

in the office compared with a baseline (interictal) HR could be a valuable diagnostic tool to help evaluate the cause of an unresponsive spell in patients with suspected PNES. Although it would not obviate definitive diagnosis by CCTV-EEG recording, it may be helpful in formulating an immediate diagnostic impression.

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Functional changes in temporal lobe activity during transient global amnesia

Abstract—The integrity of temporal lobe activity during and after recovery from transient global amnesia (TGA) was assessed in a case study using functional MRI. TGA was associated with scene-encoding deficits in a temporolimbic circuit that recovered over time. Frontoparietal areas recruited during the amnesic state may signify a compensatory reliance on visuospatial or working memory strategies. Reduction of extrastriate cortex responses over repeated testing sessions possibly indicates intact visual priming in TGA.

NEUROLOGY 2002;58:638–641

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Imaging studies have localized baseline changes in blood flow and metabolism to temporal lobe structures during transient global amnesia (TGA). However, it is unknown if TGA is associated with regionally specific deficits during cognitive challenges and whether task-related changes persist after recovery from the amnesic episode. In this case report, functional MRI (fMRI) was used to evaluate hemodynamic responses in a patient with TGA during a scene-encoding task. The experimental design investigated recovery of function over time and provided insight into potential task-related compensatory changes during the acute phase of TGA.

Methods. *Case report.* The patient was a 40-year-old man who was admitted for sudden onset of confusion and memory loss. He was a successful banker and had been in generally good health. At noon on the day of admission, he was exercising at a health club when he suddenly became disoriented to time, place, and recent events. After approx-

imately 1 hour, he asked for assistance when he could not find his way around the club, recognize his locker, or recall his locker combination. He was brought by ambulance to the emergency room. Two hours after the event began, his attention span was short, he was oriented only to person, and he repeatedly asked questions regarding his location and recent events. Bedside mental status testing revealed an anterograde memory deficit and a retrograde deficit to 10 PM the night before. By late afternoon, his thoughts partially cleared and he had a mild headache, “like coming out of a migraine.”

One year prior to this episode, the patient experienced several hours of disorientation but no memory loss. There were no other neurologic symptoms, and the episode resolved quickly. He had had migraine-type headaches in the past. Physical and sensorimotor neurologic examinations were unremarkable. Mental state examination revealed normal speech and language. Four and one-half hours after the start of the episode, he could not recall three words after 5 minutes. Six hours after the event, just prior to fMRI scanning, he was given the Three Words, Three Shapes memory test.¹ He required two learning trials to immediately recall all six items and was able to recall all stimuli 5 minutes later. However, he could recall only one shape and none of the words spontaneously 2 hours later, though he recognized all shapes and one word from a list of multiple choices. A brain CT and MRI with diffusion sequences were normal. EEG showed infrequent left temporal slowing. Lumbar puncture (LP) showed slight elevation of protein to 52 mg/dl (normal 20 to 40). Other laboratory tests were normal. The primary diagnosis was TGA.

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Supported in part by an NARSAD Young Investigator Award (K.S.L.).

Received August 7, 2001. Accepted in final form November 6, 2001.

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Table Functional MRI activation patterns in patient with transient global amnesia (TGA) and control subjects

Contrast	Subject group	Brain region	Side	Z score	Stereotactic coordinate
Session 1 vs Session 2	TGA	Posterior parietal cortex	Left	5.76	-33, -48, 60
				4.58	-21, -72, 48
		Extrastriate cortex	Right	4.60	24, -60, 63
			Right	5.27	30, -78, -18
			Left	5.12	-36, -57, -24
	Precentral gyrus	Left	4.93	-51, -9, 42	
		Right	4.85	63, -18, 36	
	Control, n = 3	Extrastriate cortex	Right	6.58	42, -72, -24
				5.64	33, -69, -6
			Left	6.55	-21, -69, -12
Posterior cingulate		Midline	4.96	3, -39, 21	
Session 2 vs Session 1		TGA	Retrosplenial cortex	Left	4.51
	Inferior temporal sulcus		Right	4.46	69, -6, -30
				4.13	57, -6, -33
	Temporal pole		Right	3.59	36, 9, -39
	Parahippocampal gyrus		Left	3.02	-30, -30, -18
		Right	2.93	30, -30, -15	
	Control, n = 3	Occipitotemporal junction	Left	5.24	-60, -51, 3
			Right	4.47	57, -51, 6
		Superior frontal gyrus	Midline	4.98	0, 48, 33

The following morning, the patient “felt back to baseline.” He reported no further anterograde memory problems but still had some memory loss from the previous day. The patient was able to recall some recent news items but failed to retrieve details. For example, he remembered seeing the Academy Awards show 4 days earlier but did not remember where he was at the time or who won the best actress award. Three months after discharge, there had been no recurrence of the episode and he was functioning normally at work. A repeat MRI scan and EEG were normal. A repeat LP showed no change in protein, and other laboratory tests were normal.

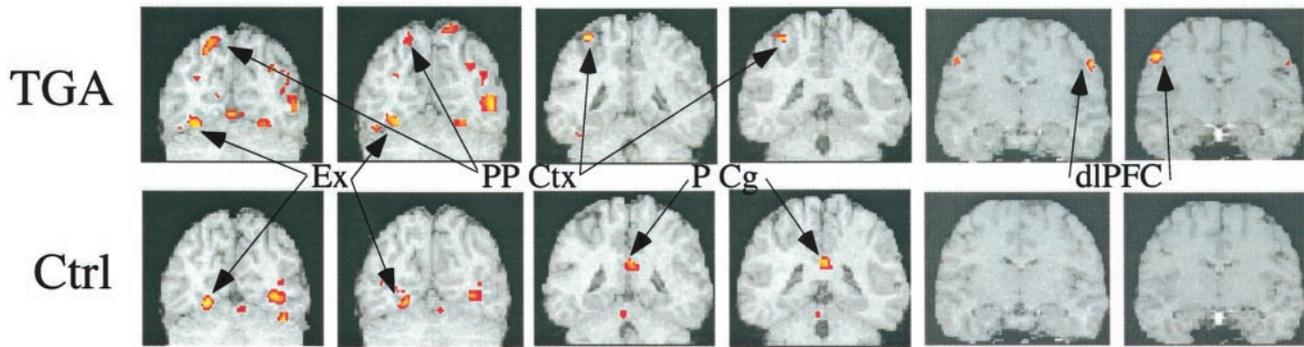
Experimental design. The patient participated in two identical fMRI sessions. The first session occurred 6 hours after TGA onset at a time when the patient was still symptomatic. The second session took place 7 months after his return to baseline. Each session lasted 40 minutes. Three age- and education-matched control subjects underwent a similar procedure. Subjects passively viewed complex visual scenes interleaved with a single repeated Gaussian-blurred scene in a blocked-design sequence. Seven pictures were presented in each block, and each run consisted of eight alternating blocks of novel picture-encoding and baseline visual stimulation. Stimuli were shown centrally for 3.5 seconds with an intervening 0.5-second fixation cross. Scenes were taken from the International Affective Picture System (Center for the Study of Emotion and Attention, University of Florida, Gainesville) and were chosen to be emotionally neutral. All pictures consisted of human figures in an environmental context. None of the scenes repeated within a testing session, but the same pictures were used across testing sessions. Stimulus order

was counterbalanced across subjects. Subjects were instructed to attend to each stimulus in anticipation of a subsequent memory test. All participants provided informed consent in accordance with the institutional review board guidelines at Northwestern University.

Imaging parameters and data analysis. Imaging was conducted on a 1.5 T Siemens Vision scanner (Munich/Erlangen, Germany). To minimize motion artifacts, subjects had their head immobilized with a vacuum pillow (Bionix, Toledo, OH). Single-shot echo planar fMRI scans were acquired in 32 contiguous transaxial slices parallel to the anterior commissure–posterior commissure line (repetition time [TR]/echo time [TE] = 4,350/40 ms, flip angle = 90°, field of view [FOV] = 220 mm, matrix = 64 × 64, slice thickness = 4 mm). Each functional run consisted of 112 scans lasting approximately 8.5 minutes. Anatomic images were acquired using a three-dimensional fast low-angle shot (FLASH) sequence (TR/TE = 15/6 ms, flip angle = 20°, FOV = 220 mm, matrix = 256 × 256, slice thickness = 1 mm). Two functional and one anatomic sequence were performed in each session.

fMRI data were analyzed using SPM96 (Wellcome Department of Cognitive Neurology, London, UK). Functional images were realigned to the image taken proximate to the anatomic study using affine transformation routines. The realigned scans were coregistered to the anatomic scan obtained within each session and normalized to SPM96 template image. The functional data were high pass filtered and smoothed with a 7-mm isotropic Gaussian kernel. Since this was a case study, a fixed-effects model was implemented to investigate within-subject changes in fMRI activity across testing sessions. A double-subtraction

Session 1 (Amnesia) vs. Session 2 (Recovery)



Session 2 (Recovery) vs. Session 1 (Amnesia)

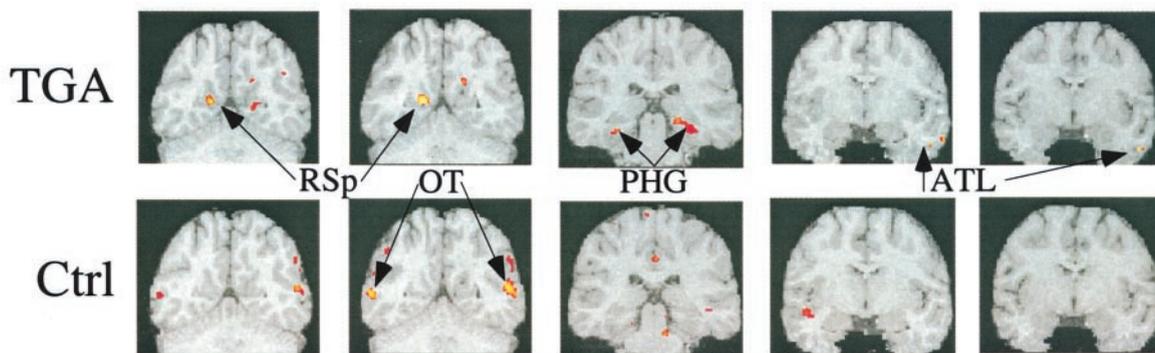


Figure. Functional MRI results in a patient with transient global amnesia (TGA) and control subjects (Ctrl). (Top) Brain regions with greater encoding-related activation in the first testing session (amnesic state) compared with the second testing session (recovery state). (Bottom) Brain regions with greater encoding-related activation in the second testing session (recovery state) relative to the first testing session (amnesic state). Ex = extrastriate cortex; PP Ctx = posterior parietal cortex; P Cg = posterior cingulate gyrus; dlPFC = dorsolateral prefrontal cortex; RSp = retrosplenial cortex; OT = occipitotemporal junction; PHG = parahippocampal gyrus; ATL = anterior temporal lobe.

procedure contrasted scene-encoding versus baseline stimulation during the first session (amnesic) minus the second session (recovery). The contrasts were masked by the main effect of encoding (mask threshold at $p < 0.05$) during the first session to rule out signal effects from deactivations in the second session.² The opposite contrasts were also computed (session 2 versus session 1). Analogous fixed-effects methods were applied to the control data to facilitate comparisons with the patient. We predicted greater temporolimbic activation in the patient following recovery, so responses in these regions were considered significant at $p < 0.01$ uncorrected. Activations in other areas were considered significant at $p < 0.05$ corrected for multiple comparisons. A cluster threshold of 3 voxels was used.

Results. During the amnesic state, the patient engaged posterior parietal cortex and precentral gyrus to a greater extent than following recovery. Following recovery, the patient showed greater encoding-related activity in four brain areas: retrosplenial cortex, parahippocampal gyrus, inferior temporal sulcus (near the temporal stem), and temporal pole. Each activation focus was observed across at least two consecutive coronal slices. None of these test-

retest patterns was evident in control subjects, either in the group average or in individuals, even at a more liberal threshold.

Both the patient and the control subjects had greater extrastriate cortex responses during the first session (amnesic state) than during the second session (recovery state). Control subjects showed additional activation in the posterior cingulate gyrus during the first testing session, which was not observed in the patient. Control subjects also had more activity in the occipitotemporal junction and premotor cortex during the second session relative to the first (table and figure).

Yes/no recognition memory for the scenes was tested immediately following scanning by showing each participant a sample of studied pictures intermixed with distracters from the same set. We did not have the opportunity to test the patient's memory for the scenes during the amnesic state. However, following recovery, he performed at ceiling (100% correct) on the recognition memory test, as did the control subjects in both sessions.

Discussion. To our knowledge, this is the first fMRI investigation of TGA. TGA was associated with

functional changes in a distributed temporolimbic circuit, including retrosplenial cortex, parahippocampal gyrus, and temporal stem/pole. These regions serve as important components of a long-term memory system in the human brain.^{3,4} Deficits in the posterior cingulate gyrus were inferred from the activation pattern in control subjects. Our results are broadly consistent with previous work showing baseline changes in blood flow and metabolism in temporolimbic regions during the acute phase of TGA.^{5,6} Variability in imaging results across cases partially relates to differences in the timing of scanning relative to TGA onset. Our initial findings were obtained between 6 and 7 hours after TGA onset at a time when the patient was still symptomatic. Since the patient was at the younger end of the age spectrum associated with TGA, the findings should be replicated in patients of a more representative age.

In contrast, TGA was associated with intact encoding-related responses in extrastriate cortex that habituated across testing sessions. Activity decrements over repeated presentations of stimuli provide neural correlates of priming,⁷ a form of implicit memory that can occur over months or years.⁸ Because these changes were specific to extrastriate regions, it is unlikely that they reflected general arousal factors. However, our design did not include a category of novel scenes in the second session, so the results provide only tentative support for a dissociation between implicit and explicit memory dysregulation in TGA.⁹

The patient showed more activation in frontoparietal regions during the acute phase of TGA than following recovery, a pattern not found in control subjects. This dorsal network has been implicated in

attentional and working memory functions.⁴ Activity in these regions would be ineffective for long-term retention without the benefit of contextual binding operations in the medial temporal lobe. Although we were unable to test the patient's memory for the scenes during the acute stage, he performed poorly on clinical bedside tests of explicit memory at the time the fMRI session was conducted. The dorsal stream activation may reflect a compensatory recruitment of short-term visuospatial encoding strategies during the acute phase of TGA.

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Ipsilateral thalamic MRI abnormality in an epilepsy patient

Abstract—In a 19-year-old patient with status epilepticus arising in the right parietal neocortex, unenhanced ictal MRI showed abnormalities mainly in the right cerebral cortex, contralateral cerebellum, and ipsilateral thalamus. The thalamus is considered a key site of functional abnormality in this patient.

NEUROLOGY 2002;58:641-644

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Transient or reversible focal cortical abnormalities have been detected in patients with status epilepticus or focal seizure disorders by CT, MRI, SPECT,

and PET. Few reports have noted crossed cerebellar diaschisis (CCD) indicated by MRI performed during epileptic seizures,¹ and none have noted thalamic MRI abnormality related to status epilepticus.

Case report. A 19-year-old right-handed woman with no past history of seizures episodically noted unusual feelings in the fingers of the left hand. On day 5 after onset, she manifested a partial seizure involving the left limbs, followed by generalization of the seizure. She was admitted to a community hospital and was found to have dys-

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