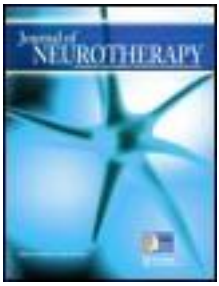


Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience

"Delusions" of Space

D. Erik Everhart PhD [a] , Heath A. Demaree PhD , David W. Harrison PhD [b] & John B. Williamson MS [b]

[a]Department of Psychology, East Carolina University, Greenville, NC, USA

[b]Department of Psychology, Virginia Polytechnic Institute and State University, USA

Published online: 20 Oct 2008.

To cite this article: D. Erik Everhart PhD , Heath A. Demaree PhD , David W. Harrison PhD & John B. Williamson MS (2001) "Delusions" of Space, Journal of Neurotherapy: Investigations in Neuromodulation, Neurofeedback and Applied Neuroscience, 4:4, 19-29, DOI: 10.1300/J184v04n04_04

To link to this article: http://dx.doi.org/10.1300/J184v04n04_04

"Delusions" of Space: A Case Study Utilizing Topographical Brain Mapping and QEEG

D. Erik Everhart, PhD
Heath A. Demaree, PhD
David W. Harrison, PhD
John B. Williamson, MS

ABSTRACT. *Introduction:* Delusions have received increased attention in the neuropsychological literature. However, there has been a relative lack of information published concerning delusions of "space." More specifically, the belief that one is moving through space from "another world," "planet," or location, has infrequently been studied with respect to localization of dysfunction in cerebral structures. Given that other types of delusions often occur as a result of right hemisphere lesions, it is hypothesized that delusions of space occur with lesion to similar structures, and particularly the right parieto-temporal region. Several lines of converging evidence, which support this theory, are discussed.

Method: In addition, a right parieto-temporo hypothesis for delusions of space is tested by use of single case study design of a male patient with closed head injury who specifically believed that he was from "another

D. Erik Everhart is Assistant Professor, Department of Psychology, East Carolina University, Greenville, NC.

Heath A. Demaree's main research interests include individual differences on emotional physiological and neuropsychological factors as well as cognitive sequelae associated with CNS disorders.

David W. Harrison is Associate Professor, Department of Psychology, Virginia Polytechnic Institute and State University.

John B. Williamson is a graduate student, Department of Psychology, Virginia Polytechnic Institute and State University.

Address correspondence to: David W. Harrison, PhD, Department of Psychology, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061.

place" with someone forcing him through space to remain in a "box" (another body).

Discussion: Results from neuropsychological evaluation and topographical brain mapping with QEEG lend support to this theory, with findings of right parieto-temporo dysfunction and relative asymmetry in beta (13-20 Hz) activity when left and right hemispheres were compared.

Conclusions: The results provide case study evidence supporting the inclusion of QEEG as part of a neuropsychological evaluation. This approach lends itself both to double dissociation techniques in syndrome analysis and in a priori predictions using nomothetic comparisons.

KEYWORDS. Hemispheric asymmetry, delusions, closed-head injury, psychosis, QEEG, right hemisphere

INTRODUCTION

Patients with delusions have received increased attention in the literature. More specifically, research has indicated that individuals who develop delusional systems often have right hemisphere lesions. For example, in review of 250 cases of misidentification syndromes, neuropsychological evaluation and CT scans showed more features of right hemisphere lesions than left hemisphere lesions (Forstl, Almaida, Owen, & Burns, 1991). This study also suggested that individuals with misidentification syndromes were most likely to be diagnosed with paranoid-type schizophrenia. Other types of delusions have also been linked with right hemisphere lesions. Young, Robertson, Hellawell, de Pauw and Pentland (1992) report on a patient with the Cotard delusion (belief that you are dead) following injury to the right parieto-temporal area.

In contrast to the plethora of literature investigating other types of delusions, delusions of "space" have received considerably less attention. There are few reports available which discuss the belief that one is traveling through space from one location to another. Similarly, there exist few, if any, group studies, which have investigated relationships between neuropsychological dysfunction and the development of delusions of travel through space.

Even though few reports are available for this type of delusion, there exists some evidence which implicates the role of the right hemisphere, and particularly dysfunction within the right parieto-temporal region in the experience of delusions of space. For example, individuals with head injuries often enable the researcher to look at lesion location as a contributor to dysfunction. Several reports exist within the literature of individuals developing delusions of space travel following head injuries. Luria (1973), in his book *The Working Brain,* may have been one of the first researchers to discuss delusions of space in terms of neuropsychological dysfunction. Luria described a group of patients who showed severe loss of direct orientation in space and time. These patients firmly believed that they were in Moscow and in another town at the same time. According to Luria, the patients with these beliefs all suffered from deep lesions of the right parieto-temporal region. More recently, Ortiz and Barraquer (1991) report on an individual who was convinced that every night he, along with his physicians was transferred to another hospital in different cities. This patient suffered from a right hemisphere hematoma.

The above studies suggest that right hemisphere dysfunction is implicated in delusions of traveling in space. A large body of evidence from visuospatial studies of individuals with cerebral dysfunction, particularly right cerebral dysfunction also implicates the right parieto-temporal region in delusions of space. For example, Hannay, Varney, and Benton (1976) asked patients with left or right hemisphere lesions to identify the locations of simultaneously exposed pairs of dots as well as single dots. Patients with right hemisphere lesions demonstrated significantly less ability to localize points in space than controls while no patients with left hemisphere lesions showed impaired performance.

Appreciation of the directional orientation of lines presented tactually or visually to individuals with brain dysfunction has also demonstrated hemispheric asymmetry for visuospatial reasoning. Specifically, Benton and Tranel (1993), after reviewing a number of studies, which involve the patient identifying directional orientation of lines, suggest that perception of directional orientation is mediated primarily by the right hemisphere in right-handed subjects. Benton and Tranel (1993) also reviewed studies of topographical orientation (e.g., spatial location and geographical location), which utilized left and right hemisphere disease patients. Among the literature reviewed, it was suggested that patients with right versus left hemisphere lesions might have decreased topographical memory and decreased ability to recognize familiar surroundings.

Conceptualization of the right hemisphere's role in far and near space further implicates dysfunction within the right parieto-temporal region in acquired delusions of space. Heilman, Chatterjee, and Doty (1995) suggest that the right hemisphere versus the left hemisphere may be specialized for attending to extra-personal space. More specifically, Heilman et al. asked normal participants to compare the size of horizontal lines presented in the sagittal plane of the left or right hemispace. When subjects looked leftward, lines appeared shorter than when participants looked to the right. Heilman et al. conclude that the right hemisphere may preferentially direct attention toward visual extra personal (far) space while the left hemisphere may preferentially direct attention toward visual peripersonal (near) space. Individuals with delusions of travel in space and right hemisphere dysfunction may have impaired ability to ascertain location of themselves with respect to extra personal space, and thus may perceive that they are moving through space against their will.

The comparative literature base also implicates right hemisphere dysfunction and more specifically the right parieto-temporal region in delusions of space. O'Mara, Rolls, Berthhoz, and Kesner (1994) found neurons within the primate hippocampus that respond to "whole-body" motion. The authors conclude that these cells may be important for spatial memory and thus spatial navigation. In addition, Oram, Perrett, and Hietanen (1993) have described cells in the anterior superior temporal polysensory region, which respond to direction and motion.

In summary, the available literature implicates the role of right hemisphere dysfunction in delusions of space. Luria's (1973) reports of right parieto-temporal lesioned patients' beliefs of traveling through space are substantiated by the literature which indicates dysfunctional performance on point localization, spatial and topographical orientation among right hemisphere lesioned patients. Similarly, the finding of cells within temporal regions of primates sensitive to "whole-body" motion, and other cells which respond to direction and motion further implicate right hemisphere dysfunction in delusions of space. Given that patients with right hemisphere disease, and particularly patients with the belief that they are traveling through space might be frequently misdiagnosed as a "psychiatric" disorder, it is important to continue research on this particular topic. A right parieto-temporal hypothesis for delusions of travel through space was tested on the following case study using neuropsychological evaluation and topographical brain mapping and QEEG.

CASE STUDY

A right parieto-temporal hypothesis for delusion of space was tested in the following case study using topographical brain mapping and QEEG. Given this particular patient, evidence of altered activation was expected over the right parieto-temporal region relative to the left parieto-temporal region during phase one of the experiment. In phase two of the experiment, an affect induction procedure was used to augment the patient's symptoms and to elicit verbal discourse in which the patient can communicate his feelings or associated cognitions. A further increase in asymmetry was expected during this phase.

METHOD PHASE ONE

Subject. The patient was a 44-year-old, right handed, divorced Caucasian male. By report, the patient sustained a closed head injury secondary to a motor vehicle accident. A truck apparently lost its trailer, and the patient's car impacted with the trailer at about forty miles per hour. The patient reported that his head struck the windshield and the top of the car. He denied loss of consciousness but reported that his memory of these events was poor. Initial CT scan and evaluations were essentially negative.

History. A psychiatrist saw the patient and concluded that he had apparent delusions and homicidal/suicidal ideation. This workup resulted in a diagnosis of major depressive episode with psychotic features and psychogenic amnesia. Reportedly, this patient had indicated beliefs of being trapped in someone's body (described as a "box"), being from "another world," with someone forcing him to move through space into the "box." There were apparently no indications of this belief prior to the accident. In addition, the patient reported becoming angry when thinking about his situation of being in another person's body. The patient was also seen for an MRI and an EEG, which were both reportedly normal.

A neuropsychological evaluation that was completed included a neurobehavioral status examination and standardized tests including the Denman Neuropsychological Memory Scale, Rey Auditory Verbal Learning Test, Controlled Oral Word Association Test (FAS), Trail Making Test, Parts A & B, and Benton's Facial Recognition Test (see Table 1).

TABLE 1. Neuropsychological Test Results

Denman Neuropsychological Memory Scale (scaled scores reported):			
Immediate Recall of a Story	4	Immediate Recall of a Figure	7
Paired Associate Learning	7	Musical Tones and Melodies	4
Memory for Digits	7	Memory for Human Faces	3
Remote Verbal Information	3	Remote Non-Verbal Information	6
Delayed Paired Associates	4	Delayed Recall of a Figure	7
Delayed Recall of a Story	1		
Verbal Memory Quotient	58	Nonverbal Memory Quotient	62
Full-Scale Memory Quotient 54			
Grip Strength (kg)			
left hand: 35		right hand: 45	
Benton's Facial Recognition Test		34 (severe impairment)	
Trail Making			
Part A		52 seconds	
Part B		1 minute, 17 seconds	
Rey Auditory-Verbal Learning		5/15, 6/15, 7/15, 7/15, 8/15	
(across 5 successive trials)			
FAS test		mean word writing = 13	
Beck Depression Inventory (BDI)		23	

The neuropsychological evaluation was suggestive of right parieto-temporal dysfunction. Though the patient displayed global deficits on memory functioning, severe deficits in facial recognition and memory for human faces were observed. Results from the neuropsychological evaluation also suggested initiation deficits and behavioral slowing, indicating bilateral frontal lobe dysfunction.

Procedure. The subject was instructed to relax and lie motionless in a supine position on a reclining chair. The chair was located in a sound attenuated chamber. A lycra electrode cap was fitted according to the appropriate anatomical marks on the subject's head. The cap was attached via elastic straps to a body harness around the subject's chest to ensure that the cap was securely positioned. QEEG was recorded from 19 scalp locations (Fp1, Fp2, F3, F4, F7, F8, FZ, C3, C4, CZ, T3, T4, T5, T6, P3,

P4, PZ, O1, O2) and referenced to the earlobes. Impedance level at each electrode was measured to be below 10 kOhm. A total of 122, 1-second epochs of data were collected for the eyes open condition. A sampling rate of 256 Hz was used. Epochs contaminated by eye-blinks and/or movement artifacts were eliminated from the analysis. The magnitude of standard beta (13-20 Hz) activity across the remaining epochs was assessed using the Neurosearch-24 (Lexicor Medical Technology, 1992).

Results. Topographical brain maps and descriptive data were derived after artifacting the EEG raw data for both the relaxed-eyes closed and anger induction-eyes closed condition.

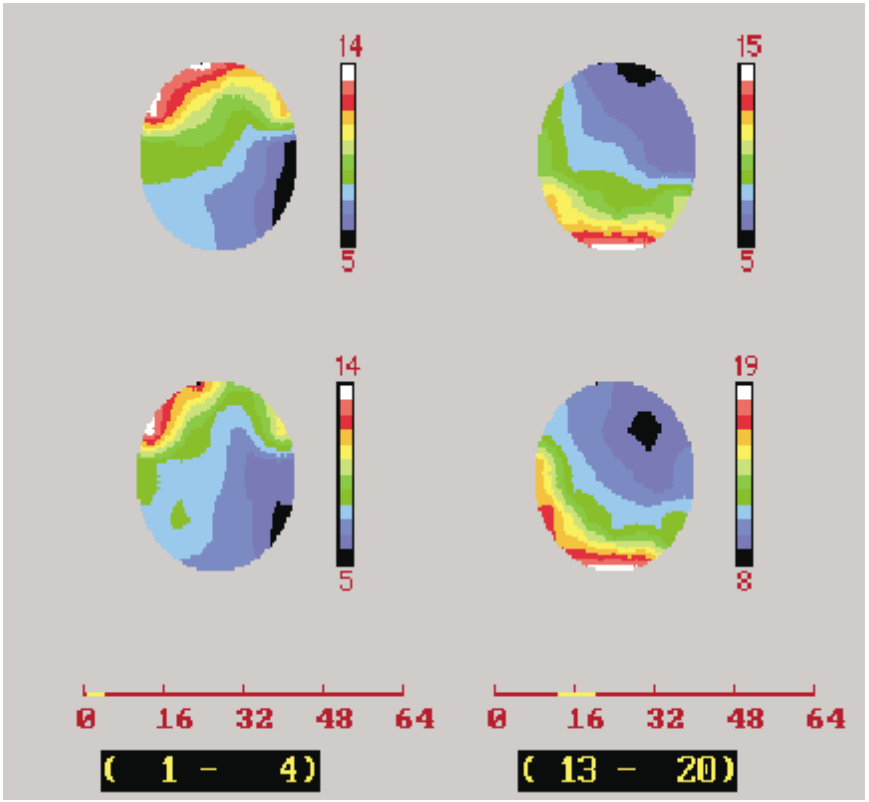
As illustrated in Figure 1 and Table 2, evidence for greater left hemisphere beta activity (13 to 20 Hz) relative to the right hemisphere was found in the relaxed-eyes closed portion of the procedure. This is consistent with the neuropsychological evaluation indicating right hemisphere dysfunction, specifically, right parietal-temporal dysfunction. Magnitude of beta activity over individual electrode locations is presented in Table 2. Also, the presence of delta activity was noted over both frontal lobes (see Figure 1), indicating slow wave activity over FP1 and FP2.

METHOD PHASE TWO

Procedure. The procedure for phase two was identical to that used in phase one, with the exception of the utilization of the affect induction procedure. Angry affect was produced using an affect induction procedure, which was selected based on the subject's apparent sensitivity to the emotional theme. Specifically, the patient believed that he was trapped in a "box" (a body) that he does not belong in. He stated that he is unsure of how he got into the box, and that he belongs in another world. He reportedly experiences anger and homicidal thoughts when thinking about being trapped in the box, and who may have placed him in the box.

During the affect induction procedure the patient was told the following: "Keep your eyes closed and start thinking about your box. I would like for you to think about unpleasant things now. If you would, think about what it is like for you to be in your box, and those people that had something to do with forcing you to stay in the box. I want you to try and experience the anger that you feel related to that. I want you to get into it; feel what it is like to be forced back into a box that you don't belong in, what it would have been like if they had let you go. Keep your eyes

FIGURE 1. (top-left) Delta activity, 1-4 Hz in eyes closed condition. (top-right) Beta activity, 13-20 Hz, in eyes closed condition. (bottom-left) Delta activity, 1-4 Hz, in aversive imagery condition. (bottom-right) Beta activity, 13-20 Hz, in aversive imagery condition.



*Absolute amplitude values are given in microvolts.

closed, and just think of what it has been like for you." After receiving the instructions, the patient was instructed to relax without contracting his muscles, and to continue to think about his box.

A sampling rate of 256 Hz was used with frequencies below 2 Hz eliminated by a high band-pass filter to substantially reduce low frequency artifact. Epochs contaminated by eye-blinks and/or movement artifacts were eliminated from the analysis. Artifact elimination continued until at least 30 substantially artifact free epochs remained for anal-

ysis. A total of 130, one-second epochs of data were collected for the eyes closed, anger induction condition. The magnitudes of high delta (2 to 4 Hz), theta (4 to 8 Hz), alpha (8 to 13 Hz), and beta (13 to 24 Hz) waves were assessed using NeuroSearch-24 (Lexicor Medical Technology, 1992). After the procedure the patient was instructed to think about things that were pleasing to him. The patient was able to relax within several minutes.

Results. During the anger induction procedure, the subject displayed increased hemispheric asymmetry in beta (13 to 20 Hz) activity. (See Figure 1 and Table 3.)

DISCUSSION

The topographical brain mapping results from the present study were suggestive of decreased activation of the right hemisphere relative to the left. Specifically, the subject exhibited decreased beta activity over the right parieto-temporal region. This finding is consistent with the

TABLE 2. Beta Magnitude (μV) Over Left and Right Hemispheres During Eyes-Closed Condition

Left Hemisphere		Right Hemisphere	
FP1	4.9	FP2	4.1
F3	5.5	F4	4.3
T3	7.9	T4	4.9
T5	10.1	T6	8.6
P3	8.0	P4	7.3
O1	12.3	O2	12.8

TABLE 3. Beta Magnitude (μV) in Left and Right Hemispheres During Aversive Condition

Left Hemisphere		Right Hemisphere	
FP1	7.7	FP2	7.4
F3	7.7	F4	6.4
T3	13.3	T4	7.9
T5	14.6	T6	9.8
P3	11.3	P4	8.7
O1	15.9	O2	16.1

neuropsychological evaluation, which indicated right parieto-temporal region dysfunction. These results support the hypothesis of right hemisphere mediation of, and more specifically right parieto-temporal mediation of awareness in relation to location in space.

Phase two yielded an increase in beta over both hemispheres and a relative increase in beta asymmetry in favor of left versus right parieto-temporal regions during an affect induction procedure. During this time period, the subject became increasingly angry regarding being "trapped in his box." The finding of increased beta activity over the right temporal region is consistent with Kalat's (1992) notion that stimulation of the right anteriomedial temporal regions yields anger. The increase in beta asymmetry in favor of left versus right further implicates right hemisphere dysfunction with respect to delusions of space. Also, though the finding of marked delta activity over both frontal lobes was not specifically hypothesized, its presence is consistent with the finding of behavioral slowing and initiation deficits found in the neuropsychological evaluation.

As previously suggested, individuals with head injuries or other types of cerebral dysfunction who develop beliefs of traveling through space may be commonly misdiagnosed as psychiatric disorders. It is therefore important to continue research in this area. Future clinical research using topographical brain mapping and QEEG will more extensively address the relationship between the right parieto-temporal region and delusions of space, and will add to the increasingly converging evidence indicated by Heilman, Chatterjee and Doty (1995), Luria (1973), and other researchers. Compilation of research findings indicating specialized cells for "whole-body" movement in the temporal and hippocampal regions, deficits in ability to localize one's self in space and time resulting from right parieto-temporal lesions, and concepts of extra personal space may prove promising for further understanding of this type of delusion.

It is recognized that the use of the induction procedure may account for the increased activity displayed over the left hemisphere. Specifically, the patient may have engaged in verbal self-talk rather than visual imagery during the procedure. This would not be surprising, given that the patient's neuropsychological evaluation demonstrated deficits in visual memory (memory for human faces). However, this would further substantiate a right hemisphere dysfunction hypothesis for decreased ability to localize the self in space, as topographical orientation may primarily be a nonverbal process.

It should also be noted that use of topographical brain mapping and QEEG with patients suffering from closed head injury is supported by

this case study. Duffy (1994) has reported on the advances of QEEG technology in the previous decade. More specifically, topographical brain mapping and QEEG are increasingly being used to provide independent confirmation of neuropsychological hypotheses. Concurrent findings between neuropsychological tests and the topographical brain map may lead to increased reliability and validity of neuropsychological assessment.

REFERENCES

Benton, A. L., & Tranel, D. (1993). Visuoperceptual, visuospatial, and visuoconstructive disorders. In Heilman, K. M., & Valenstein, E. (Eds.), *Clinical neuropsychology, 3rd edition* (pp. 165-213). New York: Oxford University Press.

Duffy, F. H. (1994). The role of quantified electroencephalography in psychological research. In Dawson, G. & K. W. Fischer (Eds.), *Human behavior and the developing brain* (pp. 93-133). New York: The Guilford Press.

Forstl, H., Almeida, O. P., Owen, A. M. & Burns, A. (1991). Psychiatric, neurological, and medical aspects of misidentification syndromes: A review of 250 cases. *Psychological Medicine*, *21*(4), 909-910.

Hannay, H. J., Varney, N. R., & Benton, A. L. (1976). Visual localization in patients with unilateral brain disease. *Journal of Neurology, Neurosurgery, and Psychiatry*, *39*, 307-313.

Heilman, K. M., Chatterjee, A. & Doty, L. C. (1995). Hemispheric asymmetries of near-far spatial attention. *Neuropsychology*, *9*, 58-61.

Kalat, J. W. (1992). *Biological psychology*. Belmont: Wadsworth, Inc.

Luria, A. R. (1973). *The working brain*. New York: Basic Books.

NeuroSearch-24 (1992). Mexicor Medical Technology, Inc., Boulder, Co.

O'mara, S. M., Rolls, R. T., Berthoz, A. & Kesner, R. P. (1994). Neurons responding to whole-body motion in the primate hippocampus. *Behavior and Brain Research*, *57*(1), 53-61.

Oram, M. W., Perrett, D. I., & Hietanen, J. K. (1993). Directional tuning of motion-sensitive cells in the anterior superior temporal polysensory area of the macaque. *Experimental Brain Research*, *97*(2), 274-294.

Ortiz, N. & Barraquer, B. L. (1991). Place disorientation as a clinical feature of a right capsulo-putaminal hematoma. Contribution to the understanding of neuropsychologic symptomatoloogy in subcortical lesions or the right hemisphere. *Neurologia*, *6*(3), 103-107.

Young, A. W., Roberston, T. H., Hellawell, D. J., de Pauw, K. W. & Pentland, B. (1992). Cotard delusion after brain injury. *Psychological Medicine*, *22*(3), 799-804.

RECEIVED: 10/12/99
REVISED: 01/24/00
05/11/00
ACCEPTED: 08/04/00