Working Memory Treatment for an Individual with Chronic Aphasia: A Case Study

Working memory (WM) is defined as a storage system limited in its capacity and involved in maintaining and manipulating information over short periods of time (Baddeley, 2003). In WM tasks, individuals are required to simultaneously store certain items in memory while updating the contents of their WM. It has been proposed that WM interacts with language abilities and deficits in WM influence language performance (Baddeley, 2003; Carpenter, & Just, 1989; Murray, 2012). Importantly, individuals with aphasia often show WM and short-term memory (STM) deficits, which may negatively affect language symptoms and recovery, and accordingly WM treatment may represent an efficient approach to addressing these individuals' cognitive *and* linguistic impairments (Kalinyak-Fliszar, Kohen, & Martin, 2011; Murray, 2012; Martin et al., 2012).

WM treatment for individuals with aphasia, however, has not yet been intensively studied (Murray, 2012). Previous results indicate that WM in individuals with aphasia can be improved with training (e.g., Kalinyak-Fliszar et al., 2011; Mayer & Murray, 2002; Vallat et al., 2005). Nonetheless, variable amounts of generalization to language abilities and types of untrained cognitive and linguistic functions responding to the WM treatment have been reported. Accordingly, to examine further the potential of WM training to remediate the cognitive-linguistic symptoms of individuals with aphasia, we administered a treatment with tasks designed not only to target WM skills but also semantic processing, the linguistic ability most compromised in our aphasic participant. The research questions were:

a) Would our participant with chronic aphasia demonstrate improved WM through treatment?
b) Would our participant demonstrate improved language performance given WM tasks that involved verbal stimuli?

Methods

Participant. G.P. was a 42-year old, right-handed male. He was a native English speaker with 13 years of education who had been working in management until suffering an anoxic brain injury due to cardiac arrest in April 2009. The injury resulted in severe aphasia and concomitant cognitive problems, particularly in the domain of memory. He had received language therapy and cognitive compensatory strategy training (e.g., memory book use) for two years prior to the study.

Procedures. Cognitive and linguistic tests were administered at pre-treatment, immediately post-treatment, and 6 weeks following treatment termination (Table 1). Spoken discourse samples were elicited in two different conditions: (a) an "online" condition in which G.P. generated a story while viewing a picture-only booklet that contained *The Bear and the Fly* story, and (b) an "offline" condition in which he generated a story after looking through and then putting away the same booklet. So far samples have been analyzed for correct information units (CIUs; Nicholas & Brookshire, 1993).

Pre-treatment testing indicated that G.P. presented with mild anomic aphasia, characterized by word retrieval, reading, and spelling difficulties. Although he showed very poor performance on semantic tasks, his phonological STM appeared relatively intact. He performed within normal on attention subtests, but on the *RBMT-III* he demonstrated severe deficits in verbal, visual, spatial, and prospective memory as well as new learning.

G.P. received a total of 20 treatment sessions (5 days a week, 60 min/session). Training tasks included: N-back with pictures, updating with pictures, reading span, naming with spaced retrieval, generating sentences with an opposite meaning to the presented sentence stimuli, N-back with written words, updating with written words, and reconstitution of words from oral spelling. Most tasks placed demands on semantic processing as well as WM by requiring G.P. to identify the semantic relationship between stimuli or to retain or retrieve certain semantic information. G.P. also completed approximately 30 minutes a day of at-home practice with his primary caregiver.

Results and Discussion

G.P. improved at all trained WM tasks over the course of treatment. On post-treatment cognitive testing (Table 1), he showed substantial gains on the verbal identity span *TALSA* subtest, with his list length increasing from 5 to 12 (the latter of which is equivalent to the mean of normal controls). Importantly, this span gain was maintained at the 6-week follow up. Improvement on the semantic span subtest was also observed, but was less substantial and more poorly maintained compared to the verbal identity span. Notably, these spans significantly increased even though treatment tasks were dissimilar to these span tasks. A substantial improvement of more than 2 standard deviations was observed on the D-KEFS *Design Fluency* subtest; it is possible that WM improvements contributed to this gain because (a) the design fluency condition on which G.P. had to demonstrate inhibition by connecting only filled dots was the condition for which he made the most improvements, and consequently, (b) components of WM include inhibition and resource allocation (Conway & Engle, 1994). Whereas it is promising that G.P. responded to this WM training to some extent despite his severe and diffuse brain damage, it must be noted that his performances of other cognitive tests did not change following treatment.

In terms of language outcomes, G.P. demonstrated nominal improvements in naming and auditory comprehension, but modest gains in his spoken discourse (Table 2). For instance, compared to his pre-treatment samples, higher percentages of CIUs and more efficient output (i.e., CIUs/min) were identified in his samples collected immediately and 6-weeks following treatment termination. These minor language improvements contrasted with those expected given (a) the previously identified significant relationship between STM/WM and language performances in individuals with aphasia (Martin et al., 2012; Sung et al., 2009; Seniow et al., 2009), supporting the premise that WM treatment may ameliorate aphasic language symptoms, and (b) WM treatments have been previously associated with remarkable improvements in the language abilities of individuals with aphasia (Kalinyak-Fliszar et al., 2011; Koenig-Bruhin & Studer-Eichenberger, 2007; Majerus et al., 2005). Our generally null language findings may relate, at least in part, to the difference between G.P.'s language profile and that of participants in prior WM treatment studies: Whereas G.P. demonstrated relatively good repetition and auditory comprehension at the onset of this study, participants in previous investigations had substantial difficulties in these language areas, and subsequently with WM treatment, demonstrated gains in these language areas (more so than in naming, the area of greatest difficulty for G.P.). Additionally, in contrast to the primarily phonological impairments and focal lesions (due to stroke) of prior participants, G.P. demonstrated semantic processing deficits and a diffuse lesion due to anoxic brain injury. Finally, the number of therapy sessions G.P. received was far less than that provided in previous investigations.

Lastly, the daily planning score and the score of social communication function of *ASHA-FACS* reported by his caregiver were increased after the treatment. Whereas these results might have been confounded by his follow up sessions of language therapy in which the use of external memory aids and strategies were emphasized, it is important to note that prior to this study, he had received similar compensatory strategy training. Other aspects of the *ASHA-FACS* did not change throughout the study.

In summary, despite cognitive improvements following participation in our WM treatment protocol, G.P. demonstrated only modest language gains. Future research is needed to address not only the limitations within the current study (e.g., weak research design), but also to identify participant characteristics and cognitive treatment procedures and therapy schedules that will foster positive cognitive-linguistic changes in individuals with aphasia following their participation in cognitive treatment.

TABLE 1. Pre-, post-treatment and 6-week follow up test results

Measure	Pre-treatment	Post-treatment	6-week follow up
Western Aphasia Battery-Revised (maximum score)			
Spontaneous speech (20)	17.5	17.5	
Comprehension (10)	9	8.85	
Repetition (10)	9.2	9.8	9.4
Naming (10)	5.3	6.3	6.7
AQ (100)	82	84.9	
Reading (100)	67	66	
Writing (100)	95.5	93	
LQ (100)	82.5	83.1	
Psycholinguistic Assessments of Language Processing in Aphasia (maximum score)			
Sentence repetition (36)	36	36	
Regularity & Spelling (40)	23	25	27
Regular words (20)	17	17	16
Irregular words (20)	6	8	11
Test of Adolescent/Adult Word Finding			
Raw score	5	7	10
Scaled score (%ile)	< 32 (0.1)	< 32 (0.1)	32 (0.1)
Percent of known words named correctly	25%	33.3%	43.48%
Prorated accuracy SS (prorated %ile)	32 (0.1)	39 (0.1)	47 (0.1)
Temple Assessment of Language and Short-term memory in Aphasia			
Word span			
Verbal response serial order	5.23	5.23	5.29
Pointing response serial order	4.29	4.31	4.2
Digit span			
Verbal response serial order	7	7	7
Pointing response serial order	7	7	7
Word span serial order	5	5	5
Nonword span serial order	3.19	3.23	3.18
Identity span	5	11.95	12
Phonological span	7	6.82	7
Semantic span	1.67	4.55	2.98
Revised Token Test (15 max)			
Raw score (%ile)	13.89 (87)	14.45 (93)	14.47 (93)
Delis-Kaplan Executive Function System			
Design Fluency Test			
Composite scaled score (M 10, SD 3)	1	8	3

Condition 1 (filled dots)	5	5	6
Condition 2 (empty dots only)	2	8	4
Condition 3 (switching)	0	3	1
The Wechsler Memory Scale-Revised			
Forward raw score	6	7	6
scaled score	6	8	6
Backward raw score	7	3	4
scaled score	10	4	5
Composite raw score	13	10	10
scaled score	8	5	5
Rivermead Behavioral Memory Test-III			
Scaled score (%ile)	30 (< .01)	27 (< .01)	
General memory index (M 100, SD 15)	53	53	
95% confidence interval	42-63	42-63	
Test of Everyday Attention	SS (%ile)		
Elevator counting	7	7	
Elevator counting with distraction	13 (> 75)	10 (> 75)	
Telephone search while counting	19/19	19/19	
Pyramids and Palm Trees (max 52)			
Raw score *(%)*	29 (55.77)	24 (46.15)	28 (53.85)
ASHA Functional Assessment of Communication Skills for Adults			
Social communication	5.62	5.62	6.29
Communication of basic needs	6.33	6.67	6.67
Reading, writing, number concept	6.4	6.44	6.4
Daily planning	5.4	6.4	6.6

TABLE 2. Correct information unit (CIU) analyses for spoken discourse samples

	Pre-treatment	Post-treatment	6-week follow up
Offline condition			
Word	55	61	96
CIUs	26	33	58
%CIUs (%)	47.27	54.1	60.42
CIUs/minute	24	34.14	37.82
Words/minute	50.77	63.1	62.61
Online condition			
Word	488	632	504

CIUs	163	242	260
%CIUs (%)	33.4	38.29	51.59
CIUs/minute	25.87	39.56	43.94
Words/minute	77.46	103.32	85.18

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