Introduction

The ability to repeat a word involves activation of phonological and semantic representations of words that must be maintained until the utterance is produced. In aphasia, the language and verbal STM impairment frequently co-occur and studies indicate that the severity of these impairments are highly correlated (Martin & Ayala, 2004). One account of this co-occurrence is that the word processing impairment in aphasia is due to an inability to maintain activation of semantic and phonological representations of words over the time course of comprehending, repeating, or producing a word. When severe, this impairment affects single and multiple word processing as well as verbal STM capacity, as measured by verbal span. When milder, the impairment affects multiple word processing and verbal STM capacity. This intimate relationship of lexical access/retrieval and the ability to maintain activation of a word's representations suggests a need to consider the role of verbal memory load on language performance. For example, it has been shown recently that performance on semantic judgment tasks is significantly reduced when memory load on the task is increased (Martin, Kohen, Kalinyak-Fliszar, Soveri & Laine, 2012). This study also identified two factors contributing to this effect, semantic STM capacity and an executive function, inhibition (performance on the Simon Task). Additionally, it has been shown that performance on phonological and lexical-semantic tasks is compromised by imposing an interval between stimulus and response (Martin, Kohen & Kalinayk-Fliszar, 2010; Martin, 2012).

Evidence that increased memory load impairs language performance has prompted some researchers to target the ability to tolerate increased memory load in language tasks as a means of improving language function as well as increasing verbal STM capacity. For example, Majerus, Van der Kaa, Renard, Van der Linden, & Poncelet (2005) treated a phonological STM deficit using delayed repetition of word pairs. There were improvements in digit and nonword span, nonword repetition, rhyme judgments, and by the client's self-report, comprehension in conversational contexts. Fridriksson, Holland, Beeson, & Morrow (2005) treated three cases of anomia using spaced-retrieval treatment, which varied interval time between presentations of a picture to be named (more time when named correctly and less time when named incorrectly). Compared to a cueing hierarchy treatment, the spaced retrieval approach showed more lasting improvements in follow-up testing. Kalinyak-Fliszar, Kohen & Martin (2011) used nonword and multisyllabic word repetition tasks combined with a delayed response (5 seconds) to improve phonological abilities of a person with conduction aphasia. Improvements were noted in repetition of treated stimuli and other language and verbal STM measures: rhyming and synonymy judgments, word pair repetition and seven verbal span tasks (of eleven administered).

These studies indicate that incorporation of variations in verbal memory load into language treatments can improve language function. However, it has not been demonstrated that the addition of STM load provides any greater benefit over and above the language treatment task. In this study, we use a short-term repetition facilitation paradigm to determine if increased memory load added to a repetition task improves performance more than repetition alone.

Aims of the study

Facilitation studies have been used to test the short-term effects of new treatments (e.g., contextual priming, Martin, Fink, Laine & Ayala, 2004). We used a one-shot intense facilitation paradigm to examine effects of repetition treatment with and without added memory load. Our aim was to determine if improvement in repetition of verbal stimuli was greater and/ or more lasting when an increase in STM load was added to the repetition training task. We examined short-term effects of massed repetition with and without increased memory load by imposing a 5-second or 10-second interval before a response. Our hypothesis was that individuals with aphasia will demonstrate greater short-term changes in repetition ability when training tasks include increased memory load compared to a no memory load condition.

Method

Participants. Four participants with fluent aphasia of varying types and severity and two participants with severe nonfluent aphasia participated in this study.

Procedure. A verbal repetition treatment task was administered under two conditions: (1) an immediate interval condition (no load) and (2) either a 5-second or 10-second unfilled interval condition (high load). In each condition, participants were trained on 10 verbal stimuli.

To accommodate variations in severity and type of aphasia, stimuli were selected by a pretest to determine the appropriate stimulus variation for each participant. Variations included multi-syllabic abstract words, multi-syllabic abstract word pairs, and multisyllabic nonwords. The stimulus type used for a participant was the one on which his/her performance was lowest. For each participant, the same stimulus variation was used for both conditions. In Condition 1, 10 stimuli were trained for immediate repetition (no load condition) for three cycles of treatment. In Condition 2, 10 new stimuli were trained for three cycles of treatment with either a 5-second or 10-second interval delay (high load condition) between stimulus and response. Stimuli were presented in a randomized order for each participant during both load conditions. The no interval (no memory load) condition was always administered first to avoid the possibility that performance on the high memory load condition would lead to better performance on the no interval (no memory load) condition. Additionally, we used different items in each memory load condition. Finally, pretests and post-tests were always administered with no-interval between stimulus and response.

Scoring. Proportions correct were noted in the pre-test. Post-tests were administered immediately after treatment, and at 10-minute, 30 minute, 24-hour, and when possible, 48 hour intervals. The dependent variable was the proportion correct on post-tests above that on the pre-test proportion correct in each condition. The rates of improvement in the no-load and high load conditions were compared using Fisher's exact test. See Table 1.

Results

Results showed that for four individuals with fluent aphasia, performance on post-tests was better when training included a 5-second or 10-second interval between stimulus and response compared to the no-interval condition. Results were significant for all four of the fluent participants. Moreover, for some, the effects lasted 24 and 48 hours. (Table 1).

Results for the two individuals with nonfluent aphasia showed a different pattern in that neither of them showed significant improvement during the high load condition (5-10 second interval) when compared to the no load condition (no interval). (Table 1)

Discussion

These results provide additional support to the hypothesis that direct training can improve tolerance of increased STM load in the context of language tasks and will lead to improved language abilities. We designed a facilitation protocol that identified very short-term effects of massed repetition of verbal stimuli without and with an added 5-second or 10-second interval before responding. We found improved performance with the high memory load repetition training for all four fluent participants, but not for the two nonfluent participants. It should be noted that both of the nonfluent participants had relatively severe aphasia with a probable confound of apraxia of speech (AOS). Thus, in future studies using this paradigm, it would be important to tease out the role of severity, lesion location, and coexistence of apraxia from any effects of increased memory load. The present results, although preliminary, suggest that adding memory load to language tasks is potentially a useful treatment approach for individuals with fluent aphasia.

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Table 1. Repetition of Verbal Stimuli under 2 Training Conditions: Immediate Repetition and after a 5-second or 10-second Interval (Trained items only)

				Proportion correct on Post-tests above Pre-test Level						Chi-Square Comparison of 1-sec vs. 5-sec or 10-sec training	
Particpant	**WAB Classification**	**Stimuli (n= 10)**	**Training Interval Condition**	**Pre-Test**	**Post-Immediate**	**Post-10 Minutes**	**Post-30 Minutes**	**24 hours**	**48 hours**	**Total correct first 3 post-tests**	**Total correct all post-tests**
TB	**Conduction with anomia**	**Abstract Word Pairs**	Immediate	.00	.00	.00	.10	.20	N/A	***p = .006***	***p =.057***
			5-sec Interval	.10	.20	.30	.40	.00			
FS	**Conduction**	**Abstract Words**	Immediate	.10	.30	.20	.10	N/A	.20	***p = .042***	***p =.01***
			10-sec Interval	.10	.40	.30	.50		.50		
KC	**Wernicke**	**Abstract Words**	Immediate	.00	.20	.40	.20	.30	N/A	***NS p = .140***	***p = .05***
			10-sec Interval	.00	.50	.60	.20	.50			
CM	**Anomia**	**Nonwords**	Immediate	.10	.20	.20	.20	N/A	.20	***p = .026***	***p = .047***
			5-sec Interval	.00	.40	.40	.50		.40		
CN	**Broca**	**Abstract Word Pairs**	Immediate	.10	.50	.20	.50	.60	N/A	**NS *p* = .40**	
			5-sec Interval	.00	.40	.40	.20	N/A			
DD	**Broca**	**Abstract Word Pairs**	Immediate	.00	.10	.40	.10	N/A	N/A	**NS *p* = .50 (Immediate plus 10-minute post-test)**	
			5-sec Interval	.00	.30	.30	N/A				