This study examines two language processing functions that have the potential to create socially handicapping language comprehension difficulties in adults with right hemisphere brain damage (RHD). The first, coarse semantic coding, allows normal comprehenders to bring to mind distant meanings or features of words that are appropriate in highly specific contexts (e.g., the "rotten" feature of the word "apple" in the context of spoiled produce). The second, suppression, is a process that inhibits contextually-irrelevant meanings (e.g., the "card-playing" meaning of the word "spade" in "He dug with the spade."). In prior work, some adults with RHD were found to have impaired suppression[1-4] or coarse coding processes[5-6]. These language processing impairments can make it difficult for individuals with RHD to participate in everyday social communication. For example, they can have trouble thinking beyond the most typical instance of an entity (e.g., an apple that's red, round, and crunchy) when another instance is being referred to (e.g., an apple that's rotten). Another possibility is they can be misled by ambiguities which are commonplace in conversation, and have difficulty getting back on track (e.g., keeping in mind the "card-playing" meaning of the word "spade" in a sentence like "He dug with the spade"). These problems predict comprehension performance on measures of narrative comprehension, as well[7,8].

To date, there is no information about how prevalent these deficits are, or how often they may co-occur in the same individual. This project identifies the proportions of a sizeable group of adults with RHD that have either a coarse coding deficit, a suppression deficit, co-occurring deficits, or neither deficit in reference to criteria developed from prior studies of healthy control subjects[1-3,5,6].

Method

Participants. (see Table 1) Forty-seven adults participated. All had unilateral RHD due to cerebrovascular accident (confirmed by CT/MRI scan reports) and met inclusion criteria for native language, handedness, and hearing.

Tasks. An auditory lexical decision task was used to identify participants with a coarse coding deficit[5-6]. There were 15 experimental stimuli built around semantically-neutral sentences ending with a common concrete, unambiguous noun (e.g., “There was a piano”). These sentences were followed by a 175 ms inter-stimulus interval and a target phoneme string for the lexical decision. In experimental trials, the target was a common, concrete, unambiguous noun that was distantly related to the sentence-final noun (e.g., SONG). Ten filler items interspersed through the task were similarly constructed neutral sentences followed by non-words (e.g., FURNIBO), closely related words, or unrelated words. The participants’ task was to indicate whether the target phoneme string was a real word or a nonword by pressing either “yes” or “no” on a manual response box. “Yes” was the correct response for all experimental coarse coding items. While participants were completing this primary lexical decision task, a secondary word monitoring task was included to encourage participants to listen carefully to each sentence.

Suppression deficits were identified using an auditory relatedness judgment task[1-2]. The probe stimuli were 20 short sentences that were semantically-biased toward the dominant meaning of a sentence final ambiguous noun (e.g., “He trained the seal”). These sentences were followed by a 1000 ms inter-stimulus interval and a target word indicative of the subordinate meaning of the sentence-final ambiguous word (e.g. TIGHTEN). The participants’ task was to indicate whether the target word was related to the sentence by pressing either “yes” or “no” on a manual response box. For all experimental suppression items, “No” was the correct response. Twenty-two filler items interspersed throughout the task were similar in structure to the experimental items and included sentences that ended in both ambiguous and non-ambiguous words. Approximately half of the filler sentences were followed by target words requiring a "Yes" response (e.g. "He ate the trout -FISH"). The other half included target words based on the dominant meaning of the sentence and also required a "Yes" response to further disguise the experimental trials.

Both accuracy and millisecond response times (RTs) were collected for all probe words via the E-Prime Serial Response Box™. To encourage participants to keep responding quickly, after 60% of filler items a "ding" (standard Microsoft Windows bell sound) was presented after the target word. Participants were diagnosed with a coarse coding or suppression deficit if they were inaccurate or too slow on over 50% of the experimental stimuli. RTs were defined as "too slow" with reference to the median RT for each experimental item based on healthy adult control group data from prior studies[1,2,5,6]. RTs that were longer than 1.5 times the per-item RT from the control group were categorized as too slow and were counted toward the deficit classification.

Procedures. Participants completed the Immediate and Delayed story retell task from the Arizona Battery for Communication Disorders[9] (ABCD) to rule out incipient dementia. In addition, an extensive hearing screening procedure was completed measuring both pure tone thresholds and speech perception. Participants with unaided hearing loss were classified into specific hearing profiles as needed. Following these screening measures, participants listened through an external speaker as the diagnostic stimuli were played via laptop computer using E-Prime 2.0 software[10]. The stimulus sound files were frequency-shaped to match participants' hearing profiles. The presentation order of the diagnostic tasks was counterbalanced across participants and the session lasted between 60-90 minutes.

Results

Table 2 provides the number of participants who were identified in one of four potential categories: coarse coding deficit only (4.3%), suppression deficit only (36.2%), both coarse coding and suppression deficits (29.8%), and neither processing deficit (29.8%). Also included in Table 2 are the means and standard deviations from these subgroups on each experimental task.

Discussion and Implications

Cognitive-communication deficits have been reported for approximately 80-90%[11,12] of adults with RHD in rehabilitation units, however, there continues to be a dearth of information in the field for accurately diagnosing and providing treatment for this understudied population. Determining the prevalence of these two central language processing deficits is a step toward filling this gap. In this sample, 66% (31/47) of the participants evidenced a suppression deficit either in isolation or in conjunction with a coarse coding deficit. The degree of ineffective suppression has predicted general narrative comprehension in prior work[3] and a suppression deficit has been linked to decreased performance on tasks that require the resolution of competing interpretations. Coarse coding deficits were considerably less frequent at 34% (16/47), but this type of deficit has been associated with decreased comprehension of implied information[6,7,13]. Both deficits are responsive to treatment[7,8,13] and improvements in these basic language processes generalize to narrative comprehension[7,8].

Suppression and coarse coding processes work in tandem during normal comprehension. Initially, coarse semantic coding activates distant word meanings and features that may be less likely depending on the broad context. The suppression mechanism then steps in to prune away contextually-irrelevant interpretations to arrive at a final interpretation. The potential impact of co-occurring comprehension deficits in adults with RHD (29.8%) is striking, especially when treatment for one these deficits may contradict the treatment needed for the other. For example, it might be possible to make a suppression deficit worse by strengthening coarse coding functions. Work in this lab continues to examine treatment response as well as the neuroanatomical correlates of ineffective suppression function and coarse coding deficits.

Table 1. Demographic and clinical characteristics of stroke population.

Characteristics	**RHD** (N=47)
Age (years)	
Mean (SD)	66.6 (11.8)
Range	42-88
Sex	20 female
Education (years; N=46)	
Mean (SD)	14.8 (2.8)
Range	10-20
Months post-onset	
Mean (SD)	64
Range	6-215
ABCD[a] Story Retell Immediate (N=45)	
Mean (SD)	14.6 (1.9)
Range	11-17
ABCD[a] Story Retell Delayed (N=44)	
Mean (SD)	14.4 (1.8)
Range	10-17
(Maximum=17)	
Site of Lesion (N=41)	
1. Right Cortical Anterior	3
2. Right Cortical Posterior	2
3. Right Cortical Mixed	4
4. Right Subcortical	14
5. Right Cortical+Subcortical	13
6. Right Middle Cerebral Artery	4
7. Right Other	1

Note. RHD = Right-hemisphere-damaged
[a]Bayles, K. A. & Tomoeda, C. K. (1993). Arizona Battery for Communication Disorders of Dementia. Tuscon, AZ: Canyonlands Publishing.

Table 2. Subgroups identified based on diagnostic task performance (errors + too slow responses).

	RHD
Coarse Coding Only Deficit[a]	N=2
Mean (SD)	9.5 (0.7)
Range	9-10
Suppression Only Deficit[b]	N=17
Mean (SD)	13.2 (3.2)
Range	10-20
Coarse Coding[a] + Suppression[b] Deficit	N=14
Coarse Coding Mean (SD)	12.5 (2.2)
Range	8-15
Suppression Mean (SD)	17.4 (2.3)
Range	11-20
No Deficit	N=14
Coarse Coding Mean (SD)	1.6 (1.8)
Range	0-7
Suppression Mean (SD)	6.2 (2.2)
Range	3-9

Note. RHD = Right-hemisphere-damaged

[a]Coarse coding deficit = inaccurate or too slow compared to a healthy control group on 8 or more of 15 experimental items

[b]Suppression deficit = inaccurate or too slow compared to a healthy control group on 10 or more of 20 experimental items

Appendix A: Sample experimental stimuli for diagnostic tasks

Coarse Coding

He drank some coffee.	BEANS
There is the mustard.	PLANT

Suppression

He ate the perch.	LEDGE
She picked up the ball.	DANCE