A Short-term Memory Treatment Approach to the Repetition Deficit in Conduction Aphasia

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Conduction aphasia is characterized by disproportionate impairment of oral repetition relative to other language modalities (Goodglass and Kaplan, 1972; Green and Howes, 1977). The nature of this deficit has been the subject of considerable debate in the recent literature. Explanations have been diverse, alternately describing the repetition deficit as a disconnection phenomenon (Geschwind, 1965; Kinsbourne, 1972); a deficiency in memory for the sequential aspects of speech programs (Tzortzis and Albert, 1972); an impairment in the selection and combination of target phonemes (Strub and Gardner, 1974); or the result of auditory-verbal short-term memory deficits (Shallice and Warrington, 1977; Caramazza, Basili, and Koller, 1981).

Treatment of conduction aphasia frequently emphasizes repetition training, not so much with improvement as its own end goal, but rather to provide a transition to spontaneous speech production (Shewan and Bandur, 1986). Training generally employs hierarchies of stimuli (Gardner and Winner, 1978) which will progressively approximate contextual speech. However, the approach does little to circumvent or stimulate the impaired mechanisms which cause the repetition deficit. Recently, Sullivan, Fisher, and Marshall (1986) utilized oral reading to improve sentence repetition. However, minimal generalization was observed on independent measures of improvement. This investigation was undertaken to evaluate a treatment program based on the hypothesis that the repetition deficit in conduction aphasia is the result of auditory-verbal short-term memory deficits.

METHOD

Subject. I.C., a 53-year-old female, suffered an embolic cerebrovascular accident following carotid endarterectomy. CT scan demonstrated a left parieto-temporal infarct. She was referred for speech-language pathology consultation eleven days post onset. The Boston Diagnostic Aphasia Examination administered at that time suggested moderate conduction aphasia (Table 1).

Design. The treatment program focused upon improving auditory verbal span for recall and production tasks. The effect of this program on sentence repetition was evaluated using a multiple baseline design. Baseline measures were obtained for sentence repetition and auditory comprehension.

Sentence repetition materials were twenty sentences 5 to 9 syllables long. Each sentence was read by the examiner and repeated by the subject. The order of presentation for the sentences was randomized for each session. A score of 2 (correct), 1 (produced correctly after self correction of errors), or 0 (no correct response after several attempts) was assigned to each of the subject's productions.

In the auditory comprehension task the subject responded to 2-unit commands by pointing to pictures in a field of 10. (Initial attempts to collect baseline data for 3-unit commands were discontinued after the first

Table 1. Pre- and post-treatment results following administration of the Boston Diagnostic Aphasia Examination (Goodglass and Kaplan, 1972).

Subtest	Pre-treatment	Post-treatment
Severity rating	2/5	3/5
Articulation rating	6/7	NA
Phrase length	7/7	7/7
Verbal agility	11/14	11/14
Word discrimination	68/72	70/72
Body-part identification	16/20	16.5/20
Commands	8/15	14/15
Complex ideational material	9/12	9/12
Responsive naming	17/30	28/30
Confrontation naming	51/105	94/105
Animal naming	2/60"	6/60"
Body-part naming	12/30	29/30
Word reading	21/30	29/30
Oral sentence reading	1/10	6/10
REPETITION (WORDS)	9/10	10/10
HIGH-PROBABILITY	2/8	7/8
LOW-PROBABILITY	2/8	8/8
NEOLOGISTIC	0	0
LITERAL	16	3
VERBAL	7	5
EXTENDED	0	0
Automatized sequences	7/8	6/8
Symbol discrimination	10/10	10/10
Word recognition	7/8	8/8
Compr. of oral spelling	5/8	8/8
Word-picture matching	9/10	10/10
Read. sent. paragraphs	5/10	10/10
Writing mechanics	2/3	2/3
Serial writing	NA	46/47
Primer level dictation	8/15	NA
Narrative writing	NA	2/4

items.) Responses were scored using Porch Index of Communicative Ability (PICA; Porch, 1971) scoring procedures. Baseline measures were continued for auditory comprehension performance after the initiation of treatment for sentence repetition. Auditory comprehension baselines were discontinued and treatment begun when criterion performance levels were reached for the repetition treatment tasks. Maintenance measurements were then obtained for sentence repetitions.

Treatment. Auditory verbal span was treated by introducing tasks of auditory and oral word sequencing. Auditory word sequencing was performed for two and three items. The subject was required to point to two or three pictures (depending on the stage of treatment) from a field of ten in the same order as spoken by the examiner immediately after presentation. Oral word sequencing consisted of the subject's repetition of 3 words in the order spoken by the examiner immediately after presentation. Twenty lists of three words were used for this task with each list consisting of a noun, a verb, and a functor. The position in which each word type was presented in each list (first, second, or third) was counterbalanced to control for order effects.

Scaled scoring procedures were developed for both auditory and oral word sequencing tasks (Table 2). Criterion for each task was set at a mean score of 9.0 or greater over two consecutive sessions before increasing complexity or discontinuing treatment.

Table 2. Scaled response values for experimental tasks.

Auditory Sequencing

10-Complete, accurate, prompt
9-Complete, accurate, delayed
8-Incomplete, accurate order, prompt response
7-Incomplete, accurate order, delayed response
6-Response characterized by self-corrected order reversal with accurate items
5-Response characterized by self-corrected response with inaccurate items
4-Response characterized by accurate items with order reversal
3-Repeat
2-Cued
1-Response contains only 1/2 or 2/3 items
0-No attempt to respond

Oral Sequencing

10-Complete, accurate, prompt
9-Complete, accurate, delayed
8-Complete, accurate, self-corrected
7-Complete, order-reversal, prompt, self-corrected
6-Complete, order-reversal
5-Repeat
4-Cued
3-Two of three sequenced correctly
2-One of three sequenced correctly
1-Failed after multiple attempts
0-No response

The initial phase of treatment consisted of auditory word sequencing for two items. Criterion was met for this task after 22 sessions (two baseline, one baseline and treatment, and nineteen treatment only sessions). The second phase of treatment consisted of auditory and oral word sequencing for three items. Criterion was met for these tasks after the 32nd and 34th sessions overall, respectively.

RESULTS

The subject's oral sentence repetition skills improved significantly during this treatment period (Figure 1). Maintenance of these gains after the withdrawal of treatment was demonstrated by criterion level performance over the subsequent 7 sessions. That these improvements were attributable to the treatment itself and not general processes such as spontaneous recovery is suggested by the absence of change in the auditory comprehension baselines obtained during the treatment period. Additional supporting evidence is provided by the rapid improvement in auditory comprehension performance for two and three item commands once treatment was initiated for these tasks. Most importantly, generalization of improved repetition performance is demonstrated by a clinically significant increase for repetition scores on the independent measure (Table 1).

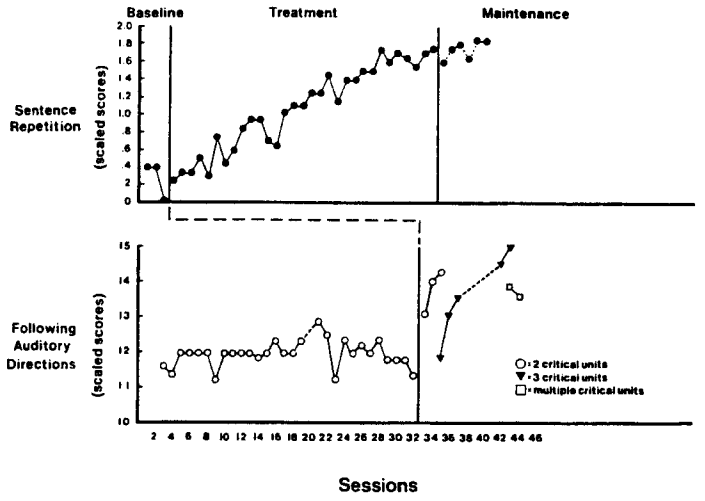

Figure 1. Scaled scores for sentence repetition and auditory comprehension performance during baseline, treatment, and maintenance phases.

In order to evaluate the correlation between treatment performance levels and sentence repetition, the scaled scores for each treatment task over time were superimposed on the sentence repetition baseline obtained during the treatment phase (Figure 2). Initially, improvements in sentence repetition were qualitatively similar to but lagging increases observed for auditory sequencing of two words. Upon attainment of criterion performance for two-word auditory sequencing, sentence repetition had reached 81% of criterion. Oral sequencing for three words was introduced 4 sessions before criterion had been achieved for two-word auditory sequencing. A precipitous regression in the patient's performance for three-word oral sequencing was observed until the subsequent introduction of auditory sequencing for three

words. Performances were then generally parallel for each of these tasks with auditory sequencing meeting criterion 2 sessions earlier than oral sequencing. During this phase, sentence repetition generally followed performance achieved for these treatment tasks, reaching 97% of criterion at the discontinuation of repetition treatment.

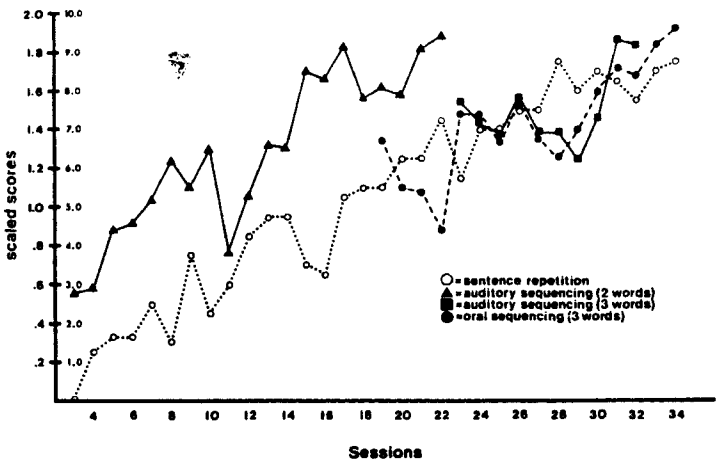

Figure 2. Concurrent performance levels for sentence repetition baseline and specific treatment tasks. (Note: sentence repetition values presented outside abscissa, values for treatment tasks presented inside abscissa.)

Improvements in auditory verbal span may be attributable to at least two factors: 1) increased short-term memory storage and 2) greater accuracy in the ordering of elements in a sequence. It was of interest to determine the nature of the improvements in the auditory and oral sequencing tasks. Accordingly, the data were analyzed to identify the degree to which errors were attributable to omission of verbal items (a short-term memory deficit) versus incorrect ordering of the items (a sequencing deficit) (Table 3). Performance on auditory verbal span tasks was characterized largely by errors of item omission in both recall and production tasks. This effect was especially pronounced for oral sequencing of three words, although verbal paraphasic errors contributed to these results to a small degree.

Table 3. Error analysis for sequencing tasks with regard to modality and time of treatment.

	Error Type					
	Omission (%)			Order (%)		
Task	1st half[a]	2nd half	Total	1st half	2nd half	Total
Auditory						
Two words	94	69	88	6	31	12
Three words	71	50	61	29	50	39
Oral						
Three words	98	90	95	2	10	5

[a]Each half determined by midpoint in number of sessions required to reach criterion for individual tasks.

The data were also analyzed to determine whether improvement was associated with a shift in the predominance of one error type versus another. Omission and order errors were totaled for the first and second halves of the treatment periods for each task. Percentages of the total errors accounted for by omission versus order errors were then calculated for each half. A strong effect was observed for omission errors during the earlier stages of each level of treatment for auditory verbal span. Later performances were characterized by mild to moderate reduction in omission errors and a concomitant increase in order errors. Generally, however, omission errors continued to contribute more substantially to overall errors than did order errors. The exception to these findings occurred in auditory sequencing for three words. For this task, improvement resulted in an equal probability for order errors and omission errors.

Results obtained from the oral sequencing task also allow some broad conclusions regarding the recovery patterns for oral word sequencing when the effects of word type and serial position are considered (Table 4). Generally, word repetition was influenced by word type, with nouns and verbs produced more accurately (85.7% and 82.3% respectively) than function words (64.6%). However, a serial position effect may have contributed to these results, since the most accurate word type at each interval appeared in the initial position of the three-word span. This serial position effect is weakened by the failure of functor accuracy to exceed that of nouns when function words preceded nouns in the second treatment interval. This argument is consistent with earlier findings (Caramazza et al., 1981) in which a consistent serial order effect for all word types (produced separately) was observed across all positions, with decreasing accuracy associated with later positions. If serial order in the present investigation were the only determinant of results across word types, functors should have been produced more accurately than nouns during the second treatment interval. Word type therefore appeared to exert a stronger influence in this task than serial position. Finally, treatment effects for all word types were characterized by a generally consistent pattern of increasing scores over time.

Table 4. Word repetition accuracy in oral sequencing task as a function of word type, treatment interval, and serial position.

Word type	Total percentage correct	Treatment interval[a]		
		1	2	3
Nouns	85.7	84_1[b]	80_3	93_2
Verbs	82.3	66_2	92_1	93_3
Functors	64.6	58_3	72_2	100_1

[a]Treatment intervals 1 (sessions #22-26) and 2 (sessions #27-31) consisted of 5 consecutive sessions while interval 3 (sessions #32-34) consisted of 3 consecutive sessions.

[b]Subscripts refer to serial position of word type in stimulus lists

DISCUSSION

In this study, improved auditory verbal span resulting from a program of direct stimulation treatment generalized to the sentence repetition skills of a subject with conduction aphasia. Error data demonstrated that the source of the subject's difficulty with auditory verbal span tasks was primarily in the storage of stimulus items for recall and production. However, an analysis of the patterns of recovery over time demonstrated a mild but consistent effect for omission errors to be replaced with order errors. Collectively, the results provide potential insight into the mechanisms for recovery of repetition skills in conduction aphasia.

Sentence repetition requires, among other processes, the ability to hold a stimulus in temporary short-term storage and to sequence the items when reproducing it. Evidence provided by the error data suggest that the initial disruption of sentence repetition in conduction aphasia is due at least in part to deficits in the short-term storage of sentences. Subsequent improvement in repetition may be associated with increased short-term storage. However, the increased storage capacities of the conduction aphasic may promote fewer errors of constituent omission while simultaneously increasing sequencing errors due to the greater availability of all items from the verbal set. Repetition improvement therefore seems to be a function of recovery from a prominent auditory-verbal short-term memory deficit complicated by a less pronounced deficit in sequencing abilities. From a treatment standpoint, stimulation of auditory verbal span requires responses which intervene in both areas of deficit.

However, auditory-verbal short-term memory deficits and sequencing deficits cannot account for the whole of IC's performance. Her difficulty in repeating function words presents a problem for these explanations previously addressed by Caramazza et al. (1981). If the source of the repetition disturbance is only due to storage deficits, then repetition accuracy should not depend on word type. In the present case, word type affected both the overall accuracy of functors and the serial order effect during the second treatment interval. Previous discussions of this word effect allude to the differential amount of semantic processing required for function words, being minimized until they are placed in an appropriate syntactic context. Although Caramazza et al. saw the effect as consistent with the auditory-verbal short-term memory deficit hypothesis, the differential effect for word type strongly implicates a linguistic element in the present subject's repetition disturbance. And, while Shallice and Warrington's (1977) and Caramazza et al.'s (1981) subjects did not present with any significant paraphasic responses, IC did demonstrate numerous paraphasias in both spontaneous speech and on clinical testing, further supporting the notion of linguistic involvement.

That IC's performance involves aspects of three models that have been viewed as more or less mutually exclusive does not present difficulties for any one of these models nor to the current description of her repetition deficits. Shallice and Warrington (1977) and others have argued for the existence of more than one type of conduction aphasia. In their terminology, inability to repeat words or sentences in a context of significant paraphasia are reproductive deficits while failure to repeat words or sentences without accompanying paraphasia are repetition deficits. The important point is that both deficits may appear together in conduction aphasia because of the close

anatomical representation for the underlying functions which give rise to these deficits. The particular distribution of the infarct producing IC's disturbances can account therefore for the presence of all three repetition deficits in her case. What is most promising, however, was the general resolution of sentence repetition deficits using the method described here which attended to processing components rather than linguistic performance per se.

Stimulation of auditory short-term storage improved those mechanisms which at least theoretically contribute to sentence repetition. As a result, treatment was directed toward underlying processes which support the behavior rather than attempting to improve performance by repetitive responses elicited over the same impaired processing routes or by deblocking approaches. For instance, Sullivan et al. (1986) attempted to utilize a more intact visual storage system through oral reading to improve performance in a related, but independent auditory storage system. No generalization of their treatment results to independent measures was observed, suggesting that those processes directly involved in sentence repetition must be treated in order to effect reasonable improvements in the target behavior. Perhaps this was the basis for the generalization to novel stimuli that was observed in the present investigation.

Given that several varieties of repetition deficit in conduction aphasia have been observed and discussed, it may be that the present treatment approach is not appropriate for all patients presenting with this deficit. However, analysis of the error types produced by specific patients may suggest that the repetition deficit is one of auditory-verbal short-term memory. For these patients, the present treatment seems to be effective in improving sentence repetition.

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DISCUSSION

Q: Was her failure in following auditory directions secondary to her short-term memory deficit?
A: Since following auditory directions is very much dependent upon short term storage abilities, memory deficits may have played a contributing role. However, in that particular task, performance would seem to be more dependent on comprehension skills per se since following directions did not improve at the same time that short-term memory skills were improving in the sequencing tasks.

Q: I was wondering why you didn't see generalization? It seems as though the types of conduction aphasic patients that have repetition deficits that are purely secondary to their short-term memory deficits should also have comprehension deficits that are purely secondary to short-term memory deficits. Also, can you describe in greater detail your diagnosis of conduction aphasia? For instance, why was her oral reading of sentences so poor? She only got one out of ten correct.
A: Because of generally numerous paraphasic responses. In her reading she was having to self-correct her paraphasic responses.

Q: Did she omit functors in reading sentences and did she omit functors in spontaneous speech?
A: No.

Q: So can you give me a little more detail about why you call this person a conduction aphasic?
A: The easiest answer would be that she generally fit the profile. With regard to oral reading, her errors were not characterized by omission but rather by continued contamination of her speech with paraphasic responses. In many attempts she demonstrated the classic conduit d'approache. There were disproportionately more literal paraphasic errors than semantic paraphasias. Comprehension was relatively intact.

Q: What was her spontaneous speech like relative to her repetition?
A: In spontaneous speech, she was hesitant, paraphasic, fluent, and grammatical. In repetition she would look at you after a stimulus and say "again," try the first word or two and then stop. So she appeared to have a storage problem with the repetition items and in that way was different in repetition than in spontaneous speech.

Q: Tell us again how this treatment task may have influenced improvement in other areas other than just in sentence repetition.
A: Which areas?

Q: Did she get better? Is she talking better? Understanding better?
A: There was improvement in other areas on testing with the BDAE. I'm not making claims, however, that this particular approach is one for general stimulation of language processes. Did you interpret my remarks as if I had made that claim?

C: No, I may have missed it and was wondering how a specific treatment for a behavior that you don't really use too much in conversation may have accomplished what we're after...to make people better communicators.

C: She did become a better communicator while I was focusing on sequential skills and sentence repetition. As she began to improve on repeating sentences and becoming less paraphasic, she seemed to also generalize to spontaneous output. This might be a way to approach sentence repetition for some patients since this is a frequent target area with these patients and may have more general effects on other forms of speech production.

Q: In your reading and thinking about conduction aphasia do you see any evidence to support the presence of nonfluent conduction aphasia?
A: Yes, but only relatively more nonfluent. Patients who have posterior lesions which are proximal to the central sulcus do seem to be relatively more nonfluent than patients who have a lesion that is more distal. The arcuate fasciculus perhaps is a multisynaptic route capable of inhibition at various points which may produce more nonfluent output.

Q: But is it more nonfluent within the fluent continuum, if you would, than just the dichotomy fluent versus nonfluent? Seems to me to be a contradiction of terms to talk about nonfluent conduction aphasia. Not that you did, I was just asking.
A: I wouldn't call it nonfluent conduction aphasia. I would speak in terms of the relative fluency of their speech characteristics. Some may be relatively more nonfluent or tend towards more nonfluency than some of the more fluent fluent patients.

C: Thank you for clearing that up for me!

Q: Could you comment on the relationship between her writing to dictation and written confrontation naming relative to her verbal productions? Specifically, did her writing in any way follow her phonemic paraphasic productions?
A: Her written output did demonstrate transposition of items which follow what she was doing at a later point in both types of word sequencing tasks.

C: I would suggest that this is something that we look at closely in these kinds of patients. If her written responses were following her oral-verbal responses, especially in terms of her errors, the implication would be that there is a breakdown at the level of phonological encoding, separate from semantic access, storage or whatever. It would provide a way of looking for those intercepts within the task that let you isolate and identify specific processes.

C: There were spelling errors that she caught very quickly in her writing which may support what was observed in her spontaneous output.

Q: It seems as though you probed quite often...for generalization.
A: Every Session.

Q: Is there a possibility that your generalization probe functioned as a treatment?
A: I tend not to think that getting the sentences every session was helping her to improve on those items. They were also randomized to reduce learning, if such an effect was present. I have a hard time believing that just hearing these sentences and repeating them was the basis for her decreased paraphasic performance.