Published in final edited form as:

Aphasiology. 2011 March 22; 25(6-7): 789–799. doi:10.1080/02687038.2010.539784.

A novel, implicit treatment for language comprehension processes in right hemisphere brain damage: Phase I data

Connie A. Tompkins¹, Margaret T. Blake², Julie Wambaugh³, and Kimberly Meigh¹

¹Communication Science & Disorders, University of Pittsburgh, Pittsburgh, PA, USA

²Communication Sciences & Disorders, University of Houston, Houston, TX, USA

³Communication Sciences & Disorders, University of Utah, and VA Salt Lake City Healthcare Systems, Salt Lake City, UT, USA

Abstract

Background—This manuscript reports the initial phase of testing for a novel, “Contextual constraint” treatment, designed to stimulate inefficient language comprehension processes in adults with right hemisphere brain damage (RHD). Two versions of treatment were developed to target two normal comprehension processes that have broad relevance for discourse comprehension and that are often disrupted by RHD: coarse semantic coding and suppression. The development of the treatment was informed by two well-documented strengths of the RHD population. The first is consistently better performance on assessments that are implicit, or nearly so, than on explicit, metalinguistic measures of language and cognitive processing. The second is improved performance when given linguistic context that moderately-to-strongly biases an intended meaning. Treatment consisted of providing brief context sentences to prestimulate, or constrain, intended interpretations. Participants made no explicit associations or judgments about the constraint sentences; rather, these contexts served only as implicit primes.

Aims—This Phase I treatment study aimed to determine the effects of a novel, implicit, Contextual Constraint treatment in adults with RHD whose coarse coding or suppression processes were inefficient. Treatment was hypothesized to speed coarse coding or suppression function in these individuals.

Methods & Procedures—Three adults with RHD participated in this study, one (P1) with a coarse coding deficit and two (P2, P3) with suppression deficits. Probe tasks were adapted from prior studies of coarse coding and suppression in RHD. The dependent measure was the percentage of responses that met predetermined response time criteria. When pre-treatment baseline performance was stable, treatment was initiated. There were two levels of contextual constraint, Strong and Moderate, and treatment for each item began with the provision of the Strong constraint context.

© 2011 Psychology Press, an imprint of the Taylor & Francis Group, an Informa business

Address correspondence to: Connie A. Tompkins, University of Pittsburgh, Communication Science and Disorders, 4033 Forbes Tower, Pittsburgh, PA 15260, USA. tompkins@pitt.edu.

Publisher's Disclaimer: Full terms and conditions of use: <http://www.informaworld.com/terms-and-conditions-of-access.pdf>

This article may be used for research, teaching and private study purposes. Any substantial or systematic reproduction, re-distribution, re-selling, loan or sub-licensing, systematic supply or distribution in any form to anyone is expressly forbidden.

The publisher does not give any warranty express or implied or make any representation that the contents will be complete or accurate or up to date. The accuracy of any instructions, formulae and drug doses should be independently verified with primary sources. The publisher shall not be liable for any loss, actions, claims, proceedings, demand or costs or damages whatsoever or howsoever caused arising directly or indirectly in connection with or arising out of the use of this material.

Outcomes & Results—Treatment-contingent gains were evident after brief periods of treatment, for P1 on two treatment lists, and for P2. P3 made slower but still substantial gains. Maintenance of gains was evident for P1, the only participant for whom it was measured.

Conclusions—This Phase I treatment study documents the potential for considerable gains from an implicit, Contextual constraint treatment. If replicated, this approach to treatment may hold promise for individuals who do poorly with effortful, metalinguistic treatment tasks, or for whom it is desirable to minimize errors during treatment. The real test of this treatment's benefit will come from later phase studies of study, which will test broad-based generalization to various aspects of discourse comprehension.

Keywords

Right brain damage; Discourse comprehension; language treatment; Suppression; Coarse coding

The language comprehension deficits in adults with relatively focal right hemisphere brain damage (RHD) can cause considerable social handicap. To date, however, treatment for language deficits in this population remains almost entirely untested and is often based on theoretically and empirically tenuous positions.

This paper presents preliminary, Phase I data from a novel language-processing treatment for adults with RHD. Phase I treatment studies are designed to detect whether a treatment has positive effects and to provide a basis for future rigorous testing of the treatment's efficacy and effectiveness (Robey & Schultz, 1998). The reported treatment has two versions, each motivated by one of two major accounts of common language comprehension problems in adults with RHD: *Coarse semantic coding* and/or *suppression* deficits.

In normal language comprehension, coarse coding and suppression processes complement one another (see Tompkins, 2008, for review). With reference to traditional comprehension models, coarse coding would be situated in an initial, context-independent, Construction phase (e.g., Kintsch, 1988, 1998; see also Gernsbacher, 1990) and suppression in a subsequent, Integration phase (Kintsch, 1988, 1998). Coarse semantic coding processes (e.g., Beeman, 1998) mentally activate wide-ranging aspects of word meaning, independent of the surrounding context. Suppression (e.g., Gernsbacher, 1990; Gernsbacher & Faust, 1991), on the other hand, reduces mental activation of concepts that are irrelevant in a specific context.

Coarse coding deficit in adults with RHD impairs the processing of *particularly* distant meanings or features of words (e.g., “rotten” as a feature of “apple”, but not “crunchy”, a subordinate feature that is less semantically distant than “rotten”; Tompkins, Fassbinder, Scharp, & Meigh, 2008). Suppression deficit in RHD is indexed by prolonged interference from (any) contextually inappropriate interpretations (e.g., the “card-playing” meaning of the word “spade” in the sentence “He dug with a spade”; Fassbinder & Tompkins, 2002; Tompkins, Baumgaertner, Lehman, & Fassbinder, 2000). A single individual with RHD hypothetically could exhibit both coarse coding and suppression deficits: impaired activation of features or meanings that are particularly semantically distant from encountered words, and a delay in pruning away activation for interpretations that are less distant but contextually incompatible.

The neurological underpinnings of coarse coding and suppression processes, and of their deficits, are as yet poorly specified. Preliminary evidence, from a small sample of adults with RHD who performed poorest on a measure of coarse semantic coding, indicates that the majority had posterior parietal involvement (Tompkins, Scharp, Meigh, & Fassbinder,

2008). Suppression deficit has been associated with damage in frontal and basal ganglia regions, in a small RHD sample (Tompkins, Klepousniotou, & Gibbs Scott, in press).

Coarse coding and suppression are particularly important treatment targets for several reasons. One is because the efficiency of these processes predicts aspects of discourse comprehension in adults with RHD. Individuals with RHD who were most impaired on a measure of coarse semantic coding were poorer comprehenders of implied information in discourse than other adults with RHD, even after accounting for factors like vocabulary knowledge and working memory capacity for language (Tompkins, Scharp, et al., 2008). Similarly, inefficient suppression predicts individual differences in RHD performance on measures of general discourse comprehension (Tompkins et al., 2000) and inferencing (Tompkins, Lehman-Blake, Baumgaertner, & Fassbinder, 2001), after controlling for the same factors. In addition, both coarse coding and suppression are partially domain-general language comprehension processes. For example, both processes have been hypothesised to underpin figurative language comprehension: suppression is important for resolving lexical and inferential ambiguities, and coarse coding is involved in processing both literal lexical items and phrasal metaphors (for a summary, see Tompkins et al., in press). Overall, treatment that improves the efficiency of coarse coding (CC) or suppression (SUPP) processes may hold promise for inducing gains in a broad range of communicative outcomes.

The reported treatment is novel in several ways. First, it aims to facilitate CC and SUPP processes implicitly, through contextual prestimulation. This approach contrasts with the majority of treatments for neurologically based cognitive-linguistic disorders, which are direct, explicit, and/or metalinguistic. We implemented this approach to avoid confounding the treatment of impaired comprehension *processes* with irrelevant, and potentially difficult, *task* demands. Adults with RHD who can perform well on assessments of language processing that are implicit or nearly so, often have difficulty with metalinguistic assessments of the same processing operations (see summary in Tompkins et al., in press). The treatment is also unique in that it targets partially domain-general operations, rather than specific language structures or forms such as metaphor.

METHOD

Participants

Table 1 provides basic information for each of three study participants. Patients were included if they had sustained RHD due to thromboembolic stroke, as confirmed by medical records including MRI scan reports, and if, by self-report, they were right-handed, monolingual, native speakers of American English. Each also met hearing criteria established for our previous research (e.g., Tompkins et al., 2000; Tompkins, Fassbinder, et al., 2008) and had vision adequate to read aloud the labels “Yes” and “No” on the response box. None reported any prior neurological or psychiatric condition, or learning disabilities. Patients with “silent” prior cerebral lesions, operationalised as having not resulted in hospitalisation and having no reported disruption on the patient’s life, were not excluded.

Identification of CC and SUPP deficits determined how the participants were assigned to treatment. CC and SUPP tasks from our original work were modified to use for deficit identification. The assessment modifications involved presenting only half of the original number of experimental trials. P1 was assigned to the coarse coding version of the treatment (hereafter, CC treatment), after testing with the modified CC stimuli (Tompkins, Fassbinder, et al., 2008) indicated that he performed similarly to patients in the original studies who were most impaired. Likewise, the two other participants (P2, P3) received the suppression version of the treatment (hereafter, SUPP treatment), because of poor performance on the

modification of our original suppression task (Tompkins et al., 2000). Discourse comprehension was not formally assessed in this study, but all three patients and/or their families acknowledged some comprehension difficulties in daily life situations (e.g., when playing cards with friends; when watching a movie on television).

Probe stimuli and tasks

Each version of the treatment had two lists of eight probe stimuli. Each probe stimulus consisted of a brief spoken sentence plus a spoken target word (see Appendix for all probe stimuli). These stimuli had been used in our prior studies of CC (Tompkins, Fassbinder, et al., 2008; Tompkins, Scharp et al., 2008) or SUPP (Fassbinder & Tompkins, 2002; Tompkins et al., 2000) in adults with RHD. The key lexical items in the probe stimuli were balanced for various lexical properties, across lists within each version of the treatment. Interstimulus intervals between the sentences and target words were based on findings from our previous work. To aid participants' perceptual segmentation between sentences and target words, a female had produced all the sentences and a male all target words.

CC sentences ended with a 1–2-syllable unambiguous noun (e.g., “There was an *apple*”). These sentences were presented in an implicit priming task. Shortly (175 ms) after the offset of the sentence-final noun, a spoken phoneme string was presented for timed lexical decision. The participant pressed a button on a response box to indicate as quickly as possible whether the phoneme string was a real word (Yes or No). *Target words* were *semantically distant subordinate features* of the sentence-final noun (e.g., “*rotten*”). All eight CC probe stimuli in each list required a “Yes” response, so eight filler stimuli with nonword targets were included in each list, as well. Four of the filler stimuli began with the same two to three words as four of the experimental probes.

SUPP sentences ended in a 1–2-syllable ambiguous noun (e.g., “She went to a *ball*”), and biased that noun's non-dominant (subordinate) meaning. Then 1000 ms after the offset of the sentence final noun, a spoken *target word* was presented. The target reflected the *unbiased (dominant)* meaning of the noun (e.g., “*kick*”). Participants responded manually to indicate as quickly as possible whether the target word fitted with the meaning of the sentence (expected response = No). Eight filler stimuli were included in each list, all of which required a “Yes” response. Again, half of these fillers began with the same two to three words as four of the experimental probes.

Dependent variable

The outcome measure for both tasks was the percentage of accurate responses to probe stimuli that met a preset response time criterion (%Crit). The criterion was a value 1 standard deviation below the mean achieved by non-brain-damaged control participants in our prior studies of RHD and CC (Tompkins, Fassbinder, et al., 2008) or SUPP (Fassbinder & Tompkins, 2002; Tompkins et al., 2000). This measure was chosen because deficient performance of adults with RHD on these measures has been overwhelmingly accurate, but delayed.

Treatment

The goal of treatment was to speed language comprehension processes that often are slowed after RHD in adults. Treatment exploited the beneficial effects of contextual bias on comprehension in adults with RHD (e.g., Blake & Lesniewicz, 2005; see also Tompkins, Fassbinder, Lehman-Blake, & Baumgaertner, 2002). The treatment introduced two levels of contextual constraint to prestimulate the target concepts—i.e., the distant semantic feature (CC) or contextually biased interpretation (SUPP) of each sentence-final noun. *Strong constraint contexts* were composed of two brief sentences, the first of which strongly biased

and the second of which moderately biased the target concept (see Appendix for all constraint context stimuli). *Moderate constraint contexts* included only the second (moderately biased) sentence. Strength of bias was validated in pilot studies. A female speaker recorded all constraint contexts.

In both versions of the treatment, treatment for each item began with auditory presentation of the Strong Constraint context, prior to the probe stimulus. If %Crit was met, the Moderate Constraint context was provided similarly, prior to the probe stimulus, and so on, as illustrated in the treatment flowchart (see Figure 1). If Moderate Constraint contexts began with a sentence-initial definite pronoun (e.g., “It”; “He”), the pronoun was replaced with its referent from the Strong Constraint context (e.g., “The fruit”; “The pilot”).

Even though the relatedness judgement task in the SUPP version of treatment is explicit, both versions of the treatment itself are implicit. The participant did not make any explicit decisions or judgements about the meaning of the *Constraint contexts*. Provision of these Constraint contexts was the entire treatment; the contexts only served as primes, and were never explicitly associated with a probe stimulus or probe task.

Both lists of probe stimuli were given in a minimum of three pre-treatment baseline sessions. In the treatment phase of the design, probes of treated lists were administered each session, immediately before treatment commenced. After the baseline phase, probes of untreated lists were taken only occasionally, as described in the results.

RESULTS

As anticipated, participants were highly accurate on the probe tasks for both versions of the treatment, performing with at most one error in any given probe session. Thus, as planned, the results are presented and interpreted with reference to %Crit, our measure of response speed.

Figures 2 and 3 represent probe data for CC and SUPP treatment, respectively. Performance on pre-treatment baseline probes was stable for each participant. Figure 2 illustrates performance on both lists of probe stimuli for P1. After just eight CC treatment sessions, P1 had met the response time criterion for 88% of the probes of List 1. At this point, List 1 treatment ended. Two post-treatment probes of List 1, administered in sessions 16 and 23, suggest that this improvement maintained while List 2 was treated. Performance on untreated probes in List 2 did not improve until treated (List 2, sessions 16–23), demonstrating treatment-contingent gains.

P2 and P3 were treated on different lists of stimuli (List 1 and List 2, respectively). P2’s probe performance improved quickly and steadily with SUPP treatment (sessions 6–10), and reached %Crit on 88% of trials in sessions 8 and 10. P3, whose performance was initially lower than that of P2, also made gradual gains with SUPP treatment (sessions 6–9), but had not achieved %Crit on 88% of trials by the time the study ended, for practical reasons. Data from the final probe session for both participants suggest stable performance on the lists that had not been treated, as would be expected if gains during the treatment sessions were associated with the treatment rather than extraneous factors.

Visual inspection of the data was augmented in two ways, first to determine the presence of reliable treatment effects, and second to document effect sizes. For the first purpose, we used the conservative dual-criteria (CDC) method (Fisher, Kelley, & Lomas, 2003). The CDC approach optimally controls Type 1 error even when autocorrelation is high. In this method, two criterion lines are created using the baseline data: a trend line based on the binomial test, and a mean line. Then these criterion lines are both raised by .25 standard

deviations. Treatment effects are reliable if a specified number of data points fall above both lines (i.e., per Fisher et al., Table 1: 8 of 10 data points for P1 List 1; 7 of 8 for P1 List 2; 6 of 7 for P2; and 6 of 6 for P3). The criterion lines have been superimposed on the data in Figures 2 and 3. As the figures show, there was a reliable treatment effect for both treatment lists for P1, and for P2. The treatment effect for P3 (the last five of the total six data points exceed both criterion lines) is close to Fisher and colleagues' criteria. Treatment was concluded for practical reasons at this point in time.

Effect sizes were determined using the *d*-Index statistic (Bloom, Fischer, & Orme, 2003). This index uses the pooled standard deviation from baseline and intervention phases, and as such is more conservative than some estimates of *d*. According to Bloom et al., the *d*-Index is more precise when there are a small number of baseline observations, as well. For P1, the *d*-Index calculations for both List 1 and List 2 (12.67 and 9.69, respectively) indicate a greater than 50% increase over baseline (Bloom et al). Similarly, the effect size for P2 (*d*-Index = 11.96) signifies a greater than a 50% increase. For P3 (*d*-Index = 2.01), the increase over baseline was 48%.

DISCUSSION AND IMPLICATIONS

The results of this Phase I treatment study suggest that this novel, implicit, facilitation-type treatment approach holds promise for addressing important underlying processing deficits in adults with RHD. One participant each made treatment-contingent gains in the efficiency of coarse coding (P1) and suppression (P2) processes, and these gains were maintained for the patient in whom we were able to collect maintenance data (P1). Statistical analyses documented reliable and substantial treatment effects for both P1, across treatment lists, and P2. For the third participant the treatment trajectory was gradually upward, trending towards a reliable effect. Treatment for this individual was terminated prematurely, for practical reasons unrelated to progress in treatment itself or to satisfaction with the treatment.

In light of the small participant sample it is impossible to associate treatment response to patient characteristics with any confidence. One could speculate that P3's lesser response to treatment reflected his lower premorbid education level, but P1 had only 1 year more of formal education; additionally, all three participants needed good literacy skills in their pre-retirement occupations. It is also possible that the SUPP List 2 treatment stimuli, on which P3 was treated, were more difficult in some way than List 1 stimuli, on which P2 demonstrated a strong treatment response. This seems unlikely, because the stimuli were balanced across lists for degree of contextual constraint and psycholinguistic characteristics, and because there was no difference in performance across lists in the baseline phase, for either P2 or P3. Future studies with more participants will allow a fuller examination of participant and list characteristics that might contribute to treatment response.

The results of this study support the potential for considerable treatment gains from implicit treatment, using an approach that is very different from the metalinguistic association tasks that typify most clinical interventions for neurologically based language disorders. If these gains are substantiated in larger studies with stricter controls and more follow-up measures, there may be hope for better outcomes for patients who cannot engage in metalinguistic association tasks, efficiently or at all. More generally, an implicit approach to treatment is likely to reduce errors, and may be desirable for many patients for this reason.

It is of course possible that the observed gains were due simply to repeated exposures to the treated items. The real measure of this treatment's value will be in generalisation to meaningful measures of comprehension. We are launching a larger Phase II effort in which we are collecting data on generalisation of treatment gains to broader communicative

outcomes that depend on CC and SUPP processes, including general discourse comprehension, interpretation of implied information in discourse, resolution of ambiguous inferences, the processing of metaphor and other kinds of figurative language, and functional reasoning tasks that involve weighing competing options. If such generalisation is evident, future studies can examine the contributions of non-specific practice.

It may be that we will need to incorporate more strategies to support these kinds of generalisation, such as integrating aspects of the natural environment into the treatment, or developing a “looser” form of the treatment. Alternately, we may need to treat long enough to effect overlearning, rather than accepting standard criteria for terminating treatment (e.g., 90% over three consecutive sessions). Or, the treatment may have more real-world consequences when provided in the acute phase, augmenting spontaneous recovery processes. These and similar questions remain for future phases of treatment development.

REFERENCES

- Beeman, M. Coarse semantic coding and discourse comprehension. In: Beeman, M.; Chiarello, C., editors. *Right hemisphere language comprehension: Perspectives from cognitive neuroscience*. Mahwah, NJ: Lawrence Erlbaum Associates Inc.; 1998. p. 255-284.
- Blake ML, Lesniewicz K. Contextual bias and predictive inferencing in adults with and without right hemisphere brain damage. *Aphasiology*. 2005; 19(3-5):423-434.
- Bloom, M.; Fischer, J.; Orme, JG. *Evaluating practice – Guidelines for the accountable professional*. 4th ed.. Boston, MA: Allyn & Bacon, Pearson Education, Inc.; 2003.
- Fassbinder W, Tompkins CA. Slowed lexical activation in right hemisphere brain damage? *Aphasiology*. 2002; 16(4-6):559-572.
- Fisher WW, Kelley ME, Lomas JE. Visual aids and structured criteria for improving visual inspection and interpretation of single-case designs. *Journal of Applied Behaviour Analysis*. 2003; 36:387-406.
- Gernsbacher, MA. *Language comprehension as structure building*. Hillsdale, NJ: Lawrence Erlbaum Associates Inc.; 1990.
- Gernsbacher MA, Faust ME. The mechanism of suppression: A component of general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, & Cognition*. 1991; 17:245-262.
- Kintsch W. The use of knowledge in discourse processing: A construction-integration model. *Psychological Review*. 1988; 95:163-182. [PubMed: 3375398]
- Kintsch, W. *Comprehension: A paradigm for cognition*. Cambridge, UK: Cambridge University Press; 1998.
- Robey RR, Schultz MC. A model for conducting clinical-outcome research: An adaptation of the standard protocol for use in aphasiology. *Aphasiology*. 1998; 12(9):787-810.
- Tompkins CA. Theoretical considerations for understanding “understanding” by adults with right hemisphere brain damage. *Perspectives on Neurophysiology and Neurogenetic Speech and Language Disorders*. 2008; 18:45-54.
- Tompkins CA, Baumgaertner A, Lehman MT, Fassbinder W. Mechanisms of discourse comprehension impairment after right hemisphere brain damage: Suppression in lexical ambiguity resolution. *Journal of Speech, Language, and Hearing Research*. 2000; 43:62-78.
- Tompkins, CA.; Fassbinder, W.; Lehman-Blake, MT.; Baumgaertner, A. The nature and implications of right hemisphere language disorders: Issues in search of answers. In: Hillis, A., editor. *Handbook of adult language disorders: Integrating cognitive neuropsychology, neurology, and rehabilitation*. New York, NY: Psychology Press; 2002. p. 429-448.
- Tompkins CA, Fassbinder W, Scharp VL, Meigh KM. Activation and maintenance of peripheral semantic features of unambiguous words after right hemisphere brain damage in adults. *Aphasiology*. 2008; 22:119-138. [PubMed: 20011607]
- Tompkins, CA.; Klepousniotou, E.; Gibbs Scott, A. Right hemisphere communication disorders: Characteristics and assessment. In: Papathanasiou, I.; Coppens, P.; Potagas, C., editors. *Aphasia and related neurogenic communication disorders*. Sudbury, MA: Jones & Bartlett; in press

- Tompkins CA, Lehman-Blake MT, Baumgaertner A, Fassbinder W. Mechanisms of discourse comprehension impairment after right hemisphere brain damage: Suppression in inferential ambiguity resolution. *Journal of Speech, Language, and Hearing Research*. 2001; 44(2):400–415.
- Tompkins CA, Scharp VL, Meigh KM, Fassbinder W. Coarse coding and discourse comprehension in adults with right hemisphere brain damage. *Aphasiology*. 2008; 22(2):204–223. [PubMed: 20037670]

APPENDIX: STIMULI

Coarse coding

<i>Constraint sentences</i>	<i>Probe stimulus</i>
<i>LIST 1</i>	
The fruit smelled awful. It had turned very soft.	There was an apple – Rotten.
The farmer harvested the plants. This year's crop was large.	There was some cotton – Field.
They used the grinder for the drink. They liked to make the morning beverage.	There was some coffee – Beans.
The setting was regal. The prince would be there.	There was a castle – Royal.
She turned on the iron. The clothes were on the floor.	There was a shirt – Wrinkled.
The food was airy. They liked the whipped vegetables.	There were some potatoes – Fluffy.
The pilot checked the gauges. He landed on the runway.	There was an airplane – Captain.
He was trying to gain weight. He had fattening foods.	There was a milkshake – Calories.
<i>LIST 2</i>	
The food had no flavor. It tasted plain.	There was some rice – Bland.
He bounced on the couch. They poked out from the cushions.	There was a sofa – Springs.
The chair was polished. The wood was shiny.	There was oak – Furniture.
The seasoning was ground up. It was in the spice jar.	There was some garlic – Powder.
She tended the herb garden. The leaves smelled strong.	There was some mustard – Plant.
The family squeezed into the room. The space was small.	They had a cabin – Cramped.
The mechanic looked at the engine. He checked the oil.	There was a car – Hood.
The drink smelled funny. It was sour.	There was some milk – Spoiled.

Suppression

<i>Constraint sentences</i>	<i>Probe stimulus</i>
<i>LIST 1</i>	
She put on the beautiful gown. She was excited about the dance.	She went to a ball – Kick.
They saw an old west exhibit. The man offered free carriage rides.	They rode on the stage – Theater.
She bought a new pillow. It was soft and fluffy.	It was filled with down – Below.
He drove to work. The traffic was heavy.	He got caught in a jam – Jelly.
The man assembled cars. He enjoyed his job.	He worked at the plant – Tree.
The bananas were not yet ready. They had not ripened.	The fruit was too green – Grass.
The young boy went to the playground. He ran around for two hours.	He began to tire – Wheel.

<i>Constraint sentences</i>	<i>Probe stimulus</i>
She had a test last week. She studied very hard.	She got a good grade – Slope.
<i>LIST 2</i>	
He was up reading very late. He needed to go to bed.	He put the book on the stand – Sit.
The man went hunting. He saw an elk in the distance.	He looked for more game – Football.
The girl bought a balloon. The balloon was filled with helium.	She watched as it rose – Daisy.
The man took people hostage. The police entered the room.	The man laid down his arms – Legs.
The woman looked at the bell. She pulled the rope.	She heard it toll – Fee.
His skin was swollen. He went to the clinic.	The doctor examined the boil – Steam.
The bear began to wake. His hibernation was over.	The bear began to stir – Mix.
The woman lost her job. She had no money to feed her children.	The situation was grave – Casket.

Figure 1.
Flowchart for coarse coding and suppression treatment. Original stimulus = Probe stimulus.

Figure 2.

Probe data for Participant 1, coarse coding treatment. %Crit = percentage of correct responses that met response time criterion. The two dotted lines superimposed on the session data represent the criterion lines calculated using the conservative dual criterion (CDC; Fisher et al., 2003) method.

Figure 3. Probe data for Participants 2 and 3, suppression treatment. P2=Participant 2; P3=Participant 3. %Crit = percentage of correct responses that met response time criterion. The two dotted lines superimposed on the session data represent the criterion lines calculated using the conservative dual criterion (CDC; Fisher et al., 2003) method.

TABLE 1

Participant information

	P1	P2	P3
Age (years)	73	81	67
Education (years)	11	13	10
Gender	Male	Female	Male
Prior occupation	Insurance company executive	Librarian	Retail store manager
Months post-onset	5	6	4.5
Lesion (MRI report)	R fronto-temporo-parietal	R temporo-parietal and old L basal ganglia lacune	R fronto-temporo-parietal

P1 = Participant 1, P2 = Participant 2, P3 = Participant 3. R = right, L = left, MRI = Magnetic resonance imaging.