# MIND TO MIND INTERACTION AT A DISTANCE: PHASE TWO

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15th October 2015

The first phase of this research (described in the article entitled MIND TO MIND INTERACTION AT A DISTANCE ) was based on the Brain Scanner™ software and allowed us to demonstrate, even at a distance of 190 Km, a significant number of coincindences in the cerebral activities of two human beings unconnected by any of the usual means.
We did however record a fall in these coincidences after around 5 minutes into the test, which we thought may have been due to a decline in effectiveness of the classification software following an increase in electroencephalographic noise caused by fatigue, with a resulting fall in concentration (along with mental connection) of the two partnered participants, whom we called the Sender and Receiver.
We therefore asked ourselves if it is possible in some way to improve the signal/noise ratio of that mental connection as well as the processing software's performance, especially in the Receiver, bearing in mind that Brain Scanner™ was created for a different purpose. This would be based on analyses of the Sender's EEG signals, the objective being to learn commands that could be used to remotely control devices.

We thus concentrated our efforts on signals generated by the brain in response to external stimuli, the most notable of these being the ERP (Event-Related Potential), with a typical profile as shown in Fig 1.

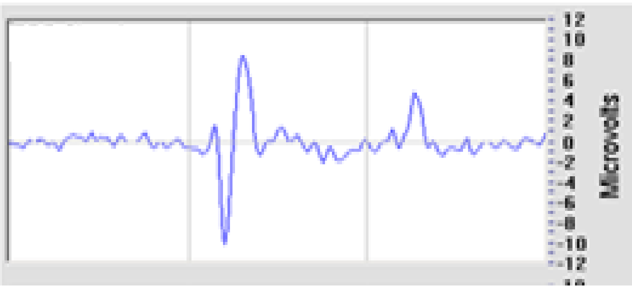


*Fig 1: Typical example of an ERP. There are usually two peaks, one negative and one positive, called P300, occurring at about 250-300 ms after the start of the stimulus (first vertical line). There is a smaller positive peak about 250 ms after the stimulus stops (second vertical line).*

The ERP from Fig. 1 represents the EEG (electroencephalograph) response produced by the brain when given a stimulus – either cognitive, sensory or motor – and is widely used in BCI (Brain-Computer Interface) applications and in the neurosciences. It has been extensively studied, but only in subjects who were directly stimulated (i.e., in those we call *Senders*), and not in those whom we designate as Receivers and who do not get any direct stimulus. Its presence in the latter subjects was an unknown.
The ERP is much weaker than normal EEG signals and its detection usually requires calculating the average of many synchronized recordings. As we have seen, it corresponds to the application of a stimulus, whereas normal EEG activity does not; consequently, if we consider the latter as noise and the ERP as the useful signal, then taking the moment the stimulus is applied as the reference

point, we add together many epochs (one *epoch* = pre-stimulus time + stimulus time + post-stimulus time) and divide the total by their number (the average). When they are synchronized to the instant the stimulus is applied, the random noise signals tend to partially cancel each other out, while the synchronized signals add up (constructive interference). Therefore the signal/noise ratio is amplified in proportion to the square root of the number of epochs used in the average. This is why hundreds are used, so that in this way (because $\sqrt{100} = 10$) increasing the signal/noise ratio 10 times allows us to clearly detect ERPs that are 6 to 7 times weaker than EEG signals, provided that they are superimposable and thus added together (they are then said to be *phase-synchronized*).
The ERP's delay after application of the stimulus is called "latency time", or simply "latency", and the ERP itself is characterized by a large positive peak with a typical latency of around 300 ms that tends to be constant (see right column in Fig. 2). If the latency is not constant, we have a phenomenon called "latency jitter", which we will refer to simply as "jitter" (left column in Fig 2).

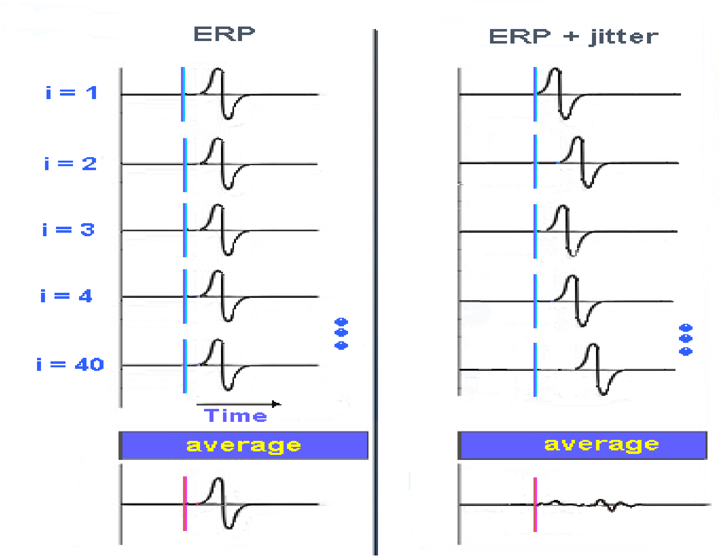


*Fig. 2: On the left is an ERP with constant latency, and right with jitter (variable latency).*

After calculating the average of ERPs with a constant latency, the noise weakens and the ERP signal clearly emerges (see ***average*** at bottom of left column in Fig 2), whereas the average of the variable latency ERPs produces a faint and useless result (see ***average*** at bottom of right column above). The pink vertical line indicates when the stimulus was applied.

Consequently we began a series of study sessions devoted to developing a new protocol which would allow us to administer 128 stimuli to the Sender in a reasonably short time, all the while preserving their randomness to avoid habituation and predictability.
At first we used the technical equipment described in MIND TO MIND INTERACTION AT A DISTANCE, which is as follows: the subjects (Sender and Receiver) were placed in two different rooms totally isolated from each other as shown in Fig 3; each was supplied with a wireless 14 channel EEG (Emotiv® EEG Neuroheadsets, used in accordance with manufacturer's instructions), a pair of video monitor glasses (Kingshop OV2 virtual glasses) used for visual stimuli, including a stereo sound channel and earphones for audio stimuli, and noise-cancelling headphones (Parrot ZIK® headphones) to eliminate ambient noise. This was under the control of three computers and monitored from the Control Room (Fig 3) which sits between the two rooms reserved for the Sender and Receiver.

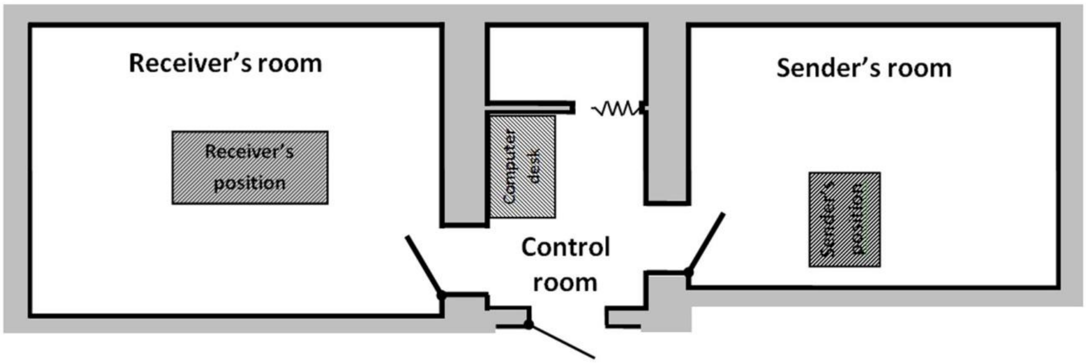


*Fig.3 – Floor plan of the EvanLab laboratory.*

Initially we had to improve the signal/noise ratio as much as possible to maximize detection of the ERP itself in the Sender, because the methods used for this purpose would later also be applied (successfully) to the Receiver. After conducting a series of tests on the Sender, we noticed that the EEG signals became clearer once the mastoidal reference electrodes of the Emotiv® headset were substituted with clamp electrodes applied to the earlobes, and furthermore by using a conductive gel instead of saline solution injected into a 3mm hole in each electrode's pad, to guarantee electrical conductivity between active electrodes and skin.
We also noted that the sound stimulus – necessarily of brief duration – could have simply been a pure 500 Hz sinusoid of constant amplitude applied at high volume through 32 Ω earphones (that don't interfere with the EEG), and that the source of the light stimulus (simultaneous to the sound and equally short) could be an array of 16 high-output red LED lights one metre away. The strong red light is also able to be seen through closed eyelids, thus eliminating disturbances in EEG signals caused by blinking.
The tests revealed that even the smallest EEG disturbances produced by active noise-cancelling headphones could be eliminated by substituting these with common earplugs in the Receiver and putting earpieces into the ears of the Sender, as long as the laboratories were well soundproofed and did not require active erasure of sound waves. If a test participant deemed it necessary to aid concentration, he/she could use normal passive noise-cancelling headphones, which are less cumbersome than active ones and do not physically interfere with the Emotiv® headphones. They also do not produce electrical disturbances. We have also developed efficient methods for reducing the effect on EEG recordings from ever-present disturbances.

When the tests were completed we realized we had substantially improved the signal/noise ratio and the participants' comfort, obtaining from the Sender extensive and well-defined ERP graphs, and getting averages from 14 EEG channels and 128 stimuli. A typical example is shown in Fig 4.

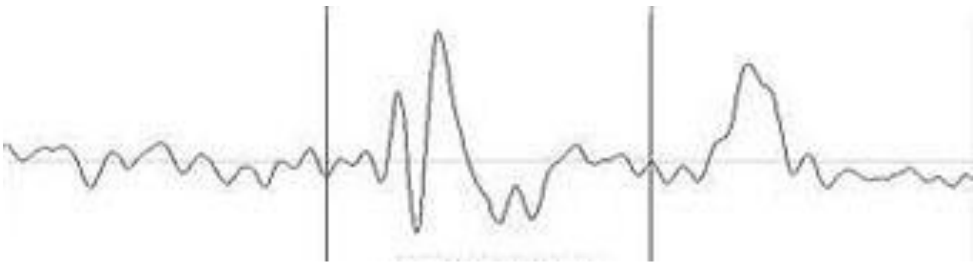

*Fig 4: A highlighted ERP from a Sender, averaged over 14 EEG channels and 128 stimuli. The two vertical lines mark the beginning and end of the stimulus. The post-stimulus ERP is also clearly visible.*

Fig 4 shows a 3-second long epoch, with a 1 second pre-stimulus period, a 1 second stimulus, and 1 second post-stimulus period. The graph perfectly matches the text-book versions, including the P300 peak, therefore the applied methods were considered valid.

Encouraged by this initial success, we devoted ourselves to the Receiver, starting with the theory (yet to be proven) that in his/her brain a signal comparable to an ERP could be generated while the Sender is getting the stimuli.
To avoid the possibility of the subjects predicting the timing of a stimulus, the notification signaling the start of each test (given simultaneously to each participant) was immediately followed by a period of silence of random duration between 2 to 3 minutes, after which the Sender was given 128x1-second sound/visual stimuli separated by pauses of random duration from 4 to 6 seconds. Each member of the subject pair had a photo of the other member upon which to concentrate before beginning the test, to be done in the dark and in silence, and continued during the test activity.

We arranged three days of data collecting with six people (5 males and 1 female), carrying out complete recordings from a total of 25 Sender-Receiver pairs. We then carefully examined the Receivers' EEG tracings using the same technique as for Senders (average of 3-second epochs synchronized to the instant the stimulus is applied). The result was disappointing: although the ERP was evident in the Senders, there was no sign of it in Receivers.
We then tried calculating the average of the powers (i.e., the EEG values squared, therefore making them all positive), hoping that changing the negative values to positive would highlight the differences and give better results, but the outcome was no better.

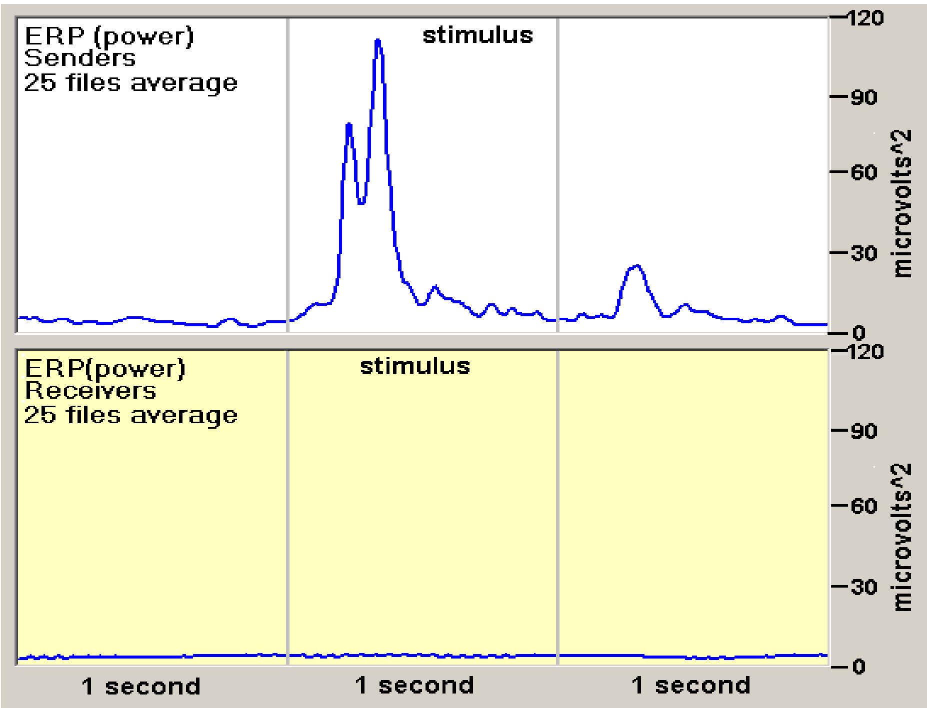


*Fig. 5: The top graph shows the total average of Senders' EEG tracings squared; the bottom graph shows the same for Receivers.*

These discouraging results, in our opinion, could only have been be due to two possibilities: either no ERP existed in Receivers, or something similar to an ERP was there but had a variable latency. Even assuming the second possibility was correct, to prove it a new method of analysis had to be invented that could overlook possible latency variations.

After a lengthy discussion, one of our team, William Giroldini, came up with an idea; throughout his years of experience with encephalography he had already encountered similar obstacles. After some fine-tuning, we developed a method which we called **GW6**. It is somewhat complicated and is described in detail in a work entitled A NEW METHOD TO DETECT ERPs BASED ON PEARSON'S CORRELATION, authored by William Giroldini, Marco Bilucaglia, Simone Melloni Patrizio Tressoldi, and myself, and which is about to be published.
The aforementioned paper also contains the software program written in Matlab (the original was written in Visual Basic and is only available in Italian), so that anybody can use it by following the protocol expounded in our recent work entitled EEG CORRELATES OF SOCIAL INTERACTION AT DISTANCE, authored by William Giroldini, Marco Bilucaglia, Patrizio Caini, Alessandro Ferrini, Simone Melloni, Elena Prati, Patrizio Tressoldi, and myself, and published in *F1000Research* [03 Aug 2015, **4**:457 (doi: 10.12688/f1000research.6755.1)]. This way our results can be replicated.

In short, the method uses a mathematical process based on Pearson's correlation (a commonly used statistical parameter) to uncover the presence of an ERP. The result is a graph showing only positive peaks that represent the increase in correlation among signals across all EEG channels corresponding to the stimuli. Applying the method to the Sender gives a typical result shown in Fig 6. It also allows singling out and highlighting components that usually remain hidden when the simple averaging method is used, due to their variable latency. Furthermore, the GW6 method is more resistant to EEG artifacts than traditional averaging.

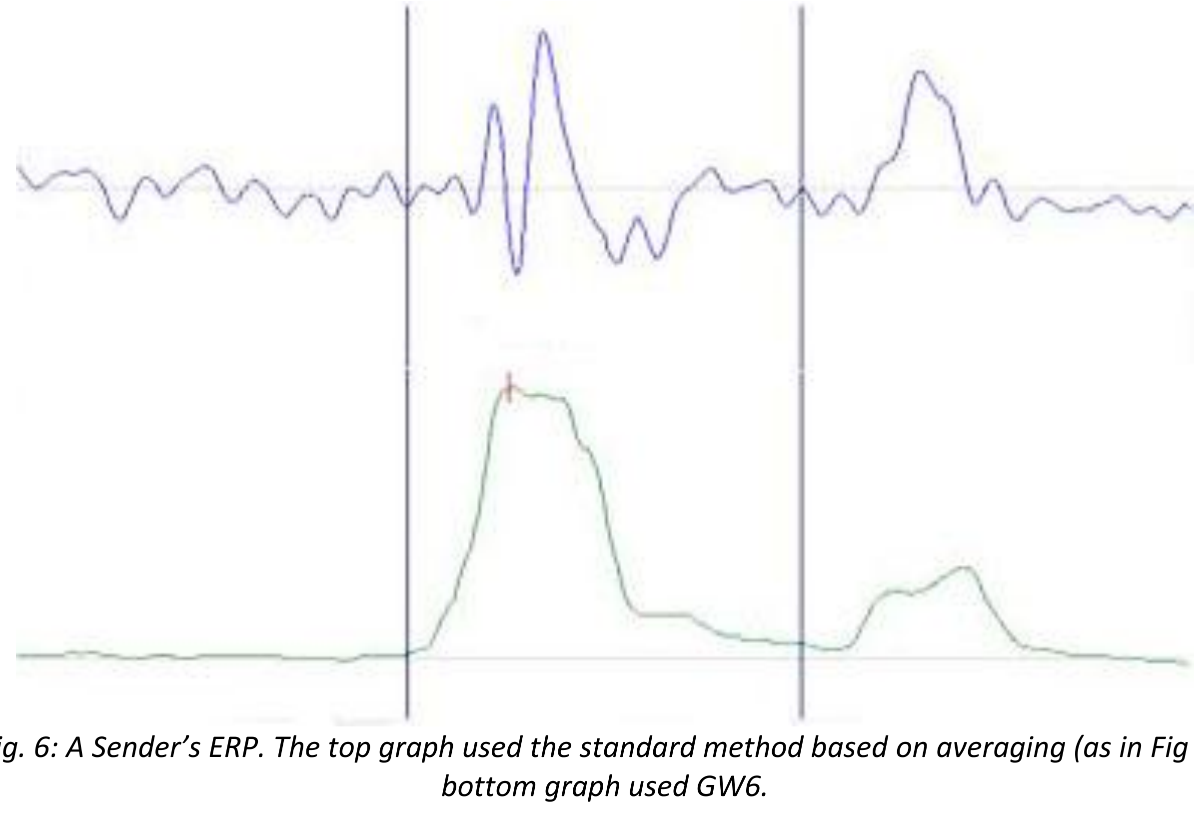

*Fig. 6: A Sender's ERP. The top graph used the standard method based on averaging (as in Fig 4); bottom graph used GW6.*

We then discovered that by limiting the EEG signal band frequency from the original 1 – 43 Hz to 1 – 16 Hz greatly improved the result quality, as can be seen in Fig 7, in which the red graph represents the overall average of the 25 Senders. We see an initial sharp peak (a correlation ERP) about 300ms after the stimulus is applied, and a second smaller peak after the stimulus ceased. The blue curve shows what would occur due to chance alone.

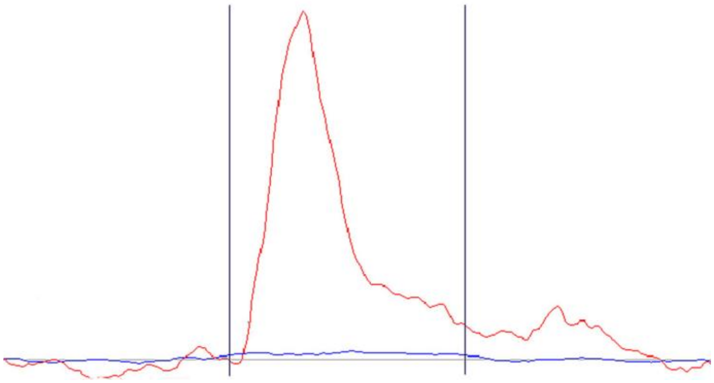

*Fig. 7*

It was therefore evident that the GW6 method was superior to traditional averaging for singling out ERPs. Subsequently we applied it to Receivers and noticed an interesting signal exactly where we expected it to be. Much work was required to improve our results but eventually – by limiting the frequency range to 9 – 10Hz – it even became possible to highlight the presence of an equivalent ERP in all 25 Receivers, regardless of the fact that not all Sender/Receiver pairs achieved an effective communication. The result is shown in Fig 8, in which the yellow area is statistically of particular significance, in that it CONFIRMS THE EXISTENCE OF AN ELECTRICAL SIGNAL IN THE RECEIVER'S BRAIN AT THE EXACT TIME A STIMULUS WAS GIVEN TO THE SENDER. The yellow area is distended and seems to pre-empt the giving of the stimulus, but this is only a consequence of the calculation method and the narrow band range.

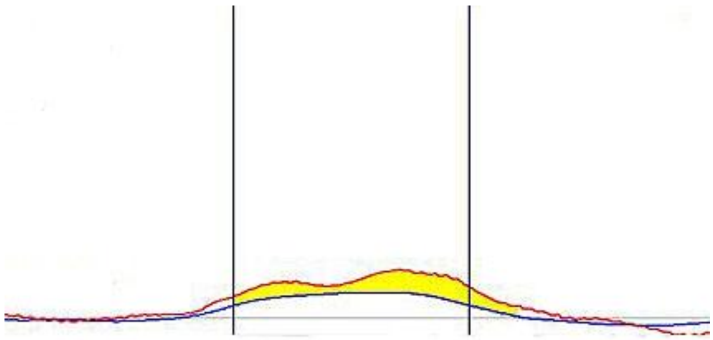

*Fig. 8: Total result from 25 Receivers obtained by filtering the EEG signals to within the 9 to 10Hz range.*

The most able subject pairs produced more prominent results, but it is of <u>considerable significance</u> that the overall result shows the probability of it being due to chance alone is less than 3 in 1000. This experiment has demonstrated the interesting effect of the unconscious perception of a remote stimulus given to a "Sender", located away from the "Receiver" and in a state of relaxation and sensory isolation. In classical 'mind reading' experiments, which use photos or videos, remote perception is tested by asking the perceiver to guess or describe something about the images or sensations received.

This implies that a possible PSI perception must enter one's conscious mind to be perceived and then reported. Our experiment demonstrated that PSI PERCEPTION EXISTS AND CAN BE TOTALLY UNCONSCIOUS. In other words, it does not necessarily cross the threshold into consciousness, although it can be detected using a sophisticated method.

This method could possibly prove useful in the more traditional fields of psychophysiology and neurology.

We will continue committing ourselves to constant - and hopefully significant – improvements in our experimental methods.