Narrative comprehension is vital to socializing and everyday communication. Understanding references to *time* is fundamental to comprehending the context and order of events within a narrative. This study examined the functioning of a central comprehension mechanism, suppression[1,2], in narratives that cue a shift in timeframe in individuals with right hemisphere brain damage (RHD).

The timeframe in normal narrative processing is assumed to be continuous[3-4]. Shifts in the timeframe of events trigger the suppression mechanism, which reduces a comprehender's mental activation of information that was processed before the time shift. When the timeframe of a narrative is disrupted (e.g., something happens "an hour later"), information that was mentally active before the time shift becomes less relevant and is suppressed.

Suppression is a general comprehension mechanism that acts across language levels and domains (e,g, words, sentences, narratives, etc.)[1,5.] Based on evidence of RHD *suppression deficit* in lexical ambiguity processing[6-7,] it was predicted that adults with RHD would also have difficulty suppressing information from a prior timeframe following a shift in narrative timeline. In addition, we predicted a correlation between suppression and narrative comprehension, as reported previously for young normal comprehenders[1-2,5] and adults with RHD[6].

Method

Participants. (see Table 1) Twenty adults participated. Twelve had unilateral RHD due to CVA (confirmed by CT/MRI scan reports); eight were non-brain-damaged (NBD) controls without neurologic impairment. All met inclusion criteria for native language, handedness and hearing acuity.

Task. Participants listened to 10 narratives, each with 12 interspersed probe words. The experimental task was speeded word recognition, in which participants indicated manually (Yes/No) whether a probe word had occurred earlier in the narrative. Each probe word occurred in both No Shift (i.e. "A moment later…") and Shift (i.e. "An hour later…") conditions. Immediately following the final response for each narrative, participants answered three Yes/No questions about the narrative content.

Stimuli. (see Appendix A) Narratives were loosely based on stimuli from Speer and Zacks[3]. Each revolved around a single character in a single location and common situation. Each consisted of three sentence types: Introduction (or transition) sentences to set up or help the story progress, Object sentences which contained the probe words, and Timeframe initiation sentences which began with the phrase "A moment/An hour later." There was a 175 ms inter-stimulus interval between the sentence-final word offset of a Timeframe initiation sentence and onset of a probe word. To aid perceptual segmentation, the narratives were spoken by a female and the probe words produced by a male.

Two versions of each narrative were developed so each probe word could occur in both No Shift and Shift conditions. The two versions differed in protagonist and setting. Each narrative contained 20-24 sentences and as audio-recorded was 2-3 minutes long.

Experimental probe words were unambiguous 1-3 syllable nouns mentioned only once in each version of their corresponding narratives. These critical nouns occurred at least seven syllables prior to being probed, to control for intralexical priming, but never in the sentence-final position. Filler probe words, which were not mentioned in the stories, were included to disguise the relationship between Timeframe sentences and "Yes" recognition responses.

Procedures. RHD participants completed all tasks in two sessions while NBDs required only one. Participants listened through an external speaker as each narrative played via laptop computer using E-Prime 1.0 software[8]. Both accuracy and millisecond RTs were collected for all probe words via the E-Prime Serial Response Box™.

Results

Table 2 provides the accuracy results for the probe words in the No Shift and Shift conditions. The NBD group was more accurate overall, with a significant difference between groups in both the No Shift ($t(18) = .001$, $p < .01$) and Shift conditions ($t(18) = .013$, $p < .05$).

RTs were analyzed only for accurate trials. RT proportions (Shift/No Shift; see Table 2) were calculated when there were valid RTs in both conditions, to adjust for inter-individual differences in basic manual RT. In the case of a functioning suppression mechanism, the Shift condition was expected to yield longer RTs than the No Shift condition, and a proportion value of >1. This is because in the Shift condition, the information being probed had been provided in a *prior* timeframe and as such would be less accessible and take longer to retrieve. A suppression deficit is index by a proportion ~ $\leq$1, indicating no RT disadvantage for information probed from a prior timeframe.

RT proportions were submitted to independent *t*-test which indicated no significant difference between groups ($t(18) = .644$, $p > .05$). Half of the RHD participants, however, had proportions values at or less than 1, indicative of a suppression deficit.

There were a few hints of differences between the RHD Suppression Deficit subgroup and the RHD subgroup that performed more like the NBD participants. One of the participants in the No Deficit subgroup had a very mild neglect, but there were 3 participants with neglect in the Suppression Deficit subgroup (1 mild; 2 moderately-severe). Perhaps more interesting, four of six participants in the No Deficit subgroup (N=6) had purely posterior lesions, but only one participant in the Suppression Deficit subgroup had a purely posterior lesion.

Within the Suppression Deficit subgroup, Pearson correlation analysis indicated clinically large relationships between RT proportions and narrative comprehension, as indexed by the Discourse Comprehension Text (DCT)[9] (*r* (DCT Total accuracy score) = 0.82; *r* (DCT Accuracy for questions about implied information = 0.74).

Discussion and Implications

It was predicted that a documented RHD deficit in suppressing contextually-irrelevant meanings of words would similarly be evident when adults with RHD processed narratives with discontinuous timeframes. This study's RHD group was expected to have difficulty suppressing mental activation for information from a prior point on a narrative timeline. This prediction, however, did not obtain for the group as a whole. In the lexical studies, the to-be-suppressed information (e.g., the card-playing meaning of "spade ") was contextually-incompatible with the intended interpretation of a stimulus ("He dug with a spade"). In the current study, there was no such incompatibility. Rather, the material to be suppressed was represented at a difference point on the single, linear dimension of "time." This representational difference may make suppression easier for concepts from a prior narrative timeframe than for distinct, contradictory meanings of lexical items.

Half of the RHD group did evidence a suppression deficit, consistent with the fact that suppression function is an individual difference variable[1,6]. The majority of the participants in the No Deficit RHD subgroup had purely posterior lesions, which is interesting in light of the suggestion that a suppression deficit is more likely to be associated with a right inferior frontal gyrus/subcortical circuit than with purely posterior lesions[10].

In addition, three of the six participants in the Suppression Deficit subgroup were also recently diagnosed with a suppression deficit for lexical-level material and are in an ongoing treatment study. It will be intriguing to evaluate whether treatment for lexical-level suppression deficit generalizes to suppression of activation for prior narrative timeframe information.

Regardless of the nature of similarities and differences between lexical-level and narrative-level suppression function, suppression at both levels predicts narrative comprehension by individuals with RHD. Overall, a better understanding of the nature and boundary conditions of RHD suppression deficits should help us make better clinical decisions for this population.

References

1. Gernsbacher, M. A. (1990). *Language comprehension as structure building*. Hillsdale, NJ. Erlbaum.
2. Gernsbacher, M. A. (1995). The structure building framework: What it is, what it might also be, and why. In B. K. Britton & A. C. Graesser (Eds.). *Models of text understanding* (pp. 289-311). Hillsdale, NJ: Lawrence Erlbaum Associates.
3. Speer, N. K. & Zacks, J. M. (2005). Temporal changes as event boundaries: Processing and memory consequences of narrative time shifts. *Journal of Memory and Language, 53(1), 125-140.*
4. Zwaan, R. A. (1996). Processing narrative time shifts. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, *22*, 1196-1207.
5. Gernsbacher, M. A. & Faust, M. (1991). The mechanism of suppression: A component of general comprehension skill. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *17*, 245-262.
6. Tompkins, C. A., Baumgaertner, A., Lehman, M. T., & Fassbinder, W. (2000). Mechanisms of discourse comprehension impairment after right hemisphere brain damage: Suppression in lexical ambiguity resolution. *Journal of Speech, Language, and Hearing Research, 43*, 62-78.
7. Klepousniotou, E. & Baum, S. R. (2005). Processing homonymy and polysemy: Effects of sentential context and time-course following unilateral brain damage. *Brain and Language*, *95*(3), 365-382.
8. Schneider, W., Eschman, A., & Zuccolotto, A. (2002). E-prime user's guide. Pittsburgh, PA: Psychology Software Tools Inc.
9. Brookshire, R. H., & Nicholas, L. E. (1993). The Discourse Comprehension Test. Tucson, AZ: Communication Skill Builders, a Division of the Psychological Corporation.
10. Tompkins C.A., Klepousniotou E., & Gibbs Scott A. (2011). Nature and assessment of right hemisphere disorders. In: Papathanasiou I., Coppens P., Potagas C., editors. *Aphasia and related neurogenic communication disorders* (pp. 297-343). Sudbury, MA: Jones and Bartlett.

Table 1. Demographic and clinical characteristics of two participant groups.

Characteristics	**RHD** (N=12)*	**NBD** (N=8)
Age (years)		
Mean (SD)	68.6 (12.2)	66.4 (8.1)
Range	49-84	53-78
Gender	5 female	4 female
Education (years)		
Mean (SD)	14.8 (3.3)	13.5 (2.1)
Range	10-20	12-18
Months post-onset		
Mean (SD)	77.8 (54.7)	Not applicable
Range	5-178	
Peabody Picture Vocabulary Test-R[a]		
Mean (SD)	157.6 (13.5)	165.8 (3.1)
Range	134-173	160-170
(Maximum = 175)	N=8	
Behavioural Inattention Test[b]		
Mean (SD)	127.8** (20.0)	143 (5.3)
Range	77-146	130-146
(Maximum = 146; neglect cutoff = 129).		
Auditory Working Memory for Language[c]		
Word recall errors		
Mean (SD)	12.4** (4.9)	7.1 (5.5)
Range	3-18	1-16
(Maximum errors = 42)		
Judgment of Line Orientation[d]		
Mean (SD)	21.1*** (7.1)	28.8 (2.7)
Range	10-31	25-33
(Age & gender corrected score; maximum = 35)		
Visual Form Discrimination[e]		
Mean (SD)	26.3** (4.7)	30 (1.2)
Range	16-32	28-32
(Maximum = 32; cutoff for defective performance = 23)		

ABCD[f] Story Retell Immediate		
Mean (SD)	15.4 (1.4)	16.4 (.92)
Range	13-17	15-17
ABCD Story Retell Delayed		
Mean (SD)	14.9 (1.3)	15.9 (1.2)
Range	12-16	14-17
(Maximum=17)		
Discourse Comprehension Test[g]		
Mean (SD)	31.8 (5.1)	34.8 (2.4)
Range	20-37	32-39
(Set A; maximum=40)		

Note. RHD = Right-hemisphere-damaged; NBD = Non-brain-damaged.
*N=11 for all clinical measures in RHD group
**Significantly different by independent *t*-test at $p<.05$
***Significantly different by independent *t*-test at $p<.01$
[a] Dunn, L. M. and Dunn, L. M. (1981). Peabody Picture Vocabulary Test: Revised Edition. Circle Pines, MN: American Guidance Service.
[b] Wilson, B., Cockburn, J., & Halligan P. W. (1987). Behavioural Inattention Test. Tichfield, England: Thames Valley Test Company.
[c] Tompkins, C. A., Bloise, C. G. R., Timko, M. L. & Baumgaertner, A. (1994). Working memory and inference revision in brain-damaged and normally aging adults. *Journal of Speech and Hearing Research, 37,* 896-912.
[d]Benton, A. L. Hamsher, K. D., Varney, N. R., & Spreen, O. (1983). Judgment of Line Orientation. In *Contributions to neuropsychological assessment*. (pp. 44-54). New York: Oxford University Press.
[e]Benton, A. L., Sivan, A. B., Hamsher, K. D., Varney, N. R. & Spreen, O. (1983). Visual Form Discrimination. In *Contributions to neuropsychological assessment* (2nd ed.), (pp. 65-72). New York: Oxford University Press.
[f]Bayles, K. A. & Tomoeda, C. K. (1993). Arizona Battery for Communication Disorders of Dementia. Tuscon, AZ: Canyonlands Publishing.
[g]Brookshire, R. H., & Nicholas, L. E. (1993). The Discourse Comprehension Test. Tucson, AZ: Communication Skill Builders, a Division of the Psychological Corporation.

Table 2. Accuracy and RT proportions (means, SDs) for probe words and comprehension questions of two participant groups

	RHD	NBD
Accuracy (max=20)		
No Shift Condition		
Mean	17.8** (1.1)	19.5 (.76)
Range	16-20	18-20
Shift Condition		
Mean	17.3* (1.5)	19 (1.2)
Range	14-19	17-20
RT proportions (Shift/No Shift)		
Suppression Probe Proportion		
Mean	1.14 (.24)	1.14 (.12)
Range	.86-1.57	.99-1.34
Comprehension Questions (max=30)		
Mean	28.1 (1.3)	28.5 (.76)
Range	27-29	27-29

Note. RHD = Right-hemisphere-damaged; NBD = Non-brain-damaged.
* Significantly different by independent *t*-test at $p<.05$
**Significantly different by independent *t*-test at $p<.01$

Appendix A: Sample Narrative Excerpt

Introduction	It was the last week of winter and Frank told his wife he would clean up the basement.
Object	As he started down the stairs, he closed the DOOR behind him.
No Shift	A moment later he turned on all the lights.
Suppression Probe	DOOR
Introduction	Frank walked to the back of the basement and got to work.
Object	He started to make room on the SHELVES to put all of the garden supplies.
Filler Probe	CARPET