Treatment of Metaphor Interpretation Deficits Subsequent to Traumatic Brain Injury

By: Hiram Brownell, Kristine Lundgren, Carol Cayer-Meade, Janet Milione, Douglas I. Katz, Kevin Kearns

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Abstract:

Objective: To improve oral interpretation of metaphors by patients with traumatic brain injury (TBI).

Design: Both single subject experimental design and group analysis.

Setting: Patients' homes.

Participants: Eight adult patients with moderate to severe traumatic brain injury sustained 3 to 20 years before testing.

Intervention: The Metaphor Training Program consisted typically of 10 baseline sessions, 3 to 9 1-hour sessions of structured intervention, and 10 posttraining baseline sessions. Training used extensive practice with simple graphic displays to illustrate semantic associations.

Main Outcome Measures: Quality of orally produced metaphor interpretation and accuracy of line orientation judgments served as dependent measures obtained during baseline, training, posttraining, and at a 3- to 4-month follow-up. Untrained line orientation judgments provided a control measure.

Results: Group data showed significant improvement in metaphor interpretation but not in line orientation. Six of 8 patients individually demonstrated significant improvement in metaphor interpretation. Gains persisted for 3 of the 6 patients at the 3- to 4-month follow-up.

Conclusion: The Metaphor Training Program can improve cognitive-communication performance for individuals with moderate to severe traumatic brain injury. Results support the potential for treating patients' residual cognitive-linguistic deficits.

Keywords: language and communication impairment | metaphor | treatment

Article:

This article describes a tool for remediating a communication impairment often associated with traumatic brain injury (TBI)[1–6] and also with right hemisphere brain damage (RHD) because of stroke.[7–9] Although patients with these etiologies are often not aphasic in the traditional sense of the term, many exhibit a decreased capacity to understand nonliteral language, which compromises their communicative effectiveness and quality of life. In an earlier article, we described successful use of a metaphor training protocol with patients with RHD due to stroke, and we provided additional detail about the training program.[10] In this article, we examine whether patients with TBI respond to the same protocol.

Our general goal is to add to the array of evidence-based treatments appropriate for cognitive-communication deficits following acquired brain injury.[11,12] There are remediation programs for cognitive-communication deficits associated with TBI such as attention,[13,14] memory,[15] problem solving,[16–18] and socialization[19]; however, the range of treatment options is limited, especially in comparison to that available for aphasia. This relative scarcity of treatment options limits a clinician's ability to address the needs of individual patients.

Our focus is difficulty interpreting figurative language such as idioms and metaphor. These forms of figurative language are common in communication, and impaired understanding of this type of utterance can undermine social interaction. For example, a family member might describe his work situation with the metaphor "My job is a prison." On a literal level, this utterance may seem ill-formed to a patient: jobs and prisons are from very different semantic domains and are not comparable. The patient may struggle with interpretation, concluding that the relative has been convicted of a crime and is about to start a prison sentence. In contrast, for a nonimpaired listener, metaphor interpretation is typically a straightforward process. Interpretation involves identifying associations to nouns from distinct semantic domains (eg, job: profession, fulfilling, frustrating, confining, etc, and prison: confining, bad, for criminals, etc.). The listener extracts associations shared by the 2 words that, accordingly, could provide a basis or "ground" for metaphor. The activation of possible grounds for metaphoric equivalence has been characterized as an automatic process for non–brain-injured listeners.[20] On hearing "My job is a prison," a nonimpaired listener will infer with ease that confinement is the relevant semantic trait held in common between the 2 nouns.

Our training program is designed to help patients with TBI, who have difficulty grappling with anything other than the literal, dominant meaning of a word or phrase, to regain facility with this form of nonliteral language. The program provides extensive practice generating and evaluating semantic associations for nouns and selecting the shared feature that makes sense in context. The program's foundation is based on 2 theoretical components: first, the ability to process "coarse grained" semantic information such as connotative associations between words [21]; and second, working memory which is implicated in selecting an appropriate alternative from a set of candidates.[22] The training format, inspired by Thinking Maps,[23] provides graphic displays of the semantic associations that underlie metaphor. A noun and the associations speakers generate from that concept can be written inside circles with lines connecting circles as appropriate, as shown in Figure 1. A metaphor would require 2 noun circles to "share" (ie, both be connected to) an association, which is also depicted within a circle. Because the basis of metaphoric equivalence is represented in graphic form, a patient can review and practice without constraint due to impaired working memory. Our prediction was that initiation of training would be associated with improvement in metaphor interpretation but not with change on an untrained comparison task involving judgments of line orientation.

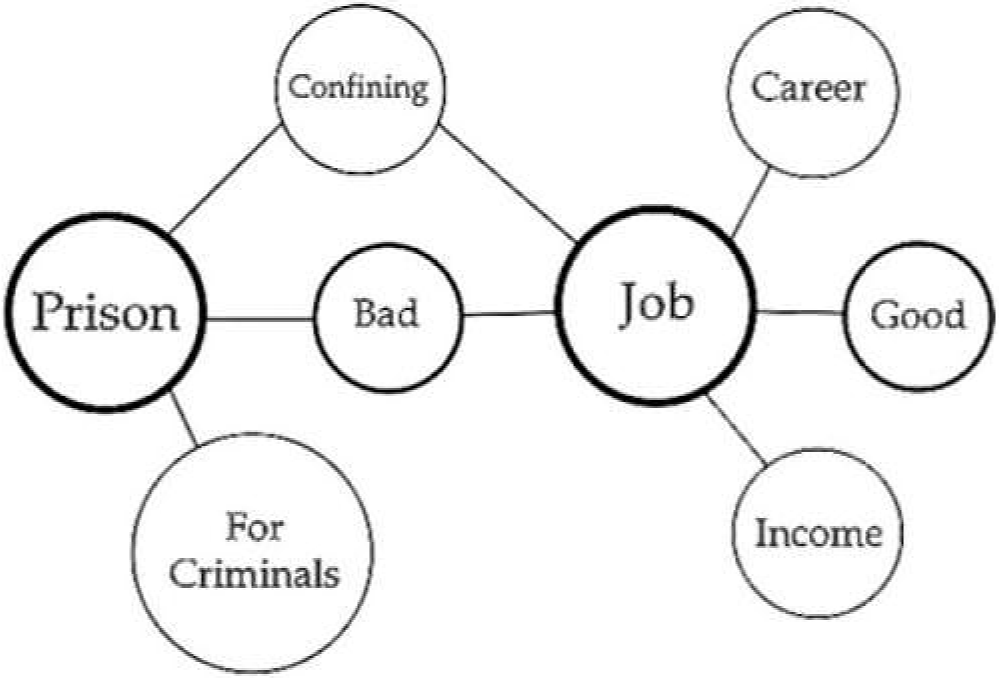

Figure 1. Representative training display for "My job is a prison."

METHODS

Participants

The 8 patients tested represented consecutive referrals to the training program who satisfied the following criteria: geographical proximity to testers; moderate to severe TBI (defined by

Glasgow Coma Scale scores) sustained at least 1 year (range = 3-20 for the patients enrolled) before testing; no report of significant drug or alcohol use, neurologic, or psychiatric illness, significant dysarthria or aphasia, or preexisting learning disability; no report of impaired (uncorrected) hearing or vision; completion of high school; and having grown up using predominantly American English. All signed an institutional review board–approved consent form. Enrolled patients' scores on one test of nonliteral language (The Formulaic and Novel Language Comprehension Test, FANL-C 24) ranged from impaired to 100% correct. Table 1 provides normative information on tests and information on individual patient performances.

Table 1. Patient background information and results

Patient	S-5	S-6	S-11	S-13	S-14	S-18	S-19	S-20
Age	44	43	31	35	54	48	39	50
Gender	F	M	M	M	F	F	M	M
Years of education	13	12	12	12	13	14	12	12
Time postonset	7	3	10	2	20	14	5	7
Initial Glasgow Coma Scale score	N/A	6	3	5-6	4-5	N/A	3	2T
Communication/cognitive features	Decreased insight, tangential	Verbose tangential, disinhibited	Concrete, disinhibited	Concrete, decreased executive function skills	Tangential	Dysarthric, concrete, disinhibited	Verbose	Poor reasoning skills, tangential
Working Memory Measure[a]								
Pretraining (total errors)	38	27	28	28	34	30	20	27
Posttraining (total errors)	38	26	37	26	35	38	29	37
Formulaic and Novel Language								
Comprehension[b]								
Pretraining (formulaic)	20	19	17	18	18	14	17	16
Posttraining (formulaic)	20	18	19	20	20	18	18	17
Total number of sessions (training sessions)	25 (4)	26 (5)	26 (5)	26 (5)	23 (2)	23 (2)	29 (8)	34 (3)
Results								
Oral metaphor interpretation[c]								
Pretraining baseline mean (SD)	33.7 (4.2)	32.0 (3.2)	27.9 (6.0)	32.0 (3.4)	35.7 (4.1)	23.1 (4.8)	28.9 (5.7)	35.5 (5.9)
Postinitiation of training mean	38.7 (4.4)	38.5 (4.9)	35.3 (4.9)	37.0 (4.5)	40.8 (2.8)	34.1 (3.2)	32.4 (5.0)	39.0 (4.9)
Effect size: change/Baseline SD	1.2	2.0	1.2	1.5	1.2	2.3	0.6	0.6
3-month follow-up	42	35	N/A	39	38	34	N/A	32
Simple r for training	0.513, P = .036	0.603, P = .031	0.572, P = .008	0.524, P = .012	0.607, P = .010	0.822, P = .007	0.309, P = .114	0.311, P = .119
Benton Line Orientation-Judgment Task								
Short Form[d]								
Pretraining baseline mean (SD)	13.9 (1.2)	14.9 (0.3)	14.2 (0.8)	12.5 (1.6)	9.7 (1.3)	8.8 (1.1)	6.4 (4.2)	8.6 (1.5)
Postinitiation of training mean	14.2 (0.9)	14.8 (0.4)	14.1 (0.8)	12.3 (1.3)	9.4 (1.0)	9.4 (0.9)	3.7 (2.9)	9.4 (1.8)
Effect size:	0.3	–.0.5	–0.1	–0.1	–0.2	0.5	–0.6	0.5

change/Baseline, SD								
3-month follow-up	14	N/A	N/A	14		10	N/A	10
Simple r for training	0.151, P = .530	–0.185, P = .232	–0.085, P = .701	–0.067, P = .683	–0.124, P = .706	0.292 P = .256	–0.358 P = .219	0.240 P = .182

Study design

We used a variant of an ABA (Baseline-Training-Baseline) single-subject experimental design in which patients served as their own control.[25,26] The replicated time series design included one pretraining assessment session of approximately 90 minutes; a baseline phase consisting of 10 or (in one case) 20 sessions of approximately 60 minutes each; a training phase consisting of 3 to 9 sessions of approximately 60 minutes each; a posttraining assessment of approximately 90 minutes; a posttraining phase consisting of 10 sessions of approximately 60 minutes each; and a long-term follow-up assessment of approximately 60 minutes 3 to 4 months after the last session to gauge the permanence of gains. The total number of training sessions varied because patients were trained to criterion on each task. Some patients progressed through the protocol more quickly than others because they were able to complete more protocol tasks in a single session. One patient performed an extra 10 baseline assessments prior to the start of training to provide information on the role of extra practice. The posttraining baseline sessions were included to support statistical analysis as well as to reinforce gains made during the training. Throughout the baseline, training, and posttraining phases, patients performed metaphor interpretation probes and also probes of an untrained line orientation task (Short Form Q of the Benton Judgment of Line Orientation Test).[27] Two licensed speech-language pathologists (SLPs) performed assessments and testing. To ensure comparability across sessions, each patient was seen by a single SLP. To ensure comparability across patients, the 2 SLPs were both trained by the second author, also an SLP, who in addition held weekly meetings and conducted periodic field observations.

Pretraining assessment session

This session consisted of administering several measures including a test of nonliteral language comprehension (the FANL-C),[24] The Cognitive and Linguistic Quick Test,[28] The Benton Line Orientation Task Short Form Q,[27] and a working memory span test 22 to assess, respectively, a patient's knowledge of figurative language, cognitive-linguistic abilities, visuospatial performance, and working memory.

Baseline phase (10 sessions—2 per week, and, for 1 patient, an extra 10 sessions—2 per week for an additional 5 weeks)

Each session included administration of probes for oral metaphor interpretation (on untrained items) and performance on the line orientation test. In addition, once each week patients were given a modified quality-of-life scale (SAQOL-39)29 that examined mood and energy.

Training phase (variable number of sessions, 2 per week)

Patients completed probes of metaphor interpretation and line orientation once per week during the training phase. The training per se consisted of 5 tasks[10] that, in some cases, built on each other and that generally progressed from easy to hard. The 2 simplest tasks required evaluation of connotations (task I) or associations (task II) of single words. The next 2, more complex tasks required abilities affected by brain injury: generating associations (Task III) and evaluating self-generated associations connecting 2 nouns (task IV). The final task, task V, required choosing, from a set of alternatives, a shared association for 2 nouns that provided the basis for a metaphor.

Posttraining assessment

This session included probes of oral metaphor interpretation (untrained items) and line orientation, as well as working memory span 22 and nonliteral language comprehension (FANL-C).[24]

Posttraining phase (10 sessions, 2 per week)

Each session consisted of oral metaphor interpretation and line orientation probes.

Long-term follow-up (1 session, 3 to 4 months after the end of training)

This session included oral metaphor interpretation and line orientation probes to gauge the permanence of gains.

The primary dependent measure, quality of the metaphor interpretation, was based on transcriptions of recorded interpretations that were scored using the Appropriateness of Metaphor Interpretation Scale (AMIS).[30] This 6-point scoring system incorporates subtle variation in performance (eg, delay, self-correction, confabulation).[31] Table 2 provides a description of the scoring system and examples.

Table 2. Appropriateness of metaphor interpretation scale and examples of scoring

Points Awarded, Rating Criteria	Sample Interpretations for “Fear is a Trap”
6. Correct. Complete and appropriate interpretation, characterized by rich, descriptive language (only rarely used).	Well, if you’re afraid of everything you are essentially relegated to a life of consistency. You’re stuck in this world. Things won’t change for you. Fear is something that can dampen your ability to think logically and . . . uhm lead you to a situation where you do nothing but think of how afraid you are . . . no action taken.
5. Correct. Complete and appropriate (nonconcrete) but basic/simple.	Fear is a trap, it stops you from doing things. That if you’re scared to do something, you’re sort of succumbing to it and thus not doing it so you’re letting fear win.

4. Correct. Complete and appropriate but (a) delayed (longer than 5 seconds required for response initiation) but eventually gets to the correct response, (b) may contain self corrections, or false starts but eventually gets to the correct response, or (c) may include some tangential comments and/or personalization but eventually gets to the correct response.	(pause) Well if you fear something . . . you . . . you're afraid to do . . . do something so your fear traps you in . . . in doing something. If you could overcome your fear you'd be able to do things. Fear is a trap. (pause) Uh sometimes you (pause) Fear is a trap. I know this . . . . (pause) You're afraid to make a move or a change. (pause) Or prevents you from going forward because you're afraid of the change.
3. Incorrect. Close substitution using appropriate alternative metaphor to close substitution/with some clear elements of abstraction but not the complete, correct/appropriate interpretation.	You have nothing to fear but fear itself, as Franklin Roosevelt said. That's what fear is. (pause) Or is that an oxymoron? It means that if we have fear then, ah . . . you lose all sense of reality
2. Incorrect. Literal associate may be partially correct with some partial or inappropriate non concrete extension.	(pause) Good question, fear is a trap . . . .you know, I don't know. I'm sorry. I should know that. Fear means you're afraid of something, that trap means you're cornered by it. Fears like a mouse trap. . . bam and slam
1. Incorrect. Literal associate without any non-concrete extension.	Fear . . . its being afraid. . . it happens (pause) It means that if you let fear take over, it could make you (pause) I don't know. (pause) Could make you feel like you are (pause) you are feeling afraid I guess that's what I needed.
0. Incorrect. No response, I don't know response, off topic comments unrelated to the metaphor.	Nope. Don't know this one. (pause) I can't

Before scoring, metaphor interpretations from different patients and different phases of the protocol were mingled. Each interpretation was rated independently by 2 judges who had been trained in the use of AMIS, one of whom was unaware of the source of the interpretation (ie, the patient's identity, protocol phase). Discrepancies were resolved using discussion that included a third judge, also trained in the use of AMIS. Previous evaluations of AMIS have yielded interrater reliability from 80% to 99% with different judges rating responses across patients with TBI and right hemisphere stroke.

RESULTS

Table 1 lists all patients' results for both metaphor interpretation and line orientation tasks. Values include the pretraining mean and standard deviation, postinitiation of training mean and standard deviation, improvement effect size (defined as the difference between the postinitiation and pretraining means divided by the standard deviation of the pretraining probes), and the

Pearson r value for change in performance. The r values were calculated by using 0s for all pretraining probes and 1s for all postinitiation of training probes and correlating pre versus post with metaphor interpretation scores and with line orientation scores.

All 8 patients remained with the program until completion. As a first step in evaluating the training protocol, we calculated for each patient their average metaphor interpretation score for the pretraining probes and then the average for all probes that followed the initiation of training. For the group as a whole, there was an overall positive effect of training: the mean difference score (ie, postinitiation average minus pretraining average: 37.0 – 31.1 = +5.9) was significantly different from 0.0, $t_7 = 6.81$, $P = .000$. In contrast, the mean difference score for the Benton line orientation task (10.9 – 11.1 = –0.2) was not reliably different from 0.0, $t_7 = –.57$, $P = .585$. These overall results suggest that the training was effective and selective.

We then evaluated patients' performances on a case-by-case basis. The statistical significance of each patient's improvement was assessed using bootstrapping/simulation software developed by Borckardt, Nash, Murphy, Moore, Shaw, and O'Neil[32] (available for download at http://clinicalresearcher.org). The null hypothesis is no overall change in a patient's performance due specifically to training. The first step in the analysis was mentioned earlier: Pearson r between a dependent measure (Y) and pre- versus postinitiation of training, that is, X consisting of 0s and 1s. This r value, presented in Table 1 for each patient for metaphor and for line orientation, reflects the combined influence of the training per se and also any gradual, steady improvement that may have started during the baseline phase (before training) and that may reflect simple practice with the task or spontaneous recovery unrelated to the training.

Next, the program separately assesses the amount of steady change across all probes together due, for example, to practice or recovery. It does this by using autocorrelation with a lag of 1 that reflects the correlation between performance on one probe and the next: the score for the first probe is paired with the score for the second probe; the score for second probe is paired with the score for the third probe, and so on. This autocorrelation provides a measure of the linear trend across sessions.

The software then illustrates what would happen under the null hypothesis of no effect of training and assuming normality. It generates 10 000 random samples (as many as specified by the user) with the same number of total probes and strength of autocorrelation (gradual change) as in the patient's data, but without any training effect. Then, for each of the 10 000 null hypothesis samples, the software calculates the r between X (pre- versus postinitiation of training) and Y to illustrate what would be expected for r values if there were only a consistent autocorrelation or change (perhaps due to practice) across baseline, training, and posttraining sessions and no specific effect of training. If the patient's actual, calculated pre-postinitiation of Training r value is stronger than 95% (2-tailed) of the null hypothesis values, the interpretation is that the change linked to the start of training is statistically "real" over and above any nonspecific improvement or practice effect. Table 1 presents the significance level for the r value for each patient.

Six of the 8 patients showed significant effects of training on metaphor interpretation; none of the 6 showed significant training effects on judgments of line orientation. Metaphor effect sizes were large and ranged from 1.2 to 2.3 for these 6 participants, and improvements were clearly maintained at 3- to 4-month follow-up for 3 of these patients.

The 2 remaining patients, S19 and S20, did not show reliable effects of training on either the metaphor or line orientation probes. Their metaphor effect sizes were both 0.6, substantially lower than those of the other patients. There are no obvious characteristics that distinguish both of these patients from the others. Both were relatively severely impaired shortly after injury (Glasgow Coma Scale scores of 3 and 3T). Although patient S19's initial working span score was quite low relative to most of the other patients, and his line orientation starting point was the lowest of all, patient S20 was not more impaired than other patients at the time of testing. Patient S20 received extra practice during extra baseline sessions, but patient S19 did not.

Our ancillary measures of cognitive and linguistic function were less informative. The independent measure of non-literal language comprehension, the FANL-C[24] was not sensitive enough to provide useful data for these patients due to what appear to be ceiling effects. The working memory span test showed greater variability in performance. However, there was no clear link between working memory span scores and improvement on metaphor interpretation. Less surprising was that weekly assessments of mood and energy level 29 did not suggest any change over sessions.

DISCUSSION

Group analysis revealed statistically significant improvement for patients with chronic TBI on the assessment task of oral metaphor interpretation but not on the untreated line orientation task. Analyses of individual patient data confirmed a selective effect of training for 6 of 8 patients tested; these patients' change from pre- to postinitiation of training divided by the standard deviation of the pretraining baseline sessions was 1.2 or greater.

The basis of the training was the extensive use of simple graphic materials based on Thinking Maps.[23] Semantic associations that provide the ground for metaphors were represented using circles and lines. Because the essence of a metaphor (a shared association that spans semantic domains) was rendered explicitly in a diagram, memory demands were reduced, and repeated practice was easy. We have previously reported similarly encouraging results using the Metaphor Training Program with patients who sustained a stroke in the right hemisphere.[10] To move beyond the reported success using graphic support for training metaphor processing, one compelling question is whether a similar approach can be applied to deficits in other domains, including domains that cannot easily be reduced to basic elements.

Study limitations

There are several factors that limit the strength and scope of interpretation of this study. The obtained results document that this protocol is a viable option for some patients with TBI. However, the small sample size disallows broad generalization of results to the greater population of individuals with TBI. More specifically, these preliminary data are insufficient to suggest which patients with TBI will benefit the most from this form of training and which basic cognitive capacities are responsible for the observed improvements. For example, the gains patients showed were not related in any straightforward way to their working memory or other aspects of executive function as measured by the Cognitive and Linguistic Quick Test.[28] The other major limitation is the scope of generalization of improvement. The target skill, oral interpretation of metaphor, showed clear effects of training. However, our independent measure of nonliteral language comprehension, the FANL-C,[24] proved too easy to provide useful information. Other unresolved questions in this domain include (1) whether the gains will be manifest in patients' daily lives and (2) how long gains will remain with or without additional clinical intervention. One goal for our program of research is determining the extent of training needed to maintain treatment gains.

CONCLUSIONS

These results argue for the potential of training that targets non-literal language use, even for patients who are, presumably, beyond the period of rapid and pronounced spontaneous recovery. The majority of patients with TBI in this study responded well to the training based on extensive visual support of basic cognitive processes. Specifically, the training protocol used graphic depiction of the semantic associations that underlie metaphor. Results support the potential for using graphic support to treat metaphor interpretation deficits in patients with TBI. Further study is needed to determine the effect of this treatment on functional cognitive-linguistic skills and maintenance of treatment gains.

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