

UNIVERSITY OF ARKANSAS FOR MEDICAL SCIENCES

# Magnitude Estimation Performance Predicts Right Hemisphere Lesions in Stroke Patients

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# Introduction

The power law function, established by Stevens (1975), quantifies the relationship between perception and an objective measure of a stimulus. The perception of the intensity of sensory stimulation is a power function (a log-log plot) of the physical stimulus intensity. After transformation into a linear function, three variables are obtained from the power function and are used to describe the pattern of this function: the exponent (slope), the constant (y-intercept), and the r-squared value (measure of linear fit).

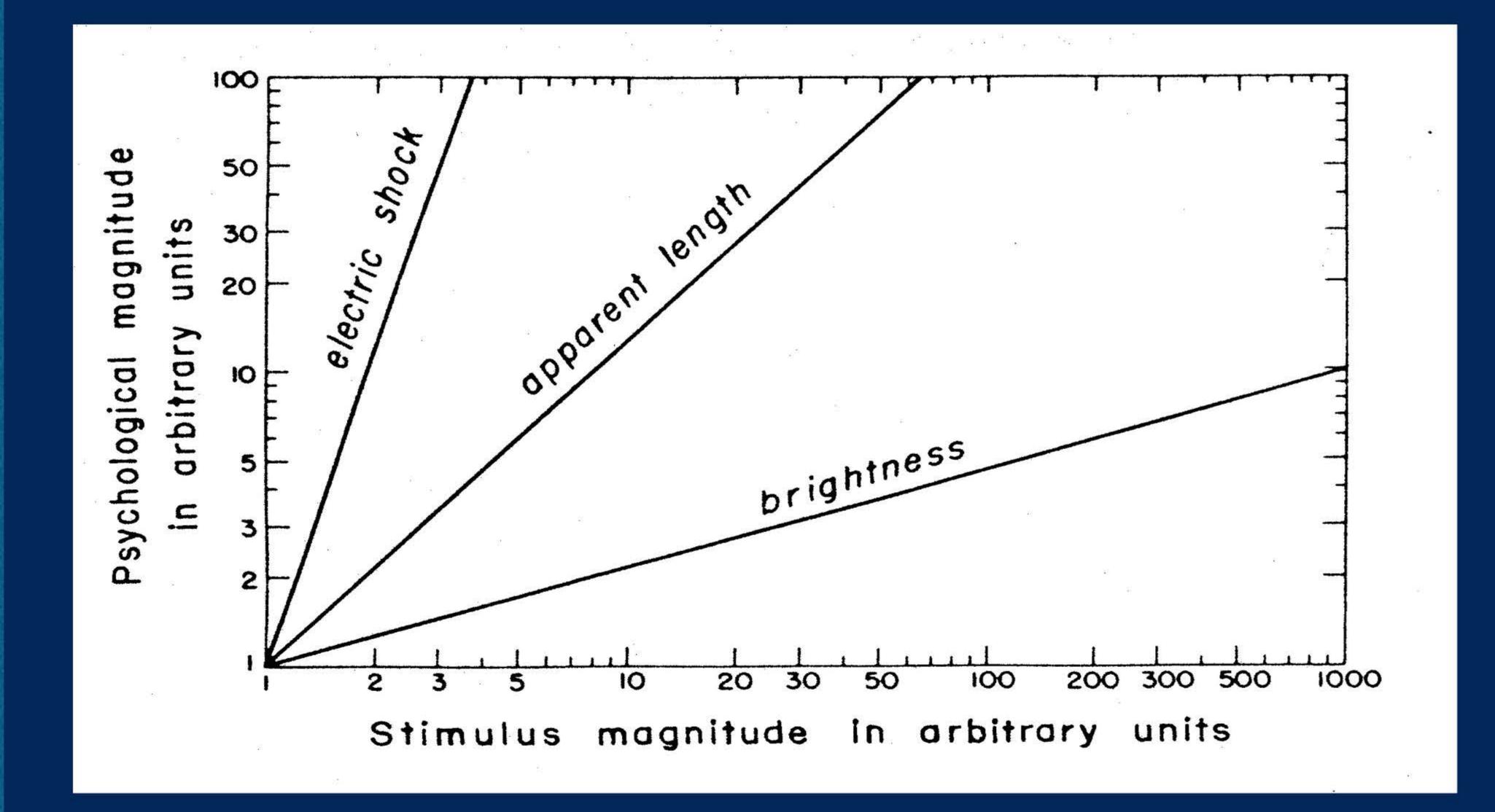


Figure 1. Adapted from Stevents (1957). The power law function of painful stimuli, like electric shock, exhibits response expansion; a phenomenon in which participants overestimate the intensity of the pain they experience. Inversly, response compression occurs when a participant underestimates the intensity of a stimulus (e.g. brightness).

Studies conducted by Stevens and others have demonstrated that power functions characterize sensory stimulation in virtually every sensory modality. There have been no systematic studies investigating a variety of perceptual stimuli in patients with right and left hemisphere lesions (RHL; LHL). Therefore, in the present study we investigate the altered power functions in RHL patients with (+) and without neglect (-) as well as LHL patients across six sensory domains with a total of twelve perceptual stimuli. We hypothesis that altered power functions are not specific to neglect but are characteristic of RHL patients in general.

# Methods

### Participant Demographics

Variable	NC (N = 39)	RHL+(N=9)	RHL-(N=13)	LHL(N=12)	Statistic	
Gender Female Male	23 (59.0%) 16 (41.0%)	3 (33.3%) 6 (66.7%)	8 (61.5%) 5 (38.5%)	5 (41.7%) 7 (58.3%)	$\chi 2 = 2.95$ $df = 3$	
Race Caucasian African American Other	32 (82.1%) 6 (15.4%) 1 (2.6%)	6 (66.7%) 3 (33.3%)	8 (61.5%) 5 (38.5%)	5 (41.7%) 7 (58.3%)	$\chi 2 = 9.77$ $df = 6$	
Handedness Right Left	35 (89.7%) 4 (10.3%)	8 (88.9%) 1 (11.1%)	13 (100%)	10 (83.3 %) 2 (16.7%)	$\chi 2 = 2.12$ df = 3	
Age (years)	58.62 (15.82)	59.33 (17.54)	57.08 (11.91)	61.08 (16.00)	F(3,69) = .11	
Education (years) (Missing N)	14.97 (3.03) 0	12.88 (2.03) 1	14.62 (4.07) 0	13.50(2.07)	F(3,68) = 1.29	
Months Post Stroke (Missing N)	N/A	9.25 (16.81) <sub>RHL-,LHL</sub>	81.67 (82.49) 1	53.92 (52.81) 0	F(2,28) = 5.92**	
NIHSS (Missing N)	.08 (.27) <sub>RHL+, RHL-, LHL</sub>	13.00 (5.29) 4	4.83 (2.86) 1	6.82 (3.89) 1	F(3,63) = 175.08 ***	

Data = mean (standard deviation) or Observed Count (Percentage observed); NC = normal controls;

RHL+ = right hemisphere lesion patients with neglect; RHL- = right hemisphere lesion patient without neglect;

LHL = left hemisphere lesion patients; NIHSS = National Institute of Health Stroke Scale;

\* p < .05, \*\* p < .01, \*\*\*p < .001 or less.

Post-hoc comparisons where p < .05 are flagged by subscripts (Games-Howell for unequal variances). Subscript NC, RHL+, RHL-, or LHL = given mean is significantly different than NC, RHL+, RHL-, or LHL. All F values reflect log transformed data.

### Procedures

Demographic, cognitive, medical, and linguistic data were collected on each participant whenever possible. RHL patients with a total BIT (Behavioral Inattention Test) score lower than 129 or who failed one or more BIT subtests (as identified by the BIT manual) were operationally defined as neglect patients.

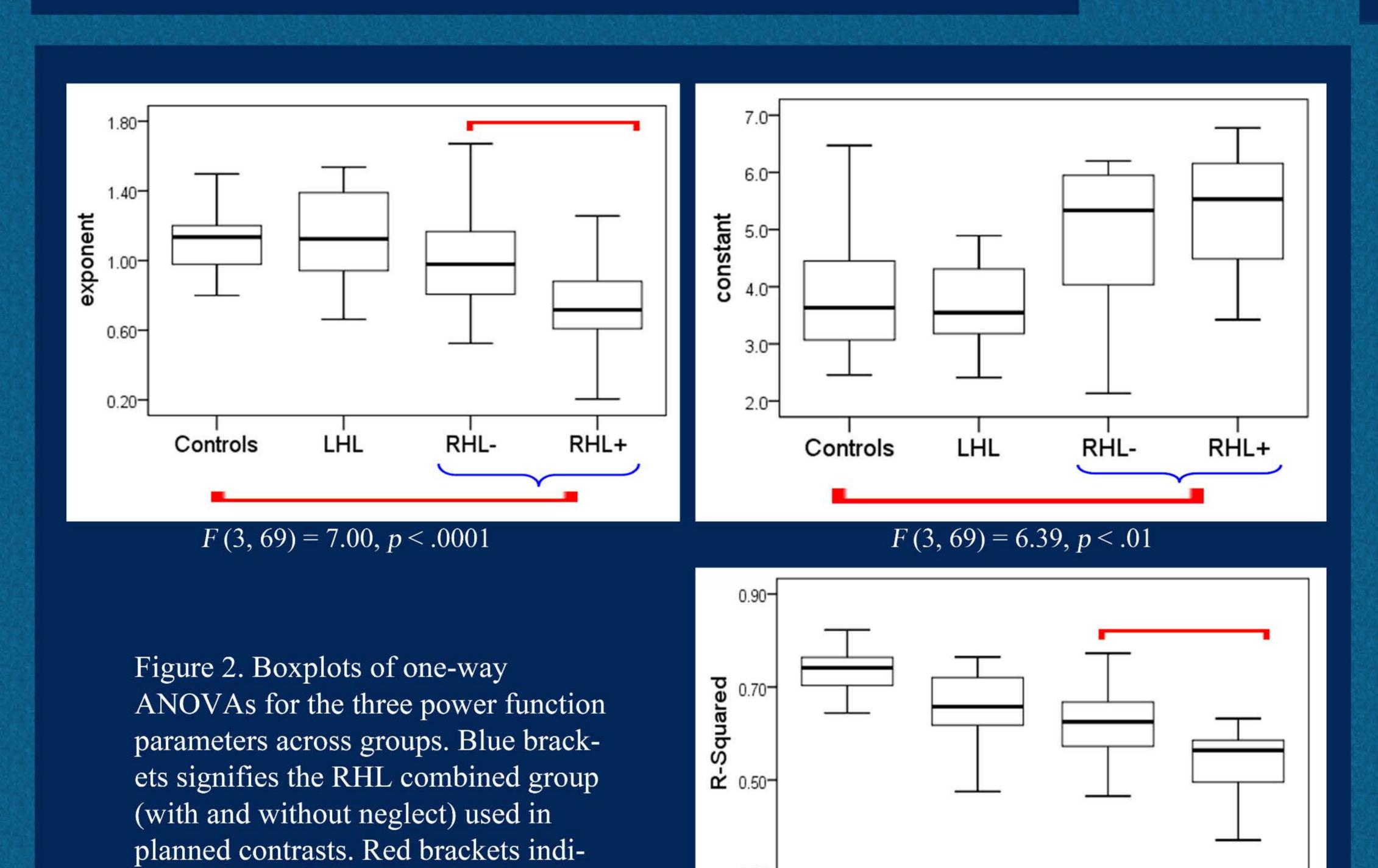
Sensory Domain Perceptual Continua		Description	Ranges of Stimulus Magnitudes			
Visual	Line length	Line lengths on a 94 X 555 cm sheet of paper	10, 32, 60, 115, 170, 280, 390, 500 cm			
	Area	Squares on a 240 X 240 cm sheet of paper	100; 299; 605; 1,537; 2,894; 6,889; 12,589; 20,000			
	Numerosity	Dots arranged about a 265 X 330 cm sheet of paper	6, 10, 15, 22, 36, 50, 71, 90 dots			
	Reflectance	Chips of light reflectance material 75 X 125 cm	84.2, 63.6, 46.8, 33, 22.19, 13.7, 7.7, 3.8% light reflectance			
Tacti le	Pressure (R & L)	Pressure cuff applied to forearm	20, 37, 54, 71, 88, 105, 122, 139 mm Hg			
	Von Frei (R & L)	Monofilaments applied to forefinger	0.6, 2, 6, 10, 26, 60, 100, 180 grams of force			
	Roughness (R & L)	Textures of sand paper applied to fingertips	300; 700; 1,100; 1,280; 1,350; 1,400; 1,440; 1,476			
Proprio- ceptive	Finger span (R & L)	Wooden spacers between thumb and fore finger	4, 8, 14, 24, 34, 44, 54, 63 cm			
Therm al	Temperature (R & L)	Heated disk (3.2 X 3.2 cm) presented to forearm	36, 38, 40, 42, 44, 46, 48, 50 degrees F			
Audi tory	Loudness (R & L)	Tones presented to one ear at 1000 Hz	35, 42, 49, 56, 63, 70, 77, 84 dB			
Gustatory	Sweetness	Sugar concentrations diluted in water	0.15, 0.30, 0.60, 0.70, 0.80, 0.90, 1.05, 1.20 M			
	Saltiness	Salt concentrations diluted in water	0.19, 0.25, 0.32, 0.46, 0.60, 0.74, 0.87, 1.00 M			

Description of twelve perceptual stimuli spanning six sensory domains. Participants were presented with a stimuli and were asked to rate the intensity or magnitud-e of that stimulus on a scale from 0-99 given no comparison anchor by the experimenter.

# Results

#### Behavioral Data

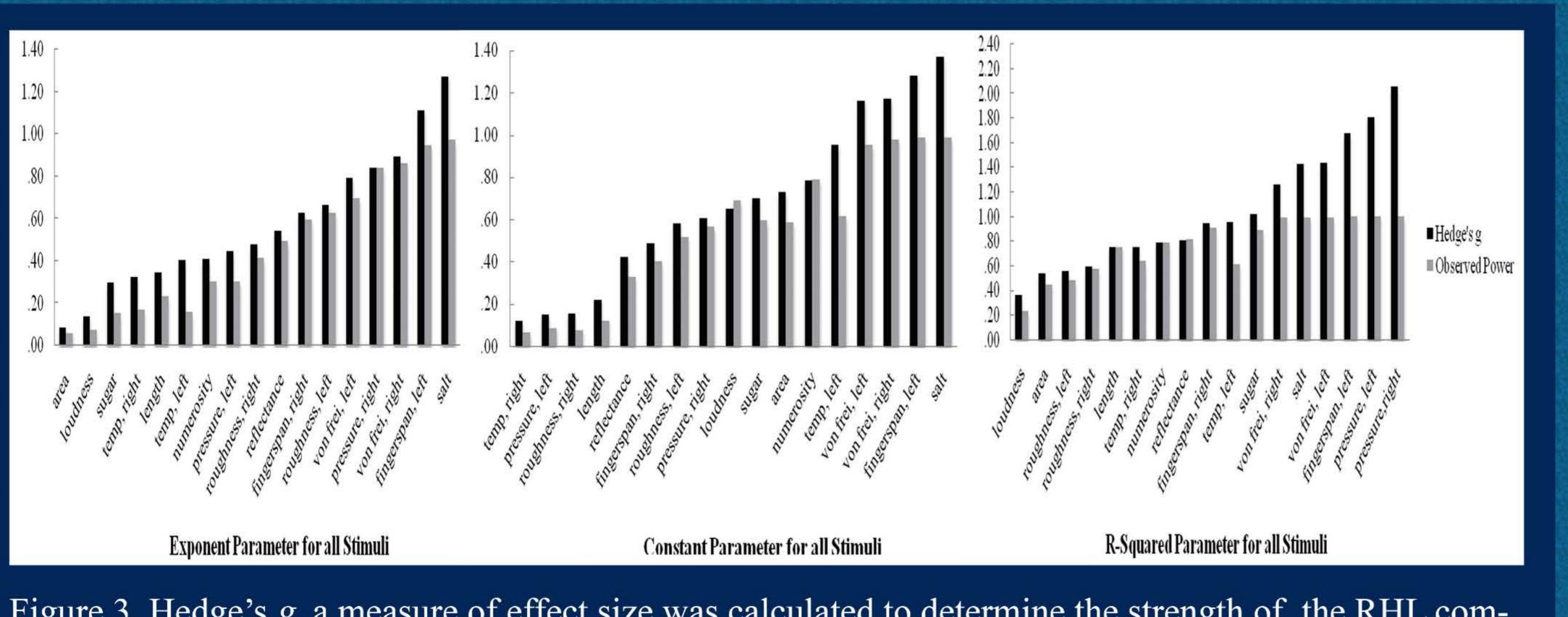
#### One-way ANOVAs across Participant Groups



#### Effect Size and Power Analysis

cates significant planned contrasts

where p < .05



F(3, 69) = 22.10, p < .0001

Figure 3. Hedge's *g*, a measure of effect size was calculated to determine the strength of the RHL combined group vs. normal controls effect for each parameter across all stimuli. Graphed here are effect size values as well as corresponding observed power values.

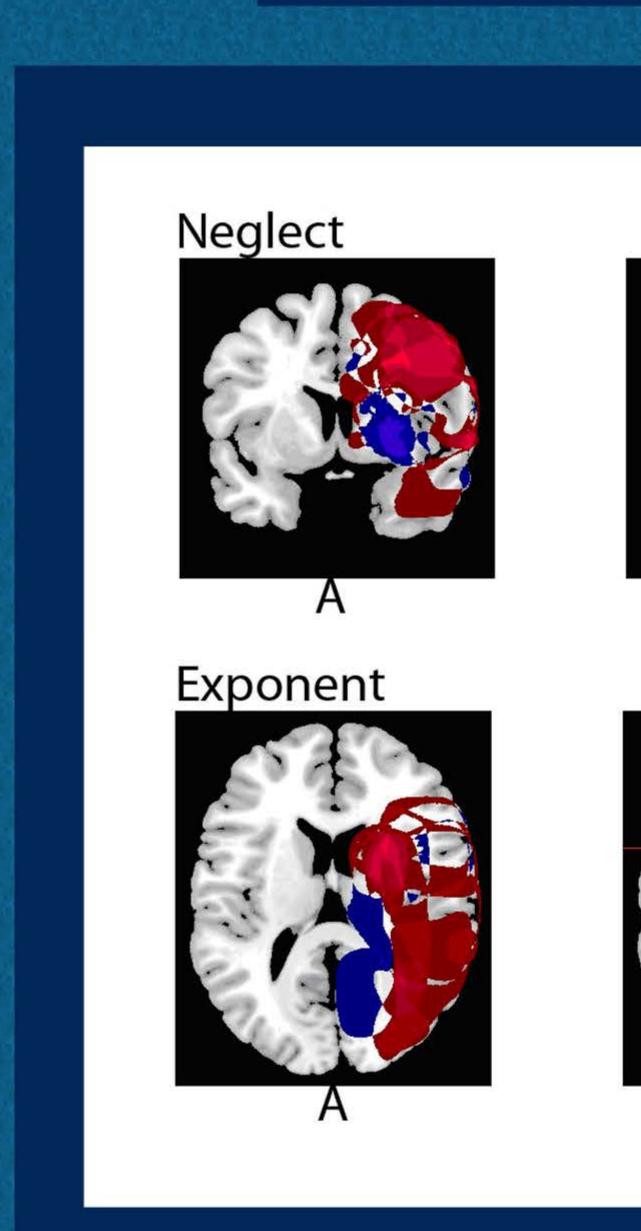
#### Binary Logistic Regresion Analysis

Variable	Variable Description
R or C	Identity of the participant as a RHL patient or a control (dichotomous variable). Dependent variable.
R2averg	Averaged r-squared values across all 12 perceptual stimuli (continuous variable). Predictor Variable.
expaverg	Averaged exponent values across all 12 perceptual stimuli (continuous variable). Predictor Variable
conaverg	Averaged constant values across all 12 perceptual stimuli (continuous variable). Predictor Variable.

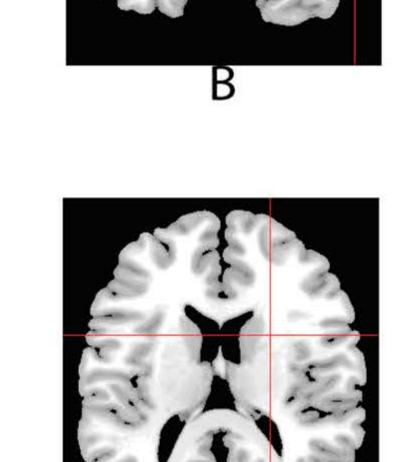
### Binary Logistic Regresion Analysis

	Model 1		Model 2		Model 3		Model 4	
Variable	Coefficient	t-stat	Coefficient	t-stat	Coeffici ent	t-stat	Coefficient	t-stat
Constant	19.64*	14.87	19.64*	14.82	15.58*	7.55	16.33*	8.63
R2 averg	-30.11*	15.76	-29.80*	13.69	-29.71*	11.87	-27.93*	12.12
expaverg		-	20	.013	1.37	.426	_	_
conaverg		_		_	.549	2.03	.43	2.06
Model Chi-Square [df]	41.44[1]*		41.45[2]*		44.47[3]*		44.03[2]*	
Block Chi -Square [df]	41.44[1]*		41.45[2]*		44.47[3]*		44.03[2]*	
% Correct Predictions	88.5		88.5		88.5		90.2	
Cox & Snell-R <sup>2</sup>	.49		.49		.52		.51	
Hosmer & Lemeshow								
Chi-square [df]	8.11[8]		7.20[8]		4.85[8]		10.02[8]	
* p < .05								

### MRI Subtration Analysis



the internal capsule.



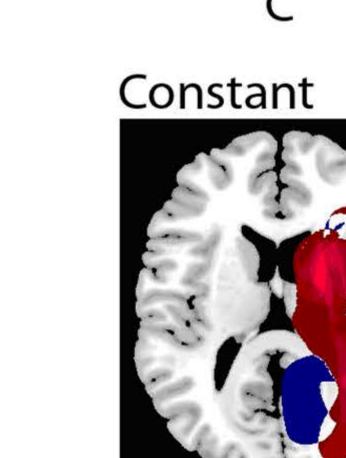




Figure 4. The top line of pictures (Neglect) shows subtraction of RHL- from RHL+ scans. Brighter red areas indicate lesions common to RHL+ but not RHL-. Brighter blue indicates the opposite. Figure A shows brighter red areas - one involving white matter beneath BA (Brodmann's Area) 6, 4 and 3 and another involving BA 38/21 in the anterior temporal lobe, and one area of brighter blue centered on the putamen. The bottom line of pictures labeled 'exponent' shows subtraction of RHL patients with normal or high exponents from those with decreased exponents. The bottom line of pictures labeled 'constant' show subtraction of RHL patients with normal or low constants from those with high constants. Figure A under exponent shows a brighter red area centered on the anterior limb of the internal capsule. Figure A under constant shows a brighter red area centered on the anterior limb and genu of

## Conclusions

- All RHL patients are characterized by underestimation of larger stimuli and increased variability (increased constant and decreased r-squared parameter).
- RHL+ patients are characterized by overestimation of smaller stimuli and increased variability (decreased exponent and decreased r-squared parameter).
- Gustatory, proprioceptive, and tactile stimuli are better at distinguishing RHL patients from controls for magnitude estimation tasks.
- RHL patients with increased constants share the anterior limb and genu of internal capsule as a lesion site
- RHL patients with decreased exponents share the anterior limb of the internal capsule as a lesion site.

#### References

Stevens, S.S & Galanter, E. H. (1957). Ratio scales and category scales for a dozen perceptual continua. Journal of Experimental Psycholog Stevens, S.S. (1957) Psychophysics: introduction to its perceptual, neural, and social prospects. New York; John Wiley & Sons.