

Case Reports is a regularly featured column meant to highlight the clinical applications of alternative or integrative therapies as they are implemented in patient care. Preference will be given to cases in which diagnosis, treatment, and outcomes are clearly defined.

EVIDENCE OF CORRELATED FUNCTIONAL MAGNETIC RESONANCE IMAGING SIGNALS BETWEEN DISTANT HUMAN BRAINS

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The hypothesis that signals travel between the nervous systems of organisms that are not in physical contact has been posited but never fully tested. The first known report in the scientific literature of correlated signals between distant brains ("neural energy transfer") appeared in *Science*¹ in 1965. Duane and Behrendt studied pairs of monozygotic human twins and reported that EEG alpha rhythms were elicited in 1 member of the pair as a result of evoking these rhythms in the other member, who was separated by 6 meters in a different room. They reported that "extrasensory induction," as they called it, occurred in 2 out of 15 pairs of twins tested. In 1994 Grinberg-Zylberbaum et al² reported that visually evoked potentials in a human brain produced by photostimulation to 1 member of a pair can induce similar evoked potentials in the occiput of another person located 14.5 meters away in an electrically shielded room. These authors claimed that the "transferred potential" was observed only after the pair, previously unknown to each other, had spent 20 minutes together in meditative silence to induce a sense of "connectedness."

The Bastyr University/University of Washington Consciousness Science Laboratory research group developed sophisticated electroencephalographic (EEG) technology and statistical signal detection methods to replicate these findings. We previously reported that correlated EEG signals were recorded from the occiput of 5 of 60 healthy subjects tested in pairs when 1 member of the pair received visual stimulation

while the other member, located in a separate chamber 10 meters away, did not receive visual stimulation.³

The next step in our research was to determine if similar results could be attained using functional MRI (fMRI) technology. We report here on the first results of our fMRI study of correlated metabolic brain signals detected between 2 human subjects separated from each other by 10 meters.

METHODS

Subjects

Two healthy human subjects provided informed consent and agreed to participate in the study. Subject 1 was a 51-year-old white woman. Subject 2 was a 54-year-old white man. They had known each other as colleagues for 2 years and spent 10 minutes with each other in meditative silence before the start of the experiment.

Experimental Procedure

During the first 300-second experimental session, Subject 1 was designated the receiver and placed in the MRI brain scanner. Subject 2 was designated as the sender and placed in the scanner control room 10 meters away from the scanner. The experimental set-up is diagrammed in Figure 1. After the first 300-second experiment, the subjects switched positions. Subject 2 was placed in the MRI brain scanner (receiver) and Subject 1 was placed in the control room (sender). A Faraday cage electromagnetically shielded the scanner room and its occupants from the control room. The sender viewed a 13-inch video monitor placed 50 cm away from the eyes. An 8×8 black-and-white checkerboard (.12 cycles/degree) reversal stimulus was presented to the sender at a reversal rate of 6 Hz using Psyscope software (version 1.2.2, Cohen, MacWhinney, Flatt Provost of Pittsburgh, Pa.).

The receiver subject was placed horizontally in the MRI scanner and was optically isolated from the control room and the sender using goggles that covered the receiver's visual field.

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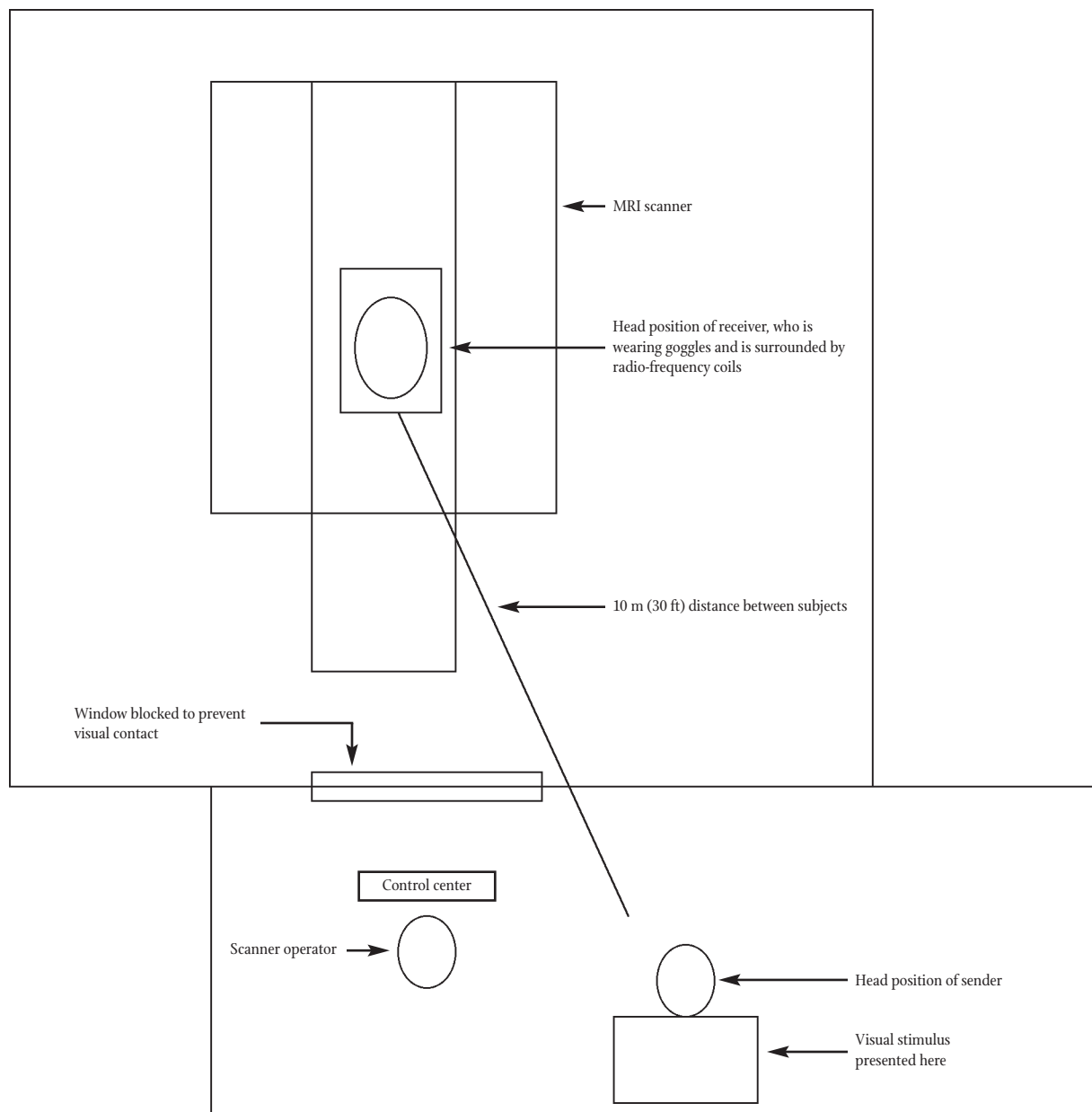


FIGURE 1 Diagram of fMRI scanner and positions of sender and receiver

The goggles were connected via high-resolution fiberoptic cables to 2 Infocus projectors (model LP435z, Infocus, Wilsonville, Ore), which were, in turn, connected to an IBM-compatible personal computer (PC). Through the goggles, the receiver viewed an unchanging static checkerboard pattern.

The start of the sender's stimuli was synchronized to the start of the fMRI scan. The 300 seconds of data acquisition yielded 100 sequentially collected brain volumes of which 50 (ie, 150 seconds) were collected during the sender's stimulus "on"

condition (flicker) and 50 were collected during the stimulus "off" condition (static).

The stimulus conditions (ie, static or flickering checkerboard image) were alternated and presented in variable-length blocks ranging from 18 to 33 seconds. The start time of the sender's first flicker condition was randomly varied from 8.3 to 51 seconds. The sender was instructed to fixate at the center of the video monitor and to attempt sending an image or thought to his or her partner. The receiver was instructed to watch the static checkerboard

presented through the goggles and to concentrate on remaining “connected” to the sender and to receive images from him or her.

Functional MRI Scan Acquisition

Blood-oxygen-level-dependent (BOLD) functional MRI scans were performed using T2*-weighted rapid gradient echo-planar images (EPI) to identify activation sites. (The T2*-weighted mechanism of MR image-signal contrast, in the case of BOLD fMRI imaging, is caused by the magnetic susceptibility changes due to the paramagnetic effects of deoxyhemoglobin during brain activations. For more information about the basics of functional MRI see Sanders et al⁴). Heavily susceptibility-weighted sequences were used to maximize the BOLD response.

Structural and functional MRIs were performed on a 1.5 Tesla (T) magnetic resonance (MR) imaging system (version 5.8, General Electric, Waukesha, Wis). Scanning included 21-slice axial MR images to be used as anatomical references (repetition time [TR]/echo time [TE] 200/2.2 ms; fast-spoiled gradient echo pulse sequence; 6 mm thick with 1 mm gap; 256×256 matrix). Each brain volume (voxel) consisted of a 3 dimensional space of 3.75 mm×3.75 mm×6 mm. These anatomical series were followed by an fMRI series using 2-dimensional gradient echo-planar pulse sequence (TR/TE 3000/50 ms, 21 slices; 6 mm thick with 1 mm gap, 64×64 matrix, 100 volumes total; time=300 sec). An additional 3-dimensional 124-slice anatomical MRI scan was performed with 1.4 mm sagittal slices using a 3-dimensional fast-spoiled gradient echo pulse sequence. Imaging parameters included a TR/TE of 11/2.2 ms, flip angle of 25 degrees, and the field of view was 24 cm (acquisition time was 4:36 minutes).

Image Processing

Functional MRI scans were analyzed using BrainVoyager (version 4.4, Brain Innovation BV, Maastricht, The Netherlands). Data were motion corrected in 3 dimensions and smoothed using a frequency domain filter (1-32 low pass, 3-42 high pass). A general linear model regression (GLM) was used to generate statistical *P* value maps based on the contrast between the flicker versus the static conditions. The GLM goes beyond simple correlation or the *t* test by allowing the application of statistical methods that contain explanatory variables (predictors). The expected response to changes in stimuli (ie, on or off) is known to follow the hemodynamic delay curve shown in Figure 2a. The regression (GLM) determined the extent to which the observed receiver's MR responses were predicted by this model. A goodness of fit statistic (*r*²) indicated the degree of fit between the hemodynamic model and the actual brain activity time-course recording during 300-second fMRI scans. Both positive and negative beta coefficients can result. A positive beta results when the fMRI signal positively correlates with the hemodynamic visual stimulus-brain response model. Negative beta coefficients result if the brain signal negatively correlates with the model.

The final display of fMRI superimposed on the structural MRI highlights only those areas of the brain in red that have

F values greater than 17 corresponding to *P* values (Bonferroni corrected for masked 30,000 voxels) less than .01. The receiving subject's activation map and 3-dimensional structural MRI were converted to the standard stereotaxic space.⁵ Stimulation typically energizes highly selected sites within the brain. The software examines the entire brain (64×64×21=86,016 brain MRI voxels) and highlights only those voxels (ie, areas) in which the metabolic brain signal fits well with the block model of stimulus presentation.

RESULTS

Figure 2 shows both theoretical and actual fMRI data obtained while Subject 1 was the receiver. An increase in blood oxygenation significant at *P*<.001 was observed in area 18 and 19 of the visual cortex in Subject 1 while Subject 2 viewed a flickering checkerboard stimulus. Figure 3 shows data from Subject 2 while he was the receiver. No such signal was observed while Subject 2 was viewing a static checkerboard.

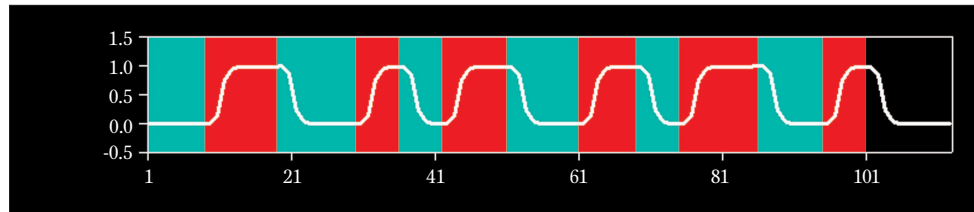
COMMENT

To our knowledge, this is the first fMRI demonstration of correlated-event-related signals between 2 human brains at a distance. The regions of activation shown in this paper (area 18 and 19) are similar to the brain regions that are activated when a subject is directly stimulated with checkerboard reversal stimulation as described by Mohamed et al.⁶

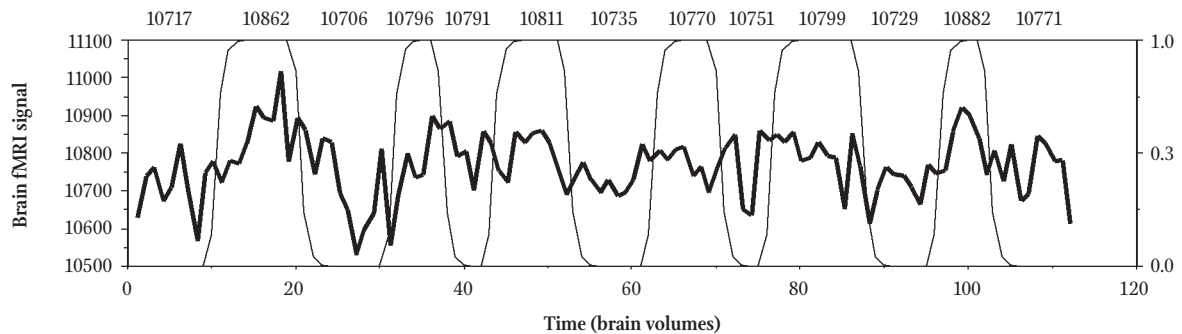
These brain scan results indicate that, at least in 1 instance, a signal was detected in the brain of a distant member of the pair when the brain of the other member was visually stimulated. That this effect was not observed when the roles were reversed suggests that the apparent “linkage” is not necessarily transitive (ie, transmission in 1 direction does not ensure or predict transmission in the other direction). Subject 2's non-significant results also indicate that the signal observed in Subject 1's visual cortex was not the result of an undetermined experimental artifact.

The brain activity observed in the visual association cortex suggests that the receiver “processed” a signal from the sender. Because Subject 1 (as receiver) was electrically, magnetically, acoustically, and visually shielded from Subject 2 (as sender), the mode of transmission for this signal is presently unclear. Whatever the physical nature of the signal, this case report suggests that living brain tissue detects this signal. The underlying mechanism of this phenomenon, first described in EEG, and now in fMRI, remains to be explained.

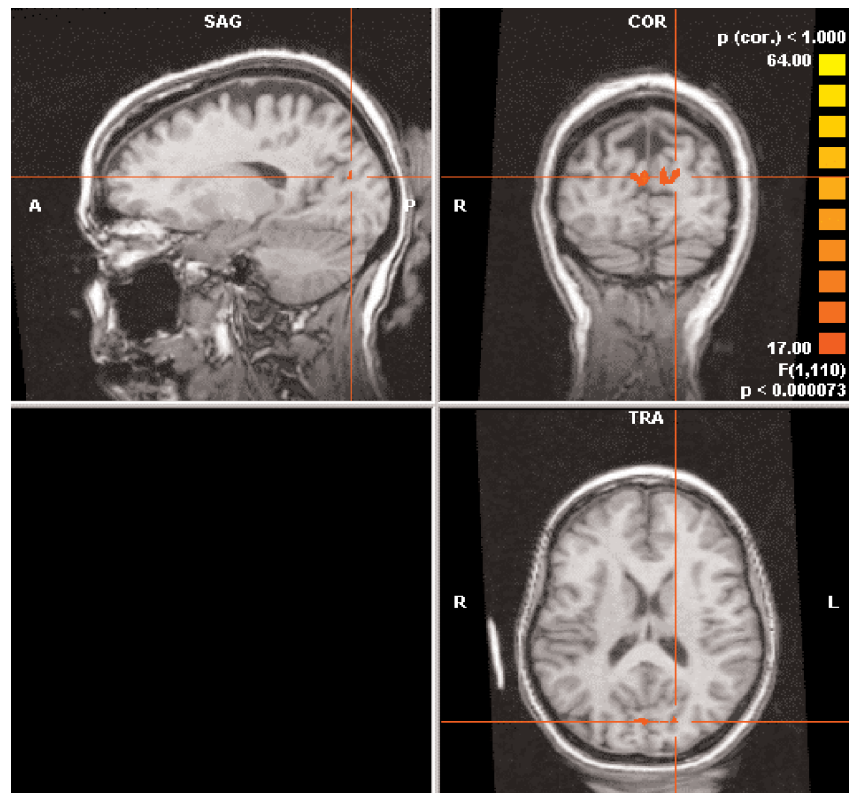
Some theoreticians have proposed a nonlocal quantum mechanical model to explain the transferred EEG data reported by Duane and Behrendt,¹ Grinberg-Zylberbaum et al,² and Standish et al.³ Systematic study of the parametric effects of distance between subjects' brains on signal intensity and delay will be necessary to evaluate the nonlocal quantum field hypothesis of neural signal transfer that has been observed in both EEG and fMRI experiments.



A. Hemodynamic model with signal delay: Hypothesized fMRI brain signal in human subjects during flickering and static checkerboard visual stimulation of their partner located 10 m away.

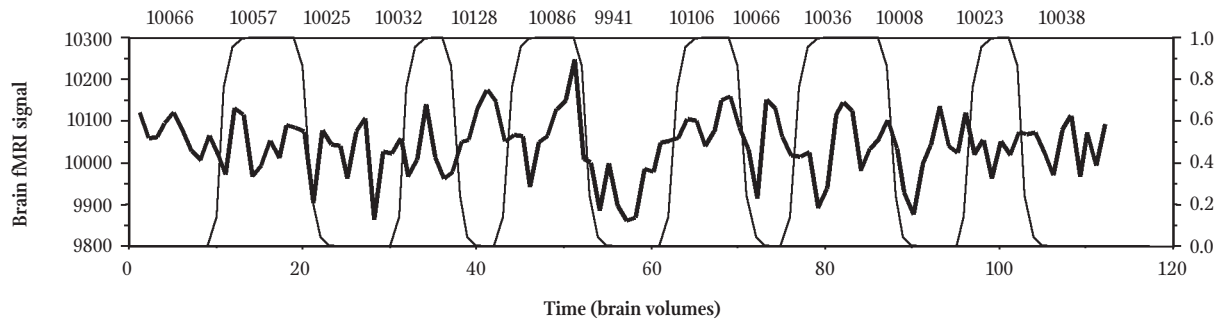


B. Bold, black line indicates the actual fMRI brain signal from the occipital region of Subject 1 during which the brain signal increased in all 6 flicker conditions compared with the static conditions of the sender. Mean brain signal intensity for each stimulus condition is indicated at the top of each interval.

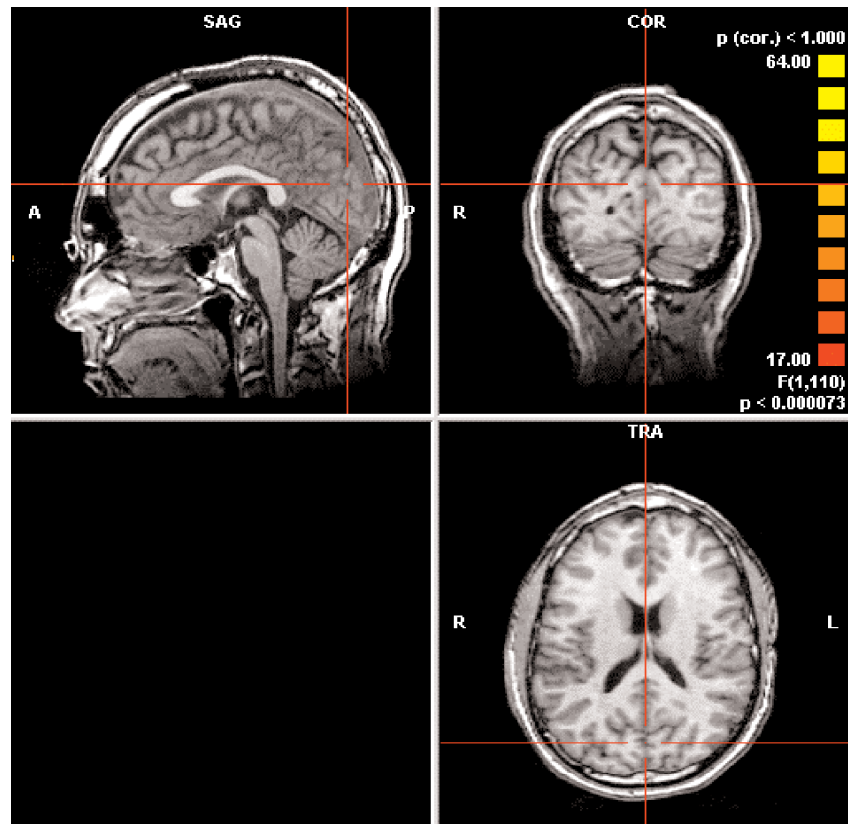


C. fMRI of Subject 1 receiving from Subject 2 with activation threshold set to $P < .01$. The red areas overlaid onto the structural brain image indicate significant areas of brain activation correlated with the sender's stimuli.

FIGURE 2 Theoretical and actual fMRI data obtained across 300-sec experiment while Subject 1 was in "receiver" mode.



A. Bold, black line indicates the actual fMRI brain signal from the occipital region of Subject 2 during which the brain signal did not change in all 6 flicker conditions, compared with the static conditions of the sender. Mean brain signal intensity for each stimulus condition is indicated at the top of each interval.



B. fMRI of Subject 2 receiving from Subject 1 with activation threshold set to $P < .01$. The absence of red areas overlaid onto the structural brain image indicates that there are no significant areas of brain activation correlated with the sender's stimuli.

FIGURE 3 Theoretical and actual fMRI data obtained across 300-sec experiment while Subject 2 was in "receiver" mode.

Acknowledgments

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