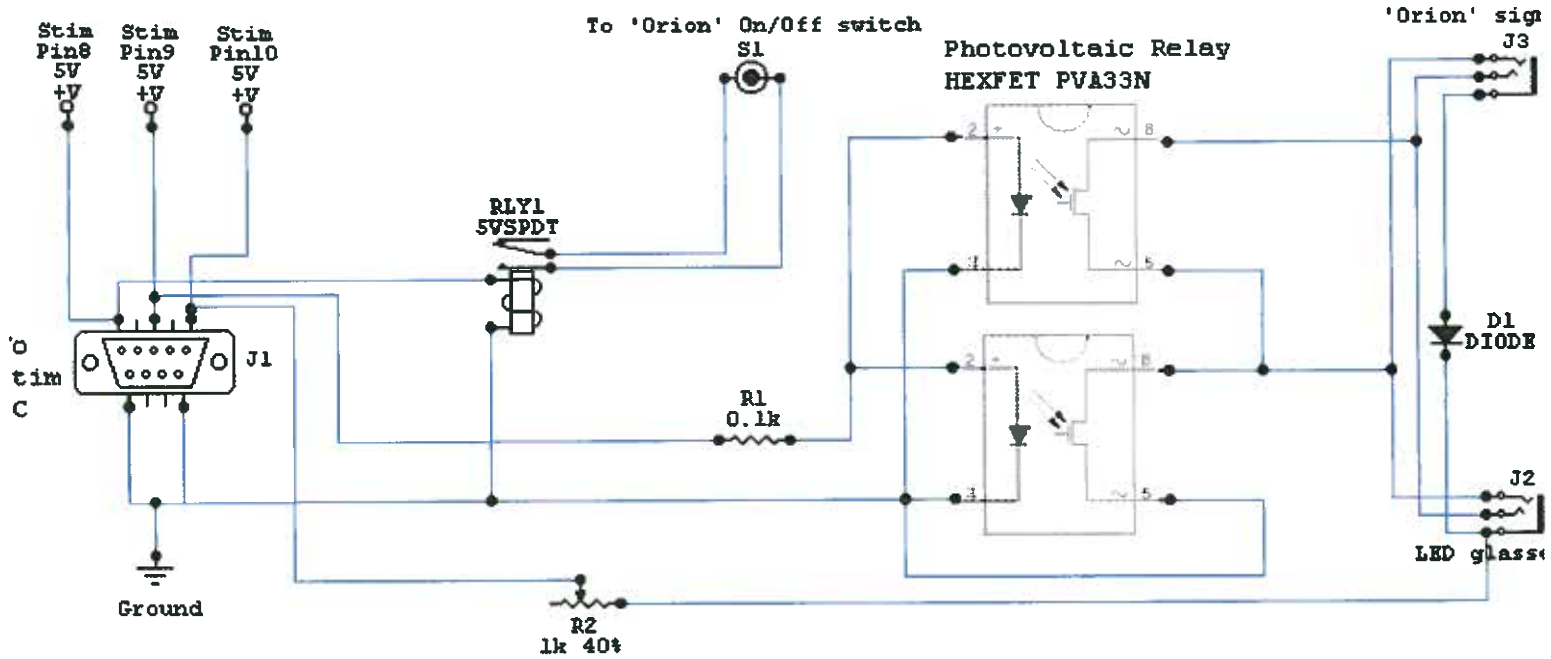
1      2      3      4      5      6      7  
Certain it will                      Uncertain                      Certain it won't

23. If you would like to describe any specific experiences you have had that possibly involved psi, or elaborate on any of the questions above then please use this page to do so.

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## APPENDIX B

Diagram of circuit used to route stimulus triggers from the parallel port of the Stim PC to the LED glasses and 'Orion' light & sound unit.



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## Appendix C

**C.1:** Relaxation script for individual (single) session. (Numbers refer to delay in seconds before next sentence and ellipses indicate brief pause.)

*Before we start, you will first listen to a relaxation exercise, to help you get rid of all physical and mental tension. 3s*

*Take some time to settle in and make yourself comfortable in your chair... 5s*

*Once you're settled, begin to become aware of your breathing... breathe slowly in and out starting from low down your belly, and take deep, full breaths, using your diaphragm to breath and fill your lungs. (you can check this by placing your hand over your belly button and as you breathe it should rise and fall) Take a few deep, long breaths, ... and feel the relief as you breath out, ... notice how your body relaxes as you do.*

*Take a couple more deep breaths...8s., and when you are ready, just allow your eyelids to close... 3s*

*Now, as you breath gently and slowly let the muscles around your eyes relax... feel the muscles move and soften and as they do, relax....let go.... let them settle comfortably, feel the softness spreading, moving gently across your face, relaxing and soothing as it spreads gently outwards ..... Over your temples, ... and your cheeks...*

*Feel the muscles around your nose beginning to soften, and let the relaxation flow down your face, relaxing your upper lip....., lower lip....., cheeks..., and your tongue, can relax. Feel it spread through your jaw..., let the relaxation spread down your throat..., relaxing the muscles of swallowing....., and the muscles of speaking.....*

*Now bring your attention to your forehead, and feel it becoming smooth.....letting go of your frown lines, and even your smile lines, just as much as you can let go. Feel the softening spread gently from your forehead, up through your hair and over you scalp, relieving any sense of tension from the tightness of the cap .... Some feeling of tightness from the cap might remain, but the more you relax the more comfortable you feel with this.... This soft sensation is now flowing down the back of your head and neck, relaxing all the muscles that are used to hold your head....., you will keep just enough tension to hold your head upright, resting against the pillow... there's a feeling of release as you let go, ... a feeling of peace and calm,..... Muscles you are not normally aware of are relaxing, and loosening, and softening , your head no longer needs to use all those muscles, it is safely, and gently letting go.. it is heavier and is resting, it seems soft and comfortable. Notice how good it feels, as your mouth, cheeks, eyes, forehead, and scalp become completely, and thoroughly relaxed.....*

*You may notice, that as each part of your body relaxes, this dilates the blood vessels and more blood is flowing to the different organs, both internal ones as well as the*

# Bial

*muscles on the surface. As more blood is available, your muscles relax even more, giving a pleasant sensation of warmth spreading throughout your body...*

*.....As your head feels fully relaxed, now, allow the feeling to flow down into your shoulders, releasing all the tension in that area, ... ..let it spread all through the shoulders now, and out and down along your upper arms, ... ..throughout your elbows and down into your wrists and hands, a warm ripple spreading right to the tips of your fingers.*

*Feel now the warmth move from your shoulders and neck down your spine, right down to the tailbone...relaxing all the muscles in your back .... both sides feeling freer and more comfortable, your muscles in your back relaxing, un-knotting, warming..., your joints enjoying the freedom and the release.... Feel now the muscles holding your ribs, ... .. they too are softening, relaxing, moving rhythmically with your breathing.. in... and out.*

*This deep feeling of relaxation is all through your torso, just let everything drift away, all thoughts gone now.... your mind as well as your body is feeling relaxed..., your self is relaxing..., just as much as is right for you.*

*With each slow, deep breath you take, allow yourself to drift deeper, and deeper, into a very pleasant state of warmth and comfort ... .. each breath out releases, letting go of unnecessary thoughts, let them all float away.*

*As you breathe you feel the relaxation wash down through your hips, ... and pelvis... the muscles you use for sitting are relaxing, allowing you to settle in more comfortably in the chair ... ..and the warm feeling now spreads down through your thighs., knees and calves...all through your legs and on down to your feet..., through your ankles..., and right to your toes. Feel the little movements as your muscles release and adjust ....., and then settle..., just allow them to let go. Each time you allow your body to relax, so it becomes easier, as it becomes easier you relax even more, more deeply, enjoying the sensation of release... Your whole body feels quiet, now, heavy, comfortable, and relaxed. Your breathing is calm and regular, taking care of itself... .. with each breath imagine yourself, falling deeper, and deeper, into complete relaxation.....*

*Let yourself relax still more. A feeling of well-being gradually comes over you... give way to the feeling, as it is so pleasant... just let yourself go.*

*Lets count backwards from ten now, to help you go even deeper, still. With each count, feel yourself go deeper, and deeper into a profoundly relaxed and pleasant state, of warmth and comfort.*

*10... 2s*

*9... 2s*

*8... 2s*

*7... 2s*

*6... 2s*

*5... 2s*

*4... 2s*

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3... 2s

2... 2s

1... 6s

*As you enjoy this deeply relaxed state, scan your body with this calm awareness... notice any areas of tension and let them release...*

*Let the pleasant sensation move and fill your body throughout....., as it spreads and moves gently relaxing all areas still having some tension.*

*That's right..., letting go even more, just as much as is right for you. Even in this deeply relaxed state, you are able to maintain a clear awareness, as you breath at this rate..., as your heart beats at this rate..., feeling so comfortable and relaxed...and at the same time calmly focused and aware, finding a state that is right and pleasant for you....*

## **Final Instructions...**

*In a while, you will listen to some drumming for about ten to fifteen minutes..., this will help you remain comfortably relaxed and keep your mind clear from any thoughts. You don't need to try to do anything during this period, just simply relax and enjoy the session. Keep your attention focused on the sound of the drumming, and if any thoughts come to mind, just allow them to come and go on their own, without trying to push them away, or paying much attention to them... and if your mind wanders, just gently bring it back to the sound of the drumming... ..*

## **(Drumming period, 15-20 minutes)**

## **Coming back.....**

*Now..., is time to start coming back soon to your ordinary consciousness, still feeling fully relaxed, and also alert and refreshed. In a few moments I am going to begin to count from one, up to ten, ....and as I do, your awareness will gradually and gently return to its most pleasant ordinary state..., feeling rested and refreshed..., you may want to breathe more deeply for a while,.. in your own time. Coming back comfortably and easily, and keeping all you need from this experience..*

*One...*

*Two...becoming aware of the sensation of your legs touching the chair or the floor*

*Three...*

*Four...becoming aware of the weight of your body on the chair*

*Five....*

*Six...becoming aware of the room you are in now*

*Seven...*

# Bial

*Eight... Becoming aware of your surroundings, the background sounds, smells and light*

*Nine... becoming much more focused now, clear, alert and calm*

*Ten... feeling alert and awake, and whenever you are ready, just let your eyes open.*

*You might like to stretch now, and take a couple of deep breaths, and whenever you are ready, take off the glasses and headphones, and I will come and help you in a moment.*

## C.2: Relaxation script for joint session (pairs).

*Before we start, you will first listen to a relaxation exercise, to help you get rid of all physical and mental tension. 3s*

*Take some time to settle in and make yourselves comfortable in your chairs... 5s*

*Once you're settled, begin to become aware of your breathing... breathe slowly in and out starting from low down your belly, and take deep, full breaths, using your diaphragm to breath and fill your lungs. (you can check this by placing your hand over your belly button and as you breathe it should rise and fall) Take a few deep, long breaths, ... and feel the relief as you breath out, ... notice how your body relaxes as you do.*

*Take a couple more deep breaths...8s., and when you are ready, just allow your eyelids to close... 3s*

*Now, as you breath gently and slowly let the muscles around your eyes relax... feel the muscles move and soften and as they do, relax....let go.... let them settle comfortably, feel the softness spreading, moving gently across your face, relaxing and soothing as it spreads gently outwards ..... Over your temples, ... and your cheeks...*

*Feel the muscles around your nose beginning to soften, and let the relaxation flow down your face, relaxing your upper lip....., lower lip....., cheeks..., and your tongue, can relax. Feel it spread through your jaw..., let the relaxation spread down your throat..., relaxing the muscles of swallowing ....., and the muscles of speaking.....*

*Now bring your attention to your forehead, and feel it becoming smooth.....,letting go of your frown lines, and even your smile lines, just as much as you can let go.*

*Feel the softening spread gently from your forehead, up through your hair and over you scalp, relieving any sense of tension .... Some feeling of tightness might remain, but the more you relax the more comfortable you feel .... This soft sensation is now flowing down the back of your head and neck, relaxing all the muscles that are used to hold your head....., you will keep just enough tension to hold your head upright, resting against the pillow... there's a feeling of release as you let go, ... a feeling of*

# Bial

*peace and calm, ..... Muscles you are not normally aware of are relaxing, and loosening, and softening, your head no longer needs to use all those muscles, it is safely, and gently letting go.. it is heavier and is resting, it seems soft and comfortable. Notice how good it feels, as your mouth, cheeks, eyes, forehead, and scalp become completely, and thoroughly relaxed.....*

*You may notice, that as each part of your body relaxes, this dilates the blood vessels and more blood is flowing to the different organs, both internal ones as well as the muscles on the surface. As more blood is available, your muscles relax even more, giving a pleasant sensation of warmth spreading throughout your body...*

*.....As your head feels fully relaxed, now, allow the feeling to flow down into your shoulders, releasing all the tension in that area, .....let it spread all through the shoulders now, and out and down along your upper arms, .....throughout your elbows and down into your wrists and hands, a warm ripple spreading right to the tips of your fingers.*

*Feel now the warmth move from your shoulders and neck down your spine, right down to the tailbone...relaxing all the muscles in your back .... both sides feeling freer and more comfortable, your muscles in your back relaxing, un-knotting, warming..., your joints enjoying the freedom and the release.... Feel now the muscles holding your ribs,..... they too are softening, relaxing, moving rhythmically with your breathing.. in... and out.*

*This deep feeling of relaxation is all through your torso, just let everything drift away, all thoughts gone now.... your mind as well as your bodies is feeling relaxed..., your self is relaxing..., just as much as is right for you.*

*With each slow, deep breath you take, allow yourselves to drift deeper, and deeper, into a very pleasant state of warmth and comfort..... each breath out releases, letting go of unnecessary thoughts, let them all float away.*

*As you breathe you feel the relaxation wash down through your hips, ... and pelvis... the muscles you use for sitting are relaxing, allowing you to settle in more comfortably in your chairs.....and the warm feeling now spreads down through your thighs., knees and calves...all through your legs and on down to your feet..., through your ankles..., and right to your toes. Feel the little movements as your muscles release and adjust....., and then settle..., just allow them to let go. Each time you allow your body to relax, so it becomes easier, as it becomes easier you relax even more, more deeply, enjoying the sensation of release... Your whole bodies feel quiet now, heavy, comfortable, and relaxed. Your breathing is calm and regular, taking care of itself..... with each breath imagine yourselves, falling deeper, and deeper into complete relaxation.....*

*Let yourselves relax still more. A feeling of well-being gradually comes over you... give way to the feeling, as it is so pleasant... just let yourself go.*

*Lets count backwards from ten now, to help you go even deeper, still. With each count, feel yourselves go deeper, and deeper into a profoundly relaxed and pleasant state, of warmth and comfort.*

# Bial

- 10... 2s
- 9... 2s
- 8... 2s
- 7... 2s
- 6... 2s
- 5... 2s
- 4... 2s
- 3... 2s
- 2... 2s
- 1... 6s

*As you enjoy this deeply relaxed state, scan your body with this calm awareness... notice any areas of tension and let them release...*

*Let this pleasant sensation move and fill your bodies throughout....., as it spreads and moves gently relaxing all areas still having some tension.*

*That's right..., letting go even more, just as much as is right for you. Even in this deeply relaxed state, you are able to maintain a clear awareness of each other, as you both breath at this rate..., as your hearts beat at this rate..., feeling so comfortable and relaxed...and at the same time, calmly focused and aware, finding a state that is right and pleasant for you both....*

## **Final Instructions...**

*In a while, you will both listen to some drumming for about ten to fifteen minutes..., this will help you remain comfortably relaxed and keep your Mind clear from any thoughts while still being clearly aware of each other. You don't need to try to do anything during this period, just simply relax and enjoy the session. Keep your attention focused on the drumming and each other, and if any thoughts come to mind, just allow them to come and go on their own, without trying to push them away, or paying much attention to them... and if your mind wanders, just gently bring it back to the sound of the drumming that you both here.....*

**(Drumming period, 15-20 minutes)**

## **Coming back.....**

*Now..., is time to start coming back soon to your ordinary consciousness, still feeling fully relaxed, and also alert, and refreshed. In a few moments I am going to begin to count from one, up to ten, ....and as I do, your awareness will gradually and gently return to its most pleasant ordinary state..., feeling rested and refreshed..., you might want to breathe more deeply for a while,.. in your own time. Coming back comfortably and easily, and keeping all you need from this experience..*

# Bial

*One... still being aware of each other in the other room*

*Two...becoming aware of the sensation of your legs touching the chair or the floor*

*Three...*

*Four...becoming more aware of the weight of your body on the chair*

*Five....*

*Six...becoming more aware of the room you are in now*

*Seven...*

*Eight...Becoming more aware of your surroundings, the background sounds, smells and light*

*Nine...becoming much more focused now, clear, alert and calm*

*Ten... feeling alert and awake, and whenever you are ready, just let your eyes open.*

*You might like to stretch now, and take a couple of deep breaths, and whenever you are ready, take off the glasses and headphones, and I will come and help you both in a moment.*

# Bial

## Appendix D

**Tables D.1-3:** Absolute mean estimates and standard deviations of alpha power changes (relative to pre-stimulus) for photic and control periods, taken from the EEGs of unstimulated participants. Separated in three groups according to relationship to “sender”; i.e. related pairs, unrelated pairs and individuals with no partner.

<b>D.1: Related Pairs</b>		
<b>Subject</b>	<b>Condition</b>	
	<b>Photic</b>	<b>Control</b>
1	50.68	69.87
2	111.14	40.41
3	85.12	63.04
4	83.55	81.82
5	91.69	83.30
6	90.66	50.55
7	215.48	59.14
8	43.05	18.98
9	74.57	20.17
10	82.37	137.07
11	112.55	50.32
12	45.79	38.32
13	83.69	22.05
<b>Mean:</b>	<b>90.03</b>	<b>56.54</b>
<b>Std. Dev:</b>	<b>43.59</b>	<b>32.47</b>

<b>D.2: Unrelated Pairs</b>		
<b>Subject</b>	<b>Condition</b>	
	<b>Photic</b>	<b>Control</b>
1	117.98	106.68
2	76.04	87.97
3	83.87	46.13
4	44.06	48.54
5	121.31	36.61
<b>Mean:</b>	<b>88.65</b>	<b>65.19</b>
<b>Std. Dev:</b>	<b>32.00</b>	<b>30.40</b>

<b>D.3: “Receivers” alone (i.e. no “sender”)</b>		
<b>Subject</b>	<b>Condition</b>	
	<b>Photic</b>	<b>Control</b>
1	38.06	125.23
2	34.82	39.53
3	49.25	32.22
4	98.07	104.95
<b>Mean:</b>	<b>55.05</b>	<b>75.48</b>
<b>St. Dev:</b>	<b>29.33</b>	<b>46.57</b>

**Bial**

# Bial

## Appendix E

**Tables E.1-3: Estimates of effect score**  
 $E = (\alpha\text{-power Test}) / (\alpha\text{-power Test} + \alpha\text{-power Reference})$

<b>E.1: Related Pairs</b>		
Subject	Data set	
	Experimental	Random Controls
1	0.514	0.532
2	0.66	0.534
3	0.627	0.540
4	0.525	0.534
5	0.519	0.575
6	0.555	0.539
7	0.708	0.517
8	0.692	0.515
9	0.571	0.547
10	0.364	0.455
11	0.639	0.550
12	0.511	0.474
13	0.690	0.607
Mean:	0.583	0.532
Std. Dev:	0.098	0.038

<b>E.2: Unrelated Pairs</b>		
Subject	Data set	
	Experimental	Random Controls
1	0.513	0.515
2	0.533	0.508
3	0.554	0.546
4	0.504	0.46
5	0.617	0.528
Mean:	0.544	0.511
Std. Dev:	0.044	0.032

<b>E.3: "Receivers" alone (no "sender")</b>		
Subject	Data set	
	Experimental	Random Controls
1	0.301	0.487
2	0.511	0.5191
3	0.568	0.548
4	0.544	0.459
Mean:	0.481	0.503
St. Dev:	0.122	0.038