Language comprehension deficits in adults with focal right hemisphere brain damage (RHD) can cause considerable social handicap. To date, however, treatment for these deficits remains almost entirely untested. This abstract reports an investigation of whether Contextual Constraint Treatment (CCT) -- a novel, implicit, stimulation-facilitation treatment for language comprehension processes[1,2] -- can yield generalized gains to measures of discourse comprehension in adults with RHD.

The focus of CCT is motivated by two major accounts of typical RHD language comprehension problems: that they are due to *coarse coding* or *suppression* deficits. Coarse coding (CC) activates wide-ranging aspects of word meaning independent of surrounding context. In RHD, CC deficits impair processing of distant meanings/features of words (e.g., "*rotten*" as a feature of "*apple*")[3]. A normal suppression (SUPP) process reduces mental activation of concepts that become less relevant to a current context. RHD SUPP impairment is indexed by prolonged processing interference from contextually-inappropriate interpretations (e.g., the "*ink*" meaning of the word "*pen*," in the sentence "He built a pen")[4,5]. CC and SUPP are partially domain-general language comprehension processes. For example, both predict aspects of discourse comprehension and are hypothesized to underpin figurative language comprehension; SUPP is important for resolving lexical and inferential ambiguities; and CC is involved in processing both literal lexical items and phrasal metaphors[1,2,6]. Thus, treatment that improves CC and SUPP processes may hold promise for improving a broad range of communicative outcomes.

CCT is novel in aiming to facilitate comprehension processes implicitly, through contextual prestimulation. Adults with RHD who perform well on implicit assessments of language processing often have difficulty on metalinguistic assessments of the same operations[2]. Thus we implemented this approach to avoid confounding treatment of impaired *processes* with irrelevant, and potentially difficult, *task* demands.

Method

Participants were 5 adults with right CVA. Using the tasks originally developed to identify CC[3] and SUPP[4,5] deficits, two each were diagnosed with CC or SUPP deficit, and one with both deficits. Each was a right-handed, monolingual, native speaker of American English. Table 1 provides additional participant data.

Probe Stimuli and Tasks. For both CC and SUPP versions of CCT, there are 3 Probe Lists: Lists 1 and 2, slated for treatment, and List 3, to examine generalization. Each list contains 25 well-validated probe stimuli, 15 experimental and 10 filler. Key lexical items in probe stimuli are balanced across lists for lexical properties. All stimulus elements are spoken and participants respond manually, as quickly as possible.

CC: experimental probes for Lists 1 and 2 are short, semantically-neutral sentences that end with a 1-3 syllable, concrete, common noun (e.g., "There was a piano"), followed by a target word (e.g., *song*). The target represents a semantically-remote subordinate feature of the sentence-final noun. For List 3, homophones whose subordinate senses are metaphoric are placed in sentence final-position of neutral sentence frames (e.g., "There was a jewel"). Experimental targets represent the subordinate, metaphoric sense of the homophone (e.g., *helpful*).

Probe stimuli were administered in an implicit priming task. Shortly (175 ms) after offset of the sentence-final noun, a phoneme string (the target) was presented for timed lexical decision (participants indicated Yes/No whether phoneme string was a real word). Experimental probe stimuli require a 'Yes' response, so filler stimuli have nonword targets.

SUPP: List 1 and 2 probe sentences end in a 1-2 syllable ambiguous noun (e.g., 'She rubbed her *temple*'), and are biased toward the noun's nondominant (subordinate) meaning. The noun is followed (1000 ms later) by a *target word* that reflects the *unbiased* (*dominant*) meaning (e.g., "*worship"*). List 3 probes are biased toward other nouns' *dominant* meanings and paired with target words reflecting *subordinate* meanings. Participants indicated Yes/No whether the target fit with the meaning of the sentence (expected response=No). Filler stimuli required a "Yes" response.

The dependent variable is the percentage of accurate responses to experimental probe stimuli that met a preset response time criterion (%Crit). This criterion was a value 1 standard deviation below the mean achieved by non-brain-damaged control participants in prior studies of RHD and CC[3] or SUPP[4,5].

Treatment introduces two levels of contextual bias to prestimulate the target concepts represented by sentence-final nouns (distant semantic feature (for CC) or nondominant meaning (for SUPP)). *Strong constraint contexts* have two brief sentences, the first of which strongly biases and the second of which moderately biases the target concept (see Table 2 for examples). *Moderate bias contexts* include only the second (moderately biased) sentence. Strength of bias was validated in pilot studies.

Treatment 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 Figure 1. CCT is implicit in that participants do not make any explicit decisions or judgments about the meaning of the constraint contexts.

Results

(See Table 3 for effect sizes, Table 4 for generalization and control data, and Appendix for social validity).

CC participants (Figure 2): %Crit improved with CCT and remained above baseline in maintenance and follow-up. *Discourse Comprehension Test*[7] (DCT) performance increased substantially from baseline to post-treatment, far exceeding the 1-point standard error, and maintained through at least one follow-up session. Response generalization was evident in substantial %Crit improvement on a Generalization Block of probe stimuli from the diagnostic assessment that were not included in treatment. Control measure performance was stable.

SUPP participants (Figure 3): %Crit improved with treatment. DCT performance improved minimally for Participant 106 (who started high), though exceeding the standard error. This participant also evidenced response generalization on the Generalization Block and stable scores on control measures. Participant 117 made substantial DCT improvement. Control measure performance improved minimally. This participant showed response generalization on List 3 but none on the Generalization Block (Follow-up measure inadvertently not administered).

CC + SUPP participant (Figure 4): CC was treated before SUPP. %Crit improved during both treatments and response generalization was evident in the Generalization Blocks. DCT score declined substantially after CC List 1 treatment, rebounded to baseline level after List 2 treatment, and improved at final follow-up (3.5 weeks-post-treatment). Control measure performance was stable until final follow-up. DCT substantially improved after SUPP List 1 treatment, while performance on a different control measure remained stable. DCT scores declined at follow-up before returning to baseline level, while scores on the control measure improved.

Discussion/Implications

CCT, a novel approach implicitly targeting underlying comprehension processes, yields

positive effects. Probe list gains were treatment-contingent, and generally maintained. These gains appear to reflect improvements in underlying comprehension processes rather than item-specific change due to repeated exposures, because response generalization was evident to untrained items. Most importantly, generalization was evident to DCT narrative comprehension. Improvements in DCT cannot be attributed simply to test practice effects, as scores typically declined from their maxima during follow-up. Gains are not likely due to some global improvement, as performance did not change from baseline to later phases for most control measures and there was minimal evidence for generalization to List 3.

Discussion will address potential demographic, cognitive, lesion, and treatment dosage correlates of better/poorer outcomes, and an intriguing possibility we have noted previously[e.g.,8]: that treating CC may exacerbate a SUPP deficit (e.g., participant 206, where initial CC treatment may have temporarily degraded discourse comprehension).

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Table 1. Data for participants with coarse coding deficit, suppression deficit, and both deficits.

CC Deficit

ID #	Age	Education	Sex	MPO	Lesion Characteristics
101	79	12	F	Stroke 1 = 87 Stroke 2 = 19	Stroke 1: temporal, occipital/PCA distribution/ thalamus Stroke 2: MCA distribution/temporal lobe
113	85	16	M	66	MCA distribution: majority basal ganglia; minimal involvement of frontal, parietal, temporal lobes

SUPP Deficit

ID #	Age	Education	Sex	MPO	Lesion Characteristics
106	54	15	M	101	MCA: frontal, temporal, parietal, posterior insular cortex, posterior limb internal capsule, caudate
117	62	20	M	148	Basal ganglia (putamen), external capsule, parietal, occipital lobes

CC + SUPP Deficit

ID #	Age	Education	Sex	MPO	Lesion Characteristics
206	88	18	M	68	Temporal, frontal, and parietal lobes; old left basal ganglia lacune

Note: ID = Participant identification number; Age, Education in years; MPO = Months post-onset; Lesion Characteristics from MRI/CT scan report, unless otherwise noted right cerebral hemisphere.

Table 2. Sample Strong Constraint context for coarse coding and suppression versions of Contextual Constraint Treatment.

CC version: (target concept: *song*).

Sentence 1: She played the melody.
Sentence 2: She forgot the words.

Probe stimulus: There was a piano – song [Response = YES]

SUPP version: (target concept: *an area of the face*).

Sentence 1: Her head hurt.
Sentence 2: She needed an aspirin.

Probe stimulus: She rubbed her temple – worship [Response = NO]

Table 3: Effect sizes for three sets of participants.

	True BL - Treatment	True BL - FollowUp
CC 101		
L1	38.1	37.26
L2	12.54	9.38
L3	n/a	10.69
CC 113		
L1	2.2	2.04
L2	2.73	1.76
L3	n/a	1.91
SUPP 117		
L1	16.0	3.63
L2	8.18	7.05
L3	n/a	3.54
SUPP 106		
L1	n/a	3.92
L2	7.73	3.6
L3	n/a	2.04
CC 206		
L1	4.15	3.63
L2	3.25	2.99
L3	n/a	1.93
SUPP 206		
L1	26.9	8.63
L2	n/a	6.22
L3	n/a	3.75

Note. Effect size = *d*-Index statistic (Bloom, Fischer, & Orme, 2003[9])

True BL = baseline probes prior to the start of treatment on any list

L1 = Probe List 1; L2 = Probe List 2; L3 = Probe List 3

n/a = not applicable because that list not treated.

Table 4: Data for generalization and control measures, across experimental phases, for 3 sets of participants

Coarse Coding Participants

CC 101	Baseline	Phase Change	Follow up 1	Follow up 3
DCT Total (80 possible)	61 (76%)	35/40 (88%)	34/40 (85%)	32/40 (80%)
DCT Implied Information (40 possible)	27 (68%)	18/20 (90%)	16/20 (80%)	14/20 (70%)
Generalization Block (untreated stimuli; 5 possible)	0	3	3	
VFD (control measure)	20, 29	28	31	24

CC 113	Baseline	Phase Change	Follow up 1	Follow up 2	Follow up 3
DCT Total (80 possible)	71 (89%)	35/40 (88%)	40/40 (100%)	37/40 (93%)	36/40 (90%)
DCT Implied Information (40 possible)	35 (88%)	16/20 (80%)	20/20 (100%)	17/20 (85%)	17/20 (85%)
Generalization Block (untreated stimuli; 5 possible)	1	5	3	4	5
VFD (control measure)	16, 20	22	21	24	18

Suppression Participants

SUPP 106	Baseline	Phase Change	Follow up 1	Follow up 3
DCT Total (80 possible)	73 (91%)	37/40 (93%)	34/40 (85%)	37/40 (93%)
DCT Implied Information (40 possible)	36 (90%)	18/20 (90%)	17/20 (85%)	19/20 (95%)
Generalization Block (untreated stimuli; 6 possible)	2	3	5	
MEC Emotional Prosody Production (12 possible)	0	0	Not administered	1

SUPP 117	Baseline	Phase Change	Follow up 1	Follow up 3
DCT Total (80 possible)	68 (85%)	38/40 (95%)	36/40 (90%)	34/40 (85%)
DCT Implied Information (40 possible)	31 (78%)	18/20 (90%)	17/20 (85%)	16/20 (80%)
Generalization Block (untreated stimuli; 5 possible)	3	3	Not administered	Not administered
JLO	19, 19	22	Not administered	24

Coarse Coding + Suppression Participant

CC 206	Baseline	Phase Change	Follow up 1	Follow up 3
DCT Total (80 possible)	61 (76%)	27/40 (68%)	30/40 (75%)	32/40 (80%)
DCT Implied Information (40 possible)	28 (70%)	14/20 (70%)	13/20 (65%)	17/20 (85%)
Generalization Block (untreated stimuli; 5 possible)	0	3	5	
JLO (control measure)	18, 20	21	22	27

SUPP 206	Baseline	Phase Change	Follow up 1	Follow up 3
DCT Total (80 possible)	32/40 (80%)*	34/40 (85%)	30/40 (75%)	32/40 (80%)
DCT Implied Information (40 possible)	17/20 (85%)*	17/20 (85%)	15/20 (75%)	16/20 (80%)
Generalization Block (untreated stimuli; 6 possible)	0	5	6	
VFD (control measure)	22, 26	23	29	29

Note: DCT = *Discourse Comprehension Test* (Brookshire & Nicholas, 1993[7]). DCT standard error: 1 point difference (1.25%). Change exceeding standard error highlighted in yellow.

VFD = *Visual Form Discrimination* (Benton, Sivan, Hamsher, Varney, & Spreen, 1994[10]), administered twice during baseline to estimate variability associated with retest.

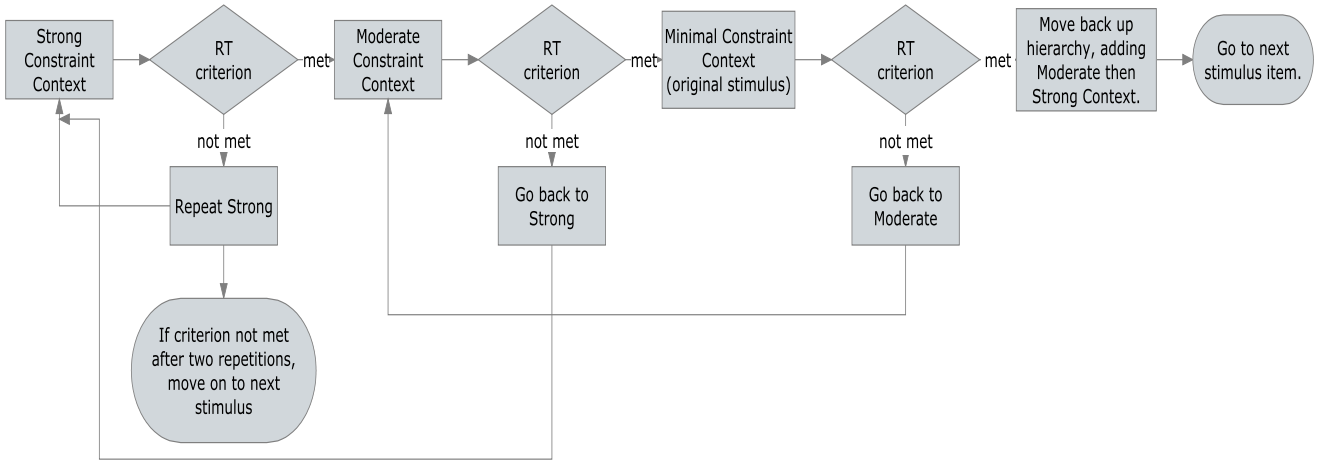
MEC = experimental English-language version of *Protocole Montreal d'Evaluation de la Communication* (Joanette et al., 2004).

JLO = *Judgment of Line Orientation* (Benton, Hamsher, Varney & Spreen, 1983[12]), administered twice during baseline to estimate variability associated with retest.

For control measures, change exceeding amount of variability in the 2 baseline administrations highlighted in aqua.

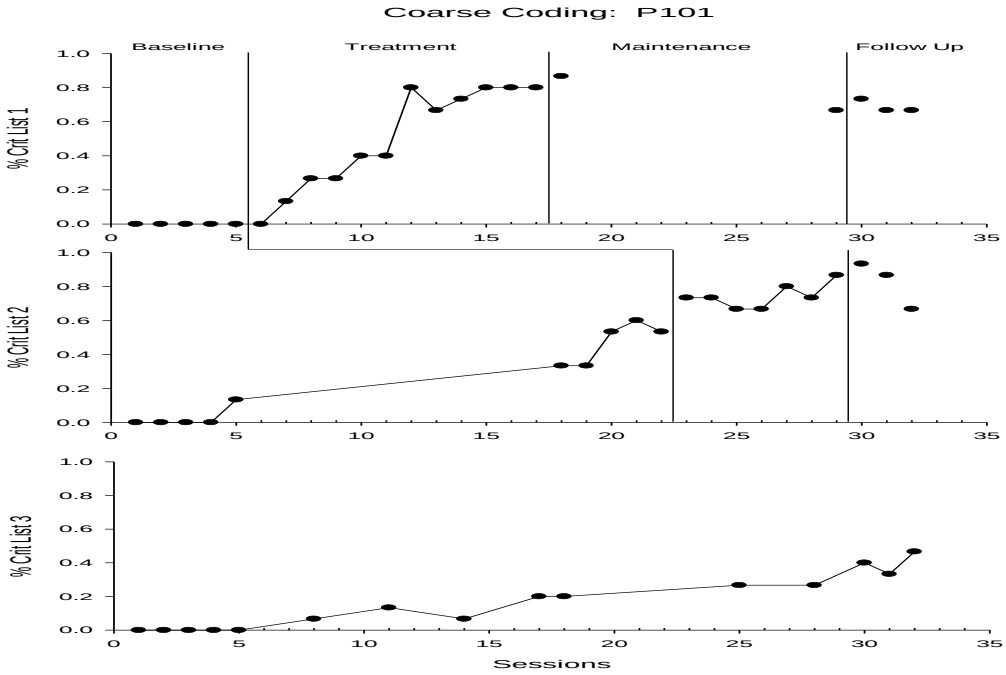
*****Baseline not repeated; these DCT scores from CC treatment Follow-up 3.

Figure 1. Flowchart for Contextual Constraint Treatment.



Original stimulus = Probe stimulus.

Figure 2. %CRIT on 3 Probe Lists for 2 Coarse Coding Participants, in Baseline, Treatment, Maintenance, and Follow-up Phases.



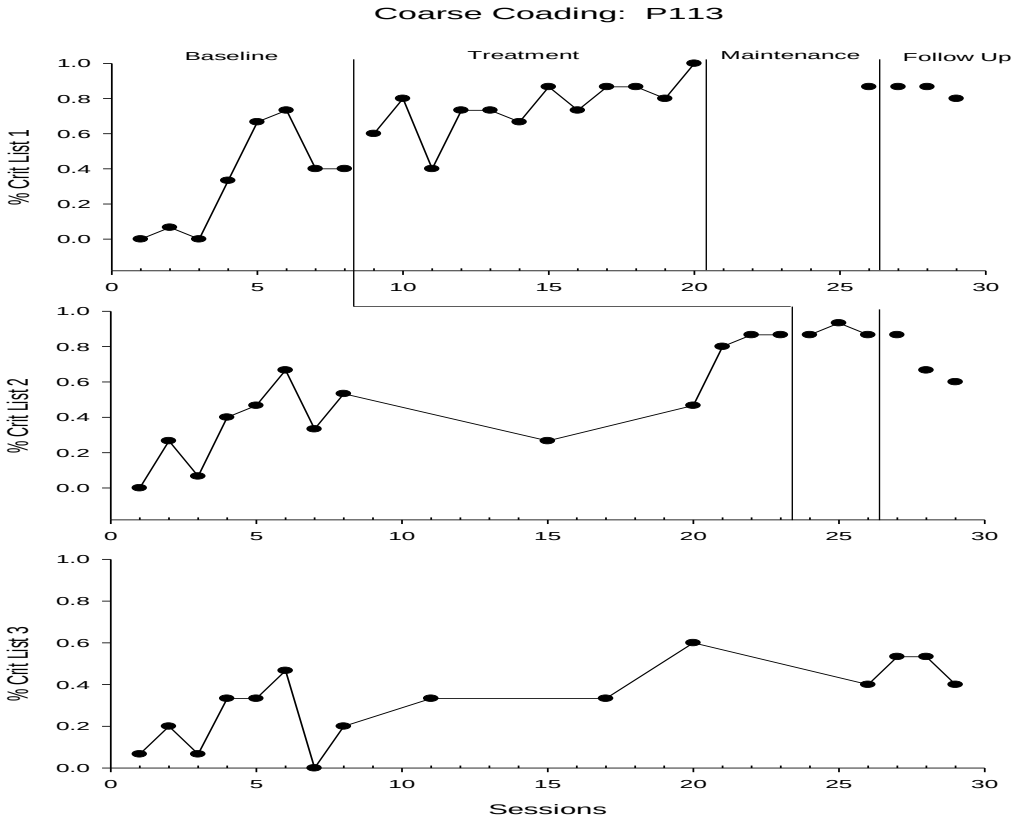
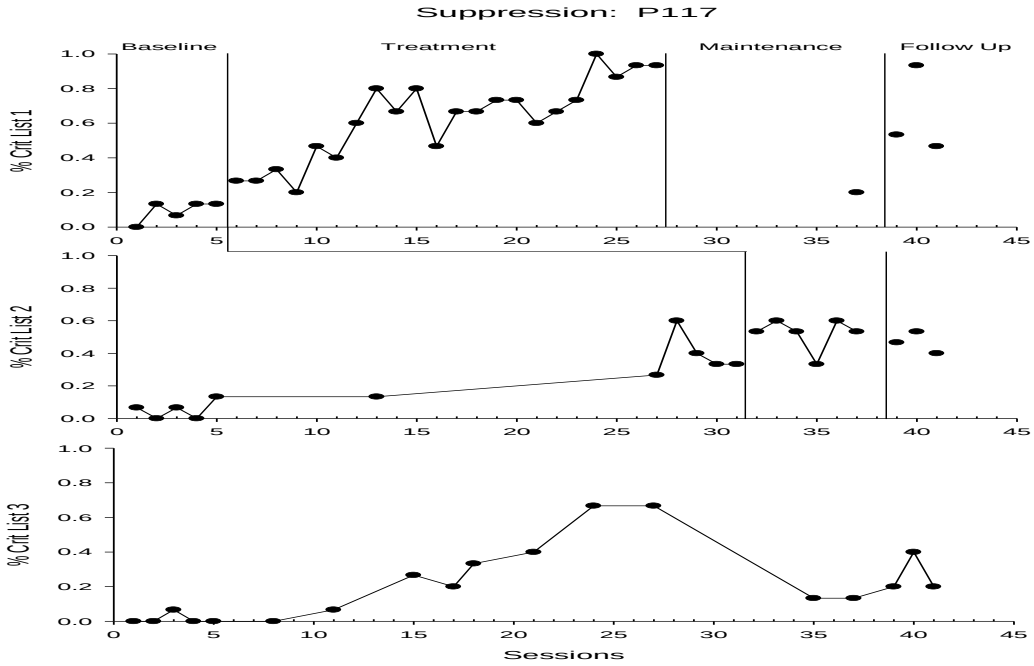


Figure 3. %CRIT on 3 Probe Lists for 2 Suppression Participants, in Baseline, Treatment, Maintenance, and Follow-up Phases.



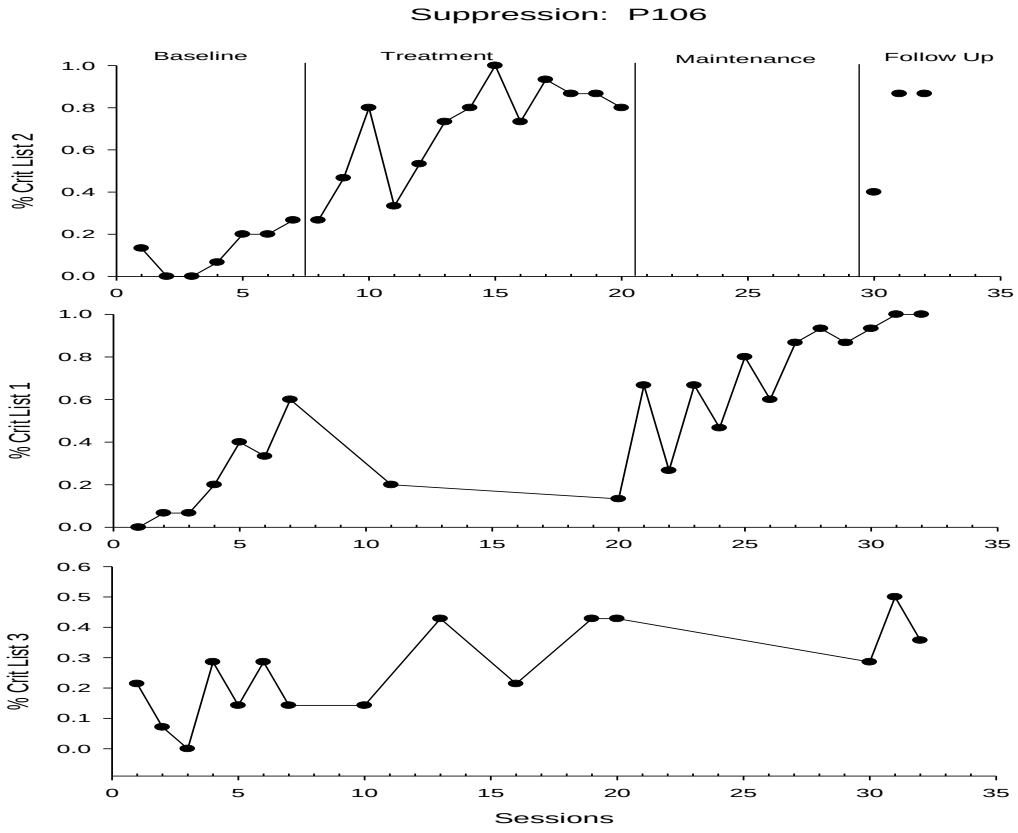
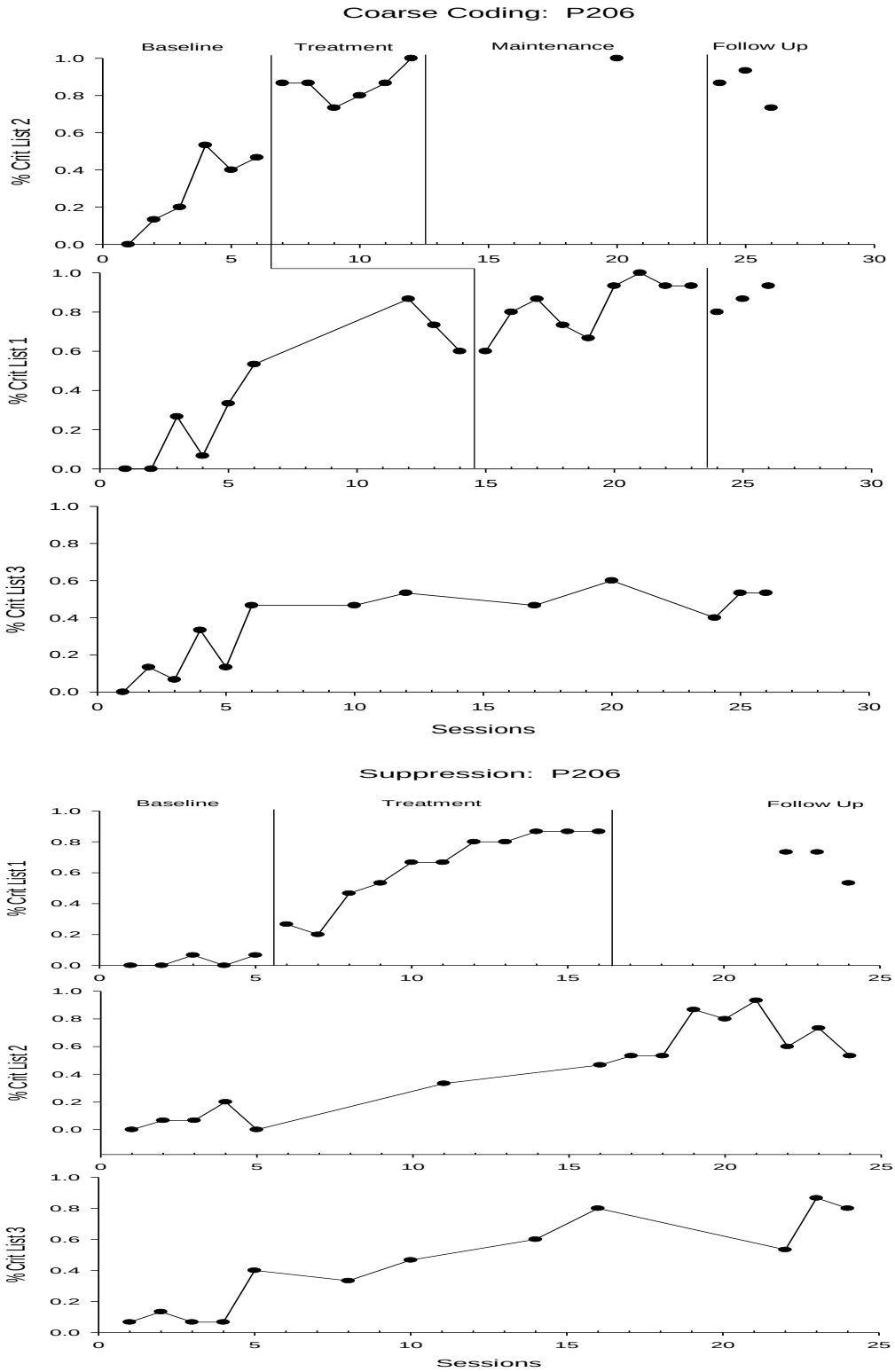


Figure 4. %CRIT on 3 Probe Lists for Participant 206, in both Coarse Coding and Suppression Treatment, in Baseline, Treatment, Maintenance, and Follow-up Phases.



Appendix

Summary Results for Social Validity for 3 Participants in Whom it was Assessed*

CC 101: Improvements noted by both participant and spouse, especially increased willingness to attempt conversations and overall socialization. Participant also reported memory improvement.

SUPP 117: Participant no differences on BOSS items but improved short-term memory. Spouse identified gains in almost all BOSS Social Outcome Scale items, and improved conversational skills.

SUPP 206: Gains noted by both participant and spouse, especially for starting conversations. Participant noted increased confidence with relationships. Both said participant listened better after treatment.

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*Comparison of participants' and spouses' pre-post treatment responses to *Burden of Stroke Scale* (BOSS; Doyle et al., 2004[13]) Social Outcomes Scale, and open-ended questioning re: whether anything had changed since initial study contact.