Introduction

This paper describes and evaluates a tool for remediating metaphor comprehension deficit often associated with right hemisphere brain damage (RHD) due to stroke and traumatic brain injury (TBI) (Kempler, 2005; Myers, 1999; Tompkins, 1995; McDonald, 1993, 1999). The intervention is based on two theoretical components: first, the ability to process "coarse grained" semantic information such as connotative associations between words (Beeman, 1998); second, working memory used to select alternatives from a set (e.g., Tompkins et al., 1994). The training format, inspired by Thinking Maps® (Hyerle, Innovative Learning Group, 1995), provides graphic displays of the associations that underlie metaphors. We have previously reported success with patients with RHD due to stroke. One question addressed in this paper is whether patients with TBI also respond to training.

Metaphor interpretation involves associations to concepts from different semantic domains (e.g., job: profession, fulfilling, frustrating, confining, etc., and prison: confining, bad, for criminals, etc.). A listener identifies which associations shared by the two words could provide a basis for metaphor: "Some jobs are prisons" could mean that some jobs are confining.

We used a single subject experimental design consisting of baseline, training, and post-training phases for metaphor interpretation and also for an untrained line orientation task (Short Forms of Benton Judgment of Line Orientation Test, Qualls et al., 2000). We also obtained measures of working memory span (Span Test; Tompkins et al., 1994) and non literal language comprehension (Familiar and Novel Language Comprehension Test, Kempler & Van Lancker Sidits, 1996). Our prediction was that initiation of training would be associated with change in metaphor interpretation but not with change in Benton performance.

Method

Patients. Data for 7 patients with TBI are reported (See Table 1).

Baseline Assessments: 10 or 20 sessions.

Rationale: To assess the patient's pre training performance level on the target of training and on the untrained task that is not expected to change.
Metaphor Task: The patient provides oral interpretations of 10 novel metaphors such as "Father is an ATM." Items were constructed using word association norms.
Scoring: 0 (no response) to 6 (complete and appropriate).
Line Orientation Task: a short form of the Benton Test.

Task I: Judgments of Single Word Connotative Meaning

Rationale: To illustrate and practice thinking about connotative meaning.

Task: The patient is familiarized with the computer display and answers yes/no questions about 10 words. For example, "Think of the word 'father'. Is this word typically considered 'beautiful' …. 'strong' …. 'active' …. 'passive'?"
Scoring: An item is "correct" if the patient responds promptly (< 5 seconds).
Criterion: Completion of 5 sets of 10 words each.

<u>Task II: Judgments of Word Associations</u>
Rationale: To illustrate and practice judging typical associations.
Task: The patient sees a target word and 5 possible associations and responds whether each association is appropriate or not. For example: "Is 'muffin' typically associated with 'moon'?" (Figure 1.)
Scoring: 1 point for correct, prompt (< 5 sec) responses (.5 points if delayed).
Criterion for this and later tasks: 90% x 3 sets or completion of 5 sets of 10 words each.

<u>Task III: Generation of Word Associations</u>
Rationale: To practice generating 5 associations to a target.
Task: Patient must generate 5 associations to fill empty bubbles linked to a target word (central bubble).

If the patient is unable to generate associations or if he or she generates personalized associations, the examiner provides cues and redirects as needed by returning to the set of 10 questions listed under Task I.

Scoring: 1 point for each correct, prompt association excluding personalized responses (.5 point if delayed).

<u>Task IV: Judgment of Patient-Generated Associations to Link 2 Words</u>
Rationale: To practice generating associations and evaluating appropriateness of associations between 2 words.
Task: A) The patient generates 5 accurate associations to Word 1. B) The patient is shown Word 2 and C) is asked whether the associations for Word 1 can also be associated to Word 2. Ideally, some will and others will not. If no associations overlap, the patient is cued to generate additional associations. (Figure 2.)
Scoring: 1 point for generating 2 common associations, .5 point for a single association.

<u>Task V: Selection of Appropriate Metaphor Ground from Candidate Dual Associations</u>
Rationale: To practice selecting the basis for a metaphor from a set of candidates.
Task: The patient views a metaphor within a double bubble map and selects the appropriate interpretation from 3 choices (correct, literal, close substitution using another metaphor). For "The child is a weed", the alternatives are
A) The child plays outside in the backyard.

B) The child is a pesky plant that grows in a garden.

C) The child grows very quickly.

Scoring: 1 point for each correct, prompt response (.5 point if delayed).

Results and Discussion.

Patients had little trouble with the first two tasks. Some patients had much more difficulty on Tasks III and IV that call on skills such as word generation and word comparisons, which are often impaired following brain-damage.

We use two approaches to assessing the selective effect of training on metaphor interpretation.

The first approach used regression. A patient's score (metaphor interpretation, Benton) for each session was the dependent variable. Predictor variables included (X1) session number (two sessions per week) to code gradual improvement over time starting during the baseline phase and continuing through the training phase, and (X2) a dummy-coded variable to distinguish baseline sessions from all later sessions starting with initiation of training. A significant regression weight for X2 indicates a change linked to training that is distinct from any steady improvement over sessions.

We also use a bootstrapping or simulation procedure (Borckardt et al., 2008). The software computes the autocorrelation (lag 1, i.e., the degree of non independence) for the entire set of observations and, then, under the null hypothesis of no effect of training, draws (from a normal population) a very large number (e.g., 10,000) of random samples of pre and post-treatment data with the identified level of autocorrelation. The obtained effect of training is indexed by Pearson’s r calculated using pre versus post initiation of training as the X variable and Metaphor (or Benton) performance as the Y variable. The software provides probabilities for different sizes of training effects under the null hypothesis.

Results, shown in Table 2, demonstrate that many patients with TBI who are years post injury can tolerate and benefit from cognitive-linguistic training. Two patients (M11, M18) who responded best to the training according to the regression analysis also yielded significant results by bootstrapping analysis. Another 3 patients (M5, M13, and M14) showed reliable effects of training by bootstrapping test, but not according to the multiple regression analyses.

One severely impaired patient (M19) showed no significant effect of training on metaphor and also showed a significant decline over sessions on Benton scores. She reported disliking the Benton task and over sessions appeared to lose focus whenever asked to complete the Benton test.

The remaining patient, M20, showed only weak effects of training on metaphor interpretation and no effects on Benton performance.

The discussion will examine individual patient results and discuss the role of initial level of severity, working memory, fading of training gains, and generalization of training effects to other measures of communication.

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Table 1: Patient Information and working memory and non literal language performance

Patient	Age	Gender	Years of Education	Initial GCS	Time post onset (years)	Cognitive and Communication Features +++++ Tompkins et al.1994 SPAN (max = 42) NC mean = 35.6 (6.4x) Brain damaged mean = 29.6 (12.4x) Kempler & Van Lancker Sidtis, 1996 FANL-C Nonliteral Items (Max = 20, Brain damaged m =10.2)
S-5	44	F	13	Not available	7 years	SPAN pre test: 38 SPAN post test: 38 FANL-C pre test 20 FANL-C post test 20
S-11	31	M	12	3	10 years	SPAN pre test: 28 SPAN post test: 37 FANL-C pre test:17 FANL-C post test: 19
S-13	35	M	12	5-6	2 years	SPAN pre test: 28 SPAN post test: 26 FANL-C pre test: 18 FANL-C post test: 20
S-14	54	F	13	4-5	20 years	SPAN pre test: 34 SPAN post test: 35 FANL-C pre test:18 FANL-C post test: 20
S-18	48	F	16	Not available	14 years	SPAN pre test: 30 SPAN post test: 38 FANL-C pre test:14 FANL-C post test:18
S-19	39	M	12	3	5 years	SPAN pre test: 20 SPAN post test: 29 FANL-C pre test:17 FANL-C post test: 18
S-20	50	F	12	2T	7 years	SPAN pre test: 27 SPAN post test: 37 FANL-C pre test: 16 FANL-C post test: 17

Table 2: Regression and Bootstrapping/Simulation Results

S5

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 25	N = 25
Baseline mean:	33.7	13.9
Post Initiation of training mean:	38.7	14.2
Std. error of est.	4.176	.907
3 month follow up:	N/A	N/A
Simple r for training:	.513, p = .036 (bootstrapping)	.151, p=.530 (bootstrapping)
Simple r for Session:	.577	.375
Regression:	R^2 = .335, F (2,22) = 5.545, p = .011	R^2 = .242, F (2,22) = 3.504, p = .048
Session:	β = .507, t (22) = 1.541, p = .138	β = +.886, t (22) = 2.520, p = .019
Training:	β = +.083, t (22) = .251, p = .804	β = -.602, t (22) = -1.712, p = .101
Increase in R^2 due to training:	.003	.000
Autocorrelation of residuals:	-.030	-.096

S11

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 26	N = 25
Baseline mean:	27.9	14.2
Post Initiation of training mean:	35.25	15.125
3 month follow up:	N/A	N/A
Simple r for training:	.572, p = .0075 (bootstrapping)	-.085, p=.655 (bootstrapping)
Simple r for Session:	.376	-.066
Regression:	R^2 = .367, F (2,23) = 6.664, p = .005	R^2 = .007, F (2,22) = .082, p = .922
Session:	β = -.368, t (23) = -1.192, p = .245	β = +.019, t (22) = .049, p = .961
Training:	β = +.883, t (23) = +2.860, p = .009	β = -.102, t (22) = -0.259, p = .798
Increase in R^2 due to training:	.353	.000
Autocorrelation of residuals:	-.286	.106

S13

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 26	N = 26
Baseline mean:	32.0	12.5
Post Initiation of training mean:	37.0	12.3
Std. error of est.	4.201	1.442
3 month follow up:	N/A	N/A
Simple r for training:	.524, p = .0124 (bootstrapping)	-.067, p=.683 (bootstrapping)
Simple r for Session:	.448	-.003
Regression:	R^2 = .275, F (2,23) = 4.360, p = .025	R^2 = .007, F (2,23) = .080, p = .923
Session:	β = .019, t (23) = .058, p = .954	β = -.091, t (23) = -.236, p = .815
Training:	β = +.508, t (23) = +1.508, p = .138	β = .010, t (23) = .026, p = .980
Increase in R^2 due to training:	.074	.007
Autocorrelation of residuals:	-.196	-.153

S14

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 23	N = 22
Baseline mean:	35.7	9.7
Post Initiation of training mean:	40.8	9.4
Std. error of est.	3.396	1.188
3 month follow up:	N/A	N/A
Simple r for training:	.607, p = .010 (bootstrapping)	-.124, p=.706 (bootstrapping)
Simple r for Session:	.631	-.157
Regression:	R^2 = .414, F (2,20) = 7.066, p = .005	R^2 = .025, F (2,19) = .245, p = .785
Session:	β= .415, t (20) = 1.240, p = .229	β = -.195, t (19) = -.437, p = .667
Training:	β = +.251, t (20) = .748, p = .463	β = .044, t (19) = .098, p = .923
Increase in R^2 due to training:	.016	.000
Autocorrelation of residuals:	-.269	???

S18

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 23	N = 23
Baseline mean:	23.1	8.8
Post Initiation of training mean:	34.1	9.4
3 month follow up:	N/A	14
Simple r for training:	.822, p = .0068 (bootstrapping)	.292, p=.256 (bootstrapping)
Simple r for Session:	.618	.185
Regression:	R^2 = .705, F (2,20) = 23.907, p = .000	R^2 = .102, F (2,20) = 1.138, p = .340
Session:	β = -.339, t (20) = -1.427, p = .169	β = -.253, t (20) = -.610, p = .549
Training:	β = +1.113, t (20) = +4.685, p = .000	β = .510, t (20) = 1.230, p = .233
Increase in R^2 due to training:	.323	.068
Autocorrelation of residuals:	-.194	.095

S19

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 29	N = 29
Baseline mean:	28.9	6.4
Post Initiation of training mean:	32.4	3.7
Std. error of est.	5.316	2.885
3 month follow up:	N/A	N/A
Simple r for training:	.309, p = .114 (bootstrapping)	-.358, p=.219 (bootstrapping)
Simple r for Session:	.324	-.592
Regression:	R^2 = .111, F (2,26) = 1.617, p = .218	R^2 = .403, F (2,26) = 8.777, p = .001
Session:	β = .217, t (26) = .666, p = .511	β = -.925, t (26) = -3.460, p = .002
Training:	β = .130, t (26) = .398, p = .694	β = .404, t (26) = 1.511, p = .143
Increase in R^2 due to training:	.006	.053
Autocorrelation of residuals:	-.004	.052

S20

Measure:	Metaphor interpretation	Benton
Number of sessions:	N= 34	N = 34
Baseline mean:	35.4	8.6
Post Initiation of training mean:	39.0	9.4
Std. error of est.	5.516	1.615
3 month follow up:	N/A	N/A
Simple r for training:	.311, p = .119 (bootstrapping)	.240, p=.182 (bootstrapping)
Simple r for Session:	.188	.351
Regression:	R^2 = .119, F (2,31) = 2.095, p = .140	R^2 = .136, F (2,31) = 2.439, p = .104
Session:	β = -.285, t (31) = .883, p = .384	β = .537, t (31) = 1.679, p = .103
Training:	β = .554, t (31) = 1.717, p = .096	β = -.218, t (31) = -.683, p = .500
Increase in R^2 due to training:	.115	.013
Autocorrelation of residuals:	.086	-.059

Figure 1.

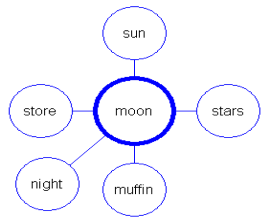
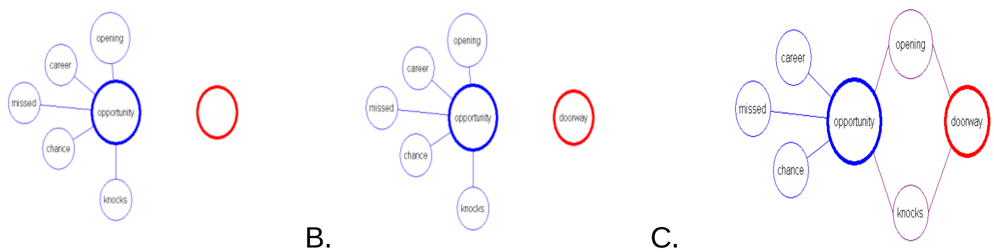


Figure 2.



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