Effect of hypnosis on motor function and cortical activation in chronic stroke patients

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Introduction

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Cerebral vascular accident, commonly known as stroke, is the leading cause of permanent disability and the third leading cause of death in the United States according to the National Stroke Association. A complementary approach to enhancing the recovery of motor function may be through the use of motor imagery [1, 2], which activates much of the same neural circuitry as actual motor function.

In the present study, we hypothesized that hypnosis-aided motor imagery would improve motor function of the paretic upper limb in chronic stroke patients. This hypothesis arose from several case reports that describe hypnosis applied to stroke recovery as resulting in improvements in paretic limb function [3, 4, 5], strength and range of motion [6]. We examined the short- and long-term effects of hypnosis on motor task performance in stroke patients. Further, we investigated whether hypnosis-related changes in motor function were associated with changes in motor task-related brain activity using fMRI.

Methods

Study participants

- Six patients with a single stroke that resulted in upper limb paresis
- The stroke at least six months prior

Patient Number	Age	Gender	Side of Hemi-paresis	Months Post Stroke	UE-FM (score)	HIP (score)
1	51	Male	Left	26	43	10
2	45	Male	Left	34	17	12
3	63	Female	Left	39	4	7
4	39	Male	Right	6	21	7
5	47	Male	Right	30	57	12
6	52	Female	Left	79	6	11
mean ± SD	50 ± 2			36 ± 24	25 ± 21	10 ± 2

Table 1. Patient characteristics.

UE-FM = Upper extremity motor component of the Fugl-Meyer Stroke scale (score 0-66, 66 = normal).

HIP = Hypnotic Induction Profile (induction score 0-12, 12 = maximum)

Experimental design

Repeated measures protocol

Three phases:

1. Baseline: each patient learned and practiced a hand-grip force-following task (Figures 1 and 2).
2. Hypnotic intervention: each patient performed the specified motor task before and after the hypnotic procedure
3. Follow-up: track changes in motor task performance for 2 to 4 weeks post-intervention

fMRI protocol

Two fMRI sessions were conducted for each patient:

1. Baseline scan
2. Hypnosis intervention session with scans during motor functioning pre- and post-hypnosis

Table 2: Testing schedule for motor performance and fMRI

	Baseline				Intervention				Follow Up			
Experimental Session	1	2	3	4	5	6	7	8	9	10	11	12
Motor Performance Testing	○	○	○	○	○	○	○	○	○	○	○	○
Functional Brain Imaging			•				•					

Some specifics

- Siemens Allegra 3.0 Tesla scanner with quadrature head coil
- Functional images: T2*-weighted gradient, blood oxygen level-dependent (BOLD), 22 slices, parallel to anterior and posterior commisures, 3.1 x 3.1 mm^2 voxels, 200 acquisitions per scan.
- Structural images: T2-weighted gradient-echo, same slice specification

Figure 1. Computer interface for the force following task. Patients control the diameter of the blue circle by applying force to the hand grip. The task is for the patient to track the diameter changes of the red circle.

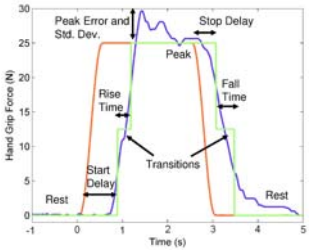

Figure 2. Classifying a patient's response to the force following task and defining performance measures.

Motor performance analysis

- The first two runs of the first experimental session were discarded as training sets
- Grip force time-series were analyzed with a state-classification algorithm (Figure 2

fMRI analysis

- Image analysis was performed with MATLAB (The Mathworks, Inc.)
- The hemodynamic impulse response function was modeled with a gamma function and fit with a linear model

Hypnosis Intervention

- Induction techniques: Eye fixation, progressive physical relaxation, or mental imagery
- Three stage process of hypnotic suggestions:

1. Imagined practice of a motor task revivified from prior to the stroke alternated with imagined practice in the present
2. Imagined practice in the present alternated with imagined practice during active-alert hypnosis
3. Active-alert imagined practice alternated with actual physical performance

Results

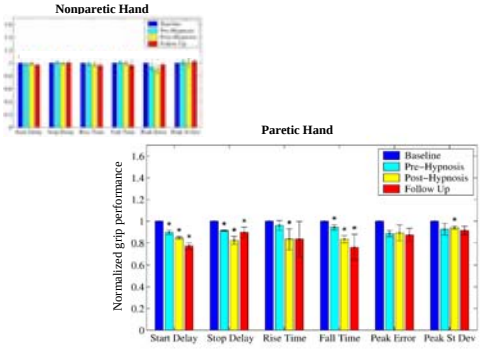

Figure 3. Mean normalized performance measures for the nonparetic and paretic hands. Significant differences relative to the normalized baseline are marked with a star (paired t tests, $p < 0.05$).

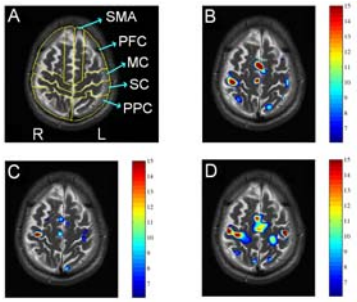

Figure 4. This example of fMRI results is from Patient 2 performing the force following task with his paretic (left) hand. Example segmented slice defining potential regions of interest (A), paretic hand activation for baseline (B), pre-hypnosis (C), and post-hypnosis (D).

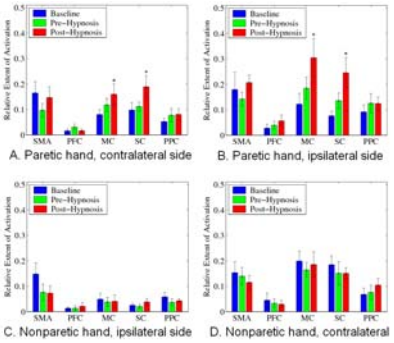

Figure 5. Relative activated brain volume. Differences with respect to baseline indicated with a star (paired t tests, $p < 0.05$).

Additional observations: Motor function testing

- Trial to trial improvement in performance of the task plateaued within the first full run of the two discarded trials on each hand.
- Deficits in motor function were qualitatively apparent in motor performance of the paretic hand versus the nonparetic hand in all patients.

Observations: fMRI images

- Right hemisphere motor and sensory activation appears similar between the baseline (B) and pre-hypnosis (C) conditions.
- The activation map appears different post-hypnosis (D) with increased extent relative to pre-hypnosis (C)
- New left hemisphere activation is apparent post-hypnosis in MC and SC.

Observations: Region of interest (ROI) analysis

- Greater activation extent observed in supplementary (SMA), motor (MC) and somatosensory (SC) cortices
- Increased extent found in the MC and SC in both hemispheres during motor task performance by the paretic hand post vs baseline; not observed with nonparetic hand

Discussion

Principle finding

- The hypnosis intervention was found to improve the motor performance of chronic stroke patients who were not otherwise expected to make spontaneous improvements.

Findings from motor function testing

- Hypnosis appears to result in faster reaction time and faster grip contraction and release rates.
- Motor performance during 2 to 3 week follow up testing was not significantly different from post-hypnosis results.

Two characteristics of hypnosis that may be involved in the response of the patients to the intervention are enhanced attention and generalized relaxation. The observed effects of hypnosis on reaction time may also be attributable to increased attention on the motor task. It is also possible that the relaxation elicited by hypnosis altered the muscle tone of the stroke patients resulting in increased the muscle contraction and relaxation rates for the paretic limb.

Findings from fMRI

- The fMRI data for paretic hand movement show increased activation extent in bilateral sensorimotor cortex
- There appears to be a lateralization shift in the fMRI activation toward ipsilateral involvement.

The observed increases in activation extent and laterality changes suggest that plasticity changes in the motor control system may have occurred in these stroke patients as a result of the hypnosis intervention. Recovery evidence suggests that ipsilateral motor activation contributes to motor recovery by compensating for damaged contralateral motor cortex in poorly recovered stroke patients.

Limitations

While providing a basis for further examination of hypnosis for stroke recovery, the present study leaves many questions unanswered.

- What if the hypnosis intervention occurred sooner after the stroke event?
- What mechanisms mediate the observed effects?
- What is the right balance of imagined and physical motor task practice?
- To what extent do the effects depend on the skill of the hypnotist and hypnotizability of the patient?

Conclusions

- Hypnosis appears to alter central nervous system function in ways that relate positively to motor function in chronic stroke patients.
- Untapped potential for motor performance gains may be accessed through hypnosis.
- Many questions remain about the limits of recovery with hypnosis and whether the mechanism is a generalized effect of hypnosis or if more complex cognitive processes provide the impetus.

References

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